# Community Lands & Waterways

# DATA SOURCE
## Coos Bay Area, Oregon

Partnership for Coastal Watersheds

South Slough NERR

Coos Watershed Association

August, 2015


*Figure 1. The "project area" referenced throughout the Communities, Lands & Waterways Data Source is defined by a network of nine environmental "subsystems," which collectively comprise the lower Coos watershed. The subsystems, shown above and in maps throughout the Data Source chapters are, South Slough, Lower Bay, North Slough, Haynes Inlet, Upper Bay, Coos River, Catching Slough, Isthmus Slough, and Pony Slough.*

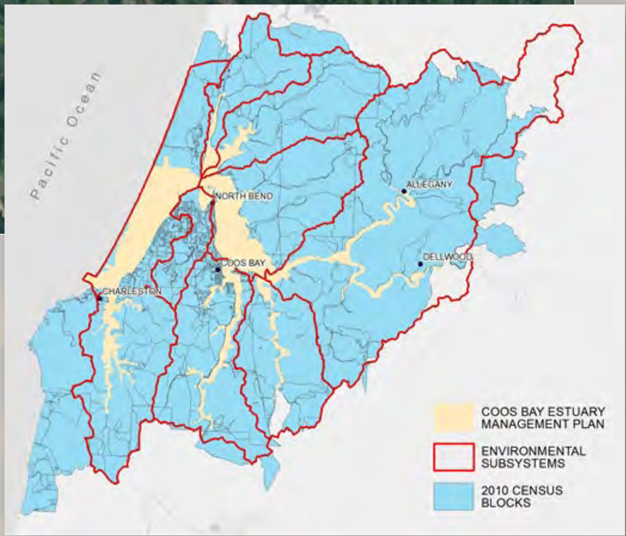


*Figure 2. The extent of project area closely matches Census blocks from which socioeconomic information was compiled as well as the administrative boundaries of the Coos Bay Estuary Management Plan, which provides the regulatory basis for estuarine conservation and development decisions in the Coos estuary.*

# Introduction

*The Communities, Lands & Waterways Data Source (Data Source) is an encyclopedic compilation of all available data describing the socioeconomic and environmental conditions in the Coos Bay area. The Data Source considers the Coos Bay area to include the Coos estuary and lower Coos watershed, referred to as the "project area" in Data Source chapters (Figures 1 and 2). The Data Source provides users with in-depth status and trends information about the project area's attributes, and includes evaluations of those attributes, and highlights significant data gaps. The Data Source is available for download here: https://files.secureserver.net/0fnREdjwci0i0s and online here: www.partnershipforcoastalwatersheds.org.*

*The Data Source is organized into 17 chapters divided into two parts. The Communities section (six chapters) characterizes socioeconomic status and trends in the project area, evaluates our community's social and economic attributes for comparison with other communities, and provides the Data Source with critical historical perspectives. The Lands & Waterways section (eleven chapters) characterizes and evaluates the status and trends of the project area's environmental attributes, and describes the likely effects of climate change on those attributes. In this section we include chapter summaries which evaluate the chapter's information sources, identifying important data gaps and limitations.*

*Drafts of each chapter have been reviewed and edited by: 1) technical reviewers (those responsible for generating the data summarized in each chapter); 2) subject area reviewers (e.g., fish biologists reviewing the Fish chapter, school district administrators reviewing the Schools and Education chapter); and 3) the Partnership for Coastal Watersheds committee guiding the development of the Data Source (see below). While most of the Data Source chapters have been reviewed, it's important to note that this process is still taking place. Those chapters still subject to additional review will be labeled as such on the chapter's front page.*

*The Data Source was developed by the Partnership for Coastal Watersheds (PCW), a group of civic-minded local community members representing county and city planners, natural resource managers, and development and conservation interests. For more information about the PCW, go to www.partnershipforcoatalwatersheds.org or contact Jenni Schmitt at the South Slough Reserve: jenni.schmitt@dsl.state.or.us.*

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Partnership for COASTAL Watersheds

# Community Lands & Waterways

# DATA SOURCE

## Coos Bay Area Oregon

Communities, Lands & Waterways DATA SOURCE Exploring our essential elements

National Estuarine Research Reserve System Science Collaborative

## Table of Contents


*The status of the environmental attributes characterized in the Data Source is evaluated in each chapter using a system of colors and symbols. Green boxes represent good status; yellow represent fair status; and red represent poor status. White is reserved for attributes for which evaluations cannot be made due to insufficient information, thereby highlighting data gaps. The boxes are accompanied by symbols representing trend information. The upward pointing arrow symbolizes increasing trends; the dash represents no clear trends; and the downward pointing arrow indicates decreasing trends. The open circle indicates that not enough information exists to determine trends.*

**LANDS & WATERWAYS (continued)**

# **Chapter 1:** A Brief Overview of the Coos Bay Area's Economic and Cultural History

*Don Ivy- Coquille Indian Tribe*

*Summary:*

- *The economic and cultural history of the Coos Bay area is one of change, transition, and response to events frequently far beyond local control or influence.*
- *Current socioeconomic and envioronmental conditions can't be understood without at least some comprehension of what has occurred before today.*
- *Archeological evidence and oral traditions of Coos Bay's Native people suggest resilient human cultures persisted and evolved through ecological, economic, and sometimes catastrophic changes occurring over the past 6,000 - 10,000 years.*

Photos: Top- Coos History Museum Bottom- nwmapsco.com

**Introduction**

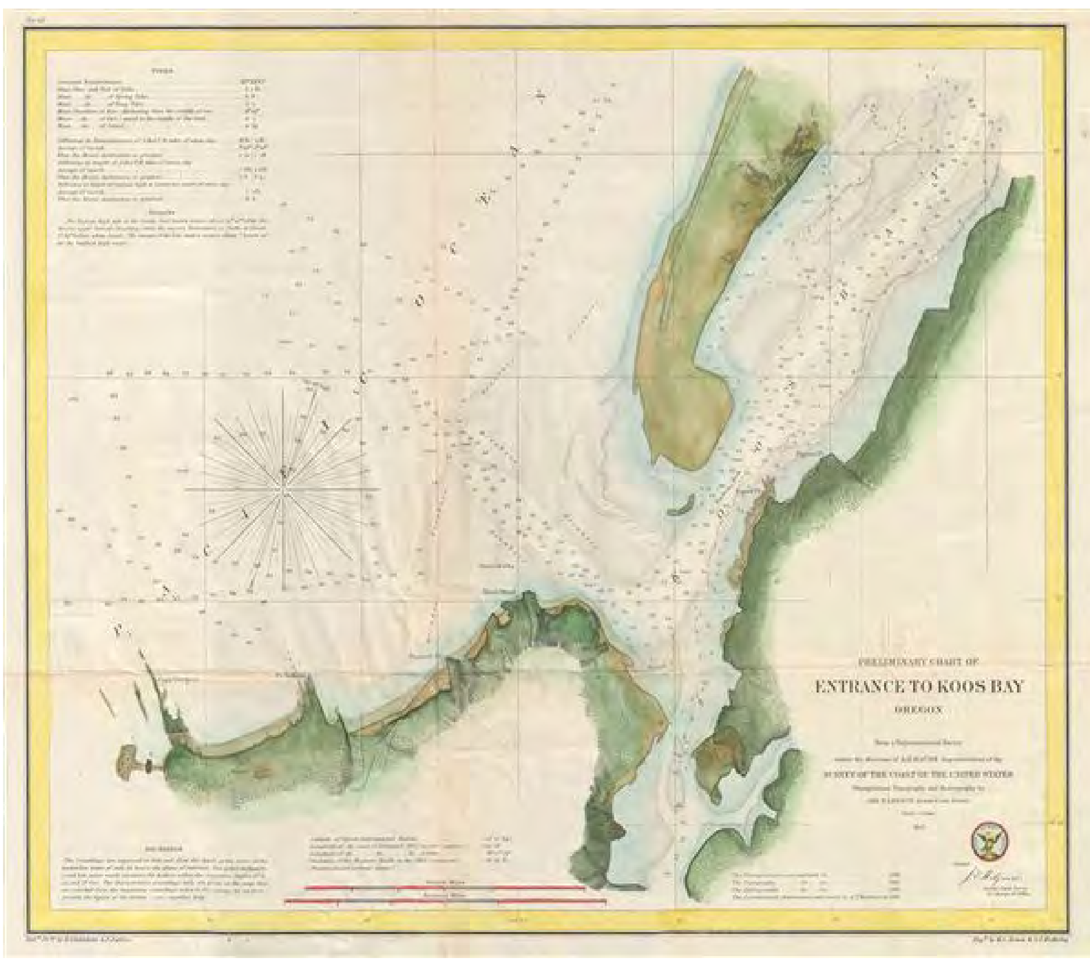
To know anything about the culture of a place and the people who inhabit it- whether a cursory description of past circumstances and happenings, or a close examination of a particular past condition- requires some understanding of what encouraged or enabled human occupation and livelihoods in the first place.

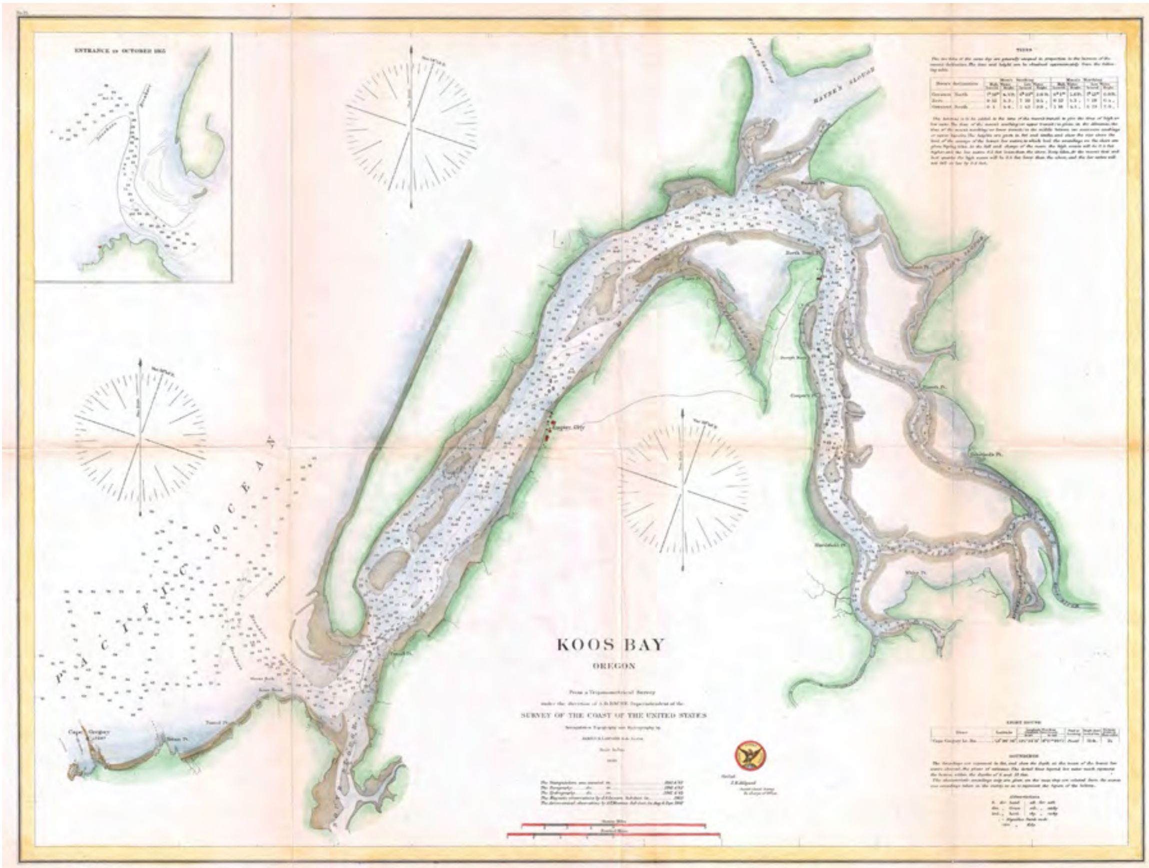
The following narrative is not a comprehensive explanation of the Coos estuary's many past and present cultural influences. Rather, it is a broad and general description of the significant events and circumstances that influenced the settlement and development of the Coos Bay estuary and its environs since the early 1800's; all of them contributing in some way to the current economic and cultural landscape. The bibliography found at the end of this chapter provides the reader a selection of published literature that elaborate many of the events and episodes mentioned herein.

Euro-American Discovery and Early Settlement on Coos Bay

The modern history of the Coos Estuary begins in January 1852 with a shipwreck on the North Spit. The crew and soldiers of the Captain Lincoln salvaged the cargo of the grounded vessel and made camp (which they named Camp Castaway) for several months until they were discovered and rescued. The accounts of the shipwreck survivors and the rescuers about this newly discovered place told of bountiful timber resources, fertile agricultural lands, friendly Natives, and a natural harbor. In 1853, led by one of those rescuers, a group of speculators calling themselves the Coos Bay Commercial Company established Empire City, almost directly across the bay from the Camp Castaway location; and virtually in the middle of the hanis Coos Indian

Map showing the entrance to "Koos Bay" circa 1862, prior to building of the jetties. Map drawn by the U.S. Coast Survey.






Map showing “Koos Bay” circa 1865. Many place names have changed since this map was created. For example Marshfield Pt is where the city of Coos Bay now resides and what is now called Kentuck Slough was labeled as Jordan’s Slough on this map. Map created by the U.S. Coast Survey

village that had kept Camp Castaway alive the year prior. Soon after, other speculators and industrialists came to stake their claims to the shores and resources of Coos Bay; and with them came the industrial, agricultural, and political ideals of America’s emerging capitalist economy.

Two earlier explorations by Euro-Americans into Coos Country have been written about: both offering only brief and scanty reports about the Native inhabitants and their habitations in the Coos Bay region. Alexander McLeod of Hudson Bay Company sojourned here in the winter of 1826; and Jedidiah Smith, an agent of the American Fur Company, traversed the country in July 1828. Both reports imply the presence of pre-existing and well-established travel routes to the north and south and into the interior; numerous “villages” that spoke differing languages and dialects; and Native people who seemed already familiar with foreigners and foreign goods, who were willing, if not eager for trade. McLeod was looking for beaver. Smith was herding 300 horses from California to Fort Vancouver on the Columbia River.
Native People on Coos Bay

Evelyn Moore, Laura Metcalf, Nancy Palmer & Laura Short. Source: Coquille Indian Tribe

Two lines of wood stakes exposed crossing a small tidal channel in a Coos estuary tributary indicate remnants of historic fish weir sites. Fish weirs were built and used by coastal tribes to seasonally harvest salmon and other fish species. Radiocarbon dating of these stakes determined one row was from 1443, and one from 1640, both predating the 1700 subsidence event. Source: Tveskov and Erlandson 2003

Americans and earlier Euro-American adventurers were clearly not the first humans to travel through, settle, or exploit the abundant and fertile natural resources of the Coos estuary and its environs. The remnants of ancient fish traps, shell fish harvesting sites, and residential locations on Coos Bay are dated by archeologist to at least two thousand years before present. Older archeological sites (6-10 thousand years before present) are well documented to the north and south of the estuary, supporting assumptions of similar older human occupations at Coos Bay; the evidence likely buried in deep estuary sediments caused by upland erosion; by sea-level rise and subsequent river valley in-filling; and by Cascadia earthquake and tsunami events.

Besides archeology, the oral histories of the two Indian Tribes who reside on Coos Bay today also speak to the Coos estuary as a place of transition and trade between often

Figure 4. Yurok-style plank house similar to those built by north coastal tribes through the 19th century. This particular plank house is from the Sumêg Village, located inside Patrick's Point State Park, California. Source: Coquille Indian Tribe

Present day "Chinuk" style canoes at the annual Salmon Festival celebration in Coos Bay. Source: Coquille Indian Tribe

far distant cultural groups and economies. The traditions of cedar plank houses, "Chinuk"-style canoes, basketry techniques, ceremonial practices, and the presence of several Native languages were all present at the time of first American settlement: all evidence of extensive long distant and long-standing trade networks and multi-cultural Native societies. Combined, the science of archeology and the oral traditions of the Native people who live on Coos Bay today speak to resilient and adaptive human cultures that persisted and evolved as environmental, ecological, economic, and sometimes catastrophic geological changes occurred over the millennia.


Map of the Coos and Coquille estuaries circa 1900. Source: USGS 2012

Workers from the Coast Fuel Corporation. Source: Coos History Museum and Maritime Collection, CHM 991-N118d

Miners at the turn of the century in front of the Henryville Mine (Later renamed Delmar Mine), approximately eight miles south of Coos Bay on the east bank of Isthmus Slough. Source: Coos History Museum and Maritime Collection, CHM 973-63d


Powers logging camp after felling old-growth spruce trees. Source: Coquille Indian Tribe

Early Developments on Coos Bay; pre-1900

The Coos Bay Commercial Company brought with it two aspects of commerce that have persisted in the local economy ever since: immigrants into the region with aims to exploit and extract natural resources for economic value; and those who came to provide the goods and services those enterprises needed. Gold prospecting and coal mining and shipbuilding brought the initial wave of investor capital and speculators to the Coos region; followed close behind by sawmill operators who to make lumber and timbers for industrial infrastructure, housing for laborers and immigrant settlers, and buildings for the subsequent commercial and merchant trade. And behind them, came farmers and ranchers.

Although Coos Bay offered a viable harbor for ocean going ships of that era, its extensive mudflats and shallow estuary sloughs and inlets limited early wharfs and docks to places along the shore that were close to deep water that also offered immediate access to non-tidal uplands. Thus, early developments on the bay centered at Empire City and North Bend and Marshfield. As coal mining and sawmilling grew, and as more speculators arrived, so did needs for additional wharfs and docks. Pilings soon stood in mudflats to support piers, gangways and rail trestles reaching over wide expanses of mudflats, all for access to deep water.

Logging yarder with Henry Metcalf Sr. c1930's. Source: Coquille Indian Tribe

Log pond at Sitka Mill circa 1936. Source: Coquille Indian Tribe

Similarly, upper reaches of the estuary and its tidelands and tidal reaches became settled; also becoming diked and drained as agricultural pursuits took hold. If not sold locally to the growing populations around the estuary- as was coal and lumber- the markets of San Francisco were the destination for early Coos Bay orchards and crops. By 1900, channel dredging began to happen; both to serve ocean-going vessels during all tides, and to provide source material to make new lands above high water. Dredging spoils also made high ground for boat landings for emerging neighborhoods and town sites growing up near the mines and mills and pasture lands. With very few good all-season roads locally, and even fewer year-round routes to the outside world of the Umpqua and Willamette valleys, the emergent neighborhoods and towns on the Coos estuary depended on Coos Bay waters as the primary connection to the outside world; oriented almost entirely to San Francisco. Similarly, nearly all internal economic and community purposes made the waters of Coos Bay the life line and travel routes for virtually every aspect of local economic, community and social life.

Developments on Coos Bay 1900-1940's

As the 20th Century began, daily life and industry on Coos Bay remained dominated by water transportation, although new overland routes to the interior were being explored and in some cases completed. A "mosquito fleet" of small boats plied up and down the bay carrying people and goods from town to town along the lower bay and produce and people from upriver farms to downtown markets and processing plants. Ferry boats made trips from downtown into the upper reaches of the estuary for Sunday picnics and summer time camping excursions. For those who could afford them, skiffs powered by gasoline motors were the private automobiles of the day.

When the Southern Pacific Railroad from the Willamette Valley to Coos Bay was completed in 1916, Coos Bay's economy took on new dimensions. Although merchant vessels still carried goods to San Francisco markets, Coos Bay now had ready access- and accessibility- to Portland and Willamette Valley interests. The railroad replaced passenger stage routes into the Willamette and Umpqua valleys, and along the rail route, new opportunities opened up for moving logs and lumber to mills and market. But as new economic possibilities emerged, old industries disappeared. After the 1906 earthquake, San Francisco made fuel oil and gas the preferred energy for its street lights, manufacturing, and residential purposes; and coal mining on Coos Bay began to end.

The railroad also brought ambitions to deepen the harbor to accommodate newer and deeper-draft cargo ships. Jetties were lobbied for, as well as large scale channel and harbor deepening projects. By the end of the 1930's, in spite of a World War and the Great Depression, the Coos Bay bar had both jetties, and the harbor could now handle those deeper draft vessels. And with larger ships now calling, and with rail access to the interior, lumbering became even more dominant in the local economy, attracting even more significant national and international interests and speculation.

A deeper harbor and safer bar also created a safe harbor for smaller vessels, and Coos Bay soon became home to a commercial fishing fleet and several fish processing docks and canneries. Salmon and crab became new commodities to ship from Coos Bay- in fully processed canned tins or as minimally processed fresh goods leaving town in refrigerated rail cars. Similarly, dairy production and processing took on bigger scales- and new markets- as rail and maritime shipping facilities became improved.

Spoils from upper bay dredging projects were pumped or dumped into and onto previous tidal sloughs and mudflats for new high ground upon which business districts and mill sites could be expanded; and where sometimes new residential neighborhoods were built. Dredge spoils also became material for dikes along upper estuary shorelines; later to become roadsteads as local transportation by water gave way to automobiles and trucks. These and later dredging projects- along with the wood waste of sawmilling- filled in as much as 80% of the estuary's pre-industrial tidal and inter-tidal mudflats, sloughs and marshes by the 1960's.

As the 1930's ended, the North Bend Airport had been expanded and improved (again with the aid of dredge spoils); the Oregon Coast Highway (later named Highway 101) and its several bridges were complete, making a modern all-weather thoroughfare connecting all of Oregon's coastal towns from Astoria to Brookings. The "Coos Bay Bridge" (later renamed McCullough Bridge) replaced the Glasgow Ferry in 1936; and as arterial highways to the interior also became improved, recreational auto travel and tourists from interior towns and cities began to visit.

Developments on Coos Bay 1950-1980

Although World War Two and the few years immediately following were “boom times” for the Coos Bay region, the early 1950’s re-established the cycles of boom and bust in the local economy. Once myriad independent sawmill and logging companies became fewer; and when Weyerhauser opened its North Bend lumber manufacturing plant in 1951, many of the remaining “gyppo” logging and mill owners soon sold out and went to work in the new big mill. Others became the cutters and fallers and truck drivers began the harvest of Weyerhauser’s 200-plus thousand acres of Coos River old growth forests- most of it purchased decades previously.

In 1956, Georgia-Pacific bought the Coos Bay Lumber Company and its “big mill,” which prior to the start-up of Weyerhauser’s North Bend operations, had been the largest mill and employer on the bay. Georgia Pacific acquired mills, transportation links (rails, roads, docks) as well as 120 thousand acres of prime timberlands mostly south of Coos Bay, in the Coquille River basin. Rail transport was soon moving lumber and plywood produced at mills on the Coquille to Coos Bay, for export by rail and ship to U.S. and foreign markets.

The outputs of “Weyco” and “G-P” (as they became called), along with that of the Menasha Corporation (previously Menasha Wooden Ware Company) and a few smaller timber companies with sufficient holdings and capacity, soon made Coos Bay the “lumber shipping capital of the world.” But even in the face of the prosperity of good jobs, the subsequent bustling retail and commercial trade, and lots of taxes going to county and municipal governments, local observers made note (in spite of proclamations to the contrary) that the volume of timber harvest was not sustainable. That is: existing timber was being cut faster than what the next generation of forest

Red Gibbs coal mine on the South Slough, c1950. Source: Coos History Museum and Maritime Collections, CHM 988-NA1.6

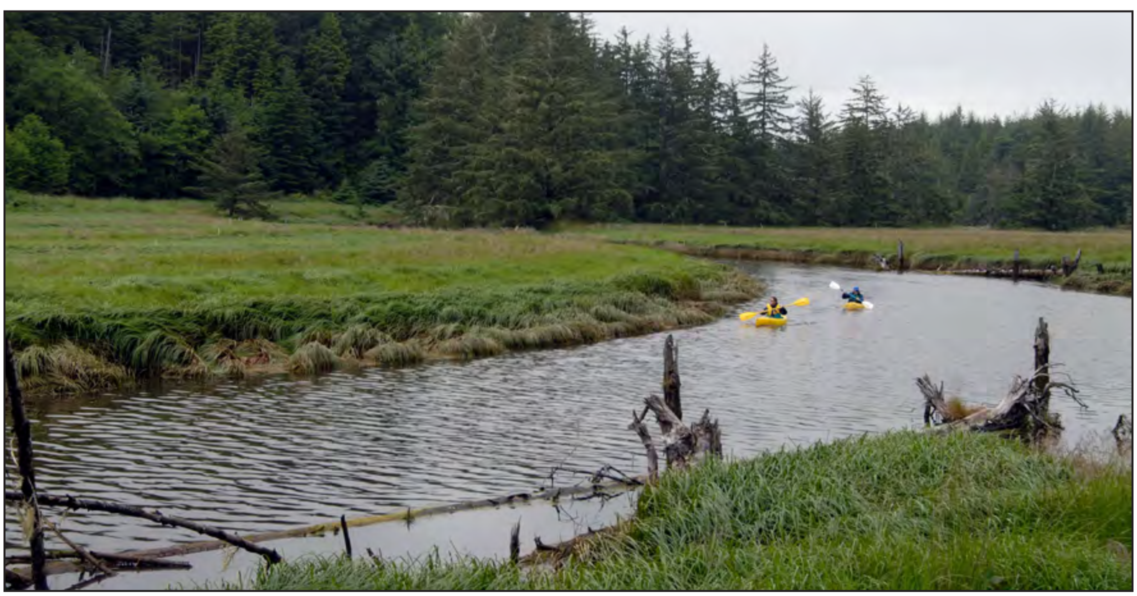
could replace before the “old growth” ran out. In effect, some were saying that when the trees ran out, so would the good times. Eventually, those predictions came true: old growth forests once deemed inexhaustible and sustainable in perpetuity even as late as the 1940’s, were in fact nearly completely exhausted as the 1980’s began.

Similarly, the once abundant and also seemingly “inexhaustible” commercial salmon fishery saw its apex and decline between the 1950’s and 1980’s. Though purse seining and gillnetting on the estuary had ended decades prior, and in spite of intensive hatchery efforts on Coos Bay tributaries since the early 1900’s, by the 1980’s salmon stocks were in serious decline. Over-harvest by commercial and recreational fisheries were part of the problem. But so too were the accumulated effects of decades of expedient and primitive logging practices, upriver splash-damming, and log rafting and storage on the tidal bay. Too, the filling-in of estuary marshes and tidelands for agricultural and commercial purposes, and toxic run-off from industrial and municipal sources were other factors contributing to Coos Bay’s salmon problem.

It would be in later decades, and as the result of scientific research conducted by Oregon Institute of Marine Biology (permanently established 1966) and South Slough National Research Reserve (permanently established 1974) and others, that variable ocean conditions and migration patterns; as well as estuary water quality and loss of habitats were also contributors to the health and abundance of all Coos Bay and Pacific coast fisheries, including salmon.

Developments 1980-Present

Nearly all aspects of Coos Bay’s business and civic landscape changed in the 1980’s; including the complexion of waterfront uses, and in some ways, the complexion of the estuary



Present day kayakers paddling along the South Slough estuary, an arm of the Coos estuary. Source: South Slough NERR

Coos Bay waterfront looking with emergent marsh vegetation in foreground and broken down pilings and dock infrastructure and a pilot boat heading out beyond. Source: South Slough NERR

itself. More than 100 years of successive natural resource extraction and exports came to end. Mills not only closed, they were dismantled and torn down; docks and piers and log yards became derelict and decayed. Many businesses that had served those industries and enterprises and their workers for generations also ended or were substantially diminished. Retail stores closed. Jobs were gone. Unemployment and family poverty soared. People left town. Coos County's population declined significantly between 1980 and 1990.

Since 1990, the population of the Coos Bay region has remained virtually unchanged, but not so its demography. The population became older, reflecting both national population trends, and the immigration of retirees and semi-retired professionals. The absence of "family wage" jobs to attract and retain younger adults and families also contributed to that aging; as did the out migration of post-high school young people for employment and education opportunities elsewhere.

The concepts of "industry" changed as well. Although forest products remained a contributor, the service industry became the majority jobs provider. Tourist and hospitality services, medical and retirement facilities, outdoor recreation businesses, and Tribal casinos became dominant employers. Commercial fishing, boatbuilding and fish processing plants still provided jobs, although "fishing" in all aspects became highly regulated. As water quality of the estuary improved, oyster aquaculture expanded; and recreational salmon fishing on the estuary during late summer and fall became a cottage industry in its own right.

Bandon Dunes Golf Resort opened in the late 90's, and by 2015 had grown to a complex of five "world class" links-style golf courses with complete resort amenities. As wealthy golfers from around the world came to play at Bandon Dunes, charter and private jet airplane traffic at North Bend Airport grew from less than 50 to more than 5,000 landings per year.

Tribal Governments emerged. The Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians regained federal recognition in 1983; the Coquille Indian Tribe in 1989. Both Tribes chose to headquarter in Coos Bay and North Bend respectively; and both now operate health, education, and social programs for their tribal communities as well as other Natives and segments of the local non-native population.

Along estuary shorelines, vacant mill sites and shipping wharfs became new kinds of places. Neglected docks and pilings became habitats for estuary wildlife shorebirds and fishes. Boardwalks replaced industrial tramways along city waterfronts. Hotels, RV parks, a Tribal casino, a public museum and boat ramps and parks became new uses of former sawmill, coal bunker and lumber yard sites. Where log booms once covered them, tide flats and inter-tidal marshes re-emerged to become destinations for recreational clam diggers, birdwatchers, and canoe and kayak enthusiasts.

Vestiges of the industrial past still persist, although much diminished in size, in numbers, and in frequency of use. Logs are still processed for export to foreign countries,

Coos Bay waterfront looking south. Showing decaying historical dock infrastructure and marsh vegetation in foreground, with new Coos Historical and Maritime Museum in upper right corner. Source: South Slough NERR sawmills still operate, ships still load wood chips for Japan's pulp and paper mills, and the railroad still carries away lumber and plywood destined for national and international markets. So too: foreign investors, local land speculators, and civic leaders still tout the advantages of Coos Bay as the "only deep water harbor between San Francisco and Puget Sound" all promoting and awaiting the next big industry that might bring new jobs, prosperity and a vibrant future to Coos Bay and the Coos region.

Developments: Looking Forward

In 2015, more than 160 years have passed since the initial American settlement and development of the Coos Bay estuary. As much as technology and successive waves of corporate investments may have transformed some of its aspects, Coos Bay still remains- at least as some past observers characterized it- "a remote outpost on the frontiers of civilization." Although all the attributes of modernity exist: a railroad, an airport, highways to the interior, and a deep draft shipping harbor, none are primary routes to the major cities and industrial manufacturing and distribution centers of the Pacific Northwest.

Highway 101 and its arterials are not freeways; rail transport is limited to 10 miles per hour; the airport is not a connector for even regional travel; and though it is deep draft, the Coos Bay harbor is constrained by a narrow shipping channel and very few deep draft wharfs with adequate uplands upon which to build terminal or trans-loading shipping facilities. These factors may have limited industrial developments in the past, and may continue to do into the future- especially in the absence of large-scale industrial sites and infrastructure.

On another hand: Coos Bay's temperate year-round climate; its year-round outdoor recreational opportunities; its full complement of commercial and retail and medical services; it close proximity to the spectacular and scenic natural beauty of nearby ocean beaches and rugged coastlines (some say rivalling or surpassing the California's "Big Sur"); and an environment that is (as a recent local Garden Club meeting proclaimed) still "green, clean, and pristine" are bring increasingly more leisure and recreational tourist visitors. These same attributes are also the attractants for the continued growth of a retired and semi-retired residential population.

At this writing, Coos Bay's future economy and cultural identity prospects are of several parts:  Bandon Dunes Resort is planning more golf courses elsewhere on the south Oregon coast, which surely will bring even more jet traffic to the North Bend airport. The Port of Coos Bay champions a liquefied natural gas export facility on the North Spit that may provide impetus for upgrades to rail and harbor facilities, which may attract ancillary manufacturing and shipping facilities. Both local Tribes are expanding their respective land bases and businesses, including commercial timbering and agriculture and visitor/convention/tourism venues.

But prospects of an eventual robust and prosperous economy- however it might occur- does little in the moment to help local municipalities deal with present circumstances: wastewater treatment facilities need critical maintenance and upgrades; streets suffer from decades of deferred repairs and improvements; local tax bases barely cover the costs of public safety and emergency services; and the shop worn appearances of downtown business districts hint every day of an economy that is surviving, but clearly not thriving.

## Conclusion

The journals of the earliest sailors, explorers, and settlers into the Coos region, the oral traditions of its Native peoples, the oratory of local historians and promoters, the discoveries of scientific inquiry, all argue that the economic and cultural history of the Coos Bay estuary is one of change, transition, and response to events frequently far beyond local control or influence. Sea levels have risen and fell many times since first humans arrived here. Cataclysmic earthquakes and accompanying horrific tsunamis have erased old shorelines and evidence of previous human habitations. Since 1852, industrial manipulation and exploitation of its natural systems and processes also imposed changes to the estuary, and as the vestiges and evidence of past industries slowly disappear, the estuary is changed once again; offering instructions to its observers about how things used to be, and might become.

The oral histories and traditions of the local Hanis and Miluk Kusan Indians recall a character called “Old Man Talapus” or sometimes “Old Man Coyote.” Depending on the purpose and context of the stories in which he appears, Talapus-Coyote is either the mythological “Creator” of the world and all that is in it, who then leaves humans to their own devices; or He is a persistent and omnipresent “Trickster” operating in the world today, who one way or another- through various mischiefs- persuades the People’s behaviors in order for them to learn and to know certain things. Either way, the stories are reminders of a world that is always subject to change.

Old Man Talapus, when realizing that humans could not live on the blue clay mud of the estuary that continually was flooded by tides and winter storms, made a place where humans could prosper: he wove mats of grass and cedar bark and laid them down upon the blue clay until there soon was a surface above the tides and floods. Thus, animals and plants took their place upon this new high ground; and soon humans did too… In another story, Coyote trades his “greasy” eyes for the clear eyes of Salmon Girl: Coyote; and now with clear eyes, he becomes able to see all things in the world, leaving Salmon Girl to only be able to see some things...

However and whatever it is that compels one to look, the “State of the Coos Bay Estuary” as it is in 2015 can’t be seen without at least some understanding of what has occurred before today. Perhaps this narrative, as brief and superficial as it is, provides some guidance about where to look and what to look for when searching for those details… As a Trial Elder once said, “What we see today is not what was, and what is seen today is not what will be seen in the future…”

**References**


1850-1900

Dodge, O. 1898. Pioneer History of Coos and Curry Counties, OR: Heroic Deeds and Thrilling Adventures of the Early Settlers. Capital Printing Company: Salem, OR.

Peterson, E. R., and A. Powers. 1952. A century of Coos and Curry: history of southwest Oregon. Binfords & Mort: Portland, OR [for] Coos-Curry Pioneer and Historical Association, Coquille.

Zybach, B. and D. Ivy. 2013. Coquelle Trails: Early historical roads and trails of ancestral Coquille Indian lands, 1826-1875.

Whereat, D. 2011. The Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians: Our Culture and History. Newport, Oregon.

Beckham, S. D. 1973. Coos Bay: the pioneer period, 1851-1890. Arago Books: Coos Bay, OR.

Douthit, N. 1999. A guide to Oregon south coast history: traveling the Jedediah Smith Trail. Oregon State University Press: Corvallis, OR.

Tveskov, M. A. 2000. The Coos and Coquille: a Northwest coast historical anthropology. University of Oregon: Eugene, OR.

1900-1950

Douthit, N. 1981. The Coos Bay region, 1890-1944: Life on a coastal frontier. River West Books: Coos Bay, OR.

Blakely, J. R. 2006. Lifting Oregon out of the mud: Building the Oregon Coast Highway. Bear Creek Press: Wallowa, OR

Mahaffy, C. L. 1965. Coos River echoes: A story of the Coos River Valley. Interstate Press: Portland, OR.

Caldera, M. 1995. South Slough Adventures: Life on a Southern Oregon Estuary. Friends of South Slough, South Coast Printing Company: Coos Bay, OR.

Beckham, D. 1995. Stars in the dark: Coal mines of southwestern Oregon. Arago Books: Coos Bay, OR.

Beckham, D. 1990. Swift flows the river: Log driving in Oregon. Arago Books: Coos Bay, OR.

Allen, J. E., Baldwin, E. M., Curran, M. D., & Reichers, M. 1944. Geology and coal resources of the Coos Bay quadrangle, Oregon. Oregon Department of Geology and Mineral Industries, Portland, OR.

1950-1980

Smyth, A. V. 2001. Millicoma: Biography of a Pacific northwestern forest.FOREST, 53.

Lansing, W. A. 2005. Seeing the forest for the trees: Menasha Corporation and its one hundred year history in Coos Bay, Oregon, 1905 to 2005. Monroe Press: Eugene, OR.

Robbins, W. G. 2006. Hard times in paradise: Coos Bay, Oregon. University of Washington Press: Seattle, WA.

1980-Present

Sandine, A. 2003. Plundertown, USA: Coos Bay enters the global economy. Hancock House: Surrey, B.C.

Johnson, B. 2013. Beyond the Dream: Bandon Dunes. Johnson Street Publishing: Portland, OR.

Douthit, N. 2001. A Brief History of the Bay Area. Prepared for the Bay Area Chamber of Commerce. Accessed 13 August 2015: http://www.cooshistory.org/page-1663997

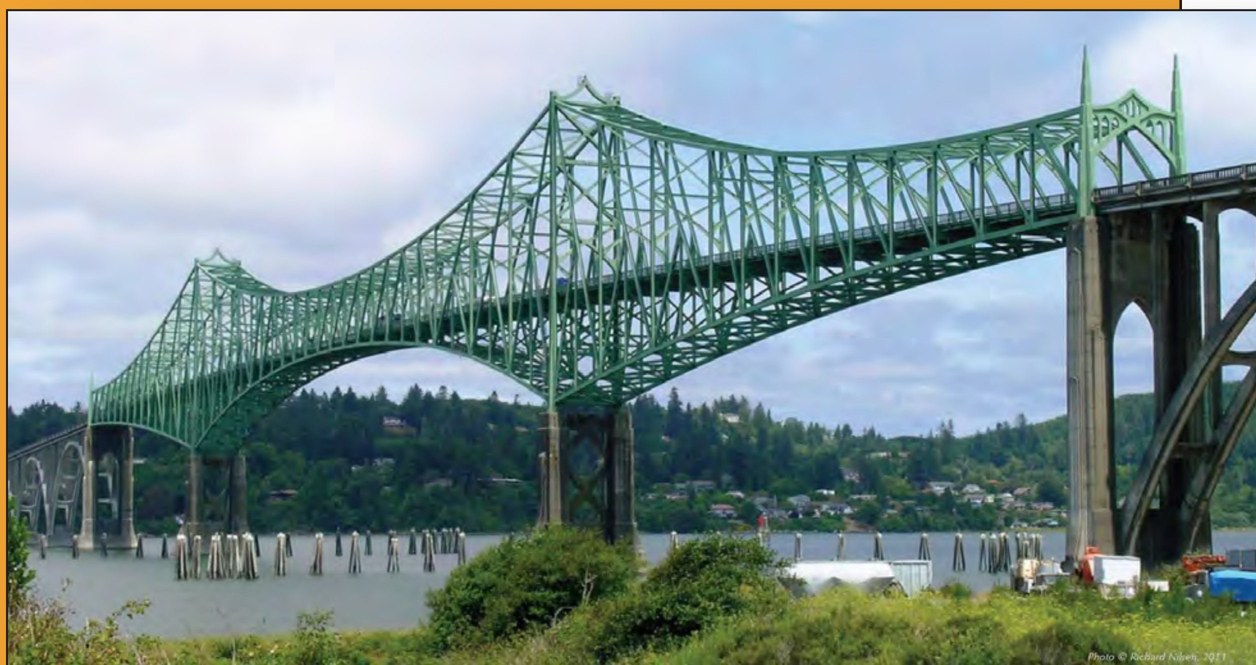
Images

Tveskov, M. A., and J. M. Erlandson. 2003. “The Haynes Inlet weirs: estuarine fishing and archaeological site visibility on the southern Cascadia coast”. Journal of Archaeological Science. 30 (8): 1023-1035.

United States Geological Survey (USGS). 2012. The USGS Store. Accessed 29 July 2015: http://store.usgs.gov/b2c_usgs/usgs/maplocator/(ctype=areaDetails&xcm=r-3standardpitrex_prd&carea=%24ROOT&lay-out=6_1_61_48&uiarea=2)/.do

# **Chapter 7:** Community Evaluation for the Coos Bay Area

*Emily Wright, Jon Souder- Coos Watershed Association*



*Summary:*

- *The Coos Bay Area community needs to have sufficient political, cultural, and financial support in order to make progress on existing and emerging priorities.*
- *Our community may benefit from anticipating new state and federal regulations and responding swiftly, emerging at the forefront to assume a leadership role among rural communities across the state and nation.*
- *Our community should continue to leverage its rural location, but must remain alert to problems that may be masked by the characteristics of the rural landscape.*

## Introduction

This Sustainability Tools for Assessing and Rating (STAR) Communities Report is a socioeconomic assessment of the communities in the Coos Coos Bay area, encompassing a broad range of socioeconomic topics that collectively define sustainability at the community level.  This evaluation in integral to the Community section of the Data Source which employs two methods to characterize and assess socioeconomic conditions in the Coos Coos Bay area. The first method uses data from the Census, state and federal agencies, and other readily available and reliable sources to analyze and characterize a standard suite of socioeconomic topics: demographics, communities and neighborhoods, schools and education, jobs, and land use (Chapters 3-6).

The second approach (this report) employs the existing STAR Community Rating System, to evaluate a comprehensive set of indicators that collectively assess community vitality, capacity, and resilience (STAR Communities, 2014). STAR uses data from the Census and agencies as the first method does, but it also includes national and state databases and local as well as informal data sources. The end product is a standardized metric that gauges socioeconomic conditions of the community.

This report has four sections: 1) Evaluation System, which details the process through which the Partnership for Coastal Watersheds (PCW) Committee chose the evaluation system used for the socioeconomic assessment; 2) Methods, which guides the reader through the steps used to gather, analyze, and evaluate data using the STAR evaluation system;  3) Results, which addresses the overall outcomes of the assessment, as well as each of the seven main socioeconomic topics that are the framework for the STAR evaluation system: Built Environment; Climate and Energy; Economy and Jobs; Education, Arts, and Community; Equity and Empowerment; Health and Safety; and Natural Systems; and 4) Discussion, which addresses caveats to the results, provides factors that appear to contribute to high or low achievement within the evaluation system, and makes suggestions for future steps that the community could take.

These sections are followed by a Reference section- a bibliography of resources used in the writing of this report-  and Appendices that include a spreadsheet of the raw assessment data, a list of data sources used in the assessment, and an example of a data collection survey used for some areas of the assessment.

## Evaluation System

### Needs Assessment

The PCW Committee first approached the socioeconomic portion of the project by conducting a needs assessment to identify the scope of socioeconomic attributes, the desired outcomes, and the envisioned uses of the results. Emerging from this assessment was a need for two types of analyses. One type of analysis would use more traditional sociological methods to evaluate key topics in the community with objectivity, but also sensitivity to local knowledge. The second type of analysis would use a standardized and widely accepted evaluation framework to assess a broader scope of topics, providing a way to objectively compare the Coos estuary communities to other communities in Oregon and nationwide.

Once the vision, goals, and needs for the Community part of the Data Source were identified, the PCW Committee explored different options for a standardized evaluation framework. Two frameworks were identified: the STAR Community Rating System (STAR Communities, 2014) and Community Vitality Indicators (Etuk, 2012), the latter of which is a product of an Oregon State University graduate student thesis based on work for the Ford Institute for Community Building. The merits and drawbacks of each framework were evaluated and presented to the PCW Committee in October 2013. The two systems are based on a similar definition of sustainability or community vitality and their scopes are similarly broad. However, STAR has significantly more breadth, depth, and detail compared to the Community Vitality Indicators. Additionally, the results from the STAR metric scores can be compared to other communities across the United States. Therefore, it was decided that the Data Source should use the STAR Community Rating System for the socioeconomic evaluation.

*WHAT IS SUSTAINABILITY?*

*"Sustainability" is often characterized as a three--legged stool that depends on positive economic, social, and environmental outcomes. STAR uses this definition as the foundation of its evaluation system, with the recognition that sustainability will differ for every community. This report adopts STAR's definition of sustainability, but prefers to consider the STAR framework as way to assess the Coos Coos Bay area in terms of locally--driven approaches to responsible development and building community capacity and resilience.*

*These elements can be found in every part of the community, including each of the 7 goal areas of the STAR system, listed in Figure 1.*

STAR Community Rating System

The STAR Rating System has seven goal areas, listed in Figure 1, which cover a broad range of topics, from health care to workforce development to water quality, that collectively define sustainability at the community level. Each goal area is supported by 5-7 objectives. The achievement of these objectives, and by extension their respective goal areas, is determined by over 500 evaluation measures. STAR uses two types of evaluation measures:


Figure 1. List of socioeconomic topics, or Goal Areas, that collectively define sustainability at the community level, according to the STAR Rating System.

1. **Community Level Outcomes** indicate a community's progress toward a desired state or condition within the objective, represented as trend lines, targets, or thresholds.

2. **Local Actions** describe decisions or investments a community makes to move closer to the given outcomes, such as municipal code changes, partnership development, and infrastructure upgrades.

STAR evaluation measures correlate to similar evaluation systems that attempt to assess the health, resilience, or sustainability of communities. For example, many of STAR's evaluation measures align with the metrics used in the Tracking Oregon's Progress (TOP) project:

*"The indicators were selected to reflect state priorities as expressed in the Oregon Benchmarks and the 10- year Plan (Governor Kitzhaber 2013). Additional indicators were added based on their inclusion in the State of Our Health 2013: Key Health Indicators for Oregonians report by Oregon Health & Science University and Portland State University. A small number of additional indicators were selected to reflect trends in social science research and to illuminate issues of disparities and equity." (Weber, Worcel, Etuk, & Adams, 2014).*

The Leadership in Energy and Environmental Design Neighborhood Development (LEED ND) rating system, a national system managed by the U.S. Green Building Council, also uses metrics that are found in the STAR system (U.S. Green Building Council, 2013). However, the LEED ND program is on a project-by-project basis, making it unsuitable for ongoing evaluation of the community as a complete system.

The correlation between the STAR rating system and similar efforts in Oregon and the across the country indicates that the PCW

Committee is using a framework that is comparable to what other cities and regions use. There are 70 communities currently participating in the STAR Community Rating System to some degree, as of July 2014. Ten of those participants are counties, and the Coos Bay area is the only regional example that spans city and county jurisdictions. However, ten percent of participating communities have a population of 30,000 or less. These statistics demonstrate that the Coos Bay area will be able to use the results of the STAR assessment to compare its responsible development efforts with other communities across the nation, which is useful both for planning and fundraising efforts. This also indicates that the Coos Bay area is unique in its collaborative and grassroots efforts to advance regional efforts for responsible and resilient development, which holds promise for the long-term viability of the outcomes that are produced.

Adapting STAR for the Coos Coos Bay area

The STAR system was designed to be inherently adaptable to the needs and available resources of individual communities. However, applying the rating system to the Data Source project creates a unique case study because (1) the Coos Coos Bay area is currently the only community using the rating system as an organization rather than a local government, and (2) the Coos Coos Bay area is the only example of a watershed-scale assessment rather than a city or county jurisdiction.

*The Coos Coos Bay area community is the only example of a watershed-scale assessment in the STAR Communities system.*

The first circumstance presents an advantage of a more bottom-up community approach, which can be useful in securing broad support from diverse stakeholders and engaging them more fully in the assessment and planning process. A disadvantage of this approach is that the local government has a major role to play in the assessment in terms of providing data and analyses, making them a more natural coordinating body that could potentially conduct the assessment with more ease, assuming they had the resources to do so.

The second circumstance is advantageous because the Coos Bay area is positioned as a leader by taking a regional approach to responsible development and community resilience. Undoubtedly there are many communities across the nation taking a similar approach, but the Coos Bay area is the only one that is doing so through the STAR framework. By conducting a watershed-scale assessment, the Data Source project transcends political boundaries, yet still acknowledges and respects them, providing a valuable perspective on development and planning for future changes.

In addition to these two circumstances, the rural nature of the community and its limited resources present some challenges to completing the STAR assessment itself, mainly because lack of data prevents certain measures from being evaluated. Nevertheless, the STAR system is extensive enough that a sufficient breadth and depth of data was collected to conduct a thorough evaluation of community conditions.

**Methods**

Strategy Development

Once the STAR system was selected, Data Source project staff completed an initial scan of the STAR system to identify data needs, sources, and create a project timeline. There were three levels of data requirements that corresponded to three phases in the timeline:

1. **Less than 3 months:** Data exists for local area and can be accessed online or through simple request process. Data requires minor to no calculations.

   *Example: Housing and transportation costs as a percentage of average household income is an indicator of housing affordability in a community. These costs, as a percentage of the Annual Mean Income for the Coos Coos Bay area community, were found using the Center for Neighborhood Technology's Housing and Transportation Index (www.htaindex.org), a simple online mapping tool that uses socioeconomic data generated from the Census and other sources with resolution at the Census block level. (See Built Environment-4, Outcome 1).*

2. **3 to 6 months:** Some local data may exist, but may need to be collected from multiple sources, or data may require some degree of analysis or calculation.

   *Example: The number of recreational facilities available to residents, in proportion to the population, indicates how conducive the community is to active living. Active recreational facilities, including swimming pools, skate parks, tennis courts, playgrounds and baseball/softball diamonds, were identified through the Coos Bay Master Parks Plan, city and county websites, and Google Earth imagery. Once an inventory of each facility type was complete, ratio of facility to 10,000 people was calculated and evaluated compared to the STAR targets. (See Health and Safety-1, Action 10)*

3. **Greater than 6 months:** Little or no local data exists, or systems may not be in place to collect data easily, or data requires more elaborate calculations or analyses.

   *Example: Reducing greenhouse gas emissions is a common strategy to reduce a community's contribution to climate change. There are many steps, big and small, that a community can take to make progress toward this broader goal, including adopting energy efficiency regulations* *for public buildings. A survey was sent to local government agencies (Coos Bay, North Bend, and Coos County) to determine exactly what the Coos Coos Bay area community was doing (see Appendix C: Sustainability Scan). The survey responses were compiled to determine achievement toward each evaluation measure. (See Climate and Energy-2)*

Data collection and analysis first focused on the "lowest hanging fruit" (less than 3 months) and attended to the more rigorous measures (3 months or longer) later.

Data Collection

Some of the STAR evaluation measures have clearly identified data sources, such as a national database accessible online. Others refer to state or local agencies that commonly collect and provide such data. The majority, however, either suggest a local city or county department that may hold the data, or do not refer to any potential source whatsoever. For the latter three instances, potential data sources—organizations or agencies—were identified for each evaluation

measure and information requests were submitted to the most likely individual responsible for the data. These requests were often referred to another staff member or a different organization or agency. In some cases, these requests followed a simple process and produced the precise data required for the given evaluation measure. In other cases, the requests could not be wholly met due to incomplete data, similar but not the exact type of data, or an entire lack of data on the topic altogether. Such situations were still productive for the evaluation, since they shed light on matters that received less attention from local stakeholders, and/or were matters less pertinent to the circumstances of a rural community—the latter of which was a common theme throughout the STAR Rating System. For certain organizations and agencies from whom a large amount of information was requested, a survey format was used in a "Sustainability Scan" (see Appendix C). The survey was modeled after a similar one used to assess sustainable actions taken by government leaders in Des Moines, Iowa as a part of their regional long-term planning efforts (Sasaski Associates, 2012). Our Sustainability Scan format was used to collect information from city, county, and school district administrators. The survey asked administrators whether their organization or agency was currently taking action, thinking about taking action, or not taking action on the pertinent evaluation measures. There was also a section where the administrator could describe what their actions entailed. For example, we asked school administrators about out-of-school tutoring programs available in their respective schools.

Data Analysis

Once collected, the data required various degrees of analysis. The majority involved minor descriptive statistics to determine average trends over a given period of time—usually the past  three years. Many also involved geographic analyses to determine access to services, concentrations of population subsets and services, and answer other geographic questions. Most of the analyses were completed and documented in the form of spreadsheets, charts, and maps. A few analyses required more time than was able to be allotted or were beyond the ability of staff, and therefore were marked for future analysis when time and/or skill was available.

Evaluation

Each evaluation measure with completed data analysis was then assessed on whether it met the target identified by STAR. Targets are based on national or widely accepted standards or on local goals and targets. Evaluation measures received two types of scores based on their achievement of targets. The first score is a numerical one derived directly from the point system in the STAR Rating System. The STAR point system is complex and a detailed explanation is beyond the purview of this report. However, it is worth noting that the point values are based on the impact that each evaluation measure has on achieving community sustainability as well as the impact it has on achieving the specified goals. In the STAR Rating System, points for each evaluation measure are used to calculate an overall sustainability score for the community, which determines the community's achievement level.

The STAR numeric score provides a dynamic metric that enables the PCW Committee to compare the Coos Coos Bay area community to others of similar size and/or achievement level across the country. However, the STAR score does not capture the intermediate progress of many evaluation measures.

Therefore, in addition to the STAR score, Data Source project staff use a categorical scoring system to recognize initial progress toward given goals and thus provide a more nuanced assessment of current conditions. For this categorical score, evaluation measures are given one of five categories:

1. Meeting/exceeding the target: The target(s) was met or exceeded across the community— including all eligible jurisdictions (cities, school districts, etc.).

2. Partially meeting the target: A number of situations could be occurring, including:
   - Only one city meets the target(s);
   - Only one school district meets the target(s);
   - Only one or some of multiple targets in a single evaluation measure are met;
   - Progress has been demonstrated, but the target has not been fully achieved; or
   - Other situations.

3. Not meeting the target: The target(s) was not met and no significant progress has been demonstrated in any of the eligible jurisdictions.

4. Pending: Data collection or analysis has begun but is not yet complete and the evaluation measure cannot be categorized at this time.

5. Unable to Evaluate or N/A: Data was insufficient at time of evaluation, required more extensive analysis, or were inapplicable to the community.

During the course of the evaluation, it became clear that some evaluation measures could not be analyzed due to either lack of data or the need for more extensive analyses with several data elements that would have to be obtained from various agencies and departments. These evaluation measures were marked as requiring assessment at a future time when data is available and completely collected.

**Results**

Overall Achievement

The Coos Coos Bay area community performed moderately in the STAR assessment. The total STAR score was 237 out of 500, and the average categorical score for meeting or partially meeting the target was 48%. The community is excelling in some areas, such as Health and Safety and the Built Environment, while other areas could use considerable improvement, such as Climate and Energy. An analysis of the varied achievement levels can be found in the Discussion section, which is preceded by sections explaining the community's performance in each STAR goal area. Figure 2 shows the STAR Score and categorical score for each goal area.

***DUAL SCORING SYSTEM***

***What is the difference?***

*The STAR Score and Categorical Score differ on their treatment of intermediate progress toward targets.*

*The* ***STAR Score*** *rarely offers partial points for intermediate progress, and only for selected evaluation measures.*

*The* ***Categorical Score*** *recognizes intermediate progress through a category of "partially meeting the target". Any evaluation measure is eligible for this category for various reasons.*

***Do the two scores align?***

*Sometimes. The sum of the two categories meeting/exceeding or partially meeting the target is usually greater than the STAR score, but sometimes it is less.*

*The main reason for this is that the STAR score does not address how to assess multiple jurisdictions in a single point system. For example, when only one city is meeting the target, no STAR points were awarded, but the evaluation measure was categorized as partially meeting the target. In this case, the STAR score would be less than the categorical score.*

***Why should we use both?***

*It is not necessary to use a dual scoring system, but it is certainly helpful. The categorical score, especially when compared to the STAR score, helps explain the community's achievement—it clarifies whether the achievement is supported by efforts spanning the entire community or only a certain portion of it. It helps direct our attention to areas that appear to be successful, but actually could use additional support. Finally, it provides an estimate of the level of achievement the community could reach if it were to shift from only partially meeting targets to fully meeting or even exceeding targets.*

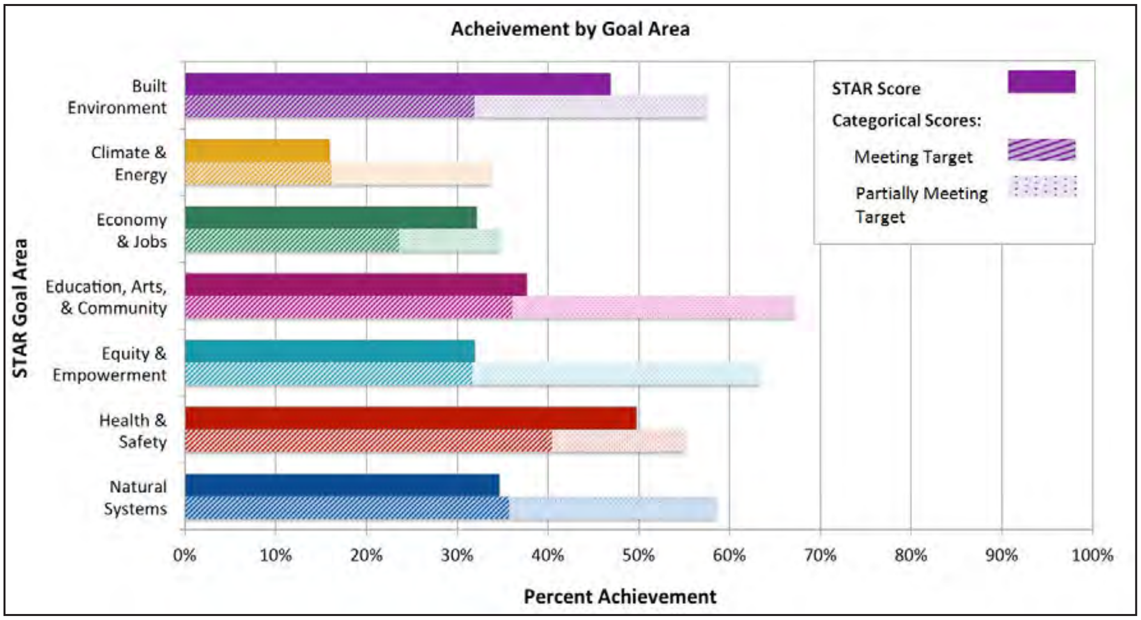



Figure 2. Achievement scores (STAR and categorical) by goal area for the Bay Area community. The top bar (darker solid color) in each goal area is the STAR Score and the lower bar is the Categorical Score, which is separated into the percentage Meeting Target (darker striped color) and Partially Meeting Target (lighter striped color).

Community Rankings

If the Coos Bay area community were seeking official certification through the STAR Rating System, its overall STAR score of 237 would qualify it as a 3- STAR Community, according to the certification levels (Figure 3). Figure 4 lists the communities nationwide that have received 3-STAR certification. Figure 5 lists the other communities either participating or certified in the STAR Rating System that have a comparable population size to the Coos Bay area.

These tables indicate that if the Coos Bay area community chose to pursue certification, it has the potential to be the community with the smallest population size to achieve 3-STAR certification (although Northhampton, MA has achieved 5-STAR certification), and be among the only communities of its size range to achieve certification status.

| Certification Rating Levels | Point Range |
|---|---|
| 5---STAR Community | 600+ |
| 4---STAR Community | 400---599 |
| 3---STAR Community | 200---399 |
| Reporting STAR Community | <200 |

Figure 3. STAR Rating System certification levels. The number of points that a community achieves in the STAR rating system determines its certification or recognition level.

Currently, the Coos Bay area is a participating community, meaning that it is using STAR to assess its current conditions and determine whether pursuing STAR certification is right for the community. If the Coos Bay area chooses to seek certification, it would be considered a reporting community while it

| Community | State | Population |
|---|---|---|
| Cleveland | Ohio | 393,806 |
| Chandler | Arizona | 240,622 |
| Albany | New York | 97,000 |
| Indianapolis | Indiana | 820,445 |
| Fort Collins | Colorado | 143,986 |
| Lee County | Florida | 348,240 |
| Des Moines | Iowa | 200,000 |

Figure 4. Communities certified as 3--STAR Communities, with population size.

| Community | State | Population | Level of Achievement |
|---|---|---|---|
| Bay Area | Oregon | 30,000 | Participating Community |
| Northampton | Massachusetts | 29,000 | 5--STAR Community |
| El Cerrito | California | 23,549 | Reporting Community |
| Rosemount | Minnesota | 22,000 | Reporting Community |
| Blacksburg | Virginia | 42,620 | Participating Community |
| Bonita Springs | Florida | 46,000 | Participating Community |
| Hamilton | Ohio | 62,000 | Participating Community |
| Flagstaff | Arizona | 64,000 | Participating Community |
| Dubuque | Iowa | 58,155 | Reporting Community |
| Portland | Maine | 65,000 | Reporting Community |
| Park Forest | Illinois | 21,975 | Reporting Community |
| Grove City | Ohio | 40,000 | Participating Community |

Figure 5. Communities participating in or certified by STAR Rating System with comparable population size to the Bay Area community.

prepares data, analyses, and documents to submit to STAR and waits for STAR verification team to review its evaluation and issue an official Community Rating based on the points achieved.

Goal Area Outcomes

The following sections detail the community's achievement for each goal area, summarized in Figure 2 above. Each section lists the STAR goal, a description of the community's overall performance, and the overall achievement in both STAR and categorical scores. Following this "snapshot" is a chart that shows the STAR and categorical scores for the 5-7 objectives in each goal area. Like the chart in Figure 2, the top bar (darker solid color) is the STAR score for that objective, and the lower bar is the categorical score, which is divided into the percentage Meeting Target (darker striped color) and Partially Meeting Target (lighter striped color). Following the charts are descriptions of objectives that are notable achievements, areas for improvement, or examples of successful or positive activity in the community.

BE

## Built Environment

### GOAL:

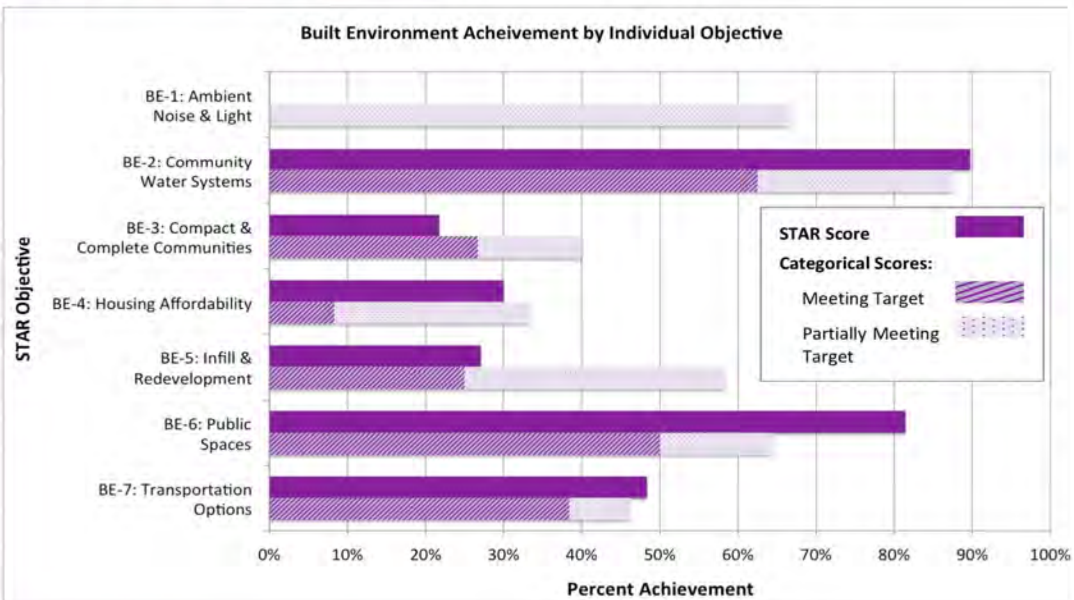
Achieve livability, choice, and access for all where people live, work, and play

### OVERALL PERFORMANCE:

The Bay Area community has reached its second highest level of achievement in this goal area. This success will likely continue into the future with long-term operations and investment programs, as well as recently funded planning projects.

| OVERALL ACHIEVEMENT: | |
|---|---|
| **STAR Score** | **45%** |
| **Categorical Score** | **55%** |
| *Meeting/Exceeding Target* | *29%* |
| *Partially Meeting Target* | *26%* |
| *Does not meet target* | *21%* |
| *Pending* | *13%* |
| *Unable to evaluate or N/A* | *12%* |

### ACHIEVEMENT BY OBJECTIVE:




### *Notable Achievements:*

**BE-2 Community Water Systems**: The community water sources are high quality, with very infrequent instances of excessive levels of contaminants, turbidity, and pathogens. Projected water availability is expected to meet projected demand through 2050, ensuring a secure water supply into the future. One area where the community is underperforming is in its efforts to increase water conservation and efficiency, particularly in regards to the support from the Water Board and city governments (see Climate & Energy for more information on this topic).

BE

**BE-3 Compact & Complete Communities:** Three urban centers—Coos Bay downtown, North Bend downtown, and Empire—have been designated as urban renewal areas and thus have been targeted for investment programs. These areas naturally developed into compact areas with mixed uses offering housing options, groceries, entertainment, stores, and other basic services that help foster vibrant communities. As urban renewal projects continue, these areas will likely become even more central to their respective communities.

## *Areas for Improvement:*

**BE-1 Ambient Noise & Light:** Based on responses from city and county administrators, ambient noise and light has not received much attention from local governments. This issue may not currently be a priority due to the community's rural setting. However, a baseline assessment should still be done in order to ensure that ambient noise and light are indeed below thresholds. Particular attention should be paid to industrial areas along the Bay Area waterfront, where industrial operations are in close proximity to residential, commercial, and recreational zones.

**BE-4 Housing Affordability:** Housing costs are currently 45% or more of annual household income for nearly all households in the Bay Area community, including those earning the Area Median Income (AMI) and those earning 80% of the AMI. While there is subsidized affordable housing and other forms of assistance for individuals living in poverty, there is a lack of efforts to systematically expand affordable housing options for individuals with a middle to low socioeconomic status.

**BE-7 Transportation Options:** Plans that inventory bicycle, pedestrian, and transit options and set goals for future expansion are in place at the city and county levels. In addition, bicycle and pedestrian safety exceed targets. However, actual infrastructure for these transportation options remains quite limited, especially bicycle lanes and routes within and connecting urban centers. This situation is evidenced by the high percentage of individuals who drive to work rather than biking, walking, and/or using transit. Additionally, 100% of households— twice the target—spend 15% or more of annual household income on transportation costs, likely due to high gasoline prices. Focusing on implementing agency plans and increasing residents' use of these alternative options would improve transportation affordability.

### SUCCESS STORIES

#### Water Quality Monitoring Network

*(BE-2 Community Water Systems)*

Several agencies and organizations conduct regular water quality monitoring at various sites throughout the estuary. The PCW has made an effort to inventory all of the environmental data collection that occurs throughout the Coos estuary by all entities, which has led to the creation of a map and online database. The Water Board monitors potable water sources and water levels. They produce annual reports for the public, but more frequent updates are available on the Oregon Department of Environmental Quality website. The South Slough Reserve

BE

operates a total of nine stations—five within South Slough and four in the upper part of the Coos estuary—as part of the System-Wide Monitoring Program to measure short-term variability and long-term changes in system characteristics to inform effective coastal zone management. The Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians maintain two stations and the Coquille Indian Tribe maintains one station, all in the middle Coos estuary area. The Coos Watershed Association maintains 11 stream gauging stations throughout the watershed where they collect continual discharge data and periodically collect other parameters. Data from all of these sites are available in report form, through the respective organization websites, or by request only. All of these efforts provide up-to-date and reliable information about conditions of the community's water source, as well as the basis for many of its industries.

### Brownfield Development Taskforce

*(BE-5 Infill & Redevelopment)*

The Coos estuary is home to a number of natural resource-based industries, including timber, fishing, and mining. Over time, these industries have left behind many inactive, underused, or abandoned properties known to have environmental contamination. Numerous brownfield sites have been identified throughout the county. Some have already been identified as promising sites for increasing opportunities for social interaction and recreation, including pedestrian walkways and bikeways (e.g., previous mill sites along Bay Area waterfront, old mining site off of Seven Devils Road). In 2013, the Coos County Public Health Department received a grant to establish a brownfield development taskforce with representatives from state and local agencies, local business interests, tribal entities, community organizations, and residents. The taskforce will work for a year to assess brownfield sites and neighboring communities, prioritize projects for development, and create a strategic plan. These activities will support the Infill & Redevelopment objective, an area where the Bay Area community is underachieving, but has significant potential for improvement.

CE

# Climate & Energy

## GOAL:

Reduce climate impacts through adaptation and mitigation efforts and increase resource efficiency

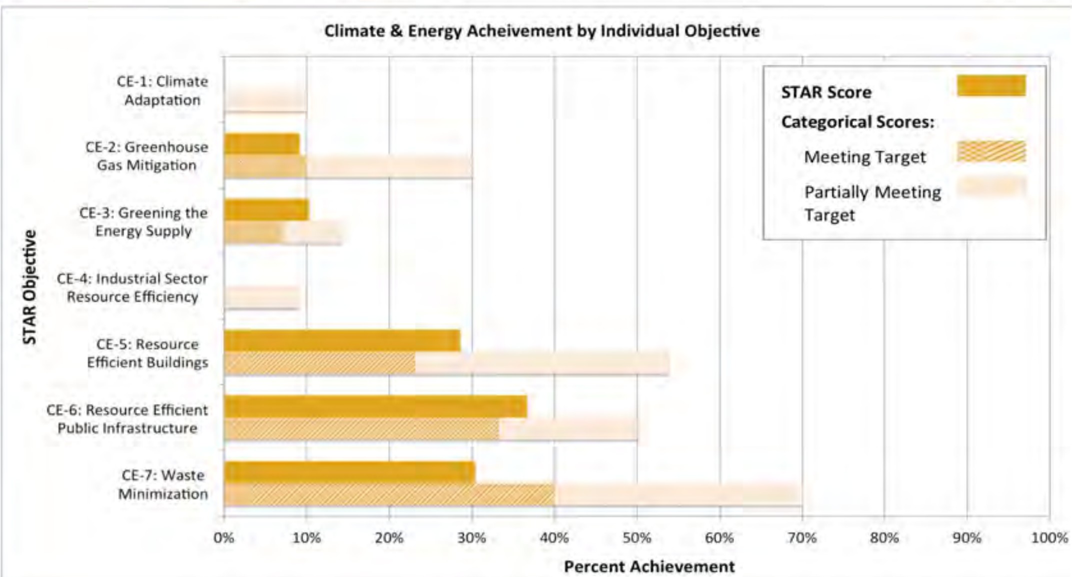
## OVERALL ACHIEVEMENT:

| | |
|---|---|
| **STAR Score** | **16%** |
| **Categorical Score** | **32%** |
| *Meeting/Exceeding Target* | *16%* |
| *Partially Meeting Target* | *16%* |
| *Does not meet target* | *54%* |
| *Pending* | *4%* |
| *Unable to evaluate or N/A* | *10%* |

## OVERALL PERFORMANCE:

This goal area is the lowest achieving one out of the seven for the Bay Area community. Except for a few efforts that agencies are making—often in response to state mandates—as well as efforts by individual residents and businesses to improve energy efficiency, coordinated action is not being taken to address climate impacts and implement adaptation and mitigation strategies. It does not seem likely that such initiative will be taken by the local government in the near-term, unless it is required by state or federal regulations.

## ACHIEVEMENT BY OBJECTIVE:




### *Notable Achievements:*

**CE-5/6 Resource Efficient Buildings and Public Infrastructure:** For the various evaluation measures regarding energy or water efficiency, city and county agencies have taken actions to increase efficiency in government buildings and public infrastructure. In some instances,

CE

these efforts follow internal protocol to reduce costs when planning new construction or renovations, and in other instances they follow state building codes. Despite such efforts, there is a stark lack of locally initiated action to systematically increase resource efficiency in public infrastructure and all buildings.

**CE-7 Waste Minimization:** Coos County and the cities provide and/or contract out recycling services and collection of specialized waste products, such as household hazardous waste. They also hold special collection events throughout the year and cooperate with organizations and businesses throughout the region to collect certain recyclable products. An opportunity for improvement is in the solid waste management plan, which was created in 2006 and is very outdated according to county staff. An update of the plan should be completed and specific and waste generation reduction and waste recovery targets should be set to align with the state mandated waste recovery goal of 30% by 2050. Local targets and a strategic plan will be especially important given that between 1992 and 2012, Coos County increased its total and per capita waste generated.

### *Areas for Improvement:*

**CE-1/2 Climate Adaptation and GHG Mitigation:** The City of Coos Bay reports considering GHG emissions for new facility projects and is considering improving its facilities to better prepare for climate change threats. However, both cities and the county report no action or consideration for almost all evaluation measures related to climate adaptation and GHG mitigation. Addressing climate change is a core component of STAR framework and the lack of attention paid to these objectives indicate a significant gap in community preparation for future changes.

**CE-4 Industrial Energy Efficiency:** Non-residential energy use, which includes industrial energy use, has decreased between 2011 and 2013—progress that is on-track to meet STAR's goal of 80% reduction by 2050. However, it is unclear whether the industrial sector was indeed the source of this reduction. Furthermore, the reduction is not driven by local policy and thus offers no guarantee that the industrial sector will continue to make these reductions in the future. Collaboration with the industrial sector to set targets and identify strategies and incentives to meet those targets is an important step to take to make progress in this objective.

## SUCCESS STORIES

### Transforming Waste into Energy

(CE-7 Waste Minimization)

Coos County contracts with Rogue Disposal & Recycling, based in southern Oregon, to manage its solid waste. Coos County waste is put into the company's Dry Creek Landfill where it decomposes, naturally producing landfill gas, nearly 50% of which is methane. The methane gas is then removed from the landfill and burned in two 20-cylinder CAT engines to power two 1.6-megawatt (MW) generators. This process produces 3.2 MW of energy daily—enough electricity to power approximately 3,000 homes each day in the Rogue Valley. Coos County waste represents nearly 10% of the total municipal solid waste, generating about 0.3 MW of energy daily. While the choice to contract with Rogue Disposal & Recycling and support the waste-to-energy system does not make a very big impact on the community's STAR score, it is an important step for supporting waste minimization efforts and incorporating sustainable thinking into the waste stream system.

CE

### *EmPower*ing Residents to Conserve Energy

*(CE-5 Resource Efficient Buildings)*

Oregon Coast Community Action (ORCCA) has been a leader in increasing energy and water efficiency for local residents, particularly those struggling to manage their energy costs. ORCCA's EmPower program works with motivated households to assess their energy use in the context of their other lifestyle costs and budget, understand their energy bill, lower their energy consumption, and reduce their energy costs by up to $200 per year. For EmPower participants, as well as other low-income households, ORCCA audits homes to identify and implement effective strategies to conserve energy and lower costs. In 2011-2012, ORCCA helped 194 households through the weatherization program and completed furnace replacements in 51 homes. In addition, ORCCA and a team of AmeriCorps volunteers piloted an educational program focused on energy and water conservation in 3 elementary schools, tutoring 302 students in 23 classes.

EJ

# Economy & Jobs

## GOAL:

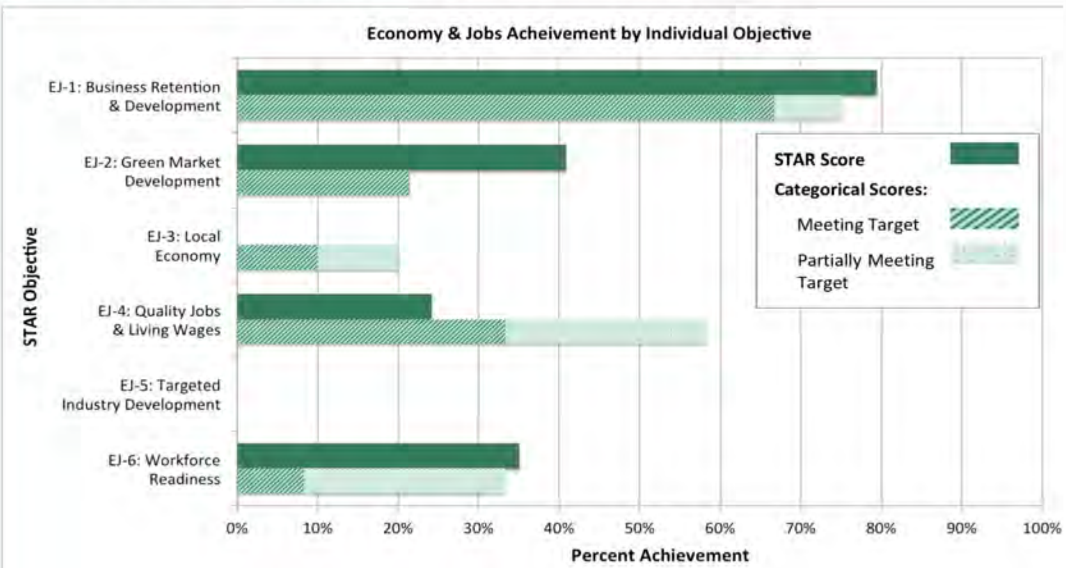
Create equitably shared prosperity and access to quality jobs

## OVERALL PERFORMANCE:

This goal is an area where the Bay Area community has attained a moderate degree of achievement. The community is excelling in certain objectives, but is taking nearly no action at all in others. Recent initiatives, however, show promise for more substantial progress in the near future.

| OVERALL ACHIEVEMENT: | |
|---|---|
| **STAR Score** | **32%** |
| **Categorical Score** | **35%** |
| *Meeting/Exceeding Target* | *24%* |
| *Partially Meeting Target* | *11%* |
| *Does not meet target* | *29%* |
| *Pending* | *17%* |
| *Unable to evaluate or N/A* | *19%* |

## ACHIEVEMENT BY OBJECTIVE:




### *Notable Achievements:*

**EJ-1 Business Retention & Development:** A wealth of resources has been injected into the local economy, particularly in enterprise districts where special investments and assistance is often directed. There is frequent collaboration between agencies and the business community, such as in the Bay Area Chamber of Commerce and the Coos Bay Downtown Association. These efforts are reflected in increasing total annual sales in the community over time. However, numbers on employment and business establishments are not as strong, indicating an area that could use more attention.

EJ

**EJ-4 Quality Jobs & Living Wages:** Cities and the county support living wages and family-friendly workplaces for employees and contractors. In addition, agencies maintain collective bargaining relationships with public employee labor organizations. Despite this support from local government, the community's median household income and the percentage of households that are economically self-sufficient are lagging behind targets, suggesting that other employers in the community are not matching the efforts of city and county agencies.

### *Areas for Improvement:*

**EJ-2 Green Market Development:** The cities and county have not taken the initiative to foster the development of green industries through internal procedures or external policies and regulations. Without this support, the growth of a green market is slow. Nevertheless, community businesses and residences have undertaken efforts on their own by purchasing renewable energy through Pacific Power's Blue Sky Program, installing electric vehicle (EV) charging stations in coordination with state efforts, and a green business recognition program through the Bay Area Chamber of Commerce (see Success Story below). Local agencies could build on these initial grassroots efforts to provide more strategic green market development in the community.

**EJ-3 Local Economy:** Indicators show a weak local economy and few efforts by city and county agencies to boost self-reliance, such as incentives, policies, or support services for local producers. There is potential for progress with a new initiative by the South Coast Development Corporation (SCDC). SCDC is conducting an assessment of the local economy with particular regard for traded sector businesses that bring "new dollars" to the local economy. The community could leverage SCDC's efforts to launch more initiatives for economic localization.

**EJ-5 Targeted Industry Development:** This objective has essentially been devoid of any action, with the exception of SCDC's local economic assessment that will ultimately lead to identification of targeted industry clusters. With this initial work, the community can move forward with strategic planning to build on existing strengths and expand related sectors to promote the clusters and fuel innovation.

#### SUCCESS STORY

**Bay Area Chamber of Commerce Sustainability Award**

*(EJ-2 Green Market Development)*

The Bay Area Chamber of Commerce began its Sustainability Award in 2011 to recognize local businesses and organizations that have taken steps to incorporate more sustainable practices. About five awards are given out each year at the Chamber's Wednesday Business Luncheons, where recipients give a presentation about their efforts to reduce their impact on the environment. The program has recognized 9 businesses and organizations thus far, many of which have third-party sustainability certifications. The Chamber's Sustainability Award is an excellent showcase of local companies, many of which are based on natural resources, successful operating with the environment and the community in mind. This program has the potential to provide a foundation for a strategic plan to further develop green markets, building on the success of these organizations.

EAC

# Education, Arts, & Community

## GOAL:

Empower vibrant, educated, connected, and diverse communities

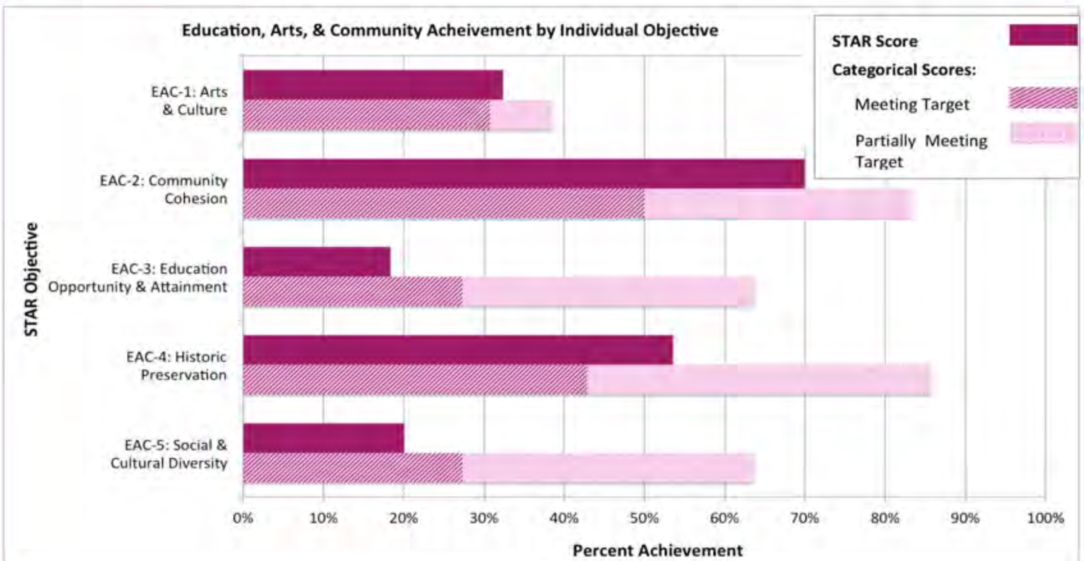
## OVERALL PERFORMANCE:

This goal area is the second-lowest achieving one for the Bay Area community. There are numerous venues and cultural opportunities that bring the community together, but government leadership to invest in art and cultural industries is lacking. In addition, educational indicators point to an area where the community is significantly under-performing.

## OVERALL ACHIEVEMENT:

| | |
|---|---|
| **STAR Score** | **31%** |
| **Categorical Score** | **56%** |
| *Meeting/Exceeding Target* | *33%* |
| *Partially Meeting Target* | *23%* |
| *Does not meet target* | *18%* |
| *Pending* | *21%* |
| *Unable to evaluate or N/A* | *5%* |

## ACHIEVEMENT BY OBJECTIVE:




### *Notable Achievements:*

**EAC-2 Community Cohesion:** The community has an abundance of venues, services, and events that support community building, especially in proportion to the population size, and the cities and county are active in supporting these venues and services. Various leadership programs engage both adults and youth to build social capital and further develop existing strengths to ultimately support the community. One area that could be improved is formalizing government support for community building efforts (e.g., farmers' markets, neighborhood planning) through policies and codes.

EAC

**EAC-4 Historic Preservation:** The Bay Area community has a large number of historic sites, many of which are listed on the National Historic Register. The City of Coos Bay has a two established historic districts—the Waterfront Heritage District and the Hollering Place District—that have design standards intended to preserve historic buildings and/or character. Coos Bay is considering a establishing a historic commission and becoming a Certified Local Government, a recognition awarded by the National Park Service. Fewer steps have been taken by the City of North Bend and Coos County. Both cities provide financial incentives for preservation, particularly for façade improvements, through their urban renewal agencies.

### *Areas for Improvement:*

**EAC-1 Arts and Culture:** Although the Coos Art Museum and other cultural venues are active, local public support in the form of incentives and policies for creative industries and professionals are lacking. There are several pieces of public artwork in the Bay Area, but new public art pieces are rarely commissioned and neither city nor the county have made a commitment to financial supporting the arts, such as a percent-for-art ordinance. Furthermore, art education in schools has been whittled down and no comprehensive, district-wide programming is in place. These efforts could be boosted to improve performance for this objective.

**EAC-3 Educational Opportunity & Attainment:** While there are several examples of important opportunities and programs in place that boost educational achievement, such as a robust Head Start program through Oregon Coast Community Action and career pathway opportunities in the Coos Bay School District and at SWOCC, performance measures do not demonstrate significant improvement. For the three key evaluation metrics—3$^{rd}$ grade reading proficiency, 4-year adjusted cohort graduation rate, and graduation rate for selected underperforming groups—none of the three districts (Coos Bay, North Bend, and Bandon) meets the benchmarks. In fact, in most cases there is a decrease in achievement over last three years. These statistics must be taken into account when planning educational strategies as well as public spending within districts.

SUCCESS STORY

**Building Local Leaders**

*(EAC-2 Community Cohesion)*

Several leadership programs sponsored by local and regional organizations provide opportunities for adults and youth to acquire skills, learn community development principles, and form social relationships that they can use to improve the community. These programs ultimately create a network of residents who have the tools to work together and successfully make progress in the community. The Ford Institute Leadership Program, sponsored by the Ford Family Foundation, has been active since 2005 and has engaged 186 adults and youth in total. Leadership Coos is a program run by the Bay Area Chamber of Commerce and engages 34 adult participants each year for a 9-month program to build awareness around community activities. Programs specifically for youth include Leadership for Bay Area Youth (L-BAY) through Oregon Coast Arts, the Keystone Program at the Boys & Girls Club that specifically works with disadvantaged youth, and the Rotary Youth Leadership Camp. These three youth programs have engaged about 88 youth total from 2011 to 2013.

EE

# Equity and Empowerment

## GOAL:

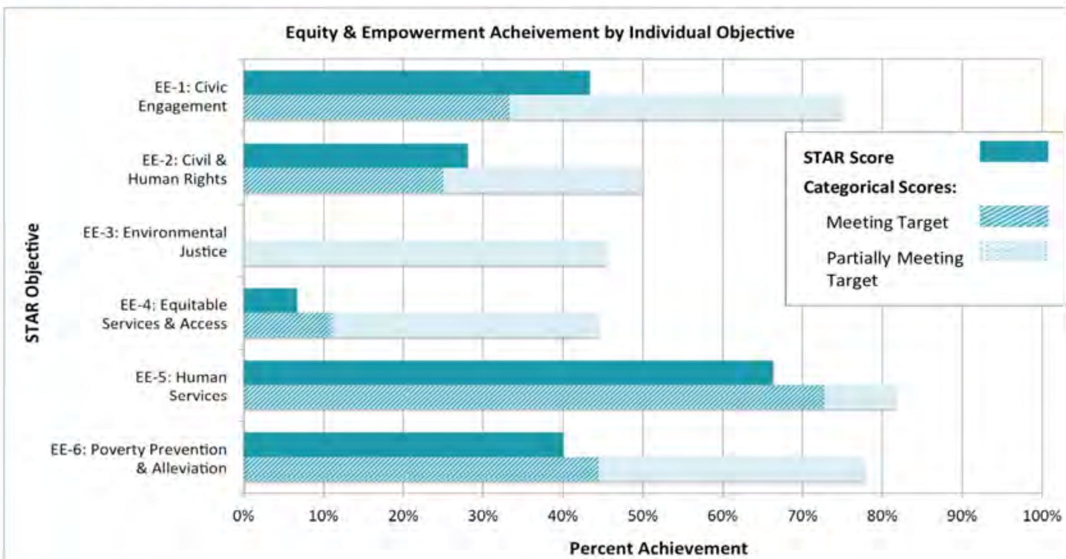
Ensure equity, inclusion, and access to opportunity for all residents

| OVERALL ACHIEVEMENT: | |
|---|---|
| **STAR Score** | **31%** |
| **Categorical Score** | **62%** |
| *Meeting/Exceeding Target* | *30%* |
| *Partially Meeting Target* | *32%* |
| *Does not meet target* | *15%* |
| *Pending* | *10%* |
| *Unable to evaluate or N/A* | *14%* |

## OVERALL PERFORMANCE:

This goal area is a middle-achieving one for the Bay Area community. While basic support services are available and agencies do a fair job of engaging residents in governmental processes, attention has not been adequately paid to evaluating and ensuring equity of services. Furthermore, despite the services provided to low-income residents, poverty remains a problem in the community.

## ACHIEVEMENT BY OBJECTIVE:




## *Notable Achievements:*

**EE-1 Civic Engagement:** The cities and county offer regular opportunities for elected officials and top government staff to meet with residents to hear their concerns and discuss issues. The cities also have volunteer programs for residents to support government activities. Both Coos Bay and North Bend high schools usually hold mock voting programs during presidential elections, which complement the regular curriculum about democracy and the electoral process. One area that represents an opportunity for improvement is in voter turnout and voter registration, which has decreased over the past three presidential election

EE

cycles. In addition, there is a lack of data on volunteerism and residents' sense of empowerment—two evaluation measures that the community may be achieving, but cannot be determined at this time.

**EE-5 Human Services:** The local office of the Oregon Department of Human Services (DHS), in conjunction with ORCCA, provide a broad range of services for the public, from nutrition and housing assistance to child welfare. Many of the services they offer receive state funding and thus must follow state regulatory procedures. Both organizations conduct outreach about the services they provide, collaborate with other agencies and organizations, and have regular monitoring, reporting, and planning procedures. An area with potential for growth is attention to specific subsets of the population that are at risk of being underserved or may have limited access to services. The Coos County DHS office is currently assessing service to the Hispanic population, after which a similar assessment could be conducted for other groups.

### *Areas for Improvement:*

**EE-4 Equitable Services & Access:** The City of Coos Bay has taken initial steps toward improving equitable access to services and facilities in the community, but comprehensive efforts are still lacking. Based on reports from city and county agencies, it appears that disparities in access and proximity to services and infrastructure have not been evaluated across diverse income levels and race/ethnicities. This type of assessment would be the first step to understand current conditions, identify population subgroups or geographic areas where there is a lack of services or limited access, and prioritize projects to improve access for all people.

**EE-6 Poverty Prevention & Alleviation:** There are a number of services available to community residents living in poverty. ORCCA and DHS are key providers of those services, including essential needs and child development programs. South Coast Business Employment Corporation (SCBEC), as the Worksource Oregon provider for the south coast region, offers job training and other forms of support for residents seeking employment. Despite these services, the county-wide poverty rate has been increasing since 2000 for the population at large, as well as for the following subgroups: Hispanic, American Indian/Alaskan Native, and children under 18. While these numbers alone do not explain the entire situation, they are important indicators of the situation facing residents. If existing programs are not having an impact on the percentage of people living in poverty, it may be fruitful to examine the effectiveness of the programs and consider alternative strategies.

#### SUCCESS STORY

**Training for Successful Careers**

*(EE-6 Poverty Prevention & Alleviation)*

The South Coast Business Employment Corporation (SCBEC) is a local leader in preparing residents for jobs and careers. SCBEC is the Worksource Oregon provider for the South Coast region and is a member of The Oregon Consortium and Oregon Workforce Alliance (TOC/OWA), a public-private partnership among 24 rural Oregon counties. SCBEC offers various workshops, resources, job-specific training, youth employment opportunities, and other forms of support for residents seeking employment for the first time or as a returnee to the workforce. SCBEC also offers assessment trainings, hiring resources, and other services to employers. All of these services support a healthy workforce and are a key indicator of a sustainable economy and community.

HS

# Health & Safety

## GOAL:

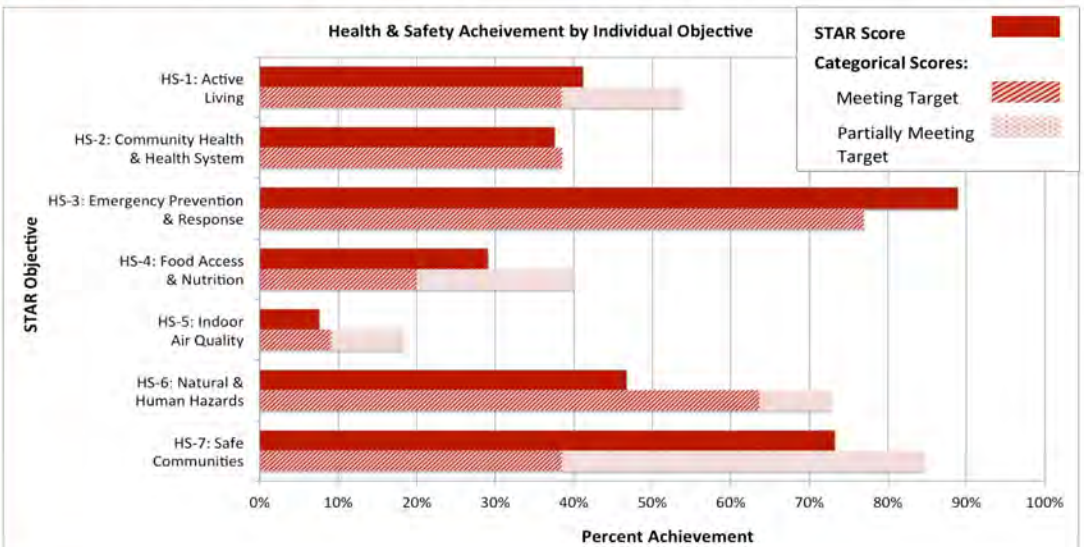
Strengthen communities to be healthy, resilient, and safe places for residents and businesses

## OVERALL PERFORMANCE:

This is the top-performing goal area for the Bay Area community. It has significant achievements across the board. With the exception of indoor air quality, developing programs and upcoming actions will strengthen the community's performance even more.

| OVERALL ACHIEVEMENT: | |
|---|---|
| **STAR Score** | **48%** |
| **Categorical Score** | **51%** |
| *Meeting/Exceeding Target* | *39%* |
| *Partially Meeting Target* | *12%* |
| *Does not meet target* | *35%* |
| *Pending* | *13%* |
| *Unable to evaluate or N/A* | *0%* |

## ACHIEVEMENT BY OBJECTIVE:




## *Notable Achievements:*

**HS-3 Emergency Prevention & Response:** The Bay Area community has identified emergency prevention and response as a top priority, and as a result, has made remarkable achievements in this area. Fire protection ratings, emergency response times, and compliance with federal standards are all meeting targets. There continues to be extensive cooperation throughout region for emergency planning and preparation, with regular updates and staff trainings. The county has active Medical Reserve Corps (MRC) and Community Emergency Response Teams (CERT) programs. Given that emergency planning is a common concern at the state level, as well as the increasing threat of natural hazards to the coastal community (see section below), the Bay Area community will likely continue to

HS

excel in this objective into the future.

**HS-6 Natural & Human Hazards:** The city and county agencies have developed extensive plans for natural and human hazard management, based on all-hazard vulnerability assessments. Zoning and building codes limit development in hazard prone areas—particularly floodplain zones. Agencies regularly conduct outreach to raise awareness about hazards and they themselves upgrade, or are considering upgrading, facilities to meet higher standards and serve as shelters or command centers during. One area that deserves further attention is data on the community's resilience to hazards in order to gauge whether the plans and actions have made an impact.

**HS-7 Safe Communities:** Coos County violent crime rates are far below national targets, although for the size of the community, the Coos County agencies consider them to be twice the desired rate (Coos County Health Improvement Plan 2013, in reference to rates between 2007 and 2009). School violence rates in both Coos Bay and North Bend districts do not meet established targets. Nevertheless, city and county agencies have established violence prevention, suppression, and enforcement programs. Some agencies have offender reentry programs and a safe communities strategic plan in place.

### *Areas for Improvement:*

**HS-1 Active Living:** Coos County does not meet targets for physically activity among adults or youth. While there are plans to make active living a more central component to community development—the cities and county's respective transportation plans and the county's Community Health Improvement Plan (CHIP)—and projects are being undertaken to improve pedestrian and bicycling infrastructure, the actual outcomes remain minimal. As several of the aforementioned plans note, active modes of transportation and regular (daily) use of those modes is very limited. In sum, this area has a lot of potential and progress will likely be made as plans continue to be implemented in the near future.

**HS-2 Community Health & Health System:** At the county level, the community is not meeting benchmarks for multiple important health indicators. On the whole, Coos County has a low ranking among other counties throughout the state for many indicators. However, the county public health department has made recent progress with the recent Community Health Assessment and associated Community Health Improvement Plan (2013-2016). As this plan is implemented, health indicators will likely improve over the next five to ten years.

**HS-5 Indoor Air Quality:** This area has received very little attention from city and county agencies. While Coos County Public Health receives indoor air quality (IAQ) complaints from tenants, they do not actively solicit them. The number of tenant complaints they have received has increased over the past three years. Additionally, there are no inspections to enforce IAQ standards, no assistance available to homeowners to improve IAQ, and no outreach to raise awareness among the community. The lack of efforts in this area seems concerning, especially given the frequency of mold in the coastal climate. A small degree of initiative taken has the potential to have a big impact on performance in this objective.

SUCCESS STORY

**Building a Local Food System**

*(HS-4 Food Access & Nutrition)*

The Bay Area community already has an active farmers' market in downtown Coos Bay, a community garden, and multiple community supported agriculture (CSA) options for residents to

HS

directly connect with regional farms. In 2013, Coos County FEAST (Food, Education, Agriculture, Solutions, Together) held a county-wide discussion about the local food system. In response to the outcomes of this brainstorming event, the South Coast Development Council (SCDC) partnered with the Wild Rivers Coast Alliance and AmeriCorps to carry out a community food assessment (CFA) for Coos County. The CFA evaluates current conditions impacting residents' access to healthy food and factors influencing the strength of the local food industry. Results from the CFA will help direct future efforts to increase food security, make healthy food accessible and affordable to all residents, and connect producers with schools, restaurants, grocers, and individual consumers to build the local food system.

ORCCA has taken steps to strengthen local food connections. The organization has started a farm-to-preschool program to bring fresh food to children and families served by South Coast Head Start. Valley Flora Farm, located in Langlois, was the first producer to work with ORCCA on this program in 2014. Efforts like these not only support community health, but boost the local economy and increase the resource efficiency of the food system.

NS

## Natural Systems

### GOAL:

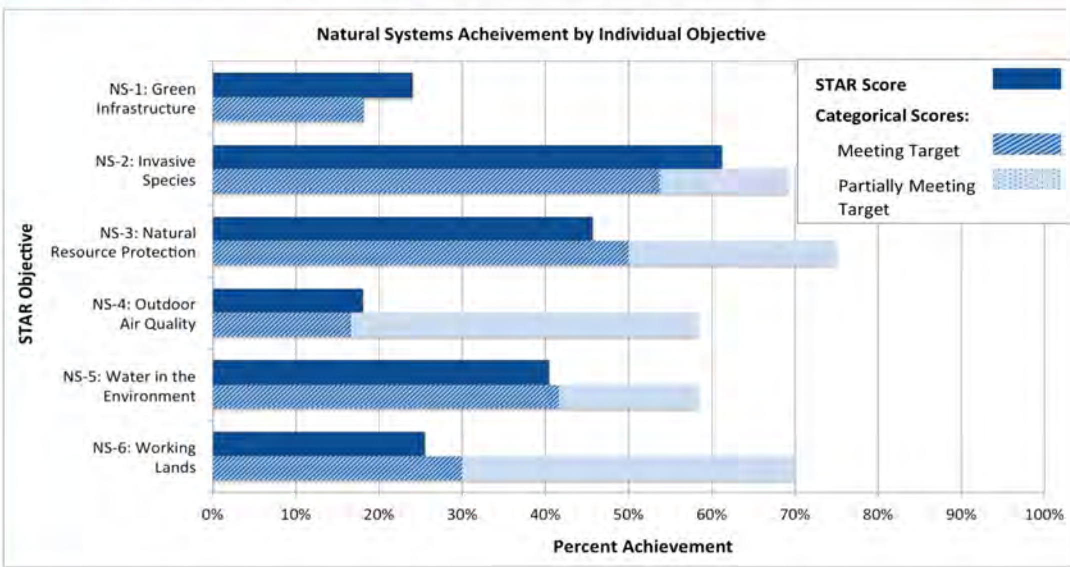
Protect and restore the natural resource base upon which life depends

### OVERALL PERFORMANCE:

This goal area is a middle-performing one for the Bay Area community. Significant strides have been made to address many components, but much of the progress has been achieved through grassroots efforts and/or state or federal-driven regulation. Local regulations and incentives through city and county agencies would be the logical next step to assess the achievements that have been made and continue making further progress.

| OVERALL ACHIEVEMENT: | |
|---|---|
| **STAR Score** | **35%** |
| **Categorical Score** | **43%** |
| *Meeting/Exceeding Target* | *26%* |
| *Partially Meeting Target* | *17%* |
| *Does not meet target* | *24%* |
| *Pending* | *30%* |
| *Unable to evaluate or N/A* | *2%* |

### ACHIEVEMENT BY OBJECTIVE:




### *Notable Achievements:*

**NS-2 Invasive Species:** The community has made significant reductions in invasive species populations within the Coos watershed. On the county level, the Coos County Cooperative Weed Management Area has a long-term management plan to address invasives, and the County Weed Board provides incentives for landowners to reduce weeds. The Coos Watershed Association has an extensive invasive/native plant program with restoration, volunteer engagement, and public outreach. City and county agencies report using native or

NS

non-invasive species in landscaping, but the next step would be to enact local regulations prohibiting certain species that have been identified as key problems in the area.

**NS-3 Natural Resource Protection:** There is extensive restoration, conservation, education, and monitoring of natural systems in the Coos estuary area, led by the Coos Watershed Association, South Slough NERR, tribal organizations, Coos SWCD, agencies, and other entities. County planning and zoning promote natural resource protection, particularly in regards to shorelines and wetlands, in accordance with state land use planning goals. However, the region is lacking local targets for conservation, with a coordinating monitoring system and local incentives (rather than state or federal) for conservation.

### *Areas for Improvement:*

**NS-1 Green Infrastructure:** The Bay Area is fortunate to be naturally endowed with extensive green space, and the community has done a good job of preserving these areas. However, there has been little effort to encourage green infrastructure within the built environment in order to extend the benefits into the urban setting as well. There have been a few isolated projects where rain gardens and other green infrastructure strategies have been implemented, such as in the LEED-certified Coos Bay Fire Station and the recent Ford Building renovation, but more comprehensive and government-led action has yet to be seen. Creating plans, establishing incentives, and working with private landowners to incorporate green infrastructure in new and existing developments would help boost achievement in this area.

**NS-4 Outdoor Air Quality:** Very little data on air quality is available at the county level, and essentially no data is available at the city level. Fine particulate matter (PM 2.5), the single parameter that is available for a consistent period of time due to a special federal program, increases slightly from 2009-2011, although those levels were lower than the levels in 2003. However, air pollution is not considered a significant health issue for the county, as reported in the Coos County Health Improvement Plan (2013). Accordingly, the cities and county have taken very few steps to address outdoor air quality. While outdoor air quality may not be an issue at this time, it is important to maintain current data on several parameters to ensure early detection of increasing trends and quick mitigation action in response.

**NS-6 Working Lands:** In the forestry industry, all harvesters are required to use BMPs to be in compliance with the Oregon Forest Practices Act, and many harvesters have taken additional steps to become certified in sustainable practices. There are active youth crew programs that assist mostly agricultural and some forestry landowners in implementing BMPs. For agricultural lands, a multijurisdictional agricultural water quality management plan establishes required conditions for farms, ranches, and other agricultural lands to protect water quality, although specific BMPs are only recommended, not required, for landowners to implement in order to meet regulations, and there appears to be no tracking system to know whether managers have adopted BMPs. It would be valuable to begin by inventorying agricultural managers to assess the current situation.

SUCCESS STORY

**Local Youth Helping Farmers and Fish**

(NS-6 Working Lands)

Various youth crew programs have been periodically active for a number of years in the Bay Area community. The Northwest Youth Corps has a history of recruiting youth from the local area. the

NS

Bureau of Land Management has hired youth during the summer to assist in their projects, and AmeriCorps teams have assisted with local projects sporadically. Additionally, in 2011 the Coos Watershed Association began youth programs that address riparian restoration practices and other BMPs—the Master Watershed Stewards Youth Program and Oregon Youth Conservation Corps (OYCC) summer program—that received assistance from individual AmeriCorps members from 2011-2014. All of these crews offer relevant and satisfying work experience for youth that can help them succeed in high school, college, and beyond. The work they achieve help landowners implement BMPs that they may otherwise not be able to, and provide important benefits for habitats, salmonids, and ecosystems.

**Discussion**

Limitations to the Evaluation

Scoring System: The STAR assessment is at once comprehensive and definite, which presents both opportunities and challenges. The opportunities lie in the ability to synthesize a very broad range of data into digestible scores that can be easily analyzed and compared. The challenges are present in the tendency toward "all-or-nothing" scoring; aside from the few instances of gradual credit, most evaluation measures award all or none of the points available. It is important to read the STAR scores in the assessment with these circumstances in mind. In addition, it is helpful to use the categorical scoring system to learn more nuanced elements of the community's current conditions. Finally, the entire STAR assessment—including the STAR score and categorical scores—should be read as one component of the entire socioeconomic analysis in Coos Estuary Inventory Project.

Data Availability: As mentioned in the method section above, some evaluation measures could not be given a score due to a data gap. These measures were noted with a "Future" or "Pending" status. These data gaps were primarily due to two reasons: limited or no data collected by the relevant agency or organization, and inability to fully collect the data and complete the analysis given time constraints on the project. In the latter case, time was often an issue because of disparate data sources and limited data availability, requiring more extensive data collection. The evaluation measures marked for future evaluation only represent 8% of the total.

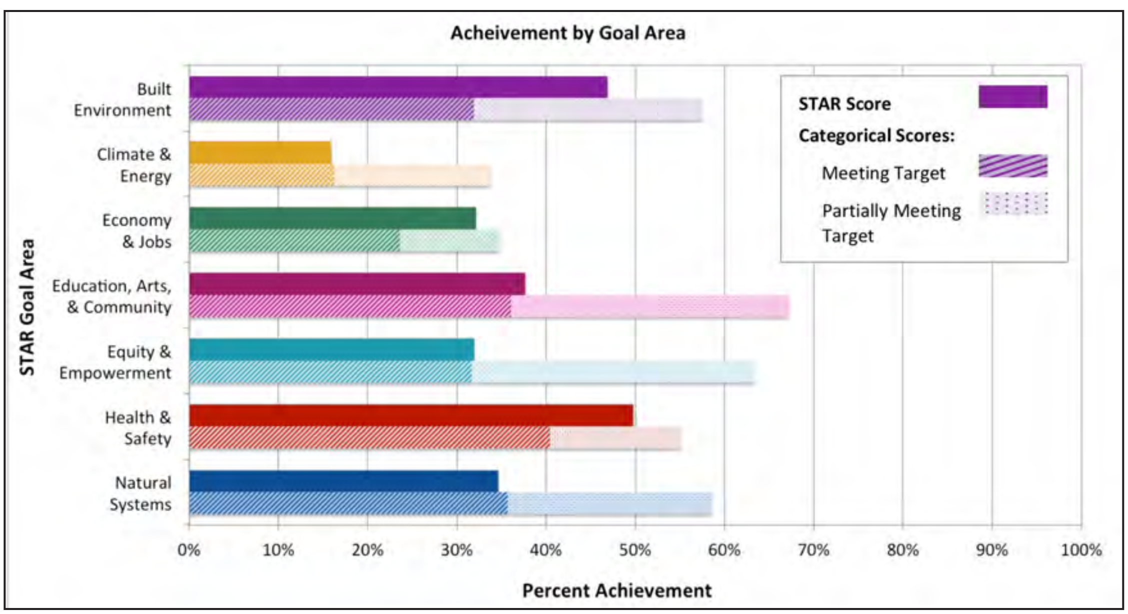



Figure 6. Achievement scores (STAR and categorical) by goal area for the Bay Area community.

***These measures do not count negatively against the STAR and categorical scores, and thus are not considered to compromise the integrity of the STAR assessment results and conclusions.***

Overall Current Conditions

The Bay Area community has moderate achievement in most goal areas of the STAR Rating System. As can be seen in Figure 8, the STAR scores and categorical scores differ slightly; in each goal area, the STAR score is less than the combined categorical score of meeting/exceeding or partially meeting targets.

As has been discussed in other sections of this report, the categorical score provides a more nuanced evaluation of the community's current progress in each evaluation measure. Therefore, the composition of the categorical score varies and it does not always correlate to the STAR score. The following sections describe the community's level of achievement in each goal area.

*High Achievement*

The Bay Area community is excelling in two categories: Built Environment and Health and Safety. The high achievement of 45-50% (STAR score) in these goal areas appears to be a result of several factors:

1. **The STAR Rating System objectives correspond with priority issues in the community.** Both community residents and local agencies agree on these priorities and give them adequate and consistent attention to make progress toward goals. One example of such a priority is having a clean and healthy water source. Steps have been taken to ensure that the community's water sources will meet the projected demand and due consideration has been given to reduce any environmental impact from extracting water from the environment.
2. **These objectives align with the community's inherent strengths.** The community is naturally endowed with abundant natural resources and green space. Its rural setting promotes less crowding, less pollution, and less of a likelihood for conflicts among people and with the environment. These strengths have served the community well in reaching many benchmarks and have helped preserve air and water quality.
3. **These areas receive adequate funding to support their progress.** Since many of the high achieving evaluation measures are often priorities or mandates of local or state agencies, they are often well-funded. Financial support is a vital element to realizing outcomes in these goal areas; even a high priority issue cannot be acted on if adequate financial support is lacking for staff time and other needs.

There are several upcoming and ongoing projects in the Built Environment and Health and Safety goal areas, which bodes well for the future. As such projects are implemented, performance in these areas will likely improve even further, and they will continue to be in the highest tier of achievement.

*Moderate Achievement*

The Bay Area community is performing moderately, with STAR scores of 30-35%, in four goal areas: Economy and Jobs; Education, Arts, and Community; Equity and Empowerment; and Natural Systems. The community is achieving objectives when conditions are similar to those for the high achievement category, listed above. When targets are not being met, there seem to be one or more of the following factors involved:

1. **The issue is not a priority for the community.** In some cases, it appears that the topic is perceived to be less relevant to the community's situation, potentially in regards to the rural setting and small population size. In these and other cases, there is no mandate by a local or state agency, allowing certain issues to receive less attention by residents and decision-makers. One example of the former case is the lack of green infrastructure in the urban setting (Natural Systems, Objective 1: Green Infrastructure). While there are plenty of spaces where people can access nature and enjoy the outdoors in less developed areas within the city and in close vicinity to its urban boundaries, the downtown and more developed areas have few instances of significant green infrastructure, or infrastructure created with an explicit purpose to provide natural benefits, such as water management through permeable surfaces or localized cooling through green roofs. This disparity may be due in part to the abundance of green space (e.g., parks, hiking trails) in the outer zones.

2. **There is a lack of funding to support initiatives.** As noted in the previous section, adequate funding is necessary to implement plans and produce results. In certain evaluation measures, the topic may have been identified as an area of concern or interest, either informally among community members or formally in government meetings. However, lack of or limited funds prohibits any action from being taken. Even if the issue is one of measurable concern for the community, little or no financial support lowers its priority level below other needs that are more likely to secure support. One instance of this issue is with arts education in schools, which has suffered in recent years as public school funding declines (Education, Arts, and Community, Objective 1: Arts and Culture).

3. **Steps have been taken, but without making measurable progress.** The community may have taken steps to address certain issues, and in some cases robust programming is in place to support the community. However, the statistics or quantifiable indicators of progress in these areas, which that would theoretically be positively affected by such actions, do not show significant improvement, and sometimes show a decline in conditions. A notable example of this scenario is in the broad range of services

provided for individuals living in poverty to aid them in managing finances and finding employment, and yet the increase in poverty levels in Coos County over recent years (Equity and Empowerment, Objective 6: Poverty Prevention and Alleviation).

4. **The timing was not favorable for evaluation.** For some evaluation measures, the community may be taking preliminary steps to explore the topic or it may be an emerging topic of conversation among residents and leaders. However, no notable action or outcomes have been observed or reported at the time of evaluation. Some of these measures that are undergoing early stages of planning or programming were marked for future evaluation or an update, such as is the case with targeted industry development that will be happening in the next couple of years, led by the South Coast Development Council (Economy and Jobs, Objective 5: Targeted Industry Development).

5. **There is a shift in the political or cultural climate creating unfavorable conditions.** In some cases, there has been a history of action taken by certain entities in the community or at least initial steps toward taking action. However, a recent change in leadership or circumstances created a climate within the organization, community, or funding sources that is less favorable for pursuing plans any further. For example, the former county health department director had initiated efforts to begin a health impact assessment (HIA) program (a positive indicator for public health), which lost its momentum when she retired. In such instances, the community may have to wait until there is another change that shifts the climate back toward more favorable conditions.

*Low Achievement*

The Bay Area community has considerably poor performance in Climate and Energy, with an achievement rate of only 15% (STAR score). All of the factors listed under the moderate achievement section affect this area as well, but a fundamental reason is that climate adaptation, greenhouse gas mitigation, and resource efficiency has not been identified as a local priority with comprehensive and systematic action planning. The few efforts that have been made are mostly a product of state mandates. It is apparent that initial conversations have started on one or more of the Climate and Energy topics, particularly in the context of emergency preparedness and sea level rise. As climate change effects are felt more strongly and with potential federal regulations limiting carbon emissions in the near future, these conversations may become more central to local and regional community planning.

## Key Findings

1. **The Bay Area community needs to have sufficient political, cultural, and financial support in order to make progress on existing and emerging priorities.**

   As the areas of high, moderate, and low achievement indicate, it is not only important for issues to be recognized by the local community members and leaders as matters that require attention, but it is also important for funders and investors—including state and federal agencies and the business community—to prioritize the issues in their strategic plans to direct funding toward those local needs. If an issue lacks a piece of this puzzle, progress will be greatly hindered. The Bay Area community can be strategic by identifying missing pieces of support, planning to secure them, and being willing to put certain issues on hold when support is unlikely.

2. **The Bay Area community may benefit from anticipating new state and federal regulations and responding swiftly, emerging at the forefront to assume a leadership role among rural communities across the state and nation.**

   In some cases, the Bay Area community responded to mandates from state or federal agencies and in doing so met or made progress toward STAR targets. However, there are instances in which the Bay Area community has not met targets and lags behind other communities. Since regulations take time to form and become institutionalized, communities could anticipate them and preemptively plan to meet the likely requirements. Furthermore, if it is a particularly salient topic in the community, they could prioritize it to be a central component of their strategic plans. Such foresight has proven advantageous in the business sector, particularly in regards to environmental regulations. For example, many timber harvesters in the Bay Area community not only meet the rules of the Forest Practices Act, but they have taken additional steps to become certified through a sustainable forestry program. Such recognition indicates their leadership in the industry to partners and consumers alike. By taking action early and prominently, the Bay Area community could turn a top-down mandate into an opportunity for excellence.

3. **The Bay Area community should continue to leverage its rural location, but must remain alert to problems that may be masked by the characteristics of the rural landscape.**

   A small and somewhat dispersed population has limited development in the Bay Area community compared to more urban areas, resulting in several benefits, including easy access to natural spaces, cleaner water bodies, and low violent crime rates. However, the amenities of the rural location may provide a misleading estimation of current conditions. For example, noise and light pollution seem to be a non-issue, but until ambient noise and light levels are measured, the community will not know actual exposure levels and whether certain neighborhoods are more exposed than others. In addition, although there is an abundance of outdoor recreational opportunities, adult and youth are not meeting the benchmarks for active lifestyles, likely due to urban hubs (downtown Coos Bay, North Bend, Empire) less suitable to walking and biking. Such cases underscore the challenges of a rural community and the importance of attending all facets of the community—even those that appear stable.

Future Directions

The STAR Rating System is a very powerful tool that can be used in many ways and at many stages in the community development process—from assessing current program strengths and weaknesses to identifying new priorities and monitoring program effectiveness. For the local community, this STAR assessment could be valuable to city and county agencies, business and industry leaders, community-based organizations, and residents. There are several next steps the community could take using this STAR assessment.

**1**

**Use the STAR Rating System to help shape community conversations and strategic planning efforts.**
STAR's comprehensive format enables leaders to examine various issues at once and see how they interact to boost the vitality of the community. Additionally, the broad coverage of topics not only appeals to a range of stakeholders' interests, it offers multiple entry points for stakeholders to become engaged, thus increasing participation in planning processes.

**2**

**Build on the community's successes.**
The PCW community has made significant progress in many goal areas thanks to adequate attention, action, investment, and monitoring. With continued efforts to reassess programs and renew support for these issues, forward progress can continue into the future.

**3**

**Turn areas of low achievement around.**
Using the STAR assessment, the PCW community could identify specific areas for improvement that are locally relevant—they should align with local goals and address local concerns. Then, the community could turn these targeted areas into priorities for the community, incorporating them into appropriate plans and initiatives and using them to secure and direct funding.

**4**

**Leverage hidden strengths.**
It became clear through the STAR assessment that the PCW community has multiple strengths that go unused, such as the grassroots efforts that individual businesses are implementing to lower their environmental impact (see Success Story under Economy & Jobs). The community could identify these underutilized strengths and plan to leverage them to make progress toward goals and priorities.

Pursuing STAR Certification

As noted above, the Coos Bay Area community has an impressive preliminary STAR score given its small population size. It is estimated that the community could receive 3-STAR certification if it pursued certification. If the community wanted to pursue certification, it would follow these steps:

1. Secure agency support. The STAR Reporting System requires extensive data from city and county agencies. Creating a memorandum of understanding or a similar agreement may help create more fluidity and efficiency in the assessment process and minimize any duplication of efforts. Establishing a formal partnership with the agencies can ease data requests and exchanges and potentially designate a portion of agency staff time to assist with completing the analysis for certain evaluation measures. Securing this level of support would be a critical step toward successfully completing the STAR assessment to the degree required for the certification process.

2. Identify coordinating organization and individuals. While the STAR assessment requires many entities to be involved, there should be a single leading entity and individuals to coordinate the project. This may be the Partnership for Coastal Watersheds, an offshoot of the PCW, or another body altogether.

3. Establish a working committee. Representatives from key agency departments, utilities, major industries, and community groups should be involved to help identify data sources, secure data, conduct analysis, and provide a degree of quality assurance/quality control of the data.

4. Coordinate with STAR leadership. The certification process will involve many steps that the staff from STAR Communities will assist with. They should be notified that the community would like to seek certification and they will help identify the path forward. Since the Bay Area community is unique in the STAR Rating System, in that it is neither a city or county agency but rather a community collaborative group, the STAR staff members will help the community navigate the appropriate next steps.

**Acknowledgements**

This assessment and report could not have been completed without the data provided by various local organizations and agencies in the Coos Bay Area. We would specifically like to acknowledge the Cities of Coos Bay and North Bend, Coos Bay's Community Manager, Coos County—especially the departments of Public Health, Environmental Health, and County Clerk, Coos Bay--North Bend Water Board, Oregon Coast Community Action, local and regional administrators from the Department of Human Services, and the Coos Bay and North Bend School District superintendents and administrators.

This report also drew on the Communities, Lands & Waterways Data Source framework and description created by the PCW Committee, technical reviewers, and Data Source project staff.

**References**

Coos County. 1975. Coos Bay Estuary Plan: An Element of the Coos County Comprehensive Plan. Coquille: Coos County.

Etuk, L. 2012. 2000 Baseline Assessment of Rural Community Vitality. Working Paper, Oregon State University, Rural Studies Program, Corvallis, OR.

Joyce, B.E., J. Souder, C. Cornu. 2012. Partnership for Coastal Watersheds Action Plan. Document prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 23 pp.

Sasaski Associates. 2012. Sustainability Scan of The Tomorrow Plan: Partnering for a Greener Greater Des Moines. City of Des Moines, Des Moines.

STAR Communities. 2014. Technical Guide to the STAR Community Rating System, Version 1.1. Washington, D.C.

Weber, B., Worcel, S., Etuk, L., & Adams, V. 2014. Tracking Oregon's Progress: A report of the Tracking Oregon's Progress (TOP) indicators project. Oregon Community Foundation and Oregon State University.

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| **BE-1** | Outcomes | 1 | **Noise:** Option A: Demonstrate that daytime ambient noise levels do not exceed 70 dBa in commercial areas<br>--OR--<br>Option B: Show progress toward locally identified key ambient noise targets | Future | Unable to be evaluated | 0 | 1.4 | City of North Bend reports that it conducted a local assessment on noise/light, informing its policy/ordinance. | |
| **BE-1** | Outcomes | 2 | **Light:** Show progress toward locally identified key light targets for light glare and/or light trespass | Future | Unable to be evaluated | 0 | 1.4 | City of North Bend reports that it conducted a local assessment on noise/light, informing its policy/ordinance. | |
| **BE-1** | Outcomes | 3 | **Light in the Night Sky:** Achieve a sky glow at or below 4 in the Bortle Dark-Sky Scale where the Milky Way is still visible in residential areas | Future | Unable to be evaluated | 0 | 0.7 | Requires local data collection. | |
| **BE-1** | Actions | 1 | Adopt a community noise policy, ordinance, or regulations as needed based upon a local assessment | Complete | Partially meeting target | 0 | 3 | Coos Bay Municipal Code §17.80.050(7) limits Industrial Zone and 17.85.050(8) Industrial/Commercial Zone and 17.90.030(9) Waterfront Industrial District noise to DEQ limits, but otherwise Coos Bay has no current action/activity.<br>City of North Bend reports currently having a noise policy based on local assessment; noise regulations are found in Municipal Code Chapter 18 regarding commercial, industrial, and airport zones (which has airport noise impact boundary with land use requirements).<br>Coos County does not have a policy/ordinance. | Coos Bay Municipal Code, Chapter 17; North Bend Municipal Code Chapter 18; Sustainability Scan of city/county governments |
| **BE-1** | Actions | 2 | Adopt a community light policy, ordinance, or regulations as needed based upon a local assessment | Complete | Partially meeting target | 0 | 3 | Coos Bay Municiapl Code 17.200.030(8) controls lighting in off-street parking and loading areas, so that light is "not to cause a nuisance either to traffic or to the living environment. The amount of light shall be provided according to the standards established by the public works department." [Ord. 344, 2004; Ord. 234, 1996; Ord. 93 § 3.15.3, 1987], but otherwise Coos Bay has no current action/activity.<br>City of North Bend reports currently having a light policy based on local assessment; light (glare) regulations are found in Municipal Code Chapter 18 regarding commercial, industrial, and airport zones.<br>Coos County does not have a policy/ordinance. | Coos Bay Municipal Code, Chapter 17; North Bend Municipal Code Chapter 18; Sustainability Scan of city/county governments |
| **BE-1** | Actions | 3 | Educate the public about standards, effects of excessive exposure, and mitigation techniques for ambient noise or ambient light | Complete | Partially meeting target | 0 | 2 | City of Coos Bay and Coos County have no current action/activity. City of North Bend currently conducts education/outreach on this topic. | Sustainability Scan of city/county governments. |
| **BE-1** | Actions | 4 | Create partnerships to address sources of noise and/or light pollution not subject to the local authority | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **BE-1** | Actions | 5 | Develop a database of noise complaints and noise measurements (e.g. roads, industrial, outdoor music venues) or of light issues and neighborhoods targeted for improvements | Complete | Partially meeting target | 0 | 1 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently has procedures to track noise/light complaints. | Sustainability Scan of city/county governments. |
| **BE-1** | Actions | 6 | Establish clear lines of authority for enforcement of nuisance noise violations relative to different noise sources | Complete | Partially meeting target | 0 | 4 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently has procedures to enforce noise/light standards. | Sustainability Scan of city/county governments. |
| **BE-1** | Actions | 7 | Enforce noise standards during the permitting, design, and construction of new large-scale developments that can significantly increase ambient noise levels | Complete | Partially meeting target | 0 | 4 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently has procedures to enforce noise/light standards. | Sustainability Scan of city/county governments. |
| **BE-1** | Actions | 8 | Enforce light standards during the permitting, design, and construction of new large-scale developments that can significantly increase ambient light levels | Complete | Partially meeting target | 0 | 4 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently has procedures to enforce noise/light standards. | Sustainability Scan of city/county governments. |
| **BE-1** | Actions | 9 | Establish programs that eliminate existing sources of light pollution coming from municipally-owned entities | Complete | Partially meeting target | 0 | 4 | City of Coos Bay implements light pollution measures on its building projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| BE-2 | Outcomes | 1 | **Drinking Water Quality:** Part 1: Demonstrate that the community is not in violation of EPA's 5% standard for coliform bacteria in water pipes<br>--AND--<br>Part 2: Option A: Demonstrate that the water supplied to residents is not in violation of EPA standards for turbidity and water pathogens<br>--OR--<br>Option B: Decrease the amount of all regulated contaminants over time | Complete | Meeting target | 3 | 3 | Received water quality data from Robert Buras. Water board is in compliance for past 3 years for Parts 1 and 2, Option A. | Water quality data report from Coos Bay-North Bend Water Board for past 3 years, available on http://www.cbnbh2o.com |
| BE-2 | Outcomes | 2 | **Secure Water Supply:** Part 1: Demonstrate that the height of the water table for subsurface aquifers has been stable or rising<br>--AND--<br>Part 2: Demonstrate that the height of surface waters is within the range to meet expected demand for the next 5 years or is rising | Complete | Meeting target | 3.8 | 3.8 | Based on CBNBWB Water Conservation and Management Plan (2009), projected population growth and rise in demand will be met by projected supply reserves through 2050. | CBNBWB Water Conservation and Management Plan (2009) |
| BE-2 | Outcomes | 3 | **Safe Wastewater Management:** Part 1: Demonstrate that all publicly owned treatment works (POTWs) are in compliance with EPA effluent permits<br>--AND--<br>Part 2: Demonstrate that existing industrial dischargers are in compliance with EPA permits | Complete Pending verification/ Update | Partially meeting target | 0 | 3.8 | Coos Bay not in compliance as of 12/2013; North Bend in compliance. Only 3 industrial facilities had violation in past 3 years; All are currently in compliance. Should update as data becomes available to check compliance.<br>No partial credit | Compliance reports from Coos Bay (2) and North Bend wastewater treatment centers and industrial dischargers. Available at: http://echo.epa.gov/ |
| BE-2 | Outcomes | 4 | **Safe Stormwater Management:** National Pollutant Discharge Elimination System (NPDES) permit(s) have been obtained prior to discharging stormwater | Complete Pending verification/ Update | Meeting target | 3.8 | 3.8 | Coos Bay/North Bend/Coos County not required to secure municipal (MS4) permit. Only one construction permit active (Coquille Indian Tribe) and no industrial permits found in past 3 years from EPA. | DEQ permits and MS4 online database |
| BE-2 | Outcomes | 1 - Bonus | Jurisdiction or water provider participates in EPA water quality research on emerging contaminants | Complete | N/A | 0 | 0.8 | | |
| BE-2 | Actions | 1 | Adopt a jurisdiction-wide management plan for both water consumption and disposal that provides a clean and secure water supply for all local uses | Complete, pending update | Meeting target | 2 | 2 | City of Coos Bay has wastewater and stormwater master plans; Coos Bay-North Bend Water Board has Water Conservation and Mangement Plan | |
| BE-2 | Actions | 2 | Adopt policies to ensure that the jurisdiction has the authority to enact water conservation measures during periods of drought | Complete | Meeting target | 3 | 3 | Cities have ability to turn off water during states of emergency (including drought). Coos Bay Municipal Code: According to §8.25.080(1)(j): Whenever an emergency is declared to exist within the city of Coos Bay, the city council may, by resolution, authorize the city manager to turn off water, gas, or electricity; North Bend Municipal Code: According to §2.24.080(1)(j): Whenever an emergency is declared to exist within the city of North Bend, the city council may, by resolution, authorize the co-managers to Turn off water, gas, or electricity;<br>The CBNB Water Board has a Risk Management Plan and Emergency Response Plan that includes progressive measures that the Water Board may implement during periods of water shortage. | Coos Bay Municipal Code, §8.25.080(1)(j); North Bend Municipal Code, §2.24.080(1)(j); CBNBWB Water Conservation and Management Plan (Section 3.7) |
| BE-2 | Actions | 3 | Collaborate with a regional water management group that includes other jurisdictions that share the same water sources | Complete | Meeting target | 1 | 1 | City of Coos Bay staff member sits on Coos Watershed Association board; Other staff are consulted on regular basis. | |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| BE-2 | Actions | 4 | Establish water quality monitoring and public reporting systems | Complete | Partially meeting target | 0 | 1 | CBNBWB does regular water quality monitoring on potable water sources, water levels. Reports to public annually, but more frequent updates are avaialble on the DEQ website. CoosWA, DEQ, SSNERR, and other agencies conduct water quality monitoring for various parameters at sites throughout estuary. Data is available to varying degrees, either via report, website, or by request only. Efforts by PCW to consolidate monitoring work has resulted in comprehensive map available online, but does not provide updated data or conditions regarding the water quality. | CBNBWB website, Oregon DEQ website, PCW website |
| BE-2 | Actions | 5 | Shift towards a full cost pricing system to ensure that users are paying for the true cost of water | Complete | Meeting target | 4 | 4 | Water rates reflect a full cost pricing system, so they incorporate infrastructural needs and environmental impacts. "The rate design includes a fixed meter charge (including 300 cubic feet of water usage) based on meter size. The commodity rate component is uniform within each customer class." - Water Conservation and Management Plan (2009), page 9 | Direct correspondance, CBNBWB Water Conservation and Management Plan (2009) |
| BE-2 | Actions | 6 | Create programs to guarantee the provision of water to low-income residents | Complete | Does not meet target | 0 | 4 | Appears that CBNB does not offer rate reduction or other programs for low-income families. "The utility employs a uniform rate design by customer class." - Water Conservation and Management Plan (2009), page 9 | CBNBWB Water Conservation and Management Plan (2009) |
| BE-2 | Actions | 7 | Develop and provide water conservation programs to residents, businesses and agricultural water users in order to help ensure that the community is not depleting its water supply | Complete | Partially meeting target | 0 | 4 | "The Water Board has a successful history of public education to encourage wise use of water. The utility will continue the following efforts: (1) Free leak detection surveys; (2) helping customers determine the possible locations of leaks; (3) Offer toilet leak detection tablets; (4) Make available brochures and pamphlets on leak detection and water conservation; (5) Maintain wise use of water information on utility website." - Water Conservation and Management Plan (2009), page 9. These public outreach efforts are still active, as of 5/21/2014. No other efforts have been taken to increase conservation. City of Coos Bay, City of North Bend, Coos County have no current action/activity on its own. | Direct correspondance, CBNBWB Water Conservation and Management Plan (2009); Sustainability Scan of city/county governments |
| BE-2 | Actions | 8 | Manage and upgrade infrastructure to reduce leaks in the system, eliminate contaminants, and achieve other local conservation goals | Complete | Meeting target | 6 | 6 | List of infrastructure upgrades provided by Water Board. | |
| BE-2 | Actions | 9 | Implement at least 3 innovative water infrastructure and facility programs | Complete | Partially meeting target | 0 | 6 | Coos Bay Fire Station at Elrod has implemented a rain garden and other innovative water infrastructure elements. City of Coos Bay and Coos County have no current action/activity. City of North Bend currently implements/has implemented projects using innovative water conservation/efficiency methods. | Sustainability Scan of city/county governments. |
| BE-2 | Actions | 10 | Upgrade and improve stormwater and wastewater treatment facilities to meet current and foreseeable needs | Complete | Meeting target | 6 | 6 | Numerous improvements made between 2011-2013. **Only projects above a certain pricing threshold require approval by the City Council. The list likely does not capture all of the improvements made during this time period. | City Councils' minutes |
| BE-2 | Actions | 11 | Engage in restoration projects for critical water bodies that provide usable water for the jurisdiction or stormwater management assistance | Complete | Meeting target | 6 | 6 | The Coos Watershed Association has provided some "stormwater management assistance". They have not done a lot (or any) restoration projects in the domestic water supply catchments (Upper Pony and Joe Ney), although there is some potential.<br>CoosWA worked with ORCCA on the rainwater gardens at their new office campus. CoosWA also worked with the City of Coos Bay on their rain gardens at the new fire station, and with Seven Devils Brewery on their new rain garden at the Ford Building.<br>CoosWA expects to be doing quite a bit more in the coming years as the City of Coos Bay initiates a Supplemental Environmental Projects through the State Revolving Fund as part of their rebuilding their two wastewater treatment plants. | Sustainability Scan survey-CoosWA |
| BE-3 | Preliminary Step | | Identify the Compact & Complete Centers (CCCs) that will be analyzed under this Objective | | N/A | | | | |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| BE-3 | Outcomes | 1 | **Density, Destinations, and Transit:** Demonstrate that each CCC achieves the following thresholds:<br>Residential Density:<br>• Average of at least 12 dwelling units per acre within a ¼-mile walk distance of bus or streetcar stops, or within ½-mile walk distance of bus rapid transit stops, light or heavy rail stations or ferry terminals<br>• Average of at least 7 dwelling units per acre average within the rest of the CCC boundary<br>Employment Density: At least 25 jobs per acre<br>Diverse Uses: At least 7 diverse uses present<br>Transit Availability: At least 60 weekday trips and 40 weekend trips | Pending data collection/request | Pending | | 10 | See relevant data document in files. | |
| BE-3 | Outcomes | 2 | **Walkability:** Demonstrate that each CCC achieves the following thresholds:<br>• 90% of roadways contain sidewalks on both sides<br>• 100% of crosswalks are ADA accessible<br>• 60% of block faces contain street trees at no more than 40 feet intervals<br>• 70% of roadways are designed for a travel speed of no more than 25 mph<br>• Minimum intersection density of 90 intersections per square mile | Future | Unable to be evaluated | 0 | 3 | | |
| BE-3 | Outcomes | 3 | **Design:** Demonstrate that each CCC achieves the following thresholds:<br>• 80% of front building setbacks along primarily single-family residential blocks are not more than 25 feet from the property line<br>• 80% of front building setbacks along primarily commercial blocks are not more than 10 feet from the property line<br>• 40% of primarily commercial blocks have ground floor street frontages free from blank walls and loading docks, and do not have structured or surface parking as the principal land use along the street | Future | Unable to be evaluated | 0 | 3 | | |
| BE-3 | Outcomes | 4 | **Affordable Housing:** Demonstrate that each CCC achieves the following thresholds:<br>• 10% of total residential units are affordable<br>• 10% of residential units built or substantially rehabilitated within the last 3 years are dedicated as subsidized affordable housing<br>• Some of the dedicated long-term affordable housing are deeply subsidized or deeply affordable for very- and extremely low income households | Future | Unable to be evaluated | 0 | 4 | | |
| BE-3 | Actions | 1 | Demonstrate that the comprehensive plan supports compact, mixed-use development | Complete, pending verification | Meeting target | 2 | 2 | City of Coos Bay has policy to support this type of development in Municipal Code Chapter 17. City of North Bend has policy/planning to support this development.<br>Coos County has certain urban and rural zoning that allow for mixed uses. | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapt 17 |
| BE-3 | Actions | 2 | Identify areas appropriate for compact, mixed-use development on the community's official future land use map | Pending data collection/request | Pending | | 1 | | |
| BE-3 | Actions | 3 | Adopt regulatory strategies that permit or incentivize increased residential and employment densities and diverse uses in transit-served areas and areas identified for compact, mixed-use development | Complete | Partially meeting target | 0 | 3 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently has incentives to increase densities in these areas. | Sustainability Scan of city/county governments. |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| BE-3 | Actions | 4 | Require walkability standards for new development that include sidewalks on both sides of roadways, street trees, ADA accessible crosswalks, roadways designed for maximum travel speeds of 25 mph, and maximum block lengths in transit-served areas and areas identified for compact, mixed-use development | Complete | Meeting target | 3 | 3 | City of Coos Bay currently has walkability standards in its Municipal Code Chapter 17. City of North Bend currently has walkability standards. Coos County has walkability requirements in urban zoning. | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapt 17 |
| BE-3 | Actions | 5 | Require build-to lines for commercial and residential structures in transit-served areas and areas identified for compact, mixed-use development | Complete | Partially meeting target | 0 | 3 | City of Coos Bay Municipal Code, Chapter 17, includes commercial property has "zero lot line". City of North Bend currently does not have build-to line requirements. Coos County did not report on this measure. | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapt 17 |
| BE-3 | Actions | 6 | Adopt advanced parking strategies in transit-served areas and areas identified for compact, mixed-use development | Complete | Meeting target | 3 | 3 | Cities of Coos Bay and North Bend and Coos County currently have parking strategies in compact, mixed-use development areas. | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapt 17 |
| BE-3 | Actions | 7 | Require, incentivize, or subsidize creation of affordable housing in transit-served areas and areas identified for compact, mixed-use development | Complete, pending update | Does not meet target | | 3 | Coos Bay has no current action/activity. | Sustainability Scan of city/county governments. |
| BE-3 | Actions | 8 | Establish a design review board, neighborhood commission, or similar appointed citizen body that provides comments on proposed development projects | Complete | Meeting target | 1 | 1 | Coos Bay has a Planning Commission that functions primarily as a comprehensive planning body by proposing policy and legislation to the city council and by implementing regulations relating to the growth and development of the community. The Commission meets the second Tuesday of each month.<br>North Bend likewise has a Planning Commission that meets the third Monday of each month. | Coos Bay Municipal Code Chapter 2.35; North Bend Municipal Code Chapter 2.08 |
| BE-3 | Actions | 9 | Implement programs to preserve and maintain existing subsidized and unsubsidized affordable housing in transit-served areas, compact and mixed-use areas, and areas with rapidly-rising housing costs | Pending data collection/request | Pending | | 4 | | |
| BE-3 | Actions | 10 | Increase the percentage of households with access to transit | Pending data collection/request | Pending | | 6 | | |
| BE-4 | Outcomes | 1 | **Housing and Transportation Costs:** Part 1: Demonstrate that there are at least 80% of Census block groups where a household earning the Area Median Income (AMI) would spend less than 45% on housing and transportation combined<br>--AND--<br>Part 2: Demonstrate that there are at least 60% of Census block groups where a household earning 80% AMI would spend less than 45% on housing and transportation combined | Complete | Does not meet target | 0 | 6 | PCW area Does not meet targets for either Part 1 (2% spends <45% of income) or Part 2 (0% spens <45% of income). | Data available at: http://www.htaindex.org/map/ |
| BE-4 | Outcomes | 2 | **Affordable Housing Production:** Option A: Achieve targets for creation of new affordable housing identified in a locally-adopted comprehensive housing strategy<br>--OR--<br>Option B: Demonstrate that 10% of residential units built or substantially rehabilitated in the past 3 years in the community's Compact & Complete Centers (CCCs) are dedicated as subsidized affordable housing | Complete, pending verification | Does not meet target | 0 | 4.5 | | |
| BE-4 | Outcomes | 3 | **Affordable Housing Preservation:** Demonstrate no loss of subsidized affordable housing units due to expiring subsidies in the past 3 years | Complete | Meeting target | 4.5 | 4.5 | No contracts have expired or have not been renewed in past 3 years. | Direct correspondance |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
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| BE-4 | Actions | 1 | Develop a comprehensive housing strategy | Complete | Does not meet target | 0 | 2 | Coos Bay has a housing section in their Comprehensive Plan. The city had a Housing Needs Analysis conducted in 2009, which recommended ammending the Comprehensive Plan to include language re: low-income and affordable housing. North Bend has housing section in their Comprehensive Plan, Chapter IV, that covers issues, goals, objectives, and implementaiton strategies. It also mentions the Areawide Housing Opportunity Plan that appears to have included Coos Bay and North Bend. This plan is not accessible online. Mike Lehman (ORCCA) does not know of any other housing plan other than 10-year plan to end homelessness published by ORCCA. | Comprehensive plans of the cities of Coos Bay and North Bend |
| BE-4 | Actions | 2 | Analyze transit access and transportation costs for neighborhoods with housing affordable to low- and moderate-income households | Future | Unable to be evaluated | 0 | 1 | | |
| BE-4 | Actions | 3 | When new transit or other major infrastructure investments are planned, analyze the likelihood and extent to which housing costs are anticipated to increase in low- and moderate-income neighborhoods so that appropriate strategies can be developed to preserve and create long-term affordable housing | Complete | Does not meet target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| BE-4 | Actions | 4 | Use regulatory and design strategies to encourage compatible infill and redevelopment with a mix of housing types in neighborhoods close to employment centers, commercial areas, and where transit or transportation alternatives exist | Complete | Partially meeting target | 0 | 3 | City of Coos Bay Comprehensive Plan, Housing section, Goal 3 Policy 3.2 "Coos Bay will continue to allow for and encourage small scale cluster housing concepts in residentially zoned areas to stimulate infill development. This strategy recognizes that infill development (1) is an acceptable way to wisely use<br>undeveloped properties, (2) improves efficiency of land use, (3) helps conserve energy, and (4) takes advantage of established public facilities and services." Otherwise, Coos Bay has no current action/activity. City of North Bend has no current action/activity on this topic. | City of Coos Bay Comprehensive Plan, Housing section; Sustainability Scan of city/county governments. |
| BE-4 | Actions | 5 | Require, incentivize, or subsidize creation of subsidized affordable housing, including deeply subsidized or deeply affordable housing, in transit-served areas and areas identified for compact, mixed-use development | Complete | Does not meet target | 0 | 3 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| BE-4 | Actions | 6 | Collaborate with other jurisdictions to address affordable housing and location efficiency needs in the region | Complete | Partially meeting target | 0 | 1 | Coos Bay partners with Oregon Coast Community Action to address housing needs. In 2007 Coos County had a major collaboration with the public, various departments to create 10-year plan to end homelessness (2009-2019), but it has a narrow focus. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| BE-4 | Actions | 7 | Partner with nonprofit organizations to provide education, counseling, and financial assistance to homebuyers or renters | Complete | Partially meeting target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend currently partners with community organizations for these purposes.<br>Coos County shares information for Neighbor Works/Dream Savers. | Sustainability Scan of city/county governments. |
| BE-4 | Actions | 8 | Implement programs to preserve and maintain existing subsidized and unsubsidized affordable housing in transit-served areas, compact and mixed-use areas, and areas with rapidly-rising housing costs | Complete | Does not meet target | 0 | 4 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| BE-4 | Actions | 9 | Work with private employers to provide live-near-your-work or employer-assisted housing financial incentives | Complete | Does not meet target | 0 | 4 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
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| BE-5 | Outcomes | 1 | **Infill Development:** Option A: Increase the percentage of new development in locally-designated infill and redevelopment areas --OR-- Option B: Increase the percentage of new development located on infill, previously developed, brownfield, and greyfield sites | Future | Unable to be evaluated | 0 | 3.5 | Requires using building permit records with zoning and planning areas, more extensive analysis.<br>Coos Bay: Could not find any info on infill/redevelopment in Coos Bay Comprehensive Plan or Municipal Code<br>North Bend: Comprehensive Plan Chapter XI - Plan Element - Energy states that as a "The City shall encourage the infilling of undeveloped parcels of land within the developed areas of the City." (Article 11.5.100 (1)) in an effort to achieve the goal: "The City will conserve energy by the efficient use of land for industrial, commercial and residential purposes." However, there is no designation of specific places targeted for infill. | North Bend Comprehensive Plan; Coos Bay Comprehensive Plan and Municipal Code |
| BE-5 | Outcomes | 2 | **Existing Infrastructure:** Demonstrate that at least 75% of new housing units in the past 3 years utilized existing water and sewer mains and did not require extending or widening public roadways | Future | Unable to be evaluated | 0 | 3.5 | Requires more extensive GIS data, including housing unit development and utility/roadway developments. | |
| BE-5 | Actions | 1 | Develop an inventory of infill, previously developed, brownfield, or greyfield sites of greatest priority and potential for development or redevelopment | Complete | Partially meeting target - in development | 0 | 1 | Coos County Public Health was recently awarded a grant to collaborate with the community, identify and prioritize brownfield sites, and conduct a health assessment at prioritized sites. City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this toipc. | Direct correspondance; Sustainability Scan of city/county governments |
| BE-5 | Actions | 2 | Adopt a policy commitment to limited or no expansion of physical jurisdiction boundaries or extension of urban services | Complete | Meeting target | 2 | 2 | Coos Bay and North Bend have Urban Growth Boundaries, as required by Goal 14 of Oregon's Statewide Palnning Goals & Guidelines (OAR 660-015-0000(14)). North Bend will develop within its urban area before land will be annexed for residential use in the Urban Growth Area (County zoning as of plan publication). | Coos Bay UGB, see Section 7.9 Urban Growth Management in Coos Bay Comprehensive Plan, Volume 1, 2000<br>North Bend UGB, see Chapter IVX, North Bend Comprehensive Plan, 2003 |
| BE-5 | Actions | 3 | Use regulatory and design strategies to encourage compatible infill and redevelopment with a mix of housing types in neighborhoods close to employment centers, commercial areas, and where transit or transportation alternatives exist | Complete | Does not meet target | 0 | 3 | City of Coos Bay is considering taking action on this topic. City of North Bend and Coos County have no current action/activity on this topic | Sustainability Scan of city/county governments. |
| BE-5 | Actions | 4 | Educate residents and community groups about the importance of infill and redevelopment, brownfield assessment findings, and design strategies for compatible neighborhood development | Complete | Partially meeting target | 0 | 2 | Coos County Public Health received a grant to collaborate with the community, identify and prioritize brownfield sites, and conduct a health assessment at prioritized sites. City of Coos Bay currently conducts education/outreach about this topic. City of North Bend has no current action/activity on this topic. | Direct Correspondance; Sustainability Scan of city/county governments. |
| BE-5 | Actions | 5 | Collaborate with state and federal authorities to advance brownfields cleanup | Complete | Partially meeting target - in development | 0 | 1 | Coos County Public Health received a grant to collaborate with the community, identify and prioritize brownfield sites, and conduct a health assessment at prioritized sites. They have many state partners on the project. City of Coos Bay has carried out brownfields cleanup in the past along the waterfront. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| BE-5 | Actions | 6 | Establish a program to provide information and assistance to owners, potential buyers, and developers regarding brownfield assessments, redevelopment strategies, and available resources | Complete | Partially meeting target | 0 | 4 | City of Coos Bay currently conducts education/outreach on this topic. City of North Bend has no current action/activity on this topic. Coos County Public Health received a grant to collaborate with the community, identify and prioritize brownfield sites, and conduct a health assessment at prioritized sites. They have many state partners on the project. | Sustainability Scan of city/county governments. |
| BE-5 | Actions | 7 | Support temporary, creative neighborhood uses for vacant properties and greyfields | Complete | Does not meet target | 0 | 4 | City of Coos Bay and Coos County have no current action/activity. City of North Bend has no current action/activity on this topic | Sustainability Scan of city/county governments. |
| BE-5 | Actions | 8 | Provide financial incentives to encourage infill and redevelopment | Complete | Does not meet target | 0 | 4 | City of Coos Bay is considering taking action on this topic. City of North Bend and Coos County have no current action/activity on this topic | Sustainability Scan of city/county governments. |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
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| BE-5 | Actions | 9 | Perform proactive zoning enforcement and vacant lot cleanup or maintenance to improve the attractiveness of a redevelopment or blighted area and to deter crime | Complete | Meeting target | 4 | 4 | Cities of Coos Bay and North Bend and Coos County currently have zoning enforcement/vacant lot cleanup for this purpose. | Sustainability Scan of city/county governments. |
| BE-5 | Actions | 10 | Target local infrastructure improvements to revitalize redevelopment or blighted areas and catalyze private reinvestment | Complete | Meeting target | 6 | 6 | City of Coos Bay currently has targeted improvements for this purpose through urban renewal projects (e.g. Empire Blvd improvement project that will start construction in 2014). City of North Bend likewise has urban renewal projects that spur redevelopment/reinvestment (though this was not reported on the Sustainability Scan). Coos County reports no current action/activity for this measure. | Sustainability Scan of city/county governments. |
| BE-6 | Outcomes | 1 | **Acreage:** Provide ample parkland based on population density as follows:<br>• High: 6.8 acres per 1,000 residents<br>• Intermediate-High: 7.3 acres per 1,000 residents<br>• Intermediate-Low: 13.5 acres per 1,000 residents<br>• Low: 20.3 acres per 1,000 residents | Complete, pending update | Meeting target | 4.5 | 4.5 | With Coos Bay, North Bend parks and State Parks, project area is already well above threshold: 41.2 acres per 1000 residents.<br>Doesn't include Millicoma Marsh (owned by Coos Bay school district, 44 acres). Other informal parks owned by private landowners may be left out. | City/Port GIS departments |
| BE-6 | Outcomes | 2 | **Proximity:** Demonstrate that housing units in the community are located within a ½-mile walk distance of a public space or park based on population density as follows:<br>• High or Intermediate-High: 85%<br>• Intermediate-Low or Low: 70% | Complete, pending update | Meeting target | 4.5 | 4.5 | About 67% of population, 68% of housing units are w/in 1/2 mile to park (city, county, and state); This might increase if other public spaces were added (would need additional GIS data); | City GIS departments |
| BE-6 | Outcomes | 3 | **Connectivity:** Demonstrate that 90% of households are located within 3 miles of an off-road trail | Future | Unable to be evaluated | | 4.5 | | City GIS departments |
| BE-6 | Outcomes | 4 | **Use and Satisfaction:** Option A: Demonstrate that 66% or more of surveyed residents visit a park at least once a year<br>--OR--<br>Option B: Demonstrate that 66% or more of surveyed residents respond favorably regarding the quality of the community's public space and park system | Complete, pending update | Does not meet target | 0 | 1.5 | In the Coos Bay Parks Master Plan, there is no specific question regarding annual use/quality of parks in the community assessment. North Bend does not have a comprable assessment. These questions should be addressed in a future survey. | Coos Bay Parks Master Plan |
| BE-6 | Actions | 1 | Adopt a parks and/or open space plan that promotes a community-wide network of public spaces that provide recreational, transportation, and environmental benefits | Complete | Meeting target | 2 | 2 | Completed inventory of Coos Bay Parks Master Plan and North Bend Comprehensive plan, Parks chapter. | Coos Bay Parks Master Plan and North Bend Comprehensive Plan, Parks chapter. |
| BE-6 | Actions | 2 | Conduct a study regarding the economic impact of parks and public spaces on the local economy to understand their contributions to community satisfaction and tourism | Complete | Does not meet target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County is considering actions on this topic. | Sustainability Scan of city/county governments. |
| BE-6 | Actions | 3 | Adopt regulatory strategies or development incentives to create, maintain, and connect parks and public spaces | Complete | Does not meet target | 0 | 3 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County is considering actions on this topic. | Sustainability Scan of city/county governments. |
| BE-6 | Actions | 4 | Adopt design guidelines for new public spaces and improvements to existing facilities to strengthen environmental benefits and provide visitor amenities | Complete | Partially meeting target - in development | 0 | 2 | City of Coos Bay is considering taking action on this topic. The Coos Bay Parks Master Plan was completed in 2013, and the next step is to create design guidelines. City of North Bend has no current action/activity on this topic.<br>Coos County is currently working on ordinance updates. | Sustainability Scan of city/county governments. |
| BE-6 | Actions | 5 | Participate in a local or regional alliance working to improve and expand the community-based or regional park system | Complete | Partially meeting target | 0 | 1 | City of Coos Bay is considering taking action on this topic. City of North Bend and Coos County currently participates in a local/regional partnership for park system improvements. | Sustainability Scan of city/county governments. |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
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| BE-6 | Actions | 6 | Create an advisory board to regularly receive feedback from residents and regarding planning, decision-making, and other issues affecting the quality and availability of parks and public spaces | Complete | Meeting target | 1 | 1 | City of Coos Bay currently has a Parks Commission appointed by the City Council. Current list available at: http://coosbay.org/departments/parks#parks-commission; City of North Bend currently has a Parks Advisory Board appointed. Current list available at: http://www.northbendcity.org/North_Bend_Oregon_Parks_Advisory_Board.htm<br>Coos County currently has an advisory board for parks/public spaces, listed at: http://www.co.coos.or.us/Departments/CoosCountyParks.aspx | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapter 2.30 |
| BE-6 | Actions | 7 | Host or partner with a volunteer program to support parks and public space maintenance | Complete, pending update | Meeting target | 4 | 4 | North Bend: 3 volunteers clear hazardous trees and brush on a regular basis in Ferry Road Park for the past 5 years. Otherwise, the Parks dept. doesn't get many calls from volunteer. Every so often, SCBEC groups come, sponsored through state funding. They used to get some school groups, but not anymore. Dept. is not allowed to solicit volunteers.<br>Coos Bay: Parks department has had volunteer events in Mingus Park, such as the annual Earth Day clean up with Marshfield High School students. | Direct correspondance |
| BE-6 | Actions | 8 | Provide assistance for low-income users to access and use parks and public spaces through subsidy, scholarships, and discounts | Complete | Meeting target | 4 | 4 | Cities of Coos Bay and North Bend currently provide this type of assistance. | Sustainability Scan of city/county governments. |
| BE-6 | Actions | 9 | Host programs and events in parks and public spaces that bring the community together and encourage physical activity | Complete, pending update | Meeting target | 4 | 4 | Events and programs are in held. See data document for details. | |
| BE-6 | Actions | 10 | Consistently invest sufficient capital and operational funding to create and maintain parks and public spaces | Complete | Does not meet target | 0 | 6 | Goal is $85/person. City departments alone do not meet this threshold, but could be occuring if there are additional sponsorships, private donations, grants, or in-kind services that are not captured in the city budgets.<br>Coos Bay Parks Department Budget<br>2010-11: $276,351 / 15967 people = $17.3 per person<br>2011-12: $340,683 = $21.3/person<br>2012-13 Adopted: $421,011 = $26.4/person<br>2013-14 Adopted: $430,696 = $27/person<br>North Bend Parks Department Budget<br>2010-11: $236,803 / 9695 people = $24.4/person<br>2011-12: $272,637 = $28.1/person<br>2012-13 Adopted: $307,670 = $31.7/person<br>2013-14 Adopted: $299,685 = $30.9/person | City of Coos Bay 2013-2014 Budget, page 60, http://coosbay.org/uploads/PDF/FYE_14_CITY_BUDGET_web.pdf City of North Bend Budget 2013-2014, http://www.northbendcity.org/documents/20132014CONBBudget.pdf |
| BE-7 | Outcomes | 1 | **Mode Split:** Achieve the following thresholds for journey-to-work trips:<br>• Drive alone maximum: 60%<br>• Bike + Walk + Transit minimum: 25%<br>• Bike + Walk minimum: 5% | Complete | Does not meet target | 0 | 10 | Driving (73%; 13% over threshold) and Walk/Bike/Transit (6.8%; 18.2% under threshold) thresholds not met. Walk/Bike threshold met (6.6%; 1.6% above threshold). | Data available from American Community Survey, Accessed from census.gov FactFinder2 |
| BE-7 | Outcomes | 2 | **Transportation Affordability:** Show that at least 50% of households in the jurisdiction are estimated to spend less than 15% of income on transportation costs | Complete | Does not meet target | 0 | 5 | 100% of households spend 15% or more on transportation costs. | Data available from http://www.htaindex.org/map/ |
| BE-7 | Outcomes | 3 | **Transportation Safety:** Demonstrate that pedestrian and bicyclist fatalities are making incremental progress towards zero fatalities by 2040, compared to a baseline year not predating 2000 | Complete | Meeting target | 5 | 5 | Baseline was at 0 (2000), most recent five year average shows decrease, back to 0 in 2012. | http://www-fars.nhtsa.dot.gov/Main/index.aspx |

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| BE-7 | Actions | 1 | Adopt a bicycle and/or pedestrian master plan that prioritizes future projects to improve safety and access to non-motorized transportation | Complete | Meeting target | 2 | 2 | A Bikeway Master Plan for the Bay Area and Coos County Parks was completed in 1991. According to County's Transportation System Plan (2011), the Bikeway Master Plan is outdated, but it identifies the existing bicycle system inventory and deficiencies, which remain relevant to current County-wide conditions. The County's Transportation System Plan (2011) has a Pedestrian and Bicycle Plan with prioritized projects. The City of Coos Bay's Transportation System Plan (2004) includes a Bicycle Action Plan and Pedestrian Action Plan, the latter of which was envisioned to inform a Pedestrian Master Plan. The City of North Bend's Transportation System Plan (2004) likwise includes a Bicycle Action Plan and Pedestrian Action Plan. | Sustainability Scan of city/county governments. Bikeway Master Plan for Coos Bay Bay Area and Coos County Parks, Gary L. Dyer, June, 1991. City of Coos Bay's Transportation System Plan (2004) City of North Bend's Transportation System Plan (2004); Coos County Transportation System Plan (2011) |
| BE-7 | Actions | 2 | Adopt a complete streets policy that addresses all users, applies to all projects with limited exceptions, and includes specific next steps for implementation | Complete | Meeting target | 2 | 2 | Coos County's Transportation System Plan (2011) embodies complete streets elements in the Goals and Objectives in Chapter 2. City of Coos Bay currently has this type of policy integrated throughout the City's Transportation System Plan from 2004, and specifically in Chapter 2: Goals and Policies. City of North Bend reported that it does not currently have this type of policy, but its Transportation System Plan (2004) specifically includes elements of a complete streets policy in Chapter 2: Goals and Policies. | Sustainability Scan of city/county governments. City of Coos Bay's Transportation System Plan (2004) City of North Bend's Transportation System Plan (2004) Coos County Transportation System Plan (2011) |
| BE-7 | Actions | 3 | Subdivision and other development regulations require walkability standards that encourage walking and enhance safety | Complete | Partially meeting target | 0 | 3 | City of Coos Bay has no current action/activity on this topic. City of North Bend and Coos County currently have walkability standards for subdivisions/other developments. | Sustainability Scan of city/county governments. |
| BE-7 | Actions | 4 | Local government offers employee incentives to encourage commuting by modes other than single-occupancy vehicles | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| BE-7 | Actions | 5 | Implement at least 2 types of focused enforcement programs to ensure pedestrian, bicycle, and motorist safety | Complete, pending update | Meeting target | 4 | 4 | City of Coos Bay Police Dept. attends to enforcement, along with occassional grants for targeted enforcement. City of North Bend currently has enforcement programs. | Sustainability Scan of city/county governments. |
| BE-7 | Actions | 6 | Increase the percentage of households with access to transit | Pending data collection/request | Pending | | 6 | | |
| BE-7 | Actions | 7 | Increase the mileage of sidewalks, particularly on arterial or collector roads that connect people with destinations | Pending data collection/request | Pending | | 6 | From the Coos Bay Transportation System Plan: "Based on the street inventory, most major arterials facilities have sidewalks (84%) while minor arterial and collector streets have very limited existing sidewalk facilities (less than 10%)...The most important needs are to fill in the gaps on the arterial system such as on Newmark Avenue and Bayshore Drive. However, the City of Coos Bay should work to continue increasing the sidewalk coverage on all arterials, collectors, and residential streets in the Coos Bay area." (p. A-23) See Figure B-4: Pedestrian Facility Deficiencies. For the Coos Bay/North Bend area, 16.7 miles of sidewalks on one/both sides were identified as priority projects in the respective transportation plans (2004). | Coos Bay and North Bend Transportation System Plans, 2004 |

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| BE-7 | Actions | 8 | Increase the mileage of striped or buffered bicycle lanes, cycle-tracks, parallel off-street paths and/or other dedicated facilities | Pending data collection/request | Pending | | 6 | Oregon Transportation Planning Rule requires all arterial and major collector roads to have either: bikeways when they are constructed or improved, or an adjacent parallel facility provided. As can be read below, there are a number of deficiencies in Coos Bay as of the 2004 Transportation System Plan. See Figure B-3: Bicycle Facility Deficiencies.<br>For the Coos Bay/North Bend area, 34.4 miles of bike lanes/routes were identified as priority projects in the respective city and county transportation plans (2004, 2011).<br>From the Coos Bay Transportation System Plan: "Within the City, bicycle trips are typically made for utility purposes between core areas such as US 101, Ocean, Newmark and other arterial and collector streets. Outside the City, trips are more recreational in nature.<br>The Oregon Coast Bike Route (OCBR) is the only marked bike route in the area. It is a combination of<br>shared roadway, shoulder and bike lane types. As mentioned previously, the only designated bike lanes<br>exist on US 101.<br>Due to the lack of bike lanes and sporadic paved shoulders (less than 10 percent of arterials and collectors have bike facilities), there is limited connectivity for bicyclists traveling to activity centers in Coos Bay. Bicycles are permitted on all roadways in the both City. Bicycle use in Coos Bay is generally for recreational, school and commuting purposes." (p. A-20) | Coos Bay and North Bend Transportation System Plans, 2004, Coos County Transportation System Plan, 2011 |
| BE-7 | Actions | 9 | Establish or support a community-wide public bike share program | Complete | Does not meet target | 0 | 6 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| BE-7 | Actions | 10 | Construct or retrofit transportation infrastructure to meet standards in the Americans with Disabilities Act (ADA) | Complete | Meeting target | 6 | 6 | City of Coos Bay requires all new projects meet standards, and retrofit projects are done as funds become available. City of North Bend and Coos County transportation infrastructure meets standards. | Sustainability Scan of city/county governments. |
| CE-1 | Preliminary Step | | Identify 4 core areas of local climate change adaptation concerns. Core areas must apply to at least 3 of 4 general groupings: Built Environment, Economic Environment, Natural Environment, Social Environment | Future | N/A | 0 | | | |
| CE-1 | Outcomes | 1 | **Vulnerability Reduction:** Demonstrate a measurable reduction in vulnerability in each of the 4 core areas identified locally | Future | Unable to be evaluated | 0 | 10.5 | | |
| CE-1 | Actions | 1 | Adopt a climate change adaptation plan | Complete | Does not meet target | 0 | 2 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County is considering actions on this topic. | Sustainability Scan of city/county governments. |
| CE-1 | Actions | 2 | Require that internal decisions by local government departments use the most current climate science and that staff monitor climate change impacts | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-1 | Actions | 3 | Develop a committee that includes climate scientists, adjacent jurisdictions, regional coalitions, state and federal agencies, and/or non-governmental organizations for the purpose of understanding and addressing shared vulnerabilities | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-1 | Actions | 4 | Create an education and outreach campaign to engage citizens and businesses in climate change vulnerability reduction efforts | Complete | Does not meet target | 0 | 2 | Neither city nor the county has climate change related materials. | |
| CE-1 | Actions | 5 | Adopt zoning code, building code, or other legally binding regulations that address future climate change threats | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |

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| CE-1 | Actions | 6 | Create or enhance programs and services that specifically help address climate change threats | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-1 | Actions | 7 | Enforce regulations or offer incentives to encourage residents and businesses to shift behaviors to prepare for future climate change impacts | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-1 | Actions | 8 | Improve facilities throughout the community to be better prepared for climate change threats | Complete | Does not meet target | 0 | 6 | City of Coos Bay is considering taking action on this topic. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-2 | Outcomes | 1 | **Greenhouse Gas Emissions Reductions:** Demonstrate incremental progress towards achieving an 80% reduction by 2050 in community-wide greenhouse gas (GHG) emissions | Complete | Does not meet target | 0 | 20 | Project area does not have a greenhouse gas inventory or other tracking of GHG. | |
| CE-2 | Actions | 1 | Adopt a climate action plan designed to reduce GHG emissions throughout the jurisdiction | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-2 | Actions | 2 | Require GHG emissions to be considered in broader local government planning processes and decision-making | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-2 | Actions | 3 | Create an education and outreach campaign to engage citizens and businesses in GHG reduction efforts | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-2 | Actions | 4 | Establish a climate change advisory group to engage diverse community stakeholders in identifying and implementing GHG reduction strategies | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-2 | Actions | 5 | Modify local government operations and facilities in order to reduce GHG emissions and serve as a leader in the community | Complete | Partially meeting target | 0 | 1 | City of Coos Bay currently considers GHG mitigation with new facility projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-2 | Actions | 6 | Adopt energy efficiency regulations for buildings within the jurisdiction | Complete | Meeting target | 3 | 3 | City of Coos Bay and Coos County currently meet energy efficiency requirements set by Oregon building codes. City of North Bend currently has energy efficiency regulations for buildings. | Sustainability Scan of city/county governments. |
| CE-2 | Actions | 7 | Create incentives to improve reliance on distributed generation of renewable energy sources | Complete | Partially meeting target | 0 | 4 | No local incentives; just through state/utilities. City of Coos Bay currently takes advantage of grants for its projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments;<br>Database of state incentives for renewables & efficiency |
| CE-2 | Actions | 8 | Implement specific programs and services or create facility upgrades that transition the community towards the use of alternatives modes of transportation and low-emissions vehicles | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-2 | Actions | 9 | Implement specific programs and services or create facility upgrades that reduce waste in the community | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Outcomes | 1 | **Green Vehicles:** Part 1: Demonstrate increased ownership of alternative fuel vehicles by residents over time<br>--AND--<br>Part 2: Demonstrate increased ownership of fuel-efficient vehicles by residents over time | Future | Unable to be evaluated | 0 | 5.3 | Fee for data is not cost effective at this time. | |
| CE-3 | Outcomes | 2 | **Electrical Energy Supply:** Demonstrate that the community receives a portion of its overall energy supply from renewable energy sources | Complete | Does not meet target | 0 | 5.3 | Renewable energy use purchased through Pacific Power's Blue Sky Program has increased for all sales in the PCW from 2011-2013. The portion of total energy use from renewable sources has also increased slightly during that period. However, the overall renewable energy is just under 1.5% of total energy use, below even STAR's minimum threshold (2%) and far below it's target threshold (50%). | Data received from Pacific Power via special request |
| CE-3 | Outcomes | 1 - Bonus | Demonstrate a decreased percentage of residents who own motor vehicles | | N/A | 0 | 0 | | |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| CE-3 | Actions | 1 | Adopt a community-wide plan that includes a comprehensive programmatic and policy approach to shift the community towards alternative fuels and renewable energy sources, especially for non-transportation uses | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 2 | Create a policy to ensure that the local government's transportation and non-transportation energy supplies increasingly come from renewable and alternative sources | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 3 | Remove zoning, height, and other regulatory restrictions on the development of small- and medium-scale renewable energy installations and alternative fueling systems | Complete | Does not meet target | 0 | 3 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County is considering actions on this topic by updating its ordinances. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 4 | Establish partnerships with critical energy providers and consumers to match renewable energy sources with community energy needs | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 5 | Adopt renewable energy or alternative fuel targets for locally owned facilities and vehicles | Complete | Partially meeting target | 0 | 3 | Oregon has state renewable portfolio standards. PacifiCorp is required to have 15% by 2015, 20% by 2020, and 25% by 2025. Coos-Curry Electric is required to have 5% by 2025. However, need to look into local requirements. Beyond the state RPS, City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments; Oregon Department of Energy Renewable Portfolio Standards |
| CE-3 | Actions | 6 | Create incentive programs to support the development of renewable and alternative fuel infrastructure | Complete | Does not meet target | 0 | 4 | City of Coos Bay transfered Business Energy Tax Credits to local individuals for renewable energy projects, thanks to renewable energy projects in Fire Station on Elrod St. $100K project completed tax credit transfer in 2013, $12K project still waiting to completed $6K credit transfer, by June 2014.(http://coosbay.org/uploads/PDF/NEWS/ODE%20Tax%20Credit/BETC2.pdf); Other than this, City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 7 | Use a feed-in tariff or other financial mechanisms to increase the mix of renewable energy sources supplied to residents | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 8 | Run a net-metering program that encourages the development of small scale renewable energy sources | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 9 | Work with state and regional partners to electrify truck stops to reduce idling and unnecessary emissions | Complete | Does not meet target | 0 | 6 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-3 | Actions | 10 | Install electrical vehicle charging stations | Complete | Meeting target | 6 | 6 | 4 stations: The Mill Casino (2013), Coos Bay Fire Station (2009), Ford Building/7 Devils Brewery (2014), Coos Bay Fred Meyer (2013) | US Dept. of Energy, Alternative Fueling Station Locator |
| CE-3 | Actions | 11 | Build the necessary distribution infrastructure to support further investment in renewable energy sources | Complete | Does not meet target | 0 | 6 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Outcomes | 1 | **Energy Efficiency:** Demonstrate incremental progress towards achieving an 80% reduction by 2050 in the energy use of industrial sector operations | Complete | Partially meeting target | 0 | 7 | Pacific Power is unable to separate industrial energy use from the rest of non-residential sales. However, total non-residential energy use has decreased between 2011-2013. From 2011 to 2012, there was a 1.8% reduction, and from 2012 to 2013 a 4.6% reduction. Although the first reduction is less than the minimum to be on track to meet STAR's goal of 80% by 2050, the second is much greater. Therefore, the non-residential energy use is on track to meeting this target. However, it since no specific goals are set by the local government at this time, there is no guarentee that such reductions will continue to be made annually. | Data received from Pacific Power via special request |
| CE-4 | Outcomes | 2 | **Water Efficiency:** Demonstrate incremental progress towards achieving an 80% reduction by 2050 in the water use of industrial sector operations | Pending request | Pending | | 3 | Water Board has data on water use, categorized by customer class, including industrial. The stacked-bar chart provided shows usage by month for the past three years. Without the specific data numbers, it is too difficult to determine a clear trend or show specific percentage progress. | |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| CE-4 | Actions | 1 | Adopt a plan designed to improve the resource efficiency of the community's industrial sector | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 2 | Adopt policies that promote shifts to improved data collection | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 3 | Adopt regulations or codes that promote the industrial sector to reduce energy and water use | Complete | Does not meet target | 0 | 3 | Oregon state building codes promote reduction of water use and energy. Locally, City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 4 | Partner with organizations to encourage the collection and reporting of energy and water use data from the industrial sector | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 5 | Work collaboratively with local industrial sector leaders to set local targets and strategies to reduce energy and water use | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 6 | Create training and educational opportunities for industrial sector employees to learn about current best practices and techniques for reducing energy and water use | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 7 | Administer programs that support the industrial sector's transition to less energy and water intensive practices | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 8 | Create financial incentives or industry-focused challenges to encourage companies to reduce the intensity of their resource consumption | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-4 | Actions | 9 | Develop the necessary infrastructure for industries to transition to less resource intensive practices | Complete | Does not meet target | 0 | 6 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-5 | Outcomes | 1 | **Energy Efficiency:** Demonstrate incremental progress towards achieving an 80% reduction by 2050 in the energy use intensity of the community's building stock | Pending analysis | Pending | | 6 | | Data received from Pacific Power via special request |
| CE-5 | Outcomes | 2 | **Water Efficiency:** Demonstrate incremental progress towards achieving an 80% reduction by 2050 in the water use intensity of the community's building stock | Pending request | Pending | | 6 | Water Board has data on water use, categorized by customer class. The stacked-bar chart provided shows usage by month for the past three years. Without the specific data numbers, it is too difficult to determine a clear trend or show specific percentage progress. | |
| CE-5 | Outcomes | 3 | **Green-Certified Building Stock:** Part 1: Increase over time the percentage of non-residential buildings achieving certification in STAR-qualifying energy efficiency and green construction programs<br>--AND--<br>Part 2: Increase over time the percentage of residential units achieving certification in STAR-qualifying energy efficiency and green construction programs | Complete | Does not meet target | 0 | 5.3 | LEED - 2 certified and 2 in process of certification. 0 projects in Green Globes. 0 projects in Living Building Challenge. | LEED website, Green Globes website, Living Building Challenge website |
| CE-5 | Actions | 1 | Adopt a building energy efficiency plan to improve the energy and water efficiency of commercial, residential, and institutional buildings in the community | Complete | Partially meeting target | 0 | 2 | The City of Coos Bay creates energy and water efficiency plans for new City buildings. The City of North Bend currently has no action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability Scan of city/county governments. |
| CE-5 | Actions | 2 | Adopt or upgrade building codes to ensure that new and renovated buildings are more water and energy efficient | Complete, pending update | Partially meeting target | 0 | 3 | Coos Bay Municipal Code 17.235.050 Insulation: Manufactured homes must be certified to meet certain thermal insulation standards for energy efficiency. City of Coos Bay currently has these codes in place. City of North Bend currently has building codes that include water/energy efficiency standards for new/renovated buildings. Coos County has no types of codes in place, but reports state building codes address this topic. | Sustainability Scan of city/county governments. |
| CE-5 | Actions | 3 | Adopt an energy and water use information disclosure ordinance requiring energy and water users to disclose consumption levels | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |

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|---|---|---|---|---|---|---|---|---|---|
| CE-5 | Actions | 4 | Create an education and outreach campaign or challenge to engage citizens and businesses in energy and water efficiency efforts | Complete | Partially meeting target | 0 | 2 | ORCCA NCCC team piloted energy and water conservation education program in 3 elementary schools, tutoring 302 students through 23 classes. Head Start provides Green training for staff members and they have an active "Going Green" committee. ORCCA Annual Report 2011-12. City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. ORCCA Annual Report 2011-12. |
| CE-5 | Actions | 5 | Establish a committee to provide recommendations on policies related to resource efficiency in buildings **OR** integrate this role into the work of existing committees | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-5 | Actions | 6 | Work with the local utilities to improve energy efficiency programs and increase sub-metering throughout the community | Complete | Partially meeting target | 0 | 1 | City of Coos Bay works with utilities to allow sub-meters for irrigation water. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-5 | Actions | 7 | Train inspectors to enforce water and energy efficiency standards in adopted building codes | Complete | Meeting target | 1 | 1 | The City of Coos Bay and the City of North Bend have inspectors enforcing standards required in building codes for new/renovated buildings. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-5 | Actions | 8 | Create incentives to encourage the construction of energy and water efficient certified buildings | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-5 | Actions | 9 | Create a program to help homeowners and renters upgrade to more energy and water efficient homes | Complete | Meeting target | 4 | 4 | ORCCA's EmPower Program helps households identify energy reduction strategies for those facing challenges paying their energy bill. Their Weatherization program helps low-income households lower heating costs through energy efficiency methods. In 2011-2012, they helped 194 households with weatherization and completed furnace replacements in 51 homes; CBNW Water Board considering a water conservation improvement program, according to Water Conservation and Management Plan 2009. Aside from leak detection and general water conservation information, no other efforts have been taken to increase conservation. Cities of Coos Bay and North Bend and Coos County have no water conservation programs. | Water Conservation and Management Plan 2009; ORCCA 2011-2012 Annual Report |
| CE-5 | Actions | 10 | Renovate local government buildings to improve energy and water use efficiency | Complete | Meeting target | 6 | 6 | City of Coos Bay follows state building codes when renovating City buildings according to energy and water efficiency standards. City of North Bend makes/has made specific upgrades to increase efficiency. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-6 | Preliminary Step | | For Outcome 1: Select public infrastructure which comprises an estimated 50% of the community's infrastructure-based energy consumption | Future | N/A | | | Requires more detailed analysis using infrastructure data and energy/water consumption data | |
| CE-6 | Preliminary Step | | For Outcome 2: Select public infrastructure which comprises an estimated 50% of the community's infrastructure-based water consumption | Future | N/A | | | Requires more detailed analysis using infrastructure data and energy/water consumption data | |
| CE-6 | Outcomes | 1 | **Energy Efficiency:** Demonstrate incremental progress towards achieving an 80% reduction by 2050 in energy use by selected public infrastructure | Future | Unable to be evaluated | 0 | 7 | Requires more detailed analysis using infrastructure data and energy/water consumption data | |
| CE-6 | Outcomes | 2 | **Water Efficiency:** Demonstrate incremental progress towards achieving an 80% reduction by 2050 in water use by selected public infrastructure | Future | Unable to be evaluated | 0 | 3 | Requires more detailed analysis using infrastructure data and energy/water consumption data | |
| CE-6 | Actions | 1 | Develop targeted strategies to improve the resource efficiency of public infrastructure systems | Complete | Partially meeting target | 0 | 2 | City of Coos Bay has no current action/activity on this topic. City of North Bend currently has strategies/codes/standards for this purpose. Coos County is considering strategies/codes/standards for this purpose. | Sustainability Scan of city/county governments. |
| CE-6 | Actions | 2 | Require public infrastructure managers to consider thorough energy and water consumption implications when designing and installing new infrastructure components | Complete | Does not meet target | 0 | 1 | City of Coos Bay does not have a requirement, but resource consumption is considered when analyzing life cycle costs for City projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| CE-6 | Actions | 3 | Adopt codes or design standards for new public infrastructure that will increase energy and water efficiency | Complete | Meeting target | 3 | 3 | City of Coos Bay follows state building codes when renovating City buildings according to energy and water efficiency standards. City of North Bend currently has strategies/codes/standards for this purpose. Coos County is considering strategies/codes/standards for this purpose. | Sustainability Scan of city/county governments. |
| CE-6 | Actions | 4 | Partner with state or regional entities that own or operate infrastructure within the jurisdiction to develop strategies to reduce energy and water usage | Complete | Meeting target | 1 | 1 | City of Coos Bay implements shared Public Works services with ODOT, Coos County, North Bend, and School Districts. City of North Bend currently cooperates with Public Works services partnership and potentially other partnerships. Coos County reports no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-6 | Actions | 5 | Engage public works and infrastructure managers in voluntary GHG reporting | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-6 | Actions | 6 | Develop training programs for infrastructure operators on energy and water efficiency techniques | Complete | Meeting target | 1 | 1 | City of Coos Bay wastewater personnel are trained in this topic. City of North Bend currently has these types of training programs. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-6 | Actions | 7 | Make specific upgrades to infrastructure systems that will increase energy and water efficiency | Complete | Meeting target | 6 | 6 | The City of Coos Bay implements these upgrades for street lighting, wastewater operations, and buildings. City of North Bend currently makes these upgrades for greater efficiency. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-6 | Actions | 8 | Increase sub-metering from specific infrastructure systems to collect better information on energy and water use | Complete | Partially meeting target | 0 | 6 | City of Coos Bay works with utilities to allow sub-meters for irrigation water. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| CE-7 | Outcomes | 1 | **Total Solid Waste:** Demonstrate incremental progress towards achieving a 100% reduction by 2050 in total solid waste generated within the jurisdiction that is disposed of via landfill or incinerator | Complete | Does not meet target | 0 | 15 | Oregon DEQ keeps records of all waste and recycling for all counties. In 2012 Waste Generation and Recovery Report, the data from Coos County, 1992-2012 show an increase in total waste generated in tons and per capita waste. | Oregon DEQ Waste Generation and Recovery Reports (online) |
| CE-7 | Actions | 1 | Adopt a waste management plan that identifies the community's greatest sources of waste, sets formal waste reduction targets and establishes actions to help reach the community's waste reduction aims | Complete | Does not meet target | 0 | 2 | Coos County has Solid Waste Management Plan from 2006, very outdated according to Cheryl. No specific waste reduction goals are set, although waste recovery goals of 30% (state mandated) are set for 2009-2050. Coos County Household Hazardous Waste Management Plan, all cities in Coos/Curry counties participate except North Bend, Powers, and Lakeside. | Direct correspondance |
| CE-7 | Actions | 2 | Adopt specific product bans that will significantly advance progress towards waste reduction goals | Complete | Does not meet target | 0 | 3 | No ban currently in place in county/cities. | Direct correspondance |
| CE-7 | Actions | 3 | Create a public education campaign or a focused outreach effort to inform residents and businesses of their roles in achieving waste reduction targets | Complete | Partially meeting target | 0 | 2 | Coos County continually sends out the acceptable recycling list when they have collection events for Brush and Metal. They also have recycling information listed on their website. They have flyers available to all the customers that use the facility. City of North Bend has also posted recycling information on their webpage. No targeted comprehensive campaign to reduce waste. | Direct correspondance |
| CE-7 | Actions | 4 | Develop or participate in a regional coalition that enhances the community's ability to address waste management targets | Complete | Meeting target | 1 | 1 | Coos County's Waste Advisory Committee is a group of volunteers that address solid waste issues and develop programs and recommendations for approval by the County's Board. Membership includes representatives from County and City governments, DEQ, waste management companies, and interested individuals. (Ordinance 88-03-008L) Member list: http://www.co.coos.or.us/Portals/0/Board%20and%20Committees/solidwasteadvisoryboard.pdf | Coos County Solid Waste Management Plan (2006) |
| CE-7 | Actions | 5 | Implement incentives or enforce regulations ensuring that residents and businesses are working toward community waste reduction targets | Complete | Partially meeting target | 0 | 4 | There is a tipping fee at Beaver Hill Landfill. The contractors that pick up may charge a collection fee that covers the County's "share", but when that waste is disposed at a non-County facility, the County is not able to collect the share that theoretically they would receive. Otherwise, no incentive programs exist. Fees documented for 2008-2013. | Coos County Solid Waste Management Plan (2006) |

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| CE-7 | Actions | 6 | Provide services to enable residents and businesses to recycle and reduce their waste footprint | Complete | Meeting target | 4 | 4 | 2010: 14,058 tons; 2011: 32,855 tons; 2012: 28,922; Coos County has exceeded is 30% recovered materials goal in all three of these years (39.5%, 47.7%, 43.7%) Extensive list of curbside recycling and drop-off sites; Household hazardous waste, e-waste, and paint collection at Beaver Hill Coos County site | Oregon DEQ Waste Generation and Recovery Reports; Coos County Solid Waste website |
| CE-7 | Actions | 7 | Collaboratively create and run at least 2 targeted recycling programs at key locations throughout the community | Complete | Meeting target | 4 | 4 | There are many drop-off sites for specific recyclable items. Various organized recycling programs occur at specific locations throughout the year, for special events. | Coos County Solid Waste Management Plan (2006), Coos County Solid Waste website |
| CE-7 | Actions | 8 | Operate at least 2 specific waste management programs for critical waste stream types found in the community, such as: organic waste, hazardous waste, electronic waste, and construction / demolition waste | Complete | Meeting target | 4 | 4 | Coos County has Household Hazardous Waste Management Plan (2008); They recycle paint, motor oil/antifreeze, batteries, and electronic wasteat Beaver Hill. They also run satellite events through year. | Coos Household Hazardous Waste Management Plan (2008), Coos County Solid Waste Management Plan (2006) |
| CE-7 | Actions | 9 | Create a waste-to-energy conversion system for the community | Complete | Partially meeting target | 0 | 6 | Coos County energy recovery decreased from about 1/4-1/3 of recovered materials to less than 10% due to closing of the incineration site and likely the closing of Greenland Recycling, which did some waste conversion. Rogue Disposal is where Coos County ships its solid waste. Their Dry Creek Landfill has a landfill gas to energy project that produces 3.2 MW of energy. The Coos County garbage is put into the landfill, along with all of our other clients, where it decomposes to produce landfill gas. Landfill gas is nearly 50% methane. The gas is removed from the landfill and burned in two 20-cylinder CAT engines to power two 1.6 MW generators. It produces enough electricity to power approximately 3,000 homes here in the valley. Coos County waste is just under 10% of the total municipal solid waste, generating about .3 MW of energy | Oregon DEQ Waste Generation and Recovery Reports (online) |
| EAC-1 | Outcomes | 1 | **Creative Industries:** Demonstrate that creative industries represent at least a 5% share of all businesses in the county | Complete | Does not meet target | 0 | 7.5 | Coos County Does not meet target, as of 2009; 3.57% | Americans for the Arts Local Arts Index |
| EAC-1 | Outcomes | 2 | **Attendance and Participation:** Part 1: Demonstrate that at least 50% of adult residents in the county attend a live performing arts event annually<br>--AND--<br>Part 2: Demonstrate that at least 30% of adult residents in the county visit an art museum annually | Future | Unable to be evaluated | 0 | 7.5 | Requires a community survey | |
| EAC-1 | Actions | 1 | Adopt a strategic plan to protect, enhance, and expand the community's arts and cultural resources and strengthen creative industries | Complete, pending update | Meeting target | 2 | 2 | Coos County Cultural Coalition produced Coos County Cultural Plan, originally in 2004, but revised in 2011 | Coos County Cultural Plan |
| EAC-1 | Actions | 2 | Adopt percent-for-art ordinance requiring public art to be installed as part of new major public development projects | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-1 | Actions | 3 | Establish enterprise zones, arts or cultural districts, or overlay zoning that encourages businesses in the creative industries to cluster together and integrate with surrounding neighborhoods | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-1 | Actions | 4 | Collaborate with private, non-profit, or regional organizations to increase access to and participation in the arts | Pending request | Pending | | 1 | | |
| EAC-1 | Actions | 5 | Track participation and attendance at major community arts and cultural events, performances, festivals, and programs | Pending response | Pending | | 1 | | |
| EAC-1 | Actions | 6 | Provide financial or logistical support to local arts, festivals, performances, or cultural tourism | Complete | Meeting target | 4 | 4 | City of Coos Bay, City of North Bend, and Coos County currently provide financial/logistical support for these activities. | Sustainability scan of city/county governments |
| EAC-1 | Actions | 7 | Hire local artists to create artwork, sculptures, or perform in public spaces | Complete | Partially meeting target | 0 | 4 | City of Coos Bay occassionally hires local artists for these purposes. City of North Bend and Coos County have no current action/ activity on this topic. | Sustainability scan of city/county governments |

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| EAC-1 | Actions | 8 | Develop special programs to advance arts education that is aligned with core curriculum in all public schools, especially early elementary grades | Complete, pending update | Does not meet target | 0 | 4 | No comprehensive programs in North Bend or Coos Bay, but individual schools making progrees. Coos Bay currently in planning process to develop 5-year vision and programming. See data document in files for further info. | |
| EAC-1 | Actions | 9 | Provide entrepreneurial and workforce development training programs that serve artists, writers, designers, and other creative industries professionals | Pending request | Pending | | 4 | | |
| EAC-1 | Actions | 10 | Ensure that major arts and cultural facilities are accessible to people with disabilities | Complete | Meeting target | 6 | 6 | All facilities are in compliance: Little Theater on the Bay, Hales Center, Dolphin Playhouse, Marshfield Auditorium. Egyptian Theater still under construction. | Direct correspondance |
| EAC-1 | Actions | 11 | Protect and maintain local public artworks and cultural resources for future generations | Complete, pending update | Meeting target | 6 | 6 | Coos Bay Downtown Association--doesn't maintain the 2nd street murals, but installed them.<br>Coos Bay, 1 sculpture CB Boardwalk and 4 carvings in City Hall maintained | Direct correspondance |
| EAC-2 | Outcomes | 1 | **Community Venues:** Demonstrate that least 75% of residents live within 1 mile of a community venue that is open to the public and offers free services and/or events for residents | Complete | Meeting target | 7.4 | 7.4 | Created layer in GIS, created 1-mile buffer around community venues. Two ways to assess:<br>1. Census blocks w/ centroid in buffer = 69.4% of population w/in 1 mile of community venue<br>2. Census blocks that intersect buffer = 75.5% of population w/in 1 mile of community venue | Generated list of community venues through knowledge of community/google searches. |
| EAC-2 | Outcomes | 2 | **Neighborhood Cohesion:** Demonstrate an increased percentage of neighborhoods reporting positive levels of neighborhood cohesion through community surveys | Future | Unable to be evaluated | 0 | 3.2 | Requires regularly conducted community surveys | |
| EAC-2 | Actions | 1 | Adopt neighborhood plans that guide future development, recommend strategies to create or preserve community venues, and address neighborhood-specific issues | Complete | Partially meeting target | 0 | 2 | City of Coos Bay is currently active in neighborhood planning. City of North Bend and Coos County currently have no action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-2 | Actions | 2 | Adopt zoning and development regulations that support or incentivize farmers markets, community gardens, and urban agriculture | Complete, pending update | Does not meet target | 0 | 3 | The City of Coos Bay has no zoning or regulations, but these activities are currently occurring; they are considering such regulations. City of North Bend has no current action/activity on this topic. Coos County reports having zoning/regulations on this topic. | Sustainability scan of city/county governments |
| EAC-2 | Actions | 3 | Provide access to information about community issues, programs, services, and activities that is also accessible to non-English speaking residents | Complete | Meeting target | 2 | 2 | City of Coos Bay provides access to the same degree that state and federal agencies provide access. City of North Bend and Coos County provide this type of access to information. | Sustainability scan of city/county governments |
| EAC-2 | Actions | 4 | Partner with neighborhood associations, community organizations, and local service providers to identify and address neighborhood-specific needs | Complete | Partially meeting target | 0 | 1 | City of Coos Bay partners with local neighborhoods to address neighborhood-specific issues. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-2 | Actions | 5 | Support neighborhood advisory councils to encourage dialogue on community issues and build the social capital of neighborhoods | Complete | Partially meeting target | 0 | 1 | City of Coos Bay partners with local neighborhoods to address neighborhood-specific issues. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-2 | Actions | 6 | Establish a department with staff assigned to work as liaisons with specific neighborhoods | Complete | Partially meeting target | 0 | 1 | City of Coos Bay has department and/or staff that work as neighborhood liaisons. City of North Bend has no current action/activity on this topic. Coos County is considering establishing such liaisons through a Citizen Advisory Group. | Sustainability scan of city/county governments |
| EAC-2 | Actions | 7 | Provide direct funding and management of at least 2 types of community and neighborhood venues | Complete | Meeting target | 4 | 4 | Mingus Park Pool ($80K, FY12-13), North Bend Swimming Pool ($232,174, FY12-13), North Bend Community Center ($24,684, FY12-13) | Coos Bay and North Bend City Annual Budgets |
| EAC-2 | Actions | 8 | Provide capacity-building programs to enable community leaders and groups to self-organize, resolve issues, and cultivate leadership | Complete | Meeting target | 4 | 4 | FILP, L-Bay, Leadership Coos, Rotary youth leadership camp, Boys & Girls Club keystone leadership program<br>See data document for more information. | Direct correspondance |
| EAC-2 | Actions | 9 | Provide programs that support the development of positive, strong youth leaders, particularly in low-income and/or minority neighborhoods | Complete | Meeting target | 4 | 4 | L-Bay, Rotary youth leadership camp, Boys & Girls Club keystone leadership program<br>See data document for more information. | Direct correspondance |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| EAC-2 | Actions | 10 | Provide financial or logistical support for publicly-accessible neighborhood events, activities, and programming, particularly in low-income and/or minority neighborhoods | Complete | Meeting target | 4 | 4 | Neighbor-to-Neighbor Mediation (http://www.n2nmediation.com/Our_Programs.html)<br>Potential neighborhood watch groups in Empire, Charleston, Eastside.<br>City of Coos Bay and City of North Bend provide financial/logistical support for neighborhood venues, public events, and programming.<br>Coos County has no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-3 | Outcomes | 1 | **Reading Proficiency:** Demonstrate at least 85% of third grade public school students meet or exceed reading proficiency standards | Complete | Does not meet target | 0 | 6.7 | North Bend and Bandon Districts met 85% standard in 2010-2011. Lighthouse School (3-8) met it in 2012-2013. Otherwise, no district met standards in 2011-2012 and 2012-2013. All districts show a decrease in percentage of students meeting/exceeding standards since 2010-2011. | Oregon Dept. of Education Report Cards |
| EAC-3 | Outcomes | 2 | **Graduation Rate:** Option A: Achieve a 90% average 4-year adjusted cohort high school graduation rate for all public schools in the jurisdiction<br>--OR--<br>Option B: Demonstrate incremental progress towards a 90% average 4-year adjusted cohort high school graduation rate for all public schools in the jurisdiction in the past 3 years | Complete | Does not meet target | 0 | 6.7 | No district (Coos Bay, North Bend, Bandon) meets 90% standard for any of the past 3 years. On an individual school basis, ORCO Tech Charter school in North Bend District had a 95% and 98% graduation rate in the past two school years. All other schools do not meet the 90% threshold. Coos Bay District shows marginal decrease in rate, while North Bend District shows marginal increase, and Bandon District shows no change. The (weighted) average rate for the districts shows a marginally decreasing rate. See data sheet: EAC-3-O2-O3_GradRate-Subgroups-Analysis.xls | Oregon Dept. of Education Report Cards |
| EAC-3 | Outcomes | 3 | **Graduation Rate Equity:** Increase the average 4-year adjusted cohort high school graduation rate for all students in all public schools in the jurisdiction from selected underperforming groups of race/ethnicity, disability, English proficiency, or income | Complete | Does not meet target | 0 | 6.7 | Sub-groups showing slight increase: Coos Bay: American Indian/AK Native (7%), Latino (3.6%), North Bend: Asian/Pacific Islander (2.5%), Low-income (1.6%). Others show slight decrease: Coos Bay: Asian/Pacific Islander (-3.3%) and Low-income (-0.5%), North Bend: American Indian/AK Native (-14.7%) and Latino (-5.6%). No clear increase for a sub-group in both district. | Oregon Dept. of Education Report Cards |
| EAC-3 | Actions | 1 | Engage local education authorities, teachers, families, and young people to advance collaborative decision-making and a community-driven framework for improving education | Complete | Meeting target | 1 | 1 | Coos Bay District has Superintendant's Advisory Team (http://cbd9.net/superintendents-advisory-team)<br>Parent-Teacher Associations/Booster Clubs: Blossum Gulch Elementary (CB), Millcoma Middle School (CB), Sunset Middle School (CB), Madison Elementary (CB), Hillcrest Elementary (NB), Lighthouse School (NB), North Bay Elementary (NB), North Bend Middle School, North Bend HS, Bandon School District<br>No PTA/Booster Club: Marshfield HS (CB), | State PTA site, individual school websites |
| EAC-3 | Actions | 2 | Strengthen opportunities for parental and community involvement in schools | Complete, pending update | Partially meeting target | 0 | 1 | Based on 3 reporting schools----Schools are currently active in: communication with families, family engagement in school activities and governance, encouragement of positive academic support strategies at home, and coordination with community entities to provide resources.<br>Schools have moderate activity in assisting families with parenting skills, family support, and understanding child/adolescent development.<br>Schools have no activity in setting home conditions to support learning at each age and grade level. | School administrator survey |
| EAC-3 | Actions | 3 | Prepare an annual progress report for the public outlining the local school system's performance | Complete | Meeting target | 1 | 1 | Oregon Dept. of Education prepares annual report cards that are available on their website | Oregon Dept. of Education Report Cards |
| EAC-3 | Actions | 4 | Provide funding or other resources to support Head Start programs in community | Complete, pending verification | Does not meet target | 0 | 4 | Head Start is run by ORCCA. 2012-2013 Annual Report states that local contributions was $2,681, but it doesn't specify whether the source is from individuals or agencies. Cities and county budgets do not specifically have Head Start line item, but it may be grouped into another heading. | ORCCA Annual Report |
| EAC-3 | Actions | 5 | Provide full-day kindergarten for low-income students and students with special needs | Complete | Partially meeting target | 0 | 4 | Coos Bay just started full-time kindergarten in 2013-2014 school year. Of 270 students enrolled total, 31 are receiving special education and 167 of them are eligible for free or reduced lunch program.<br>North Bend does not have full-day kindergarten. Only part-time. full-day is mandated to start in 2014-2015 school year. | Direct correspondance |

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| EAC-3 | Actions | 6 | Program or support after-school activities, tutoring, extended day- and/or summer programs for students who need additional academic assistance | Complete, pending update | Partially meeting target | 0 | 4 | Based on 3 reporting schools----All are active in academic programs focused exclusively on instruction or tutoring. Only school focused on alternative programming provides day care for teen parents. No schools have academic enrichment during non-school hours. | School administrator survey |
| EAC-3 | Actions | 7 | Offer multiple pathways to graduation as a way to improve educational outcomes for students | Complete, pending update | Meeting target | 4 | 4 | Harding Learning Center / Destinations Academy (CB) offers a variety of programs that provide alternative learning environment and paths to graduation. 2012/13: 91; 2011/12: 83; 2010/11: 56<br>Alternative Youth Activities (NB): (http://www.aya-or.org/) # of students enrolled in: 2011 = 475; 2012 = 524; and 2013 = 464<br>Transitional Education at SWOCC; (http://www.socc.edu/transitional/index.shtml) | |
| EAC-3 | Actions | 8 | Implement career pathway initiatives | Complete, pending update | Partially meeting target | 0 | 4 | Harding Learning Center offers Community Experience for Career Education (CE2)<br>SWOCC offers Career Pathways Certificates, Internships Program; CASE Career Center; Based on 3 reporting schools----High schools have many opportunities for internships/apprenticeships and career pathways; Middle school provides a host site location for college students serving as interns. | School administrator survey |
| EAC-4 | Outcomes | 1 | **Local Historic District(s):** Designate at least one local historic district with specific design standards and a process for reviewing new projects | Complete | Meeting target | 1.4 | 1.4 | North Bend city has Historic Landmark Commission, see North Bend Municipal Code Chapter 15.60. But Julianne (North Bend City Recorder) said that Historic Landmark Commission has not met for years, though they used to be slightly more active. There is no historic district in North Bend.<br>Coos Bay has Waterfront Heritage District that has design standards Coos Bay Municipal Code: Chapter 17.125. The Hollering Place District Chapter 17.127 has design standards, and is a historic location, but is not necessarily meant to preserve the character of historic buildings.<br>According to Frank Smoot from Coos Historical and Maritime Museum, "The "Hollering Place District," as it's called, is surely the oldest area of human habitation on Coos Bay (the actual bay). The Hollering Place has most certainly been inhabited for 5,000 years." | North Bend Municipal Code Chapter 15.60<br>Coos Bay Municipal Code: Chapter 17.125, Chapter 17.127<br>Direct correspondence |
| EAC-4 | Outcomes | 2 | **Preserved Structures and Sites:** Increase over time the annual number of eligible structures and sites designated as local historic landmarks, added to local historic districts, and/or rehabilitated, restored, or converted through adaptive reuse | Complete, pending update | Meeting target | 2.1 | 2.1 | The region has seen a steady increase in the number sites listed in the National Historic Register. See document: EAC-4-O2_HistoricRegisteredSites.xlsx. Rehabilitation, restoration, and adaptive reuse is not readily available online, but may be available locally. | |
| EAC-4 | Outcomes | 3 | **Green Retrofits:** Increase over time the annual number of historic structures retrofitted or rehabilitated with energy efficiency or clean energy technologies | Pending request | Pending | | 2.1 | | |
| EAC-4 | Outcomes | 4 | **Economic Impact:** Demonstrate that historic preservation efforts have had a positive, measurable impact on the local economy | Future | Unable to be evaluated | 0 | 1.4 | Requires a local study of the economic impact | |
| EAC-4 | Actions | 1 | Create an inventory of designated and eligible historic structures and sites in the community (Bonus: Inventory includes archeological resources) | Complete | Meeting target | 1 | 1 | Reconnaissance level survey was completed in 2011 by the State historic preservation office in cooperation with the City of Coos Bay. A similar effort has not been completed in North Bend. | RLS Inventory; Direct correspondance |
| EAC-4 | Actions | 2 | Adopt a historic preservation plan that establishes community priorities for preservation | Complete | Partially meeting target | 0 | 2 | City of Coos Bay has historic preservation plan in Municipal Code Chapt 17. City of North Bend has no current action/activity on this topic. Coos County has a historic preservation plan. | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapt 17 |

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| EAC-4 | Actions | 3 | Adopt a historic preservation ordinance that establishes procedures for designation of local historic districts and landmarks and authorizes establishment of a historic preservation commission | Complete | Partially meeting target | 0 | 3 | North Bend city has Historic Landmark Commission, see North Bend Municipal Code Chapter 15.60, though inactive. Otherwise, City of North Bend has no current action/activity on this topic. Coos Bay has Design Review Committee in charge of reviewing architectural designs for historic preservation/restoration projects, but dedicated to historic preservation. Coos Bay is consiering establishing such a commission. Coos Bay has a Cultural Resource code, Chapter 17.365, that addresses the preservation of cultural resources. Chapter 17.125 establishes the WATERFRONT HERITAGE DISTRICT (WH), and Chapter 17.127 establishes the HOLLERING PLACE DISTRICT (HP) | Coos Bay, North Bend Municipal Codes |
| EAC-4 | Actions | 4 | Adopt land use, zoning, and design regulations that support and reinforce existing community character in older and historic neighborhoods and commercial areas, and promote development of sensitive, compatible infill | Complete | Partially meeting target | 0 | 3 | Coos Bay Municipal Code: Chapter 17.125 WATERFRONT HERITAGE DISTRICT (WH), Chapter 17.127 HOLLERING PLACE DISTRICT (HP). City of North Bend has no current action/activity on this topic. Coos County has such regulations on this topic. | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapt 17 |
| EAC-4 | Actions | 5 | Collaborate with local non-profit or for-profit entities to support local events, recognition programs, and tourism efforts that celebrate and leverage the economic value of local historic resources | Complete | Meeting target | 1 | 1 | Coos Sawmill & Tribal Trail (2011) with historic points throughout, city, county, tribal, other partners, http://www.oregonsadventurecoast.com/listings/sawmill-tribal-trail/; City of Coos Bay and City of North Bend regularly support local events/programs that celebrate and leverage historic resources. Coos County reports no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-4 | Actions | 6 | Achieve Certified Local Government status, as recognized by the National Park Service | Complete, pending update | Partially meeting target | 0 | 1 | City of Coos Bay is considering become certified, according to Kuri Gill 4/23, although this was not reported in Sustainability Scan. City of North Bend reports it is certified. Coos County reports no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-4 | Actions | 7 | Establish a demolition by neglect ordinance | Complete | Partially meeting target | 0 | 4 | City of Coos Bay currently has this ordinance. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-4 | Actions | 8 | Provide incentives to encourage the rehabilitation of historic buildings and reinvestment in older and historic neighborhoods and commercial areas | Complete | Meeting target | 4 | 4 | City of Coos Bay provides incentives for any building, including historic buildings, within Urban Renewal zones. Coos Bay Urban Renewal Agency has provided funding for Façade Improvements/building projects with historic elements (Egyptian Theater, Hollering Place, Coos Art Museum façade). City of North Bend provides incentives/assistance for rehabilitation/maintenance, likely through Urban Renewal Agency. Coos County has no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-4 | Actions | 9 | Provide local financial assistance to low- and moderate-income homeowners, residents, seniors, and/or businesses vulnerable to rising real estate values and maintenance costs associated with historic preservation | Complete | Meeting target | 4 | 4 | City of Coos Bay provides incentives for any building, including historic buildings, within Urban Renewal zones. City of North Bend provides incentives/assistance for rehabilitation/maintenance, likely through Urban Renewal Agency. Coos County has no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-4 | Actions | 10 | Provide technical assistance to property owners or non-profit organizations seeking to add properties or historic districts to the National Register of Historic Places or the comparable state register | Complete | Partially meeting target | 0 | 4 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently offers this type of technical assistance. | Sustainability scan of city/county governments |
| EAC-5 | Outcomes | 1 | **Diverse Community Representation:** Demonstrate that appointments to local advisory boards and commissions reflect the racial and ethnic diversity of the community | Pending request | Pending | | 3.5 | | |
| EAC-5 | Outcomes | 2 | **Social and Cultural Events:** Demonstrate that public events celebrating social and cultural diversity are held in the community | Pending request | Pending | | 3.5 | Tribes have frequent events throughout year. Notably, Salmon Celebration (Coquille Tribe) and Open House in conjunction with Empire Clamboree (CTCLUSI). | |
| EAC-5 | Actions | 1 | Conduct an assessment of the community's social and cultural diversity to inform local government actions | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EAC-5 | Actions | 2 | Use the Diversity Index to analyze the effectiveness of policies, programs, service delivery, and infrastructure investments | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |

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| **EAC-5** | Actions | 3 | Adopt a policy to encourage diversity in local government appointments | Complete | Partially meeting target | 0 | 2 | City of Coos Bay follows federal rules & guidelines for government appointments. City of North Bend has no current action/activity on this topic, but presumably follows the same federal rules & guidelines. Coos County is considering taking action on this topic. | Sustainability scan of city/county governments |
| **EAC-5** | Actions | 4 | Promote events and programs that recognize and celebrate social and cultural diversity in the community | Complete | Meeting target | 2 | 2 | City of Coos Bay and City of North Bend currently promote such events and programs. Coos County reports no current action/activity on this topic. | Sustainability scan of city/county governments |
| **EAC-5** | Actions | 5 | Provide equity and diversity training for local government staff | Complete | Partially meeting target | 0 | 1 | City of Coos Bay provides equity and diversity training for staff. City of North Bend has no current action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability scan of city/county governments |
| **EAC-5** | Actions | 6 | Establish an office within the jurisdiction to ensure access, equity, and inclusion in policies, programs, procedures, and service delivery | Complete | Partially meeting target | 0 | 1 | City of Coos Bay has an office that encompasses these responsibilities. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| **EAC-5** | Actions | 7 | Provide leadership and training programs that encourage and support representation on local boards and commissions reflective the community's diversity | Complete | Partially meeting target | 0 | 4 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County provides training of this type. | Sustainability scan of city/county governments |
| **EAC-5** | Actions | 8 | Provide programs that support the development of positive, strong youth leaders, particularly in low-income and/or minority neighborhoods | Complete | Meeting target | | 4 | See EAC-2-Action 9. | |
| **EAC-5** | Actions | 9 | Provide financial or logistical support to programs, activities, or events that celebrate and deepen understanding and respect for the community's diversity | Complete | Meeting target | 4 | 4 | City of Coos Bay and City of North Bend currently provide financial/logistical support for such events and programs. Coos County does not provide this type of support. | Sustainability scan of city/county governments |
| **EE-1** | Outcomes | 1 | **Voting:** Part 1: Increase the percentage of registered voters over time<br>--AND--<br>Part 2: Increase the percentage of voters participating in local elections over time | Complete | Does not meet target | 0 | 4.2 | Percentages decrease between 2004, 2008, and 2012. | |
| **EE-1** | Outcomes | 2 | **Volunteerism:** Option A: Demonstrate that at least 30% of residents in large jurisdictions or 35% of residents in small or mid-sized jurisdictions volunteered in the past year<br>--OR--<br>Option B: Demonstrate an increase in the percentage of residents who volunteered over the past 3 years | Future | Unable to be evaluated | 0 | 3.2 | Requires extensive data collection on resident volunteering, perhaps through community-wide survey. | |
| **EE-1** | Outcomes | 3 | **Sense of Empowerment:** Option A: Demonstrate that at least 50% of residents believe they are able to have a positive impact on their community based on a local survey<br>--OR--<br>Option B: Increase over time the percentage of residents who believe they are able to have a positive impact on their community based on local surveys | Future | Unable to be evaluated | 0 | 3.2 | Requires data collection through local survey. | |
| **EE-1** | Actions | 1 | Adopt a policy to encourage diversity in local government appointments to advisory boards and commissions | Complete | Partially meeting target | 0 | 2 | City of Coos Bay follows federal rules & guidelines for government appointments. City of North Bend has no current action/activity on this topic, but presumably follows the same federal rules & guidelines. | Sustainability scan of city/county governments |
| **EE-1** | Actions | 2 | Adopt guidelines to instruct local government agencies or departments about how to successfully engage residents | Complete | Partially meeting target | 0 | 2 | City of Coos Bay currently has guidelines/training for engaging residents. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| **EE-1** | Actions | 3 | Conduct education campaigns about the electoral process, voter registration and participation, and other issues related to civic literacy | Complete | Partially meeting target | 0 | 2 | Coos County does not have or use a formal campaign to raise awareness of the electoral process, voter registration or civic participation. The County Clerk does on occasion speak to civic organizations with a power point that does just that, and it is typically well received. The League of Women Voters of Coos County does conduct voter registration drives at various events and conduct candidate forums during election seasons. | Direct correspondance |

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| EE-1 | Actions | 4 | Partner with business, civic, and neighborhood organizations to increase voter registration and turnout **OR** volunteer opportunities and participation **OR** ongoing civic engagement in local decision-making | Complete | Partially meeting target | 0 | 1 | Coos County does not partner with businesses or organizations to increase voter registration and turnout in a formal/official capacity. Civic minded and/or interested citizens are always encouraged to observe the electoral process during the election cycle when we are processing ballots. Citizens are hired to serve as Election Board Workers to assist in the electoral process in the Election office for each election that is held. It's typically a 5-6 day work schedule for them for each county wide election as they assemble ballot packets for mailing to the voters and then assist in processing ballots once they are voted and returned. In relation to elections, the County Clerk is integrally involved with the Oregon Secretary of State's Election Division in Salem in all things related to election law/administrative rule. Our County Clerk Association has a legislative committee which is heavily involved in the legislative process during each session to monitor, support/oppose bills that affect elections and/or county funding of those elections. There is an Active League of Women Voters chapter in Coos County with regular forums/discussions for voter education. | Direct correspondance |
| EE-1 | Actions | 5 | Provide training to local government agencies or departments on successful public engagement techniques | Complete | Partially meeting target | 0 | 1 | City of Coos Bay currently has guidelines/training for engaging residents. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-1 | Actions | 6 | Establish regular, ongoing opportunities for elected officials and/or senior government staff to meet with residents to answer questions and listen to concerns | Complete | Meeting target | 1 | 1 | City of Coos Bay, City of North Bend, and Coos County currently provide these types of opportunities. | Sustainability scan of city/county governments |
| EE-1 | Actions | 7 | Create a volunteer program for residents to assist the local government with special events, services, and operations | Complete | Meeting target | 4 | 4 | City of Coos Bay and City of North Bend currently have this type of volunteer program. Coos County is considering taking action on this topic. | Sustainability scan of city/county governments |
| EE-1 | Actions | 8 | Provide support and resources to local community groups to help them achieve their missions | Complete | Meeting target | 4 | 4 | City of Coos Bay and City of North Bend currently provide support and resources to community groups. Coos County currently does not provide this type of support. | Sustainability scan of city/county governments |
| EE-1 | Actions | 9 | Create a mock youth voting program to teach children about democracy, elections, and the importance of voting | Complete | Meeting target | 4 | 4 | Marshfield students in social studies classes do a mock presidential election every four years, run by Debbie Brown. This has occurred for the past 3 elections.<br>North Bend has had mock voting in the past, but only during Presidential elections. The North Bend Introduction to Government, and our Civics classes cover characteristics of democratic countries, the electoral process and civic participation | |
| EE-2 | Outcomes | 1 | **Resolution of Complaints:** Demonstrate that all civil and human rights complaints in the past 3 years have been investigated and violations redressed in a timely manner | Pending response | Pending | | 7 | | |
| EE-2 | Actions | 1 | Adopt specific policies or amend the jurisdiction's charter to specifically protect the civil and human rights of all community residents | Complete | Meeting target | 2 | 2 | City of Coos Bay reports that policies currently exist that protect these rights of all residents. City of North Bend reports that these policies currently exist. Coos County reports having these policies. However, this language does not appear in Coos Bay Municiapl Code or Charter, Coos County Code, or North Bend Code/Charter. | Sustainability scan of city/county governments |
| EE-2 | Actions | 2 | Establish an office within the jurisdiction with the authority and capacity to investigate civil and human rights complaints | Complete | Partially meeting target | 0 | 1 | Coos County does not have an office that handles civil and human rights complaints (Terri Turi, 4/24). The Civil Rights Division of the Bureau of Labor and Industry handles all complaints within their jurisdiction (falling under the classes/activities protected by state law). Coos County citizens would contact the Eugene office. The City of Coos Bay's City Manager office handles these complaints. City of North Bend has no current action/activity on this topic. | Direct correspondance; Sustainability scan of city/county governments |
| EE-2 | Actions | 3 | Conduct local public education campaigns regarding civil and human rights, such as the process for filing complaints | Complete | Partially meeting target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |

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| EE-2 | Actions | 4 | Establish an independent civil and/or human rights commission to ensure access, equity, and inclusion | Complete | Does not meet target | 0 | 1 | City of Coos Bay does not currently have an independent commission; City Manager's office attends to these responsibilities. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-2 | Actions | 5 | Provide training for police officers focused on non-discrimination and conflict prevention | Pending response | Pending | | 1 | North Bend PD provides ongoing training for officers. Without regard for the discipline studied, civil rights and ethics are a part of every training. Periodically, they provide training specific to ethics and civil rights. Often, it is part of the study of new case law. | |
| EE-2 | Actions | 6 | Operationalize the local government's civil and human rights policies in programs, services, and operations | Pending data analysis/request | Pending | | 4 | | |
| EE-2 | Actions | 7 | Provide language translation or interpretation services to ensure that residents have access to information about local government programs, services, and operations | Complete | Meeting target | 4 | 4 | Coos County Public Health offer interpreters free of cost, otherwise Coos County reports no other services. City of Coos Bay provides interpretation/translation for police services. City of North Bend provides interpretation/translation services. | Sustainability scan of city/county governments |
| EE-3 | Preliminary Step | | Identify the community's prioritized environmental justice sites for evaluation in this Objective | Complete | N/A | | | There are no EPA reporting sites that appear to disproportionately affect minority populations or residents living below the poverty line. However, the community may still develop priorities for clean-up. | EPA Environmental Justice online database |
| EE-3 | Outcomes | 1 | **Reduced Risk and Exposure:** Demonstrate progress towards achieving targets for prioritized environmental justice sites identified in a locally-adopted plan | Future | Unable to be evaluated | 0 | 10.5 | Requires that sites have been selected and targets set in an EJ plan | |
| EE-3 | Actions | 1 | Create an Environmental Justice Collaborative Group (EJCG) composed of residents, stakeholders, and environmental professionals to assess risk and exposure, set targets, implement projects, and monitor improvements | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-3 | Actions | 2 | Assess the risk and exposure to toxins related to the community's prioritized environmental justice sites | Complete | Partially meeting target | 0 | 1 | City of Coos Bay conducts assessment of EJ sites when related to public works projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-3 | Actions | 3 | Adopt an environmental justice plan aimed at reducing polluted and toxic environments in the jurisdiction | Complete | Partially meeting target | 0 | 2 | City of Coos Bay adopts EJ plan when related to public works projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-3 | Actions | 4 | Establish targets for each of the prioritized environmental justice sites related to air or water improvements | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-3 | Actions | 5 | Incorporate environmental justice criteria and priorities into zoning, land use planning, permitting policies, and development of new projects | Complete | Partially meeting target - in development | 0 | 3 | City of Coos Bay is currently revising Municipal Code Chapt 17 to include EJ criteria/priorities. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments; Coos Bay Municipal Code Chapt 17 |
| EE-3 | Actions | 6 | Create community benefit agreements (CBAs) for projects associated with prioritized environmental justice sites and proposed development projects with environmental justice concerns | Pending data analysis/request | Pending | | 2 | | |
| EE-3 | Actions | 7 | Create an interdepartmental working committee within the local government to guide and support environmental justice activities | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-3 | Actions | 8 | Monitor and enforce environmental regulations for existing facilities that impact environmental justice sites | Complete | Partially meeting target | 0 | 4 | City of Coos Bay monitors/enforces EJ plan when related to public works projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-3 | Actions | 9 | Implement projects to reduce acute exposure to contaminants and risks associated with environmental justice sites | Complete | Partially meeting target | 0 | 6 | City of Coos Bay considers exposure or risk when doing projects. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability scan of city/county governments |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| EE-4 | Outcomes | 1 | **Equitable Access and Proximity:** Demonstrate increased access and proximity by residents of diverse income levels and race/ethnicity to the following community facilities, services, and infrastructure: • Public transit facilities and service levels • Public libraries • Public schools • Public spaces • Healthful food • Health and human services • Digital access or high speed internet • Urban tree canopy • Emergency response times | Future | Unable to be evaluated | 0 | 14 | Requires very extensive analysis with assessment using many layers from agencies and possibly unavailable or nonexistant at this time. | |
| EE-4 | Actions | 1 | Adopt an equity plan that evaluates current conditions in the community and establishes targets to improve equitable access and proximity in at least the categories identified in the outcome measure | Complete | Does not meet target | 0 | 2 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability scan of city/county governments |
| EE-4 | Actions | 2 | Adopt an equity or social justice policy that establishes a clear commitment to equity in local government decision-making, activities, and investments | Complete | Does not meet target | 0 | 3 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability scan of city/county governments |
| EE-4 | Actions | 3 | Promote events and programs that recognize and celebrate social and cultural diversity in the community | Complete | Meeting target | 2 | 2 | See EAC-5, Action 4. City of Coos Bay and City of North Bend currently promote such events and programs. Coos County reports no current action/activity on this topic. | |
| EE-4 | Actions | 4 | Publicize efforts to improve equitable access and proximity to community facilities, services, and infrastructure | Complete | Partially meeting target | 0 | 2 | City of Coos Bay and Coos County currently conduct outreach on its efforts to improve equitable access to community facilities, services. City of North Bend has no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-4 | Actions | 5 | Establish partnerships that engage key community groups and stakeholders in activities to advance equitable access and proximity to facilities, services, and infrastructure | Complete | Partially meeting target | 0 | 1 | City of Coos Bay and Coos County currently have community partnerships to advance equitable access. City of North Bend has no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-4 | Actions | 6 | Provide equity and diversity training for local government staff | Complete | Partially meeting target | 0 | 1 | See EAC-5, Action 4. City of Coos Bay currently provides this training. City of North Bend has no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-4 | Actions | 7 | Modify the deployment of local programs and services to reduce disparities within the categories identified in the outcome measure | Future | Unable to be evaluated | 0 | 4 | Depends on the completion of the assessment in Outcome 1 measure | |
| EE-4 | Actions | 8 | Construct new facilities and infrastructure in locations that reduce existing disparities within the categories identified in the outcome measure | Future | Unable to be evaluated | 0 | 6 | Depends on the completion of the assessment in Outcome 1 measure | |
| EE-5 | Preliminary Step | | Select at least 3 priority populations and up to 5 priority human services for evaluation in this Objective | Complete | N/A | | | DHS reports that throughout the state, the agency has some minority populations prioritized, but those are not fully represented in either our service programs or in our staffing. Currently, the local DHS office is addressing the Hispanic population in Coos County. Although the population is a small percent of the larger population, they are attempting to better serve the Hispanic community members with all of the services and also as an employment resource. DHS is hosting a community forum to come together with Hispanic community members and make sure that DHS is accessible and approachable in a manner which fits the community's needs. Laurie reports that there are probably several more sub-populations that DHS will be addressing, but she is not sure of the order or specific details other than the efforts with the Hispanic population. From ORCCA: Priority human services: Health care, Counseling (CASA), Housing assistance and financial education (includes energy assistance and weatherization, Workforce development or training, Substance abuse Priority populations ("In an unscientific manner"): Homeless, Children, Low income | Direct Correspondence; Sustainability Scan survey of DHS services |
| EE-5 | Outcomes | 1 | **Human Services Assistance:** Reduce the percentage of people in selected priority populations who need assistance obtaining selected priority human services | Future | Unable to be evaluated | 0 | 14 | Requires extensive data analysis with data that may or may not be available for the PCW area. | |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
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| EE-5 | Actions | 1 | Conduct a community needs assessment to identify priority service needs and resources, including the needs of priority populations | Complete | Partially meeting target | 0 | 1 | DHS does not conduct a community needs assessment, but they rely on partner assessments such as County Public Health and Mental Health, Head Start and Community Action. DHS stays connected to service providers and meet regularly to discuss ways to improve community service and communication. | Sustainability Scan survey of DHS services |
| EE-5 | Actions | 2 | Adopt a human services plan designed to guarantee that basic human needs are met in the community | Complete | Meeting target | 2 | 2 | DHS reported having a human services plan. They report that the community has a variety of nonprofits and agencies that service our populations.<br>Coos County has Comprehensive Health Implementation Plan, 2013-2016, which covers many aspects of services and access.<br>There is a 10-year plan to end homelessness through ORCCA. | Sustainability Scan survey of DHS services; County and ORCCA websites |
| EE-5 | Actions | 3 | Establish an advisory committee that provides ongoing consultation to local government departments and agencies responsible for providing priority human services | Complete | Meeting target | 1 | 1 | Local DHS staff sit on several advisory groups that provide a different view to the efforts of DHS service and keep them aware of any problems. These groups include Coordinated Care Organization, Coos Public Health Improvement Plan, Mutliple Disciplinary Team, Safe and Equitable Foster Care Reduction, and Children's System of Care. | Sustainability Scan survey of DHS services |
| EE-5 | Actions | 4 | Develop public education campaigns to inform residents about available service programs to help meet basic needs | Complete | Meeting target | 2 | 2 | 211info.org has comprehensive resources for services.<br>ORCCA does public education campaigns in some areas - energy assistance, weatherization, Head Start enrollment. They assist food pantries in publicizing their location and times of operation, but that is mostly up to them.<br>DHS has public education informing residents about service programs. They participate in local community events, promoting our services and also interacting with community members. | Direct correspondance; Sustainability Scan survey of DHS services |
| EE-5 | Actions | 5 | Implement information technology solutions to improve client support services and management | Complete | Meeting target | 1 | 1 | DHS reports having several new reporting systems that allow us to monitor our effects on the local population. | Sustainability Scan survey of DHS services |
| EE-5 | Actions | 6 | Monitor and evaluate the quality, comprehensiveness, and effectiveness of priority human services to selected priority populations | Complete | Meeting target | 1 | 1 | DHS reports to monitoring using a variety of reports including county specific reports, Results Oriented Management, ORKids, Office of Equity and Multicultural Services reports, and others.<br>Coos County Public Health is working on implementing regular monitoring effectiveness. | Sustainability Scan survey of DHS services |
| EE-5 | Actions | 7 | Equip human services personnel with the skills and training needed to effectively improve the well-being of the community's priority populations | Complete | Meeting target | 1 | 1 | DHS reports providing direct training with partners; specific training through Office of Equity and Multicultural Services; new employee training and on-going opportunities to improve skills and learn. | Sustainability Scan survey of DHS services |
| EE-5 | Actions | 8 | Support the provision of high quality, priority human services in coordination with non-governmental service providers | Complete | Meeting target | 4 | 4 | DHS reports coordination with other providers and working extensively with local nonprofits by promoting their "Good Acts" and service projects. We also help distribute donated goods to our clients. | Sustainability Scan survey of DHS services |
| EE-5 | Actions | 9 | Upgrade existing facilities or build new facilities to better provide needed human services | Complete | Meeting target | 6 | 6 | ORCCA moved into its new facility in 2013. DHS helps nonprofits apply for grants which are intended to improve their facilities and services. | Sustainability Scan survey of DHS services |
| EE-6 | Outcomes | **1** | **Poverty Reduction:** Demonstrate progress towards no residents living below the poverty line by 2025 | Complete | Does not meet target | 0 | 12 | Completed analysis on county-level; Coos County has been increasing in the popluation in poverty since 2000, and especially in the most recent 5-years. | SAIPE online |
| EE-6 | Outcomes | **2** | **Equitable Poverty Reduction:** Demonstrate a decrease over time in the percentage of residents living below the poverty line from at least 3 population subgroups | Complete, pending update | Does not meet target | 0 | 8 | DHS repots to monitoring percentage of residents living below poverty line. They have available monthly and annual reports showing the population and its subsets living at or below the poverty level. Hispanic population was the only priority population sub-group identified by DHS. The percentage of residents living in poverty increases from 2010-2012 for these 3 sub-groups: Hispanic/Latino, Children under 18, and American Indian/Alaskan Native. See data spreadsheet "EE-6-O2". | Sustainability Scan survey of DHS services; SAIPE online; American FactFinder2 |
| EE-6 | Actions | 1 | Adopt a community-wide plan to reduce poverty | Complete, pending update | Partially meeting target | 0 | 2 | City of Coos Bay takes part in community-wide poverty reduction efforts. City of North Bend has no current action/activity on this topic. Coos County has a plan as part of its Community Health Implementation Plan. | Sustainability scan of city/county governments |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
|---|---|---|---|---|---|---|---|---|---|
| EE-6 | Actions | 2 | Create a team of local government staff to work collaboratively and coordinate with non-governmental organizations to provide high-quality services and reduce poverty | Complete | Partially meeting target | 0 | 1 | City of Coos Bay and Coos County have teams working collaboratively on this topic. City of North Bend has no current action/activity on this topic. | Sustainability scan of city/county governments |
| EE-6 | Actions | 3 | Develop public education campaigns to inform residents about how to enroll in available service programs to help meet basic needs | Complete | Meeting target | | 2 | See EE-5, Action 4.<br>211info.org has comprehensive resources for services.<br>ORCCA does public education campaigns in some areas - energy assistance, weatherization, Head Start enrollment. They assist food pantries in publicizing their location and times of operation, but that is mostly up to them. DHS participates in local community events, promoting our services and also interacting with community members. | Direct correspondance; Sustainability Scan survey of DHS services |
| EE-6 | Actions | 4 | Establish or support programs that reduce the costs of basic needs for low-income households | Complete | Meeting target | 4 | 4 | ORCCA Programs: Food Share (Snack Pack -700 kids), Housing (over 500 households), Energy (over 3000 households), Medical support (about 500 people) 2011-2012 Annual Report. ORCCA occasionally gets small grants from the cities for food share and they have got some for CASA, none from the County recently.<br>DHS provides TANF, SNAP, Oregon Health Plan, among other services. | Direct correspondance, ORCCA 2012 Annual report |
| EE-6 | Actions | 5 | Implement supportive workplaces programs for people living at or near the poverty line | Complete | Partially meeting target | 0 | 4 | ORCCA does some limited workforce support - e.g. we have used some small amounts of money to get people clothing, shoes or equipment for work. It is very limited. Head Start and Early Head Start provide some assistance for people entering the work force, but generally pretty limited. | Direct correspondance |
| EE-6 | Actions | 6 | Create programs to improve employment opportunities for low-income individuals by strengthening hard and soft work skills | Complete | Meeting target | 4 | 4 | South Coast Business Employment Center (SCBEC) is the local Worksource service provider. SCBEC offers various training for people looking for work, including construction crew certification, on-the-job training, and work experience in a variety of sectors. Their resource room is open for people in the job search. They also have a variety of workshops for job readiness and career planning. | |
| EE-6 | Actions | 7 | Provide child development programs for children living at or near the local poverty line | Complete | Meeting target | 4 | 4 | ORCCA offers Head Start (436 children/babies), Snack Pack program (720 individuals) and Healthy Kids (5 individuals), 2011-2012 Annual Report. DHS has available monthly and annual reports showing the pupulation and its subsets living at or below the poverty level. | ORCCA Annual Report, Sustainability Scan survey of DHS |
| EJ-1 | Outcomes | 1 | **Businesses:** Option A: Demonstrate an increased number of business establishments in the county over time<br>--OR--<br>Option B: Demonstrate an increased number of business establishments in the municipality over time | Complete, pending update | Does not meet target | 0 | 6.7 | Data shows decreasing number of establishments over time. | Data available on county level from FactFinder2. City level: Coos Bay available from library in most recent year. North Bend data received directly from city department. **See notes re: North Bend city data accuracy. |
| EJ-1 | Outcomes | 2 | **Annual Sales:** Demonstrate an increase in annual sales from businesses located in the jurisdiction over time | Complete | Meeting target | 6.7 | 6.7 | Increase demonstrated between 2002 and 2007. | American FactFinder 2 |
| EJ-1 | Outcomes | 3 | **Employment:** Part 1: Demonstrate an increase in the percentage of residents employed over time<br>--AND--<br>Part 2: Demonstrate a decrease in the unemployment rate of residents over time | Complete | Does not meet target | 0 | 6.7 | From 2007-2009, employed population increases by 0.5 percentage points, but unemployment rate also increases by 3.3%. No partial credit. | American FactFinder2: Data ID S2301, Employment Status tables for "ACS 1-year estimates". (1-year estimates unavailable for Coos County/Coos Bay. 3-year estimates are only available, for 2007-2009.) |
| EJ-1 | Actions | 1 | Negotiate project labor agreements, community benefit agreements, and local hiring agreements | Complete | Does not meet target | | 3 | City of Coos Bay reports that there are no agreements due to state law, but it is done as it is more cost effective. City of North Bend and Coos County have no current activity/action on this topic. | Sustainability Scan of city/county governments. |
| EJ-1 | Actions | 2 | Formally engage with the business community on a regular basis to improve conditions and address specific needs | Complete | Meeting target | 1 | 1 | City of Coos Bay engages regularly with the Coos Bay Downtown Association and the Bay Area Chamber of Commerce. City of North Bend and Coos County regularly engage with business community, likely through Chamber of Commerce and possibly other venues. | Sustainability Scan of city/county governments. |

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| EJ-1 | Actions | 3 | Appoint an advisory body to provide recommendations and represent the business community in local decision-making | Complete | Partially meeting target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend currently as such an advisory board. Coos County reported uncertainty about an advisory board of this kind at the county level. | Sustainability Scan of city/county governments. |
| EJ-1 | Actions | 4 | Engage in regional coordination with other governmental, public, private, and non-governmental entities to attract and retain businesses in the region | Complete | Meeting target | 1 | 1 | CCD Business Development Corporation for Coos, Curry, Douglas Counties, http://ccdbusiness.org/; South Coast Business Employment Corporation, South Coast Development Council, SWOCC's Small Business Development Center | |
| EJ-1 | Actions | 5 | Utilize tax incentives to retain or expand businesses, including property tax abatement, local sales tax rebates, and/or tax increment financing (TIF) | Complete | Meeting target | 4 | 4 | 3 businesses currently receive 100% tax abatement (1 approved in 2010, 1 in 2011, 1 in 2013). Bay Area Enterprise Zone<br>"The Enterprise Zone program is designed to encourage businesses of all sizes to make new or additional investments that will improve employment opportunities, spur economic growth and diversify business activity within the communities each zone encompasses.<br>The primary benefit to qualifying businesses is 100 percent abatement from local property taxes for at least three, and in some cases up to five years on plant and equipment newly invested in the zone. Property tax exemptions of seven to 15 years may be available to businesses, making a sizeable investment and bringing well-paying jobs." | Direct correspondence, CCD website |
| EJ-1 | Actions | 6 | Provide direct financial assistance to businesses in the form of municipal bonds, grants, or loans | Complete | Meeting target | 4 | 4 | The CCD Business Development Corporation provides loans for businesses annually that are often higher-risk, thus assisting businesses that otherwise would not receive this support. Cities of North Bend and Coos Bay provide support to businesses through their Urban Renewal Projects, including capital projects and facade improvement programs, in the Urban Renewal Districts. See data in document: "EJ-1-A6_URAspending"<br><br>**Minor issue with Coos Bay data: 2011-2012 data is less detailed, with funds being lumped together and not broken down by business vs. public projects. | Coos Bay and North Bend Urban Renewal Agencies reports and budgets; Direct correspondance |
| EJ-1 | Actions | 7 | Support business development activities in special investment zones, such as Business Improvement Districts, Enterprise Zones, or other similar districts | Complete | Meeting target | 4 | 4 | Bay Area Enterprise Zone<br>"The Enterprise Zone program is designed to encourage businesses of all sizes to make new or additional investments that will improve employment opportunities, spur economic growth and diversify business activity within the communities each zone encompasses.<br>The primary benefit to qualifying businesses is 100 percent abatement from local property taxes for at least three, and in some cases up to five years on plant and equipment newly invested in the zone. Property tax exemptions of seven to 15 years may be available to businesses, making a sizeable investment and bringing well-paying jobs."<br>Urban Renewal Districts in Coos Bay, Empire, and North Bend | Direct correspondence, CCD website |
| EJ-1 | Actions | 8 | Provide direct services and trainings tailored to the needs of the business community | Complete | Meeting target | 4 | 4 | Leadership Coos Program through Chamber of Commerce accepts 34 participants each year (2011-2013).<br><br>SWOCC Small business development center:<br>2011 45 events 344 participants<br>2012 44 events 296 participants<br>2013 32 events 149 participants<br><br>SCBEC (Worksource service provider) offers training (SCBEC doesn't have discrete numbers from the their trainings due to complicated database) From WIA Report: 2012: 3857 individuals exited programs (not necessarily trainings--all programs) | Direct Correspondence, WIA Report |

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|---|---|---|---|---|---|---|---|---|---|
| EJ-1 | Actions | 9 | Provide focused support, resources, and services to young entrepreneurial companies through business incubators | Complete | Meeting target | | 4 | Business incubator at SW Oregon Regional Airport provides affordable rental space that includes reception services, Conference/meeting room, kitchen, copy/fax machine. The incubator has 8 manufacturing bays and 2 offices available for businesses to rent on a month to month basis for up to 5 years. Typically 1 office and 4-5 of the bays are rented at any given time. As far as distinct businesses that have had space in the incubator in the past 3 years there have been 12. The businesses in the incubator receive mentoring and training to assist them in growing a business. Some move on to larger commercial spaces as their business grows. Others choose to downsize or close.<br><br>SWOCC Small Business Development Center provides "Ready, Set, Start your Business" workshops every week Neighborworks Umpqua provides small business training and funding support | Direct correspondence |
| EJ-2 | Outcomes | 1 | **Community Resource Efficiency:** Demonstrate decreased greenhouse gas (GHG) intensity over time | Future | Unable to be evaluated | | 2.6 | | |
| EJ-2 | Outcomes | 2 | **Green-Certified Building Stock:** Part 1: Increase over time the percentage of non-residential buildings achieving certification in STAR-qualifying energy efficiency and green construction programs<br>--AND--<br>Part 2: Increase over time the percentage of residential units achieving certification in STAR-qualifying energy efficiency and green construction programs | Complete | Does not meet target | 0 | 2.6 | See CE-5-O3; LEED - 2 certified and 2 in process of certification. 0 projects in Green Globes. 0 projects in Living Building Challenge. | LEED, Green Globes websites; Contact at Living Building Challenge |
| EJ-2 | Outcomes | 3 | **Renewable Energy Use:** Demonstrate an increased number of renewable energy certificates (RECs) purchased by residents annually | Complete | Meeting target | 2.6 | 2.6 | Pacific Power provided data in the form of renewable energy purchased (Kwh) rather than number of RECs. The amount of renewable energy purchased by residential and non-residential users in the PCW area increased from 2011 to 2013, by about 100,000 Kwh. In addition, the portion this amount represents out of total energy purchased increased during that period, by about 0.1%. | Data received from Pacific Power via special request |
| EJ-2 | Outcomes | 4 | **Green Vehicles:** Part 1: Demonstrate increased ownership of alternative fuel vehicles by residents over time<br>--AND--<br>Part 2: Demonstrate increased ownership of fuel-efficient vehicles by residents over time | Future | Unable to be evaluated | 0 | 2.6 | See CE-3-O1. Fee for data is not cost effective at this time. | |
| EJ-2 | Actions | 1 | Amend existing local economic policies and strategies to increase market demand for green products and services | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-2 | Actions | 2 | Adopt policies and regulations that increase overall market demand for green buildings and associated materials, renewable energy products and infrastructure, and recyclable products | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-2 | Actions | 3 | Review and amend zoning regulations to remove barriers or provide flexibility for green businesses | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-2 | Actions | 4 | Create a green purchase policy to ensure that the local government's transportation and non-transportation energy supplies increasingly come from renewable and alternative sources | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-2 | Actions | 5 | Partner with other local governments, community groups, and private entities in the region to articulate an overarching sustainable economic development strategy and work collaboratively to increase demand for green products and services | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-2 | Actions | 6 | Create educational materials to define the larger vision of economic sustainability as one that proactively fosters green businesses, green jobs, and green practices | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |

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| EJ-2 | Actions | 7 | Create an environmentally preferable purchasing program for local government procurement of safe, healthy, and environmentally responsible products | Complete | Does not meet target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County did not respond in the Sustainability Scan on this topic. | Sustainability Scan of city/county governments. |
| EJ-2 | Actions | 8 | Create programs to help businesses transition to new green practices | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-2 | Actions | 9 | Implement a green business promotion program | Complete | Meeting target | 4 | 4 | Chamber of Commerce's sustainable business program has given out 7 awards since November 2011. They give out roughly 4 awards/year and select businesses or organizations that implement the three tiers of sustainability: ecological, economic, and social. | |
| EJ-2 | Actions | 10 | Install electrical vehicle charging stations | Complete | Meeting target | 6 | 6 | See CE-3-A10 | |
| EJ-3 | Outcomes | 1 | **Community Self-Reliance:** Demonstrate that 50% of *import sectors* have increasing *location quotients* over the past 3 years | Complete | Does not meet target | 0 | 5.3 | Target unmet; Only 45% of import sectors increased over past 3 year period (2010-2012) | Data from Bureau of Labor Statistics Location Quotient Calculator |
| EJ-3 | Outcomes | 2 | **Local Financial Institution Deposits:** Increase the total funds deposited in locally-owned and operated financial institutions over time | Pending analysis | Pending | | 5.3 | | |
| EJ-3 | Actions | 1 | Conduct an assessment of local economic conditions, including economic leakage and targeted sectors for future investment | Complete | Meeting target | | 1 | SDAT report made recommendation to create an Economic Development Strategy with an assessment of local economic conditions and identification of target industry clusters (pages 44-47).<br>SCDC will be working on this coming fiscal year (July 1, 2014 - June 30, 2015) as part of the 2014-15 workplan. We are currently targeting what are called traded sector businesses for our outreach. A traded sector business is a business that sells goods or services in market areas outside of their own local market area. This is a business that brings "new dollars" to the local economy. We have put together an initial list in Coos County and parts of Curry County of approximately 40+ such businesses. We will begin interviewing several of these companies this week to determine what their needs are and how we as an organization can help them expand, improve, or adjust as needed. These interviews will allow us to be able to create targeted industry clusters that would be beneficial to current businesses, and maybe supplement or enhance those same businesses. This could also lead to bringing other businesses that use the same of similar products. | Direct correspondance |
| EJ-3 | Actions | 2 | Adopt an economic localization plan to increase local production for local consumption and export | Complete | Does not meet target | 0 | 2 | City of Coos Bay did not respond on Sustainability Scan. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-3 | Actions | 3 | Promote purchasing preferences for locally-produced goods and services in anchor institutions, including the local government | Pending request | Pending | | 2 | | |
| EJ-3 | Actions | 4 | Create or support promotional campaigns to bank locally, buy locally, or buy from small and independent businesses and retailers | Complete | Partially meeting target | 0 | 2 | City of Coos Bay did not respond on Sustainability Scan. City of North Bend currently has a campaign of this sort. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-3 | Actions | 5 | Provide incentives for businesses that use materials produced within the region and sell their products within the region | Complete | Does not meet target | 0 | 4 | City of Coos Bay did not respond on Sustainability Scan. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-3 | Actions | 6 | Provide support services to targeted sectors to strengthen value chain infrastructure and develop market channels | Future | Unable to be evaluated | | 4 | Targeted sectors first have to be identified, pending SCDC workplan completion 2015 | |
| EJ-3 | Actions | 7 | Connect entrepreneurs and business owners with lenders and investors to facilitate investment in the local economy | Complete | Does not meet target | 0 | 4 | City of Coos Bay did not respond on Sustainability Scan. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |

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| EJ-3 | Actions | 8 | Support import substitution strategies that positively impact key sectors of the local economy | Complete | Does not meet target | 0 | 4 | City of Coos Bay did not respond on Sustainability Scan. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-4 | Outcomes | 1 | **Median Household Income:** Increase real median household income over time | Complete | Does not meet target | 0 | 10 | Threshold not met: Decrease over time, from 2005-2007 baseline 3-year average to 2010-2012, taking inflation into account. | Data from Census FactFinder 2: DP03-Selected economic characteristics |
| EJ-4 | Outcomes | 2 | **Living Wages:** Option A: Demonstrate that 90% of median household incomes in the jurisdiction meet or exceed the living wage standard<br>--OR--<br>Option B: Demonstrate that 90% of households are economically self-sufficient | Complete | Does not meet target | 0 | 10 | Threshold not met: Only 74% of households meet or exceed the self-sufficiency income of $20,000 | FactFinder2, Propserity Planner for Oregon residents |
| EJ-4 | Actions | 1 | Enact a living wage policy for local government employees and contractors | Complete, pending update | Meeting target | 3 | 3 | Growth of living wage jobs is identified as a common goal in CCD Business Development Corporation's Comprehensive Economic Development Strategy (CEDS) 2014-2018, but no specific policy/efforts are in effect. http://ccdbusiness.org/images/stories/pdf/final%20version%20ceds%20 2014-2018a.pdf; City of Coos Bay follows state BOLI and Davis-Bacon rules for public works projects, in addition to wage policies established through union agreements. City of North Bend currently has living wage policy for all employees and contractors. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 2 | Enact family-friendly workplace policies for all local government employees that include at least 2 of the following benefits: paid sick days, paid family leave, flexible scheduling, job sharing, and easily available childcare | Complete | Meeting target | 3 | 3 | City of Coos Bay has these policies for City government workplaces. City of North Bend and Coos County have these policies for employees. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 3 | Require that local government contractors provide at least 2 of the following benefits to their employees: paid family leave, flexible scheduling, job sharing, and easily accessible childcare | Complete | Meeting target | 3 | 3 | City of Coos Bay has these policies for City government workplaces. City of North Bend and Coos County have these policies for contractors. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 4 | Align local economic development policy strategies with workforce development programs | Complete | Partially meeting target | 0 | 3 | City of Coos Bay and Coos County currently have this type of policy alignment. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 5 | Support living wage campaigns in the community | Complete | Partially meeting target | 0 | 2 | City of Coos Bay has no current action/activity on this topic. City of North Bend and Coos County currently support living wage campaigns and/or economic self-sufficiency campaigns. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 6 | Support a Best Places to Work campaign to recognize local businesses that support employees and their families | Complete | Partially meeting target | 0 | 2 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently recognizes local businesses supporting employees and families. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 7 | Maintain collective bargaining relationships with public employee labor organizations that represent local government workers | Complete | Meeting target | 1 | 1 | City of Coos Bay, City of North Bend, and Coos County currently maintain collective bargaining relationships. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 8 | Provide training programs and assistance to local businesses to encourage them to provide family-friendly workplace policies and extended benefits | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 9 | Provide job training and assistance programs for employees and employers in professions or sectors where wages are below the living wage | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-4 | Actions | 10 | Enforce the living wage policy with a living wage officer or equivalent function | Pending data analysis/request | Pending | | 4 | | Sustainability Scan of city/county governments. |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
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| EJ-5 | Preliminary Step | | Locally define at least 3 targeted industry sectors for evaluation | Future | N/A | | | See EJ-3-Action 1: SCDC will be working on this coming fiscal year (July 1, 2014 - June 30, 2015) as part of the 2014-15 workplan. We are currently targeting what are called traded sector businesses for our outreach. A traded sector business is a business that sells goods or services in market areas outside of their own local market area. This is a business that brings "new dollars" to the local economy. We have put together an initial list in Coos County and parts of Curry County of approximately 40+ such businesses. We will begin interviewing several of these companies this week to determine what their needs are and how we as an organization can help them expand, improve, or adjust as needed. These interviews will allow us to be able to create targeted industry clusters that would be beneficial to current businesses, and maybe supplement or enhance those same businesses. This could also lead to bringing other businesses that use the same of similar products. | |
| EJ-5 | Outcomes | 1 | **Targeted Industry Businesses:** Demonstrate an increase in the annual sales or total value of businesses in *targeted industry sectors* relative to growth in non-target industries, compared to a baseline year not predating 2000 | Future | Unable to be evaluated | 0 | 3.5 | Analysis will be easily completed once targeted industry clusters are identified by SCDC. | |
| EJ-5 | Outcomes | 2 | **Targeted Industry Sales:** Demonstrate an increase in the total number of new businesses in *targeted industry sectors* relative to growth in non-targeted industries, compared to a baseline year not predating 2000 | Future | Unable to be evaluated | 0 | 3.5 | Analysis will be easily completed once targeted industry clusters are identified by SCDC. | |
| EJ-5 | Outcomes | 3 | **Targeted Industry Employment:** Demonstrate an increase in total employment in *targeted industry sectors* relative to growth in non-target industries, compared to a baseline year not predating 2000 | Future | Unable to be evaluated | 0 | 3.5 | Analysis will be easily completed once targeted industry clusters are identified by SCDC. | |
| EJ-5 | Actions | 1 | Conduct a local economic analysis or participate in the development of a regional analysis of existing industry sectors to understand current needs and opportunities | Future | Unable to be evaluated | 0 | 1 | See EJ-3-Action 1: SCDC will be working on this coming fiscal year (July 1, 2014 - June 30, 2015) as part of the 2014-15 workplan. | |
| EJ-5 | Actions | 2 | Invest in market studies and research to support the continued growth and expansion of targeted industry sectors | Future | Unable to be evaluated | 0 | 1 | Pending identification of targeted industry clusters by SCDC in 2014-2015. | |
| EJ-5 | Actions | 3 | Coordinate or support local and regional associations or formal networks of related businesses in the targeted industry sectors | Future | Unable to be evaluated | 0 | 1 | Pending identification of targeted industry clusters by SCDC in 2014-2015. | |
| EJ-5 | Actions | 4 | Coordinate with universities, community colleges, the local Workforce Investment Board, private firms and other community stakeholders to align research, workforce development, and resources to support targeted industry sectors | Future | Unable to be evaluated | 0 | 1 | Pending identification of targeted industry clusters by SCDC in 2014-2015. | |
| EJ-5 | Actions | 5 | Educate residents about the economic impact of targeted industry sectors in the community | Future | Unable to be evaluated | 0 | 2 | Pending identification of targeted industry clusters by SCDC in 2014-2015. | |
| EJ-5 | Actions | 6 | Use tax incentives to attract, retain, or expand businesses in targeted industry sectors | Future | Unable to be evaluated | 0 | 4 | Pending identification of targeted industry clusters by SCDC in 2014-2015. | |
| EJ-5 | Actions | 7 | Provide direct financial assistance, such as local bonds, grants, or loans, to attract, retain, or expand businesses in targeted industry sectors | Future | Unable to be evaluated | 0 | 4 | Pending identification of targeted industry clusters by SCDC in 2014-2015. | |
| EJ-5 | Actions | 8 | Provide capacity building services and support for professionals in emerging and existing targeted industry sectors | Future | Unable to be evaluated | 0 | 4 | Pending identification of targeted industry clusters by SCDC in 2014-2015. | |
| EJ-6 | Outcomes | 1 | **Trained Workforce:** Demonstrate improvements in workforce training outcomes for participants over the past 3 years | Pending data analysis/request | Pending | | 5.3 | | |

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| EJ-6 | Outcomes | 2 | **Workforce Mobility:** Demonstrate increased post-secondary educational attainment in the community over time | Complete | Meeting target | 5.3 | 5.3 | Combining all three (associate's, bachelor's, and graduate/professional), there is an increase from 2005-2007 to 2010-2012. *When viewed by category, the graduate/professional shows a decline of 0.4 percentage points. | Data available from Census FactFinder2: S1501 - Educational attainment |
| EJ-6 | Actions | 1 | Adopt a workforce development plan or comprehensive strategy to educate, train, and prepare residents for local employment opportunities | Pending data analysis | Pending | | 2 | The Oregon Consortium & Oregon Workforce Alliance (TOCOWA) has a strategic plan for their whole 29-county area. Coos and Curry counties are joined in Region 7. The plan has some detailed information specific to Region 7, much of which refers strictly to Coos County. TOC is the workforce provider for Coos County, and SCBEC is the service provider that they contract with. | |
| EJ-6 | Actions | 2 | Align local economic development policy strategies with workforce development programs | Complete | Partially meeting target | 0 | 3 | City of Coos Bay and Coos County currently have this type of policy alignment. City of North Bend has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-6 | Actions | 3 | Require local government contractors and entities receiving financial incentives to prioritize hiring local residents | Complete | Partially meeting target | 0 | 3 | City of Coos Bay requires contractors and entities receiving incentives to encourage local business to bid; Law requires contract let to lowest responsible bidder. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-6 | Actions | 4 | Participate in and promote community workforce agreements or project labor agreements | Complete | Partially meeting target | 0 | 3 | City of Coos Bay reports that there are no agreements due to state law, but it is done as it is more cost effective. City of North Bend and Coos County has no current activity/action on this topic. | Sustainability Scan of city/county governments. |
| EJ-6 | Actions | 5 | Create a workforce development committee to align post-secondary education, workforce development training programs, and economic development strategies | Pending response | Pending | | 1 | | |
| EJ-6 | Actions | 6 | Create data sharing agreements between the local government and private sector employers to maximize the availability and use of data in economic and workforce development planning | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| EJ-6 | Actions | 7 | Produce an annual report that tracks workforce readiness performance measures | Pending response | Pending | | 1 | | |
| EJ-6 | Actions | 8 | Provide support services and training tailored to the needs of the local workforce | Pending response | Pending | | 4 | | |
| EJ-6 | Actions | 9 | Support expansion of community college programs to address the educational and training needs of the local workforce | Pending response | Pending | | 4 | | |
| EJ-6 | Actions | 10 | Invest in community college facilities and capital improvements to accommodate residents and members of the local workforce | Pending response | Pending | | 6 | | |
| HS-1 | Outcomes | 1 | **Active Adults:** Demonstrate that 21% or less of adults aged 20+ report no leisure time physical activity within the past month | Complete | Does not meet target | 0 | 5.3 | Coos County - 22% report inactivity, County ranks 32 of 33 in Health behaviors | County Health Rankings |
| HS-1 | Outcomes | 2 | **Active Kids:** Option A: Increase the percentage of high school students that are physically active for 60 minutes per day on 5 or more days<br>--OR--<br>Option B: Increase the percentage of public schools that require some form of physical activity daily, such as physical education classes or recess | Complete | Does not meet target | 0 | 5.3 | Decreased percentage over time of 8th and 11th grade survey respondents who participate in 5+ days of 60 min. of physical activity. | |
| HS-1 | Actions | 1 | Include a chapter, section, or plan element focused on active living or active transportation in the comprehensive plan or transportation plan | Complete | Partially meeting target | 0 | 2 | Coos County has Bicycle and Pedestrian section in Coos County Transportation Plan 2011, but does not discuss "active living", which is a key part of this action. http://www.co.coos.or.us/Portals/0/Planning/cctsp03-28-11.pdf; Coos Bay and North Bend Transportation Plans also address Bicycle/Pedestrian transportation improvements, but does not discuss active living per se. Coos County Community Health Implementation Plan incorporates active living in various sections, notably Chronic Illness Prevention and Socioeconomic Disparities. | Coos County Transportation Plan, Transportation Plan for Coos Bay and North Bend, Coos County CHIP |

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| **HS-1** | Actions | 2 | Require or incentivize bicycle and pedestrian amenities in new major development projects in high-density, mixed-use areas or near transit stations | Complete | Meeting target | 3 | 3 | City of Coos Bay currently has standards/incentives for these amenities in new developments, in Transportation System Plan and Chapt 17 of Municipal Code. City of North Bend currently has standards/incentives for these amenities. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **HS-1** | Actions | 3 | Create guidelines to encourage incorporation of active building design features in new public, commercial, office, and multi-family residential buildings | Complete | Does not meet target | 0 | 2 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. Coos County Community Health Improvement Plan makes sets an objective to promote this type of development, but does not state specific guidelines. | Sustainability Scan of city/county governments, Coos County CHIP |
| **HS-1** | Actions | 4 | Establish school siting guidelines that give preferential considerations to locations that maximize the number of students who can walk or bicycle safely to school | Complete, pending update | Does not meet target | 0 | 2 | Based on 3 reporting schools---No schools have these school siting guidelines. | School administrator survey |
| **HS-1** | Actions | 5 | Create an advisory board to advise the local government on issues related to planning, policies, code requirements, and other actions affecting active living in the community | Complete | Meeting target | 1 | 1 | City of Coos Bay's Parks Commission advises the City on these matters. City of North Bend has this type of advisory board/committee. Coos County has this type of advisory board, likely through the Community Health Improvement Plan.. | Sustainability Scan of city/county governments. |
| **HS-1** | Actions | 6 | Achieve recognition as a *Bicycle-Friendly Community* or *Walk-Friendly Community* | Complete | Does not meet target | 0 | 1 | Neither recognition has been achieved by any community in the project area. | |
| **HS-1** | Actions | 7 | Appoint a *physical activity* specialist within the local health department has a physical activity specialist on staff to serve as a liaison with relevant local government departments or agencies | Complete | Does not meet target | 0 | 1 | Coos County Public Health does not have a staff member devoted to physical activity as a specialist and liaison. | |
| **HS-1** | Actions | 8 | Host or partner with community groups to support at least 2 programs that encourage active living for adults and kids | Complete | Meeting target | 4 | 4 | Blossum Gulch Elementary hosts an annual Walk to School program (according to Coos Bay District Wellness Program). City of Coos Bay, City of North Bend, and Coos County support programs encouraging active living. | Sustainability Scan of city/county governments. |
| **HS-1** | Actions | 9 | Implement a local program that systematically improves bicycle and pedestrian amenities community-wide | Complete | Partially meeting target | 0 | 6 | City of Coos Bay's Transportation System Plan includes this type of program. City of North Bend is currently considering this type of program. Coos County did not report on the Sustainability Scan, but deferred to cities. | Sustainability Scan of city/county governments. |
| **HS-1** | Actions | 10 | Provide at least 3 types of active recreation facilities that are available for community use, by population size | Complete | Meeting target | 6 | 6 | Coos Bay, North Bend, State Parks, and County Parks, collectively provide abundant recreation facilities. The Bay area exceeds STAR targets for playgrounds, swimming pools, and skate parks. See complete list in document: HS-1-A10_RecreationFacilities. | Coos Bay Master Parks Plan, City/county websites, Google satellite imagery |
| **HS-1** | Actions | 11 | Enable joint use of school-based recreation facilities during non-school hours | Complete | Meeting target | 6 | 6 | Coos Bay and North Bend Districts allow joint-use of facilities through agreements. Some require a fee for certain uses. In both districts, there are currently agreements in place. Coos County CHIP idenfities setting up mutual use agreements that enable indoor use of facilities as an objective through 2016. | Coos Bay School District policy: North Bend School District Policy |
| **HS-2** | Outcomes | 1 | **Health Outcomes:** Demonstrate that the community is a county, or is a municipality located in a county, ranked in the top 15% in the state in regards to morbidity and mortality | Complete | Does not meet target | 0 | 5 | Does not meet 15%/30% benchmarks. Coos County ranks 28 and 23 out of 33 for mortality and morbidity, respectively. | County Health Rankings |
| **HS-2** | Outcomes | 2 | **Health Behaviors:** Demonstrate that the community is a county, or is a municipality located in a county, ranked in the top 15% in the state in regards to key behaviors that impact health | Complete | Does not meet target | 0 | 5 | Does not meet 15%/30% benchmarks. Coos County ranks 32 out of 33 for overall health behaviors. | County Health Rankings |
| **HS-2** | Outcomes | 3 | **Clinical Care:** Demonstrate that the community is a county, or is a municipality located in a county, ranked in the top 15% in regards to quality of clinical care, including access to health care | Complete | Does not meet target | 0 | 5 | Does not meet 15%/30% benchmarks. Coos County ranks 17 out of 33 for clinical care. | County Health Rankings |

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| HS-2 | Outcomes | 4 | **Quality of Local Health System:** Option A: Demonstrate that at least one hospital in the county is recognized as a top performer by the Joint Commission<br>--OR--<br>Option B: Demonstrate that the local public health department is accredited by the Public Health Accreditation Board (PHAB)<br>--OR--<br>Option C: Demonstrate that least 30% of public health clinicians are board certified in their specialty areas and ancillary staff holds professional certification in their respective fields | Complete | Meeting target | 5 | 5 | Option C: Appears 100% of Coos County Public Health practitioners are certified. Cynthia's response, 3/17/14: "We contract with one medical doctor to act as our Health Officer; this position oversees and signs off on all standing orders. We have another OBGYN that volunteers two days a week, one nurse practitioner that works two days a month, and two nurses." | |
| HS-2 | Actions | 1 | Conduct a comprehensive community health assessment, which includes data collection and analysis of public health conditions, trends, and problems affecting the community | Complete | Meeting target | 1 | 1 | Coos County Public Health Dept. completed Coos County Community Health Assessment on June 1, 2013. | |
| HS-2 | Actions | 2 | Develop a community health improvement plan to strengthen the delivery of health services and improve community health | Complete | Meeting target | 2 | 2 | Coos County Public Health Dept. completed Coos County Community Health Implementation Plan, 2013-2016. | Sustainability Scan of city/county governments. |
| HS-2 | Actions | 3 | Adopt a *health in all policies* statement or policy commitment for local decision-making | Complete | Does not meet target | 0 | 3 | City of Coos Bay does not have a specific statement or policy, but is a natural part of decision making at the City. City of North Bend does not have this type of policy. Coos County is considering adopting such a policy. | Sustainability Scan of city/county governments. |
| HS-2 | Actions | 4 | Collaboratively engage the public in the assessment of community health problems and developing strategies to improve the delivery of health services | Complete | Meeting target | 1 | 1 | According to e-mail correspondance: "Coos County Public Health staff participated in many local and state organizations, coalitions, and task forces this past fiscal year. Our staff represented the public health perspective, lent their expertise, and joined with others in our communities to work on significant issues that help to make our community a better place to live.<br><br>Regional or Statewide:<br>l ARES/RACES Amateur Radio Emergency Services<br>l Assoc. of OR PH Nursing Supervisors<br>l Coos-Curry Early Childhood Transition Planning Team<br>l Coos-Curry Early Learning<br>l Conference of Local Health Officials & Joint Leadership Team<br>l Conf. of Local EH Supervisors<br>l National WIC Association<br>l Neurosequential Model of Therapeutics – Coos County Team<br>l Oregon Community Foundation Ready to Smile Steering Committee<br>l Oregon Environmental Health Association<br>l Oregon Healthy Start | Direct correspondance |
| HS-2 | Actions | 5 | Collaboratively engage the local public health department and relevant local government departments or agencies to integrate health considerations into local plans and policies that affect the built environment, *physical activity* , and access to fresh food | Complete | Does not meet target | 0 | 1 | According to e-mail correspondance: "Currently no. However our previous Public Health Administrator has initiated various conversation with City and County leaders to address health in all policy and activity. Also our department was just awarded a Brownfield grant to assemble local government to strengthen and develop relationships that further common community goals, identify common community goals and efforts, prioritize brownfield projects that Coos county Public Health can be involved in by brining potential public health issues to the forefront at the earliest phase of the projects, and asses current health status and health concerns of communities where brownfield projects with Coos County Public Health Department involvement are planned." | Direct correspondance |

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| **HS-2** | Actions | 6 | Provide information and education to the public regarding health issues and available local programs and services that support prevention and wellness | Complete | Meeting target | 2 | 2 | According to e-mail correspondance: "A few: WIC program offers monthly nutrition classes, last year we received grant funding for targeted awareness and outreach for breastfeeding, and the last two years we have hosted the Living Well Program for those with chronic conditions (this program has now been moved to our local CCO)." | Direct correspondance |
| **HS-2** | Actions | 7 | Demonstrate that the local public health department, local government, or major hospital has received *HealthLead* workplace accreditation | Complete | Does not meet target | 0 | 1 | Coos County Public Health, city governments, or hospitals are not on either list. | HealthLead website |
| **HS-2** | Actions | 8 | Use a performance management system to monitor and improve health services and programs that promote positive health outcomes and expand *access to health care* | Complete | Does not meet target | 0 | 4 | According to e-mail correspondance: "We do not have a formal performance management system. Over the years we have however recorded and reported through an annual report program outcomes. We are currently starting the process of creating a formal performance management system; the plan should be completed by the end of March and then we will start creating dashboards and associated reporting. We will start by looking at the measures we have historical collected (see attached annual report) and then consider what other measures we should include based on population health goals." | Direct correspondance |
| **HS-2** | Actions | 9 | Conduct *health impact assessments (HIAs)* on proposed infrastructure investments and development projects to increase positive health outcomes and minimize adverse impacts | Complete | Does not meet target | 0 | 6 | According to e-mail correspondance: "No, this is not something we have ever done. Our most recent administrator wanted to but now that she left I fear nothing new will be taken on." | Direct correspondance |
| **HS-3** | Outcomes | 1 | **Superior Fire Protection:** Achieve a Class 4 *ISO* rating or better | Complete | Meeting target | 6 | 6 | Coos Bay and North Bend have ISO ratings of Class 3. | City fire departments websites |
| **HS-3** | Outcomes | 2 | **Emergency Response Times:** Demonstrate that 90% of response times are in compliance with standards set by the *National Fire Protection Association (NFPA)* | Pending data analysis/request | Pending | | 6 | North Bend Fire Department reported that an average response time out of the station is 2 minutes, which meets the NFPA requirements. | |
| **HS-3** | Outcomes | 3 | **National Incident Management System:** Demonstrate that the community is in compliance with the *National Incident Management System (NIMS)* | Complete, pending update | Meeting target | 3 | 3 | North Bend Fire completed NIMS training September 2011, according to council minutes and City Administrator Jan Willis. According to the Coos County Emergency Management Strategic Plan 2013, the County-level NIMS is supposed by updated annually, but the last reported update was September 2005. The Coos County Emergency Operations Plan (EOP), created 2009, provides a framework for coordinated response and recovery activities for any type or size of emergency affecting the County. The EOP complements the State of Oregon Emergency Management Plan (EMP) and integrates the concepts and principles of the National Response Framework (NRF), National Incident Management System (NIMS), and NIMS Incident Command System (ICS). (1.1, p. 1-1). Throughout the EOP, compliance with NIMS is clearly a top priority and underlying protocol. | Coos County Emergency Operations Plan (2009) |
| **HS-3** | Actions | 1 | Develop a *NIMS*-compliant local inventory of assets and resources available for emergency response and *mutual aid* requests | Complete | Meeting target | 1 | 1 | A NIMS Resource Typing Tracking can be found in Emergency Support Function (ESF) Annex 7: Logistics Management and Resource Suppor. A list of mutual aid agreements is available in Appendix A of the Coos County Emergency Operaions Plan (2009). | Coos County Emergency Operations Plan (2009) |
| **HS-3** | Actions | 2 | Publish information to encourage residents to develop emergency kits and evacuation plans and encourage businesses to develop emergency procedures and shelter-in-place plans | Complete | Meeting target | 2 | 2 | Materials include: Preparedness fairs throughout county, Tsunami Roadshow event (OEM), Leadership Coos presentation, in additino to various requests for infmation and presentations throughout the year; Existing educational materials and literature from various sources are distributed at public events throughout year; Presentations to church groups, Chamber of Commerce, et.; Usually 1-2 or more presentations quarterly; Additionally, website has various links and resources | Direct correspondance |
| **HS-3** | Actions | 3 | Participate in interstate, statewide, regional, or inter-jurisdictional *mutual aid* response systems | Complete | Meeting target | 1 | 1 | Several Mutual Aid Response Agreements/MOUs are listed in Appendix A of Coos County Emergency Operations Plan (2009) | Coos County Emergency Operations Plan (2009) |

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| HS-3 | Actions | 4 | Participate in a regional emergency planning commission | Complete | Meeting target | 1 | 1 | Health Emergency Response Task Force (HERT), Coos County Emergency Management Advisory Council (CCEMAC); See Coos County Emergency Management Strategic Plan for more information. | |
| HS-3 | Actions | 5 | Adopt a local comprehensive plan for emergency response that include provisions for evacuating low-income, disabled, and other persons likely to need assistance | Complete | Meeting target | 2 | 2 | There are 19 plans that address emergency management. The main County one is: Coos County Emergency Management Plan (2009) | Coos County Emergency Management Plan (2009) |
| HS-3 | Actions | 6 | Participate in training drills that involve the public and emergency management personnel from multiple departments and/or multiple jurisdictions | Complete | Meeting target | 1 | 1 | County Emergency Management offers periodic trainings to Cities, Tribes, County employees, and representatives of other agencies (hospitals, responders, etc.) periodically throughout the year. | |
| HS-3 | Actions | 7 | Perform an annual review or assessment of plans, procedures, resources, and trainings based on emergency response incidents and demands | Complete | Meeting target | 1 | 1 | Emergency response plans are reviewed officially every 4 years. Naturally, deficiencies are rectified when discovered, even "out of cycle" of review. Resource lists and contact lists are updated annually. | |
| HS-3 | Actions | 8 | Achieve accreditation by the *Emergency Management Accreditation Program (EMAP)* | Complete | Does not meet target | 0 | 1 | Not accredited, 3/11/2014 | EMAP website |
| HS-3 | Actions | 9 | Host an active *Community Emergency Response Team (CERT)* or *Medical Reserve Corps (MRC)* | Complete | Meeting target | 4 | 4 | 111 MRC participants, 400 CERT participants since 2011 | Direct correspondance |
| HS-3 | Actions | 10 | Distribute emergency kits or supplies to residents, particularly low-income and vulnerable populations | Complete | Does not meet target | 0 | 4 | County does not distribute supplies or kits to citizens. There is no funding for purchasing them. We give educational materials for people to make up their own kits. They can be done relatively inexpensively, over time. Purchase a few items each month, and it doesn't hurt an individual budget to a great extent. If things are given to people, they value them less than if they acquire them themselves. If budgets ever improve, this is something that could be looked at. However, supply caches create their own requirements for maintenance, rotation, vermin control, etc. No staffing or funding to deal with them, let alone their initial purchase. | Direct correspondance |
| HS-4 | Outcomes | 1 | **Local Fresh Foods:** Option A: Demonstrate an increase over the past 3 years in the amount of fresh food produced through local urban agriculture<br>--OR--<br>Option B: Demonstrate an increase over the past 3 years in the amount of fresh food sold locally at farmers markets or other direct farm-to-consumer activities | Pending data collection/request | Pending | | 2.6 | Port Orford CSF: http://posustainableseafood.com/<br>Winter Green Farm CSA, Valley Flora Farm CSA, Growing Crazy Farm CSA | |
| HS-4 | Outcomes | 2 | **Food Security and Assistance:** Demonstrate an increase over the past 3 years in the ability of low-income families to access low-cost, healthful food | Complete | Meeting target | 2.6 | 2.6 | Coos County increases food security for overall population and children from 2009-2011. | Map the Meal Gap online tool |
| HS-4 | Outcomes | 3 | **Access to Healthful Food:** Option A: Demonstrate an increase over the past 3 years in the percentage of residents within a walkable 1/4-mile of a healthful retail food outlet<br>--OR--<br>Option B: Demonstrate a decrease over the past 3 years in the percentage of residents living in a urban or rural food desert | Pending data collection/request | Pending | | 2.6 | | |

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| HS-4 | Outcomes | 4 | **School Nutrition:** Demonstrate an increase over the past 3 years in the food service sales of fresh fruits and vegetables in the largest public school district | Complete | Unable to be evaluated | 0 | 2.6 | Current accounting/reporting does not allow us to demonstrate an increase in fruits & vegetable sales. NB District provided estimate for current year: $47,338 total. CB District could not provide amount at all, since accounting/ordering does not keep track of fruits/vegetables separately. Both districts have special fruit and vegetable grant that provides additional funding to serve fruits and vegetables. North Bend has provided $8,801 for all the schools monthly. Coos Bay provided $20,000 for each of the elementary schools (2) annually for the last three years.<br>ORCCA's Head Start began a "Farm to Preschool" project in 2014, partnering with Valley Flora farm in Langlois to secure donations of fresh produce and plant starts to the South Coast Head Start program. This program will serve the children and families of Head Start. | Direct correspondance; News release: http://www.orcca.us/images/stories/kudos%20valley%20flora.gif |
| HS-4 | Actions | 1 | Conduct an assessment of the local food system, including existing policies and programs that increase access to healthful food and nutrition education | Complete | Meeting target | 1 | 1 | South Coast Development Council is collaborating with the Wild Rivers Coast Alliance to carry out a community food assessment (CFA) for Coos County. The CFA is a part of SCDC's 2014-2015 Workplan. The CFA is a part of a broader project led by the Oregon Food Bank. It will be completed July 2014. | |
| HS-4 | Actions | 2 | Adopt zoning and development regulations that allow farmers markets, community gardens, and urban agriculture | Complete | Partially meeting target | 0 | 3 | City of Coos Bay does not have these types of regulations, but these activities are occuring. City of North has no current action/activity on this topic. Coos County reports having such zoning/regulations. | Sustainability Scan of city/county governments. |
| HS-4 | Actions | 3 | Adopt zoning and development regulations that limit or prohibit the sale of unhealthful foods | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| HS-4 | Actions | 4 | Adopt menu-labeling requirements or regulations that discourage, tax, or prohibit the sale of unhealthful foods or beverages | Complete | Does not meet target | 0 | 3 | City of Coos Bay, City of North, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| HS-4 | Actions | 5 | Demonstrate that the local public school district has adopted a model school wellness policy | Complete | Meeting target | 3 | 3 | Both Coos Bay and North Bend have wellness programs that cover the requirements listed in the state. | Coos Bay,North Bend School District policies |
| HS-4 | Actions | 6 | Establish a local or regional food policy council that includes health professionals, community organizations, schools, farmers, and/or related businesses | Complete | Does not meet target | 0 | 1 | No such council exists | Direct correspondence |
| HS-4 | Actions | 7 | Develop public outreach materials, classes, or workshops for residents to learn about food, nutrition, and gardening **OR** develop public outreach materials to promote food assistance programs | Complete, pending update | Partially meeting target | 0 | 2 | In April 2013, FEAST, SCDC, and Wild Rivers Coast Alliance hosted an event to discuss the community food system. In November 2013, RSVP, Rep. Cadd McKeown, Partners for Hunger Free Oregon, and OSU Extension hosted First Annual Regional Meeting on Hunger in Older Adults. City of Coos Bay, City of North, have no current action/activity on this topic. Coos County reports having outreach about these topics. | Sustainability Scan of city/county governments. |
| HS-4 | Actions | 8 | Demonstrate that local schools or the public school district has received certification from the USDA Healthier US Schools Challenge or an award from the Alliance for a Healthier Generation in the past 3 years | Complete, pending update | Partially meeting target | 0 | 1 | Neither district has been recognized through USDA program. Madison Elementary School (bronze, 2010-2011, Coos Bay District) was only school to win a Healthier Generation award in the past three years. | |
| HS-4 | Actions | 9 | Purchase and sell healthful food at facilities owned, leased, and operated by the local government | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| HS-4 | Actions | 10 | Implement an *"Increase Your Food Bucks"* program for farmers markets | Pending request | Pending | | 4 | | |
| HS-4 | Actions | 11 | Provide incentives for healthful retail food outlets to locate in underserved areas or for mobile vendors that only sell fresh food | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| HS-5 | Outcomes | 1 | **IAQ Complaints to School District:** Decrease the number of student, parent, and staff complaints to the public school district regarding indoor air quality (IAQ) over time | Complete, pending update | Does not meet target | 0 | 1.8 | Based on 3 reporting schools---No schools have IAQ management program in place, although Madison Elem. Is considering it due to high number of illnesses/absenses. | School administrator survey |

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| **HS-5** | Outcomes | 2 | **IAQ Complaints to Enforcement Agency:** Decrease the number of tenant complaints regarding IAQ over time | Complete | Does not meet target | 0 | 1.8 | Coos County Environmental Health tracks IAQ complaints by tenants, but they do not actively solicit complaints. For the past several years, the number of complaints have been: 2011 - 0; 2012 - 0; 2013 - 6; 2014 - 4 (as of 6/09/14) | Sustainability Scan survey of County department; Direct correspondance |
| **HS-5** | Actions | 1 | Prohibit smoking in all enclosed public places, including restaurants, bars, and workplaces | Complete | Meeting target | 3 | 3 | Statewide ban in bars, restaurants, and workplaces. | Oregon Smokefree Workplace Law |
| **HS-5** | Actions | 2 | Prohibit smoking in multi-family buildings community-wide **OR** residential buildings controlled by the local housing authority **OR** affirm by local ordinance the right for landlords to legally establish smoke-free rental units | Complete | Partially meeting target | 0 | 3 | City of Coos Bay has no current action/activity on this topic. City of North has no current action/activity on this topic. Coos County reports having this type of ban. | Sustainability Scan of city/county governments. |
| **HS-5** | Actions | 3 | Require all new or substantially renovated local government and school buildings to incorporate *advanced ventilation standards* | Complete, pending update | Does not meet target | 0 | 3 | City of Coos Bay, City of North, and Coos County have no current action/activity on this topic. Based on 3 reporting schools----No schools have such a requirement. | Sustainability Scan of city/county governments; School admininstrator survey |
| **HS-5** | Actions | 4 | Conduct local public education campaigns regarding prevention and safe remediation of common indoor air pollutants | Complete | Does not meet target | 0 | 2 | Coos County Environmental Health does not currently have education campaigns of this type, but reports that if an on-going funding source was available, they would be interested in visiting homes with a resident diagnosed with asthma for the purpose of identifying asthma triggers and teaching remediation activities. | Sustainability Scan survey of County department |
| **HS-5** | Actions | 5 | Reduce or eliminate toxic pesticide use in locally owned or managed buildings through the use of *integrated pest management (IPM)* techniques | Complete | Does not meet target | 0 | 1 | Coos County Environmental Health is not currently taking action on this topic. | Sustainability Scan survey of County department |
| **HS-5** | Actions | 6 | Address residential IAQ problems related to mold, pests, and other hazards through inspections and enforcement using authority from the state or local housing code or public health code | Complete | Does not meet target | 0 | 4 | Coos County Environmental Health is not currently taking action on this topic. | Sustainability Scan survey of County department |
| **HS-5** | Actions | 7 | School district implements a system-wide IAQ management program to monitor and address IAQ problems | Complete | Does not meet target | 0 | 4 | Based on 3 reporting schools----No schools have an IAQ management program. | |
| **HS-5** | Actions | 8 | Provide free, subsidized, or at-cost supplies to test and monitor IAQ to prevent harm from common pollutants | Complete | Does not meet target | 0 | 4 | Coos County Environmental Health is not currently taking action on this topic. | Sustainability Scan survey of County department |
| **HS-5** | Actions | 9 | Provide grants or loans to remediate indoor air pollution problems in low-income homes or affordable rental units | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **HS-6** | Outcomes | 1 | **Location-Specific Hazards:** Part 1:<br>Option A: Reduce over time the number of homes below code standards that are located in designated high risk areas<br>--OR--<br>Option B: Reduce over time the percentage of residents living in designated high risk areas<br>--AND--<br>Part 2: Reduce over time the critical infrastructure below code standards that is located in designated high risk areas | Pending data collection/request | Pending | | 5.3 | | |
| **HS-6** | Outcomes | 2 | **Full Community Hazards:** Demonstrate increased resilience to hazard threats over time | Pending data collection/request | Pending | | 5.3 | | |
| **HS-6** | Actions | 1 | Develop a hazard mitigation action plan that includes an all-hazard vulnerability assessment of the community's primary hazard threats | Complete | Meeting target | 2 | 2 | City of Coos Bay, City of North Bend, and Coos County have these assessments as part of their action plans/comprehensive plans. | Sustainability Scan of city/county governments. |
| **HS-6** | Actions | 2 | Develop a post-disaster plan that addresses long-range redevelopment issues such as land use, economic development, housing, infrastructure, public services, and environmental restoration | Complete | Meeting target | 2 | 2 | City of Coos Bay, City of North Bend, and Coos County currently have post-disaster plans addressing these issues. | Sustainability Scan of city/county governments. |

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| HS-6 | Actions | 3 | Increase community awareness of natural hazards through education and outreach materials | Complete | Meeting target | 2 | 2 | City of Coos Bay, City of North Bend, and Coos County currently conduct education/outreach on this topic. | Sustainability Scan of city/county governments. |
| HS-6 | Actions | 4 | Integrate an all-hazard vulnerability assessment or other key local hazards information into the community's comprehensive plan | Complete | Meeting target | 2 | 2 | City of Coos Bay, City of North Bend, and Coos County have these assessments as part of their action plans/comprehensive plans. | Sustainability Scan of city/county governments. |
| HS-6 | Actions | 5 | Adopt zoning regulations that limit development in areas of high hazard vulnerability | Complete | Meeting target | 3 | 3 | Codes prohibiting new development/alterations in floodways: Coos Bay Municipal Code, Chapter 17.195 FLOOD DAMAGE PREVENTION**Ordinance updated March/April 2014; North Bend Municipal Code, Chapter 18.48 FLOODPLAIN ZONE F-P | Coos Bay, North Bend Municipal Codes |
| HS-6 | Actions | 6 | Enact building codes with heightened standards for buildings in areas of high hazard vulnerability | Complete | Meeting target | 3 | 3 | Codes regulating development/alterations in special flood hazard areas: Coos Bay Municipal Code, Chapter 17.195 FLOOD DAMAGE PREVENTION; North Bend Municipal Code, Chapter 18.48 FLOODPLAIN ZONE F-P | Coos Bay, North Bend Municipal Codes |
| HS-6 | Actions | 7 | Create insurance or incentive structures to help equitably remove residents from hazardous situations | Complete | Partially meeting target | 0 | 4 | City of Coos Bay currently participates in these programs that FEMA provides. City of North Bend and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| HS-6 | Actions | 8 | Build or renovate locally-owned public facilities to meet higher building code standards to be used as shelters, command centers, and to set an example for the community | Complete | Meeting target | 6 | 6 | City of Coos Bay and City of North Bend are currently doing this/have done this in the past. Coos County is considering taking action on this topic. | Sustainability Scan of city/county governments. |
| HS-6 | Actions | 9 | Implement highest priority projects utility improvements listed in the hazard mitigation plan | Pending data analysis/request | Pending | | 6 | | |
| HS-7 | Outcomes | 1 | **Violent Crime Rate:** Option A: Demonstrate that the average violent crime rate for the past 3 years is below the following thresholds:<br>• 5.5 homicides per 100,000 residents<br>• 70 incidents of rape or attempted rape per 100,000 residents<br>• 462.7 aggravated assaults per 100,000 residents<br>--OR--<br>Option B: Achieve targets for a percentage decrease in violent crime identified in a locally-adopted safe communities strategic plan | Complete | Meeting target | 7.5 | 7.5 | Option A: Coos County far below thresholds. City-level unavailable, since North Bend is too small to get data from PD. | FBI's Uniform Crime Reports system |
| HS-7 | Outcomes | 2 | **School Violence:** Demonstrate that the average number of incidents of school violence is less than 10 per 1,000 students for all public schools in the jurisdiction | Complete | Does not meet target | 0 | 7.5 | Coos Bay: 2010/11: Total students 3,381, Total incidents 56-60; 2011/12: 51 incidents, 3,178 students; 2012/13 was under-reported due to new software adjustment, 13 incidents; 3104 students; Coos Bay incidents are >10 per 1000 students; North Bend: 2010/11: 40-44 incidents (exact number of one category is 5 or less, so it is not shown to protect confidentiality), 2700 students; 2011/12: 26-30 incidents, 3650 students; 2012/13: 57 incidents, 3985 students; North Bend has been >10 per 1000 students for 2 of past 3 years; | |
| HS-7 | Actions | 1 | Conduct a survey of community perceptions of safety recognizing that some crimes are not reported and to illuminate safety issues that need to be addressed | Complete | Partially meeting target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County has conducted a community survey about this topic. | Sustainability Scan of city/county governments. |
| HS-7 | Actions | 2 | Adopt a *safe communities strategic plan (plan)* with a comprehensive, balanced approach that includes *violence prevention*, *intervention*, *suppression and enforcement*, and *reentry* strategies | Complete | Partially meeting target | 0 | 2 | City of Coos Bay currently has a safe communities strategic plan. City of North Bend has no current action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability Scan of city/county governments. |
| HS-7 | Actions | 3 | Educate the public and the media about the *plan*, its implementation, and successful programs and strategies | Complete | Partially meeting target | 0 | 2 | City of Coos Bay currently has education/outreach efforts about the plan. City of North Bend has no current action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability Scan of city/county governments. |
| HS-7 | Actions | 4 | Develop partnerships with local agencies, nonprofit organizations, schools, and residents to implement the strategies and programs recommended in the *plan* | Complete | Partially meeting target | 0 | 1 | City of Coos Bay currently has partnership related to the plan. City of North Bend has no current action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability Scan of city/county governments. |

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| **HS-7** | Actions | 5 | Establish cross-agency coordination and procedures to support balanced implementation of the *plan* | Complete | Partially meeting target | 0 | 1 | City of Coos Bay currently has cross-agency coordination around the plan. City of North Bend has no current action/activity on this topic. Coos County is considering taking action on this topic. | Sustainability Scan of city/county governments. |
| **HS-7** | Actions | 6 | Perform ongoing data collection, evaluation, and monitoring from multiple agencies to track trends and identify emerging community needs | Complete | Meeting target | 1 | 1 | City of Coos Bay, City of North Bend, and Coos County currently have ongoing data collection, evaluation, and monitoring. | Sustainability Scan of city/county governments. |
| **HS-7** | Actions | 7 | Implement *violence prevention* programs and strategies to address community-identified risk and protective factors | Complete | Meeting target | 4 | 4 | City of Coos Bay, City of North Bend, and Coos County currently have these types of programs/strategies. | Sustainability Scan of city/county governments. |
| **HS-7** | Actions | 8 | Implement school-based *violence prevention* programs and strategies, particularly in highly impacted, urban, and at-risk neighborhoods | Complete, pending update | Meeting target | 4 | 4 | Based on 3 reporting schools---All schools have violence prevention programs. Madison Elem. has Second Step curriculum that addresses social and emotional skills for young students. | School administrator survey |
| **HS-7** | Actions | 9 | Develop *violence intervention* programs and strategies to support at-risk families and youth and to prevent the escalation of violence | Pending data analysis/request | Pending | | 4 | | |
| **HS-7** | Actions | 10 | Adopt violence suppression and enforcement programs and strategies that support and build trust within the community | Complete | Meeting target | 4 | 4 | City of Coos Bay, City of North Bend, and Coos County currently have these types of programs/strategies. | Sustainability Scan of city/county governments. |
| **HS-7** | Actions | 11 | Create or support a multi-faceted, monitored *reentry* program for ex-offenders that includes training, education, mentoring, and employment opportunities and other support services to reduce recidivism | Complete | Partially meeting target | 0 | 4 | City of Coos Bay has no current action/activity on this topic. City of North Bend and Coos County currently have a reentry program. | Sustainability Scan of city/county governments. |
| **NS-1** | Outcomes | 1 | **Designated Green Infrastructure:** Option A: Demonstrate that 35% of the jurisdiction's land area has protected vegetated surfaces performing a minimum of 2 of the following functions:<br>• Localized cooling through tree canopy cover, green roofs, or green walls<br>• Water management through wetlands, stream buffers, and permeable surfaces<br>• Recreation through parks and/or greenways<br>--OR--<br>Option B: Demonstrate a 2-5% increase in land area with protected vegetated surfaces over time | Future | Pending | | 8.4 | | |
| **NS-1** | Outcomes | 2 | **Green Infrastructure Distribution:** Demonstrate that 85% of the population lives within a 1/2-mile walk distance from green infrastructure features that are performing a minimum of 2 of the following functions:<br>• Localized cooling through tree canopy cover, green roofs or green walls<br>• Water management through wetlands, stream buffers, and permeable surfaces<br>• Recreation through parks and/or greenways | Future | Pending | | 5.6 | | |
| **NS-1** | Actions | 1 | Create a community-wide green infrastructure plan that is integrated with other relevant local plans | Complete | Does not meet target | 0 | 2 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend is currently considering taking action on this topic. | Sustainability Scan of city/county governments. |
| **NS-1** | Actions | 2 | Adopt local design criteria and associated codes that require proactive green infrastructure practices for new developments | Complete | Does not meet target | 0 | 3 | City of Coos Bay reports that these criteria/codes are in Green Building Code from the State of Oregon, however the Oregon Energy Efficiency Specialty Code, mandatory for residential and commercial buildings, does not include a requirement for green infrastructure. The Oregon Reach Code is an optional set of standards that reduce energy use and increase water conservation for new and renovated buildings, but these have not been adopted as a requirement for the local area. City of North Bend is currently considering taking action on this topic. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments; Relevant Oregon Building Codes, |

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| NS-1 | Actions | 3 | Adopt a policy requiring relevant departments be engaged during early reviews of proposed developments to ensure that project sites are evaluated for green infrastructure potential and environmental protections are put in place prior to construction | Complete | Does not meet target | 0 | 3 | City of Coos Bay reports that these criteria/codes are in Green Building Code from the State of Oregon. Should a new development choose to build in accordance with the Oregon Reach Code, the relevant local officer would review and permit the development accordingly. City of North Bend is currently considering taking action on this topic. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments; Relevant Oregon Building Codes, |
| NS-1 | Actions | 4 | Partner with key community groups and other stakeholders to ensure that green infrastructure practices are used in appropriate settings | Complete | Does not meet target | 0 | 1 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| NS-1 | Actions | 5 | Create incentive programs to encourage land owners to adopt green infrastructure practices that link to the broader green infrastructure systems | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| NS-1 | Actions | 6 | Establish a green infrastructure monitoring program and regularly report on status of desired outcomes | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| NS-1 | Actions | 7 | Increase the percentage of funding invested in green infrastructure | Complete | Does not meet target | 0 | 6 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| NS-1 | Actions | 8 | Upgrade public spaces and public buildings based upon locally-adopted or recognized best practices in green infrastructure. Where possible, create demonstration projects to enhance public support | Complete | Meeting target | 6 | 6 | City of Coos Bay and City of North Bend currently upgrades/has upgraded public spaces/buildings accordingly. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| NS-1 | Actions | 9 | Provide for ongoing maintenance of green infrastructure at level required to maintain evapotranspiring functions | Complete | Meeting target | 6 | 6 | City of Coos Bay and City of North Bend currently provides/has provided for maintenance of public spaces/buildings accordingly. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| NS-2 | Preliminary Step | | Use a species-led or site-led approach to identify the invasive species of greatest threat, priority areas for protection, and critical entry points | Complete | N/A | | | CoosWA takes a species-led approach for invasive species management. CoosWA's approach is to target weed species that pose the greatest risk to our restoration programs–especially those species for which early, targeted efforts can prevent uncontrollable infestations. Knotweed, purple loosestrife, and gorse. (1) Knotweed (S.F. Coos River, small urban sites), (2) Gorse (north Charleston/south Hauser, rural/urban lowland CB/NB), (3) Purple loosestrife (Catching and Coalbank Sloughs, Barview, Noble Creek, Eastside). | |
| NS-2 | Outcomes | 1 | **Invasive Species Prevention:** Show that no new invasive species have established themselves in the last 5 years in priority natural systems areas and critical entry points | Complete | Does not meet target | 0 | 2.3 | We are not able to demonstrate that new invasive species have not begun to reproduce or significantly expand. A new potential invader, dense-flowered cordgrass (Spartina densiflora), was found in Coos Bay last August. | |
| NS-2 | Outcomes | 2 | **Invasive Species Containment:** Show that existing invasive species have not moved into priority natural systems areas and critical entry points | Complete | Meeting target | 2.3 | 2.3 | CoosWA would likely be able to demonstrate this. Some "new" sites have come up, but the plants established are older, meaning they aren't newly established plants. | Direct correspondence |
| NS-2 | Outcomes | 3 | **Invasive Species Eradication:** Option A: Eradicate existing invasive species from priority natural systems areas and critical entry points<br>--OR--<br>Option B: Demonstrate progress towards targets identified in the community's local integrated pest management plan | Complete | Meeting target | 1.6 | 1.6 | Option B: While we have achieved a reduction in size of total net acres of the main invasive species, we have not fully eradicated an invasive species from the watershed. Knotweed infestation has been effectively reduced by 75% from 12 acres to 3 acres since 2008. | Direct correspondence |
| NS-2 | Actions | 1 | Develop a community-wide invasive species integrated pest management plan | Complete | Partially meeting target | 0 | 2 | Coos County Cooperative Weed Management Area has a Long-term Management Plan that uses integrated weed management principles. It identifies weeds of concern for the county, activities, and structure/process. It's a living document that fluctuates based on needs. Confederated Tribes also has an Invasive Species Management Plan, | Direct correspondence |

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| **NS-2** | Actions | 2 | Adopt local ordinance requiring control of listed priority invasive species or enact a native plant ordinance for private and public landscaping | Complete | Does not meet target | 0 | 3 | North Bend Municipal Code §8.12.010: Ulexeuropaeus, also known as gorse or Irish furze, is classified as a nuisance and may be subject to abatement.<br>Oregon rule 603-052-1200 prohibits import, transport, propagation or sale of select "A" and "B" State listed noxious weeds and plants on the Federal Noxious Weed List. All three key species (knotweed, gorse, and purple loosestrife) are "B" species. According to Steve Scheer, there is no county/city ordinance prohibiting sale, etc. However, City of Coos Bay, City of North Bend, and Coos County report that there is such an ordinance in place. The cities and county may be referring to the Oregon state rule. | Sustainability Scan of city/county governments; Direct correspondance |
| **NS-2** | Actions | 3 | Partner with local volunteer groups or neighborhood associations to restore priority natural systems areas by planting native plants or improving local wildlife habitat | Complete | Meeting target | | 1 | Coos Watershed Association has extensive invasive and native plan program that continues to grow. They partner with public and private entities to restore systems and improve habitat. | |
| **NS-2** | Actions | 4 | Partner with local volunteer groups to monitor critical entry points or areas at greatest risk of invasive species invasion, and organize "weed pulls" and other invasive management actions | Complete | Partially meeting target | 0 | 1 | Coos Watershed Association organizes periodic weed pulls and other volunteer events, but not on a regular basis. Also no volunteer program to monitor invasive species establishment. | |
| **NS-2** | Actions | 5 | Create a public education campaign or targeted outreach effort to inform residents and/or plant or animal sellers about the hazards of invasive species | Complete | Meeting target | 2 | 2 | We have reached out to landowners who have purple loosestrife and knotweed on their properties. We tabled at the Salmon Celebration and Octoberfish with information about invasive species in the watershed at our booth. Weed Board is at Coos County Fair every year, and they have a Forage and Pasture Management class in spring 2014 | |
| **NS-2** | Actions | 6 | Use incentive programs to encourage local businesses and private owners to grow and sell native or desirable plants and animals and not sell invasive species or other harmful plants and animals | Complete | Meeting target | 4 | 4 | Coos County Weed Advisory Board has herbicide cost-share program. 67 participants in 2013, treating 10 square miles. Comparable numbers in previous years. Coos Watershed Association provides free herbicide application to knotweed infestations for any landowner within the watershed's boundaries, and to date has successfully worked with 28 landowners on the Coos River to control the spread of these species. | |
| **NS-2** | Actions | 7 | Enforce regulations to control the use and sale of listed invasive species | Complete | Does not meet target | 0 | 4 | Coos County has no enforcement. Coos County Commissioners has chosen to take an education-driven approach. | |
| **NS-2** | Actions | 8 | Ensure that all local government-owned buildings use native plants or non-invasive species in landscaping | Complete | Meeting target | 6 | 6 | City of Coos Bay, City of North Bend, and Coos County currently take action to ensure native or non-invasive species are used. | Sustainability Scan of city/county governments. |
| **NS-2** | Actions | 9 | Take actions to prevent the spread of invasive species, especially in priority natural systems areas, such as monitoring, eradication, or other control programs | Complete | Meeting target | 4 | 4 | Coos Watershed Association has two staff members (one project manager and one field leader) that spend 50-60% on invasive species control, including surveying, fieldwork, planning, report/grant writing, and outreach. During the summer months, about 10 full-time, temporary crew members assist in fieldwork. | |
| **NS-3** | Outcomes | 1 | **Priority Natural System Areas:** Option A: Achieve targets for acres of land conserved in priority natural systems areas identified in a locally-adopted natural systems or land conservation plan<br>--OR--<br>Option B: Demonstrate incremental progress towards achievement of targets for acres of land conserved identified in a locally-adopted natural systems or land conservation plan | Complete | Partially meeting target | 0 | 3.5 | Coos Watershed Association has developed a plan as part of its 10-year Model Watershed Program (2008-2017) through the Bonneville Environmental Foundation. The plan has been adopted by the CoosWA Board. There is no equivalent governmental agency plan with specific targets, although the county's comprehensive plan and zoning incorporate objectives for natural system conservation in accordance with State Land Use Planning goals. | CoosWA Model Watershed Plan: CoosWA Sustainability Scan survey |

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| NS-3 | Outcomes | 2 | **Wetlands, Streams and Shoreline Buffers:** Achieve no-net-loss of these critical resources | Complete, pending update | Partially meeting target | 0 | 3.5 | Oregon has a strategic goal of no-net loss of wetlands. Coos Bay Estuary Management Plan states as a goal "Limit, to the areas indicated in this plan, estuarine filling that will further reduce the volume of the estuary, significantly alter the character and shape of the shoreline, destroy marshlands and tide flats, or significantly change land use in an area." (Goal IV.5) Implementation states that "Primary responsibility for this goal rests with the State Land Board which governs such filling by permit. It also involves County and city planning and zoning, the Port of Coos Bay, the Department of Environmental Quality, and the Army Corps of Engineers." Marshland is considered to be "Those marsh areas within the main bay and along the tributary sloughs that are vital to the organic, aesthetic, and recreational integrity of the estuarine system; no filling or dredging permitted; public recreational use permitted." (Water use categories 2.e.)<br>Coos Bay/North Bend does not have a Local Wetland Inventory according to state standards. | State wetland conservation planning rules;<br>Local Wetland Inventories<br>CBEMP:<br>Wetlands mapper |
| NS-3 | Outcomes | 3 | **Connectivity:** Increase the area of land directly connected to regional natural systems in order to improve ecosystem services | Future | Pending | | 3.5 | | |
| NS-3 | Outcomes | 4 | **Restoration:** Reduce the difference between the actual acreage restored and targeted acreage established in the natural systems plan or land conservation plan | Future | Pending | | 3.5 | | |
| NS-3 | Actions | 1 | Develop a plan to protect and restore natural resources through land conservation, corridor connectivity, and restoration of biological integrity and function | Complete | Meeting target | 2 | 2 | Protection and restoration of natural resources are addressed in watershed assessments conducted by Coos Watershed Association. These assessments guide the organization's restoration and monitoring activities throughout the watershed. There is not a single consolidated plan, but sub-basins are grouped in assessment documents. | CoosWA Assessments:<br>Sustainability scan survey-CoosWA |
| NS-3 | Actions | 2 | Adopt land use regulations that establish appropriate wetland, stream, and shoreline buffer widths and adjacent land uses | Complete | Meeting target | 3 | 3 | These regulations are specified in Oregon Statewide Planning Goals, with which local comprehensive plans are required to comply. Coos County Comprehensive Plan and the Coos County Zoning and Land Development Ordinance lays out specifics regarding buffer widths. Forestry land uses are regulated by the Northwest Forest Practices Act. Agricultural land uses are covered by the Coos and Coquille Area Agricultural Water Quality Management Plan, 2010. | Sustainability scan survey-CoosWA; Coos County Comprehensive Plan: Zoning and Land Dev. Ordinance: Ag WQ plan |
| NS-3 | Actions | 3 | Create an advisory board to inform land conservation and restoration activities | Complete | Meeting target | 1 | 1 | Coos Watershed Association Board of Directors as well as the Restoration Projects Committee (Board members, agency staff, and technical experts). City of Coos Bay staff member sits on CoosWA Board. There is a County liaison to CoosWA, who is currently Bob Main. The County Planner, Jill Rolfe, has participated in the CoosWA's Partnership for Coastal Watersheds project.<br>CoosWA has quite a bit more interaction with Coos Bay compared to North Bend. | Sustainability scan survey-CoosWA |

| Goal | Outcome/ Action | # | Description | Evaluation Status | Categorical Score | STAR Points Awarded | STAR Potential Points | If achieving or not, why? | Source |
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| NS-3 | Actions | 4 | Partner with adjacent jurisdictions, state and federal agencies, and local or regional non-profit organizations to advance land conservation and restoration efforts | Complete | Meeting target | 1 | 1 | The following partnerships address land conservation and restoration in various ways: Coos Watershed Association: local, state, and federal agency representatives sit on Board of Directors, along with community members and groups. Board meets monthly and committees meet on varying schedules.<br>Coos Soil & Water Conservation District: farming, ranching, and general landowner representatives from the various zones of the county work with landowners to improve their properties and enhance natural resources through voluntary measures and state support; the Coos SWCD also assists in the reveiw and update of the Agricultural WQ Management Plan every two years.<br>Coos Bay Estuary Water Quality Partnership: Has been in existence for about 15 years, though it has gone through periods of less activity. It is supported by DEQ Section 319 funding and currently led by the Coos Watershed Association.<br>Partnership for Coastal Watersheds: Started in about 2011, representatives from local, state, federal agencies, businesses, community organizations, etc. are involved. PCW committees meet on varying schedules. | Sustainability scan survey-CoosWA |
| NS-3 | Actions | 5 | Sponsor educational and outreach activities to increase ecological literacy and knowledge about natural resource protection | Complete | Meeting target | 2 | 2 | The South Slough NERR offers a variety of field trip activities, regularly scheduled programming, and summer camps for students preK-12. They also have adult programming including workshops, special hikes, and periodic teacher training for curriculum development. The Coos Watershed Association offers watershed stewardship programming for 8-12th grade students, summer riparian vegetation youth crew programs, and internships for college students. CoosWA alos offers periodic trainings and workshops for adults and teachers in the community. Both South Slough NERR and CoosWA participate in community events to conduct outreach to the community at large. The Coos Soil & Water Conservation District sponsors and participates in various events and activities that focus on 5-12th grades and adults. | |
| NS-3 | Actions | 6 | Adopt land use strategies to incentivize permanent land conservation | Complete | Does not meet target | 0 | 4 | CoosWA is not aware of any incentive programs at the local/County level. | Sustainability scan survey-CoosWA |
| NS-3 | Actions | 7 | Implement local and market-based financing strategies to acquire land or development easements, or fund restoration and maintenance activities | Complete | Partially meeting target | 0 | 4 | Federal programs are active locally: USDA programs such as the Conservation Reserve Enhancement Program and the Wetland Reserve Program provide incentive mechanisms; On the state level, OWEB has an acquisitions program and all of its grant programs for restoration receives funding from the Oregon Lottery. The Water Board is working with CoosWA to finance restoration at Matson Creek Wetland Preserve as a way to mitigate for their expansion of water resource infrastructure. Otherwise, CoosWA is not aware of any programs at the local/County level. | Sustainability scan survey-CoosWA; OWEB program; CREP |
| NS-3 | Actions | 8 | Restore, maintain, and monitor conserved natural lands to increase natural resource resilience, adaptability, and biological integrity | Complete | Meeting target | 6 | 6 | The North Spit, managed by BLM, is conserved for mixed uses, including recreation and some areas in particular are managed for important snowy plover habitat (most successful breeding area on the Pacific coast). State Parks land (Cape Arago, Golden & Silver Falls, Shore Acres, Sunset Bay) is conserved area used for restoration and recreation. South Slough NERR is conserved natural land with a high emphasis on restoration and maintaining natural integrety of the entire system.<br>The Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians' (re-)acquired acquisition the Cape Arago Lighthouse, which may be managed for natural resource restoration. | Sustainability scan survey-CoosWA |

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| NS-4 | Outcomes | 1 | **Concentration and Emissions:** Option A: Achieve attainment or maintenance status for all measured criteria pollutants<br>--OR--<br>Option B: Part 1: Demonstrate a decrease in the annual concentration of the non-attainment criteria pollutant(s) that have the greatest impacts on public health, specifically PM 2.5, PM10, and ozone<br>--AND--<br>Part 2: Demonstrate a decrease trend in the annual number of days in which the Air Quality Index (AQI) exceeds 100 over the past 5 years | Complete | Does not meet target | 0 | 15 | Air Quality Index is unavailable for Coos Bay/Coos County, both on EPA's website and DEQ's website. Air quality data would have to be collected locally.<br><br>Coos County Environmental Health does not currently montior and track outdoor air quality. They report that DEQ may have some role in this function.<br><br>Coos County Community Health Assessment (2013) reported that the annual number of unhealthy air quality days due to fine particulate matter in 2007 was 14 (Oregon average: 12) and the annual number of unhealthy air quality days due to ozone was 0 (Oregon average: 1), according to County Health Rankings, accessed 2013.<br><br>According to DEQ, the air quality on the coast is generally good thanks to frequent air exchanges in coastal airsheds. Therefore, the DEQ manages its air sampling resources to monitor large urban areas like Portland, Salem and Medford, as well as areas of concern along the Willamette Valley (Oakridge, Klamath Falls). The Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians maintains its own AQ monitoring station, which has a webpage with updated data available at: http://trexwww.ucc.nau.edu/cgi-bin/daily_summary.pl?cams=1036 . Thanks.<br><br>Data from CDC WONDER program on fine particular matter (PM2.5) from 2003-2011 shows an overall decline in Coos County from 2003, but 2009-2011 shows a slight increase. 2009: 7.2 μg/m³; 2010: 7.57; 2011: 7.71. (CDC Wonder program data is used in Robert Wood Johnson Foundation County Health Rankings. http://www.countyhealthrankings.org/) | Sustainability Scan survey of County department; CDC Wonder program; Direct correspondance |
| NS-4 | Actions | 1 | Adopt regulatory strategies that permit or incentivize increased residential and employment densities and diverse uses in transit-served areas and areas identified for compact, mixed-use development | Complete | Partially meeting target | 0 | 3 | See Built Environment-3, Action 3: City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently has incentives to increase densities in these areas. | Sustainability Scan of city/county governments. |
| NS-4 | Actions | 2 | Adopt performance -based parking pricing, establish parking maximums, or eliminate parking minimums in transit-served areas and areas identified for compact, mixed-use development, **AND** incorporate at least 2 other advanced parking strategies. | Complete | Meeting target | 3 | 3 | See Built Environment-3, Action 6: Cities of Coos Bay and North Bend and Coos County currently have parking strategies in compact, mixed-use development areas. | Sustainability Scan of city/county governments. |
| NS-4 | Actions | 3 | In collaboration with a local university or health department, conduct a study to evaluate the health impacts of acute exposure to outdoor air pollutants, particularly in consideration of environmental justice and equity impacts | Complete | Does not meet target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County has conducted an evaluation about this topic for the Community Health Implementation Plan by assessing three measures from County Health Rankings, but air pollution was not identified as a significant health issue for the county (Page 36, CHIP 2013). | Sustainability Scan of city/county governments; Coos County Community Health Implementation Plan (2013) |
| NS-4 | Actions | 4 | Collaborate with local industrial operations to reduce and minimize the release of noxious odors in the community | Complete | Partially meeting target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend currently collaborates with industries on this topic. Coos County has conducted an evaluation about this topic for the Community Health Implementation Plan by assessing three measures from County Health Rankings, but air pollution was not identified as a significant health issue for the county (Page 36, CHIP 2013). | Sustainability Scan of city/county governments; Coos County Community Health Implementation Plan (2013) |
| NS-4 | Actions | 5 | Partner with a local or regional organization to support one or more transportation management association(s) that promote rideshare programs and incentives for commuters to use alternative modes of transportation to work other than single-occupancy vehicles | Complete | Partially meeting target | 0 | 1 | City of Coos Bay and Coos County have no current action/activity on this topic. City of North Bend currently promotes rideshare programs/incentives for commuters to use alternative modes of transportation. | Sustainability Scan of city/county governments. |

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| **NS-4** | Actions | 6 | Educate the public about the impacts of poor air quality on human health and the natural environment and the efforts they can take to reduce pollution and exposure | Complete | Does not meet target | 0 | 2 | Coos County Environmental Health currently does not have education or outreach on this topic. | Sustainability Scan survey of County department |
| **NS-4** | Actions | 7 | Enforce anti-idling regulations or burning restrictions to prevent emission of excess pollution, particularly on Air Quality Action Days | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **NS-4** | Actions | 8 | Improve traffic signal timing or upgrade intersections to relieve congestion | Complete | Meeting target | 6 | 6 | City of Coos Bay and City of North Bend currently make/have made these improvements. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **NS-4** | Actions | 9 | Increase the mileage of sidewalks and dedicated bicycle infrastructure that connect people with destinations | Complete | Partially meeting target | 0 | 6 | City of Coos Bay has increased mileage to connect key locations. City of North Bend has no current action/activity on this topic. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **NS-4** | Actions | 10 | Create or enhance programs aimed at increasing tree canopy through active planting or direct tree protections | Complete | Partially meeting target | 0 | 4 | City of Coos Bay has a tree canopy planting/protection program. City of North Bend has no current action/activity on this topic. Coos County has no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **NS-4** | Actions | 11 | Implement targeted programs to encourage residents to transition to cleaner products | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **NS-5** | Outcomes | 1 | **Hydrologic Integrity:** Demonstrate that the amount of water withdrawn from the system for human uses does not exceed the amount of freshwater entering the system through precipitation, river flow, and other sources | Future | Unable to be evaluated | 0 | 5 | The CBNB Water Board has specific amounts of water that can be withdrawn on a daily basis for each of its water sources. However, the Conservation and Management Plan does not include an assessment of the amount of water withdrawn and the amount flowing into the system. | CBNB Water Board Water Conservation and Management Plan |
| **NS-5** | Outcomes | 2 | **Biologic Integrity:** Achieve a biological integrity rating of 'Very Good' or 'Good' based on EPA's 305(b) reporting requirements for all water bodies with appropriate designated uses | Complete, pending update | Does not meet target | 0 | 5 | Based on the Oregon 2010 305(b)/(d) Integrated Report, 13% of water segments in the Coos watershed that have aquatic life as a beneficial use are Categories 1 or 2, meaning water quality standards are met. 12% are Categories 3B or 3C, meaning there is potential concern. 5% are Category 4, meaning WQ is limited, but a TMDL is not needed. 10% are Category 5, meaning WQ is limited and a TMDL is needed. 59% cannot be determined due to insufficient data. View datasheet: NS-5-O4 | Oregon 2010 Integrated Report on surface waters |
| **NS-5** | Outcomes | 3 | **Chemical Integrity - Pollutants:** Option A: Demonstrate pollutant loadings below Total Maximum Daily Load (TMDL) levels<br>--OR--<br>Option B: Demonstrate a steady decrease in pollutant levels towards a long-term goal of below TMDL levels | Future | Unable to be evaluated | 0 | 5 | TMDL is prequisite for achieving this outcome. | |
| **NS-5** | Outcomes | 4 | **Chemical Integrity - Usability:** Demonstrate that all non-industrial water bodies are swimmable and fishable during 90% of days in the past year<br>--OR--<br>Option B: Demonstrate a steady reduction in water closures of at least 2% annually towards achieving 90% of days being swimmable and fishable | Pending response | Pending | | 5 | ODA website maintains shellfish harvest closures. Oregon Department of Health maintains Algae Bloom Advisories (swimming), which are also reported on the Coos County Public Health website.<br>Only 2 beach closures in past 3 years, as reported on EPA's BEACON website: a 2-day closure in 2011 and a 6-day one in 2013, both at Sunset Bay State Park. | Algae Bloom Advisory archive:<br>ODA shellfish harvest closures:<br>Beach closures: BEACON program: |
| **NS-5** | Actions | 1 | Adopt a watershed management plan that integrates natural water bodies with human water use and addresses inputs and outputs of the water systems | Complete | Meeting target | 2 | 2 | Water Board has a Watershed Conservation and Management plan that addresses water use and supply. The Water Board and City of Coos Bay have a joint management plan for the Pony Creek and Joe Ney watersheds that focuses more specifically on forest management (adopted by City Council November 20, 2012, according to minutes). There is not this type of plan for the entire Coos watershed, with the exception that CoosWA always includes a section on water appropriation (human and livestock use) in its watershed assessments. | Water Board Watershed Conservation and Management plan; Pony Creek/Joe Ney WMP; City of Coos Bay Council minutes |
| **NS-5** | Actions | 2 | Adopt community regulations that protect water quality **OR** participate in a regional pollutant trading program that reduces watershed pollution levels | Complete | Does not meet target | 0 | 3 | This is not currently happening locally. However, there may be some developments with stormwater management. It is also likely that regulations or a trading program will develop as the TMDL for the Coos watershed is developed in the next few years. | Sustainability scan survey-CoosWA |

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| NS-5 | Actions | 3 | Create partnerships to address sources of non-point source water pollution not directly covered by local authority or control | Complete | Meeting target | 1 | 1 | The Coos Bay Estuary Water Quality Partnership was originally convened by SSNERR, but has been in existence (in a manner) for probably 15 years. Needs identified in the late 1990s led to the installation of the 4 initial stream gaging stations, beginning in about 2002 with funding from an OWEB grant. The past few years have been more active. CoosWA has led the Estuary Water Quality Partnership with DEQ §319 funding.<br><br>The Partnership for Coastal Watersheds is a collaborative group that also addresses water quality and pollution by looking at a water quality data network. It has developed a Water Quality Inventory with a georeferenced database of all the data collection sites for water quality. These partnerships may develop more fully as the TMDL for the Coos watershed is developed in the next few years. | Sustainability scan survey-CoosWA |
| NS-5 | Actions | 4 | Create an education campaign about ambient water quality, pollution prevention, mitigation, and restoration techniques | Complete | Meeting target | 2 | 2 | See NS-3, Action 5: The South Slough NERR offers a variety of field trip activities, regularly scheduled programming, and summer camps for students preK-12. They also have adult programming including workshops, special hikes, and periodic teacher training for curriculum development. The Coos Watershed Association offers watershed stewardship programming for 8-12th grade students, summer riparian vegetation youth crew programs, and internships for college students. CoosWA alos offers periodic trainings and workshops for adults and teachers in the community. Both South Slough NERR and CoosWA participate in community events to conduct outreach to the community at large. The Coos Soil & Water Conservation District sponsors and participates in various events and activities that focus on 5-12th grades and adults. | |
| NS-5 | Actions | 5 | Provide incentives to residents and developers to protect and restore critical watershed protection areas | Complete, pending update | Partially meeting target | 0 | 4 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County currently has such incentive programs. Oregon Watershed Enhancement Board provides grants to Coos Watershed Association and small grants to landowners to restore watersshed areas. The Coos SWCD helps landowners apply for small grants and secure them, and the CoosWA works with landowners as well to secure funds and implement projects. Unless the county provides separate funding, it appears there is no local incentives available. | Sustainability Scan of city/county governments; OWEB |
| NS-5 | Actions | 6 | Engage in restoration projects for critical water bodies and buffer zones that protect those water bodies | Complete | Meeting target | 6 | 6 | All of the restoration projects that Coos Watershed Association conducts are in high priority streams and their riparian areas. Project information can be acquired through CoosWA. | Sustainability scan survey-CoosWA |
| NS-5 | Actions | 7 | Develop and provide water conservation programs to residents, businesses and agricultural water users in order to help ensure that the community is not depleting its water supply | Complete | Partially meeting target | 0 | 4 | See BE-2, Action 7: "The Water Board has a successful history of public education to encourage wise use of water. The utility will continue the following efforts: (1) Free leak detection surveys; (2) helping customers determine the possible locations of leaks; (3) Offer toilet leak detection tablets; (4) Make available brochures and pamphlets on leak detection and water conservation; (5) Maintain wise use of water information on utility website." - Water Conservation and Management Plan (2009), page 9. These public outreach efforts are still active, as of 5/21/2014. No other efforts have been taken to increase conservation. City of Coos Bay, City of North Bend, Coos County have no current action/activity on its own. | Direct correspondance, CBNBWB Water Conservation and Management Plan (2009); Sustainability Scan of city/county governments |

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| NS-5 | Actions | 8 | Establish or partner with a group that routinely inventories and monitors natural water bodies for biological, chemical, and hydrological integrity | Complete | Meeting target | 4 | 4 | Coos Watershed Association conducts Aquatic Habitat Inventories and Road and Landing Sediment Surveys, and manages stream gaging stations.<br>CoosWA stream gaging station data (daily discharges) are provided to the Oregon Water Resources Department for incorporation into the State Water Record Archive. All the data CoosWA collects with OWEB funding is required to be deposited in either the ODFW Monitoring Database (aquatic habitat inventory; spawning surveys) or the DEQ Volunteer Monitoring Database (temperature).<br><br>CoosWA conducts monitoring under contract for the Coos Bay/North Bend Water Board (streamflows at Pony, Tenmile and Eel Creeks), stream flow in Tioga Creek under contract with BLM, and for the Bandon Dunes Resort on Whiskey Run Creek. CoosWA will also be doing Western Lily monitoring for the U.S. Fish & Wildlife Service soon.<br><br>The South Slough Reserve has a system-wide water quality monitoring network, as well as four additional sites in the upper estuary. | Sustainability scan survey-CoosWA |
| NS-6 | Outcomes | 1 | **Land Management:** Option A: Use critical best management practices (BMPs) on 100% of working lands in the jurisdiction<br>--OR--<br>Option B: Demonstrate a 2-5% increase in working lands utilizing critical BMPs over time | Complete, pending update | Partially meeting target | 0 | 6.3 | Forestry operations are required to follow BMPs for Forest Practices Act. 2004; It is assumed that all forestry operations follow the FPA and utilize BMPs; The Coos-Curry Area Agricultural Water Quality Management Plan (2010) suggest "positive management practices" to improve water quality among agricultural lands, but compliance with these practices does not seem to be monitored; State DOGAMI mining permits require best management practices. | |
| NS-6 | Outcomes | 2 | **Certified Sustainable Harvests:** Increase the number of certified sustainable harvesters for a locally-selected industry over time | Complete, pending update | Meeting target | 4.2 | 4.2 | Industry: Forestry; Certification systems: Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI), American Tree Farm System; The latter two certifications are included in the Programme for the Endorsement of Forest Certification (PEFC).<br>The most recent 5-year average percent change in number of harvesters with FSC and SFI certification: 17% (2009-2013). See document "NS-6-O2_SustainableHarvest" | Forest Stewardship Council (FSC), Sustainable Forestry Initiative (SFI) websites; Direct correspondence |
| NS-6 | Actions | 1 | Include considerations for protecting working lands and identifying areas where BMPs are necessary in the community's land conservation or natural resource plan | Complete | Meeting target | 2 | 2 | Coos County has such measures included in the Comprehensive Plan and the Zoning and Land Development Ordinance regarding agricultural lands (Chapter 5.3, Exclusive Farm Zones), forest lands (Ch. 5.4, Forestry Zones), and mining lands (Ch. 5.5). | Coos County Comprehensive Pland and Zoning and Land Development Ordinance |
| NS-6 | Actions | 2 | Convene owners and operators of working lands to promote sustainable harvesting practices | Complete | Partially meeting target | 0 | 1 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County reports partnering with owners/operators for this purpose. | Sustainability Scan of city/county governments. |
| NS-6 | Actions | 3 | Educate owners and operators of working lands about current best management practices | Complete | Partially meeting target | 0 | 2 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County reports education/outreach on this topic. | Sustainability Scan of city/county governments. |
| NS-6 | Actions | 4 | Promote the value of locally produced, certified sustainable harvests and products to the public | Complete | Partially meeting target | 0 | 2 | City of Coos Bay has no current action/activity on this topic. City of North Bend has no current action/activity on this topic. Coos County reports education/outreach on this topic. | Sustainability Scan of city/county governments. |
| NS-6 | Actions | 5 | Work with youth groups and community organizations to implement BMPs on local working lands | Complete | Meeting target | 2 | 2 | Coos Watershed Association has two programs that involve youth in restoration practives for riparian zones and other BMPs: Master Watershed Stewards Youth Program and Oregon Youth Conservation Corpsv(OYCC) summer program. These efforts were assisted by AmeriCorps members from 2011-2014. Additional crews have been active periodically over the years, including AmeriCorps teams, Northwest Youth Corps crews, other OYCC crews, and special BLM crews. | Sustainability scan survey-CoosWA |

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| **NS-6** | Actions | 6 | Provide conservation programs and services tailored to the needs of the working lands community | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **NS-6** | Actions | 7 | Encourage owners of working lands to conserve their properties in perpetuity | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |
| **NS-6** | Actions | 8 | Implement financing strategies to conserve working lands and support ongoing restoration efforts | Complete | Does not meet target | 0 | 4 | City of Coos Bay, City of North Bend, and Coos County have no current action/activity on this topic. | Sustainability Scan of city/county governments. |

| Author/Organization | Title | Prepared By | City of Publication | Publisher | Date of Publication | Electronic Resource Access Date | Electronic Resource Web Address |
|---|---|---|---|---|---|---|---|
| Americans for the Arts | Local Arts Index | | | | | 2014 | www.artsindexusa.org/where-i-live |
| Center for Neighborhood Technology | H+T Affordability Index | | | | 2012 | 2014 | http://htaindex.cnt.org/ |
| City of Bandon | Local Wetlands Inventory | Pacific Habitat Services, Inc. | Bandon | City of Bandon | 2003 | 2014 | http://www.oregon.gov/dsl/WETLAND/Pages/lwi_disclaimer_agreed |
| City of Coos Bay | Coos Bay Municipal Code: A Codification of the General Ordinances of the City of Coos Bay, Oregon | | Seattle | Code Publishing Company | | 2014 | http://www.codepublishing.com/or/coosbay/ |
| City of Coos Bay | Minutes of the Proceedings of the City Council | | Coos Bay | City of Coos Bay | 2011-2013 | | |
| City of Coos Bay | Comprehensive Plan | | Coos Bay | City of Coos Bay | 2000 | | |
| City of Coos Bay | Parks Master Plan: FY 2013/23 | | Coos Bay | City of Coos Bay | 2013 | | |
| City of Coos Bay | Transportation System Plan | DKS Associates | Coos Bay | City of Coos Bay | 2004 | | |
| City of Coos Bay | Housing Needs Analysis Final Report | Cogan-Owens-Cogan and Angelo Planning Group | Coos Bay | City of Coos Bay | 2009 | | |
| City of Coos Bay and Coos Bay-North Bend Water Board | Watershed Management Plan | Stuntzner Engineering & Forestry, LLC | Coos Bay | City of Coos Bay and Coos Bay-North Bend Water Board | 2012 | 2013-2014 | http://cb.delaris.com/uploads/PDF/WMP_Final.pdf |
| City of Coos Bay Budget Committee | City of Coos Bay Budget: Approved FY 2013/2014 | | Coos Bay | City of Coos Bay | 2013 | | |
| City of North Bend | Comprehensive Plan | | North Bend | City of North Bend | 2003 | | |
| City of North Bend | North Bend City Council Minutes | | North Bend | City of North Bend | 2011-2013 | | |
| City of North Bend | North Bend Municipal Code: A Codification of the General Ordinances of the City of North Bend, Oregon | | Seattle | Code Publishing Company | 2005 | 2014 | http://www.org/documents/NorthBendORfullcode-May2014 |
| City of North Bend | Transportation System Plan | DKS Associates | North Bend | City of North Bend | 2004 | | |
| City of North Bend Budget Committee | City of North Bend Budget: FY 2013/2014 | | North Bend | City of North Bend | 2013 | | |
| Community Service Center | University of Oregon: Coos County Multi-Jurisdictional Natural Hazards Mitigation Plan: Report for Coos County and the cities of Bandon, Coos Bay, Coquille, Lakeside, Myrtle Point, North Bend, and Powers | The Oregon Partnership for Disaster Resilience, University of Oregon | Eugene | University of Oregon | 2010 | | |
| Coos Bay School District | Online Policy Manual | | | | | 2014 | http://policy.osba.org/coosbay/ |
| Coos Bay-North Bend Water Board | Consumer Confidence Report | | Coos Bay | Coos Bay-North Bend Water Board | 2011-2013 | | |
| Coos Bay-North Bend Water Board | Water Management and Conservation Plan | | Coos Bay | Coos Bay-North Bend Water Board | 2009 | | |
| Coos County | Coordinated Transportation Plan, First Update | Umpqua Community Development Corporation and Coos County Area Transit Service District | Coquille | Coos County | 2009 | | |
| Coos County | Coos County Transportation System Plan | | Coquille | Coos County | 2011 | | |
| Coos County | Solid Waste Management Plan | URS | Coquille | Coos County | 2006 | | |
| Coos County | Coos Bay Estuary Plan: An Element of the Coos County Comprehensive Plan | | Coquille | Coos County | 1975 | | |
| Coos County | Coos County Zoning and Land Development Ordinance | | Coquille | Coos County | 1985 | | |
| Coos County | Coos County SDAT Report | Coos County Sustainable Design Assessment Team | Coquille | Coos County | 2010 | | |
| Coos County | Coos County 10-Year Homeless Plan | Oregon Coast Community Action and Shoji Planning, LLC | Coquille | Coos County | 2009 | | |
| Coos County and Curry County | Household Hazardous Waste Management Plan | Kies Strategies with Tabor Consulting Group and Bell & Associates, Inc. | Coquille | Coos and Curry Counties | 2008 | | |
| Coos County Commission on Children and Families | Community Comprehensive Plan Update | | Coquille | Coos County | 2010 | | |
| Coos County Cooperative Weed Management Area | Long Term Management Plan | | Coquille | Coos County Cooperative Weed Management Area | | | |
| Coos County Cultural Coalition | Coos County Cultural Plan, 2011 Revision | | Coos Bay | Coos County Cultural Coalition | 2004 | | |
| Coos County Emergency Management Division | Coos County Emergency Management Strategic Plan | Community Planning Workshop and Oregon Partnership for Disaster Resilience, Community Service Center of the University of Oregon | Coquille | Coos County | 2013 | | |
| Coos County Emergency Management Division | Coos County Emergency Operations Plan | Ecology and Environment, Inc. | Coquille | Coos County | 2009 | | |
| Coos County Public Health | Coos County Community Health Improvement Plan: 2013-2016 | | Coquille | Coos County | 2013 | | |
| Coos County Public Health | Coos County Community Health Assessment | | Coquille | Coos County | 2013 | | |
| Coos County Public Health | Annual Plan, 2012-2013 | | Coquille | Coos County | 2012 | | |
| Coos Watershed Association | Model Watershed Program | | Charleston, Oregon | Coos Watershed Association | 2008 | | |
| Coos Watershed Association | Watershed Assessments | | | | | 2013-2014 | http://www.cooswatershed.org/publications.html |
| Dyer, Gary L | Bikeway Master Plan for Coos Bay Bay Area and Coos County Parks | | | | 1991 | | |
| Federal Bureau of Investigation | Uniform Crime Reporting Statistics | | | | | 2013-2014 | http://www.ucrdatatool.gov/Search/Crime/Local/LocalCrime.cfm |
| Feeding America | Map the Meal Gap | | | | 2012 | 2014 | http://tinyurl.com/mapthemealgap |
| Forest Stewardship Council | Global FSC Certificate Database | | | | | 2014 | http://info.fsc.org/certificate.php |
| Green Building Initiative | Green Globes Certification Lists | | | | | 2014 | http://www.thegbi.org/green-globes/ |
| Living Building Challenge | Certified Projects | | | | | 2014 | http://living-future.org/node/132 |

| Author/Organization | Title | Prepared By | City of Publication | Publisher | Date of Publication | Electronic Resource Access Date | Electronic Resource Web Address |
|---|---|---|---|---|---|---|---|
| National Highway Traffic Safety Administration | Fatality Analysis Reporting System (FARS) Encyclopedia | | | | | 2014 | http://www-fars.nhtsa.dot.gov/Main/index.aspx |
| North Bend Redevelopment Agency | Annual Financial Impact Report | | North Bend | City of North Bend | 2011-2013 | | |
| North Bend School District | School Board Policies | | | | | 2014 | http://www.nbend.k12.or.us/NB13_Board/Policies/NBSD13-School-Board-Policies.htm |
| Oregon Building Codes Division | 2014 Oregon Energy Efficiency Specialty Code | | | | | 2014 | http://ecodes.biz/ecodes_support/free_resources/Oregon/14_Energy/14_OREnergy_main.html |
| Oregon Building Codes Division | 2011 Oregon Reach Code | | | | | 2014 | http://ecodes.biz/ecodes_support/free_resources/Oregon/11_Reach/11_ORReach_main.html |
| Oregon Building Codes Division | 2011 Oregon Resident Specialty Code | | | | | 2014 | http://ecodes.biz/ecodes_support/free_resources/Oregon/11_Residential/11_ORResidential_main.html |
| Oregon Coast Community Action | Annual Report 2011-12 | | North Bend | Oregon Coast Community Action | 2012 | | |
| Oregon Department of Agriculture | Shellfish Safety Closures | | | | | 2014 | http://www.oregon.gov/ODA/FSD/Pages/shellfish_status.aspx |
| Oregon Department of Education | Oregon School and District Report Card for Coos Bay School District, North Bend School District, and Bandon School District | | Salem | Oregon Department of Education | 2010-2014 | | |
| Oregon Department of Energy | Oregon Renewable Portfolio Standard | | | | 2007 | 2014 | http://www.oregon.gov/ENERGY/RENEW/Pages/RPS_home.aspx |
| Oregon Department of Environmental Quality | Oregon's 2010 Integrated Report on Surface Waters, Using Assessment Database | | | | | 2013-2014 | http://www.deq.state.or.us/wq/assessment/rpt2010/search.asp |
| Oregon Department of Environmental Quality | Wastewater Permits Database | | | | | 2013-2014 | http://www.deq.state.or.us/wq/sisdata/sisdata.asp |
| Oregon Department of Environmental Quality | Water Quality Permit Status Database | | | | | 2014 | http://www.deq.state.or.us/permittracker/StatusOfPermitApplicationSearch.aspx |
| Oregon Department of Environmental Quality, Land Quality Division | Oregon Material Recovery and Waste Generation and Rates Report | | Portland | Oregon Department of Environmental Quality | 2010-2012 | 2014 | http://www.deq.state.or.us/lq/sw/recovery/materialrecovery.htm |
| Oregon Department of State Lands | Administrative Rules on Removal-Fill/Wetlands | | | | | 2013-2014 | http://www.oregon.gov/dsl/Pages/all_rules.aspx#Removal_Fill_Wetlands |
| Oregon Health Authority | Algae Bloom Advisory Archive | | | | | 2014 | http://public.health.oregon.gov/HealthyEnvironments/Recreation/HarmfulAlgaeBlooms/Archive/Pages/index.aspx |
| Oregon Health Authority | Oregon Healthy Teens Survey for Coos County | | Salem | Oregon Division of Public Health | 2005, 2008, 2013 | | |
| Oregon Parent Teacher Association | PTA Database | | | | | 2014 | http://www.oregonpta.org/index.htm |
| Oregon State Historic Preservation Office | Coos Bay Historic Downtown Reconnaissance Level Survey | Leesa Gratreak, Kenneth Gunn, and Cara Kaser | Salem | Oregon State Historic Preservation Office | 2011 | | |
| Sustainable Forestry Initiative | SFI Certificate Database | | | | | 2014 | http://64.34.105.23/PublicSearch/MainSearch.aspx?AspxAutoDetectCookieSupport=1 |
| The Oregon Consortium and Oregon Workforce Alliance | Local Implementation Plan | | Albany, Oregon | The Oregon Consortium and Oregon Workforce Alliance | 2012 | | |
| U.S. Bureau of Labor Statistics | Quarterly Census of Employment and Wages, Using Location Quotient Calculator | | | | | 2013-2014 | http://data.bls.gov/location_quotient/ControllerServlet |
| U.S. Census Bureau | American Community Survey: various tables 2010-2013, Using American FactFinder | | | | | 2013-2014 | http://factfinder2.census.gov |
| U.S. Census Bureau | Small Area Income and Poverty Estimates (SAIPE) | | | | | 2014 | http://www.census.gov/did/www/saipe/data/index.html |
| U.S. Department of Energy | Alternative Fueling Station Locator | | | | | 2014 | http://www.afdc.energy.gov/locator/stations/ |
| U.S. Department of Energy | Database of State Incentives for Renewables & Energy (DSIRE) | | | | | 2014 | http://www.dsireusa.org/incentives/index.cfm?re=1&ee=1&spv=0&st=0&srp=1&state=OR |
| U.S. Environmental Protection Agency | Beach Advisory and Closing Online Notification System (BEACON) | | | | | 2014 | http://iaspub.epa.gov/waters10/beacon_data.about_beacon |
| U.S. Environmental Protection Agency | EJView: Environmental Justice Sites Mapping Tool | | | | 2013 | 2014 | http://epamap14.epa.gov/ejmap/entry.html |
| U.S. Environmental Protection Agency | Enforcement and Compliance History Online (ECHO) | | | | | 2014 | http://echo.epa.gov/ |
| U.S. Fish & Wildlife Service | National Wetland Inventory, Using Wetlands Mapper | | | | | 2014 | http://www.fws.gov/wetlands/Data/Mapper.html |
| U.S. Green Building Council | Leadership in Energy & Environmental Design (LEED) Projects Directory | | | | | 2014 | http://www.usgbc.org/projects |
| University of Wisconsin Population Health Institute and Robert Wood Johnson Foundation | County Health Rankings & Roadmaps | | | | | 2013-2014 | http://www.countyhealthrankings.org |
| Urban Renewal Agency of the City of Coos Bay | Annual Financial Impact Report | | Coos Bay | City of Coos Bay | 2011-2013 | | |
| US Healthiest | HealthLead Workplace Accreditation | | | | | 2014 | http://www.ushealthiest.org |
| Worksource Oregon | Workforce Investment Act (WIA) Annual Report: Program Year 2012 | | | Worksource Oregon | 2012 | | https://ccwd.oregon.gov/WIARept/perfrept.aspx |
| Worksystems, Inc. | Propsperity Planner for Oregon Residents | | | | | 2014 | https://www2.prosperityplanner.org/ |

# SUSTAINABILITY SCAN: City and County Governments

## Background

This Sustainability Scan is a part the Coos Estuary Inventory Project, an effort to conduct a comprehensive assessment of environmental and socioeconomic conditions in the greater Coos Bay area. The Sustainability Scan will specifically inform the socioeconomic component of the assessment. The Coos Estuary Inventory Project is an initiative of the Partnership for Coastal Watersheds (PCW), which is described below:

The mission of the Partnership for Coastal Watersheds (PCW) is to collaborate to understand watershed conditions and address their capacity and resiliency to serve ecological, economic, and social needs for present and future generations. The PCW is guided by four subcommittees comprised of community stakeholders from a wide range of sectors and industries in the greater Coos Bay area. The PCW subcommittees are supported by staff from the Coos Watershed Association and the South Slough National Estuarine Research Reserve. For more information about the PCW, please visit http://www.partnershipforcoastalwatersheds.org/.

## Purpose & Methodology

The purpose of the Sustainability Scan is to learn about the steps that local government agencies are taking to improve the sustainability of the Coos Estuary and its communities. In this document, "sustainability" is used in a comprehensive way. Drawing on the STAR Community Rating System, an evaluation framework developed by a large group of nationally-recognized leaders and experts in community sustainability, the Sustainability Scan addresses seven key areas:

- Built Environment
- Economy & Jobs
- Education, Arts, & Community
- Equity & Empowerment
- Climate & Energy
- Health & Safety
- Natural Systems

The results of the Sustainability Scan will help PCW staff complete the STAR Rating System. The data, compiled from this broad range of sectors, will be entered into a formula to provide a "score" that is intended to give communities a quantitatively-based estimate of how they are doing in terms of social, economic, cultural, and environmental parameters. Once completed, the STAR evaluation will contribute to the Coos Estuary Inventory Project and its State of the Watershed report, which will give the community a dynamic resource to track community and watershed health over time.

For more information about the STAR Community Rating System, visit http://www.starcommunities.org/.

## Instructions

1. Please go through each section and mark <u>one</u> box in the appropriate column to indicate whether your government is: (a) currently doing the given action, (b) considering the action or initiative either in formal discussions/proposals or informal meetings, or (c) not doing the action and not currently considering it.

*Please note:* This Sustainability Scan is being completed by city and county agencies. If an item is not under your jurisdiction or is not pertinent to your level of government, please mark "Not doing it" and write as much in the *Notes* column.

2. If you mark "Doing it now" or "Thinking about it," please explain your answer in the *Notes* column. For example, if there is currently a code, zoning rule, ordinance, policy, plan, regulation, or standard is in place, or in development, please detail its specific number/name so it can be documented by PCW staff. If some issues have a longer history, try to focus on changes or improvements that have been made in the past three years.
3. A general rule of thumb is the more information, the better. The more details you provide, the more comprehensive the overall assessment will be, making it a more useful tool for our community.
4. Save the document and e-mail it back to e.wright@cooswatershed.org.

**If you have questions...**

...About the table, how to fill it out, or what specific actions mean, please contact Emily Wright at e.wright@cooswatershed.org or (608) 697-7896.

...About the PCW, Coos Estuary Inventory Project, or partnering with your agency, please contact:

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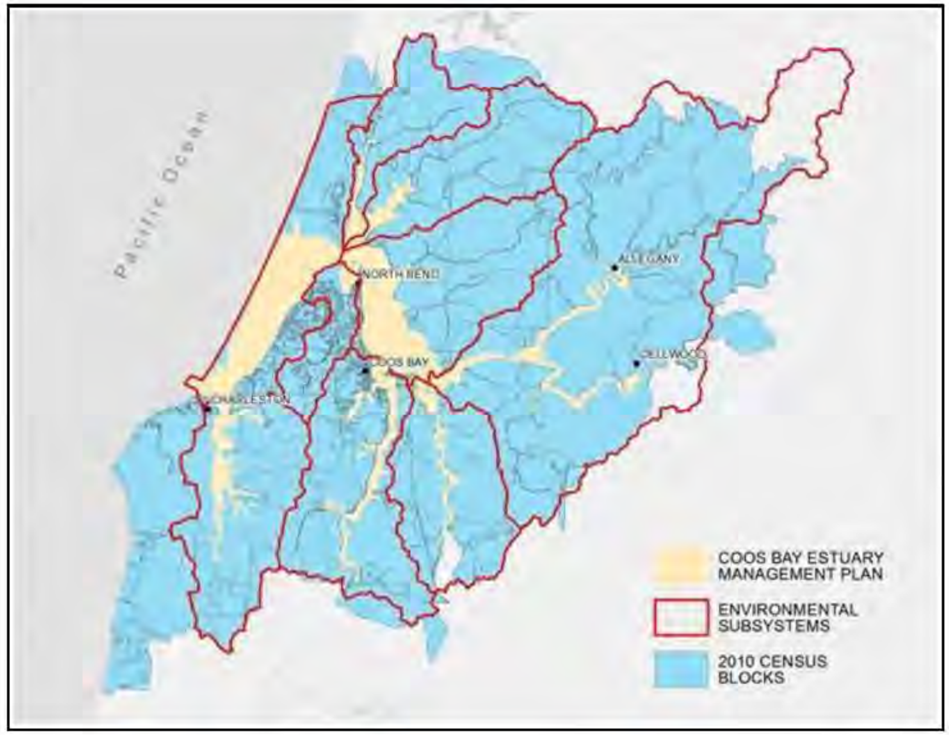



Map of the Environmental (red outline) and Socioeconomic (blue) boundaries for the Coos Estuary Inventory Project Area

Agency: Name: Title: Date:

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| **BUILT ENVIRONMENT** | | | | | |
| Ambient Noise & Light | Community noise or light policy/ordinance based upon local assessment | ☐ | ☐ | ☐ | |
| | Education/outreach about standards, effects, and mitigation of excessive noise/light | ☐ | ☐ | ☐ | |
| | Partnership to address noise/light pollution not subject to local authority | ☐ | ☐ | ☐ | |
| | Procedures to track noise/light complaints, prioritize improvements, and enforce standards | ☐ | ☐ | ☐ | |
| | Program to eliminate light pollution from government buildings | ☐ | ☐ | ☐ | |
| Community Water Systems | Water conservation program for residents, businesses, and agricultural users | ☐ | ☐ | ☐ | |
| | Water infrastructure or facility projects utilizing innovative water conservation/efficiency methods | ☐ | ☐ | ☐ | |
| Compact Communities | Policy and/or planning to support compact, mixed-use development | ☐ | ☐ | ☐ | |
| | Incentives to increase residential/employment densities in compact, mixed-use development areas | ☐ | ☐ | ☐ | |
| | Parking policies in compact, mixed-use development areas | ☐ | ☐ | ☐ | |
| | Build-to lines for commercial/residential structures in compact, mixed-use development areas | ☐ | ☐ | ☐ | |
| | Development standards involving walkability requirements (sidewalks on both sides of roads, street trees, ADA accessible crosswalks, etc.) | ☐ | ☐ | ☐ | |
| Affordable Housing | Analysis of impact on housing costs when planning infrastructure investments | ☐ | ☐ | ☐ | |
| | Strategies to encourage infill and redevelopment with mixed housing types in key neighborhoods | ☐ | ☐ | ☐ | |
| | Incentives for creation/preservation of affordable and subsidized housing in compact, mixed-use development areas | ☐ | ☐ | ☐ | |
| | Partnership with other agencies to address housing needs | ☐ | ☐ | ☐ | |
| | Partnership with community organizations to offer education and financial assistance homebuyers/renters | ☐ | ☐ | ☐ | |
| | Promoting live-near-your-work or employer-assisted housing financial incentives for private employers | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| Infill & Redevelopment | Prioritized inventory of infill, previously developed, brownfield, or greyfield sites to (re)develop | ☐ | ☐ | ☐ | |
| | Education/outreach about infill, redevelopment, and brownfields assessments, strategies, and resources | ☐ | ☐ | ☐ | |
| | Brownfields cleanup, in collaboration with state/federal entities | ☐ | ☐ | ☐ | |
| | Support neighborhood uses for vacant properties and greyfields | ☐ | ☐ | ☐ | |
| | Incentives for infill and redevelopment | ☐ | ☐ | ☐ | |
| | Zoning enforcement/vacant lot cleanup in redeveloped or blighted area | ☐ | ☐ | ☐ | |
| | Targeted infrastructure improvements to catalyze redevelopment | ☐ | ☐ | ☐ | |
| Public Spaces | Economic impact assessment of parks/public spaces on local economy | ☐ | ☐ | ☐ | |
| | Regulation/incentives to create, maintain, and connect parks/public spaces | ☐ | ☐ | ☐ | |
| | Design guidelines for new public spaces/improvements for environmental or visitor benefits | ☐ | ☐ | ☐ | |
| | Local/regional partnership for park system improvements | ☐ | ☐ | ☐ | |
| | Advisory board for parks/public spaces | ☐ | ☐ | ☐ | |
| | Assistance to low-income park/pool users | ☐ | ☐ | ☐ | |
| Transportation | Bicycle and/or pedestrian master plan | ☐ | ☐ | ☐ | |
| | Complete streets policy explicitly stating that streets should be designated for the safety, comfort, and convenience of all common users: pedestrians, cyclists, drivers, and public transit riders. The policy should apply to all projects with limited exceptions and include implementation steps. | ☐ | ☐ | ☐ | |
| | Walkability standards for subdivisions/other developments | ☐ | ☐ | ☐ | |
| | Employee incentives to commute via carpool, transit, or bike/walk | ☐ | ☐ | ☐ | |
| | Enforcement programs for pedestrian, bicycle, motorist safety | ☐ | ☐ | ☐ | |
| | Public bike share program | ☐ | ☐ | ☐ | |
| | Transportation infrastructure meets Americans with Disabilities Act standards | ☐ | ☐ | ☐ | |
| **CLIMATE AND ENERGY** | | | | | |
| Climate | Climate change adaptation plan | ☐ | ☐ | ☐ | |
| | Policy to use climate science to inform internal government decisions | ☐ | ☐ | ☐ | |
| | Collaborative committee addressing climate change vulnerabilities | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| Adaptation | Codes/regulations and/or programs addressing climate change threats and effects | ☐ | ☐ | ☐ | |
| | Regulations or incentives for residents and businesses to prepare for climate change impacts | ☐ | ☐ | ☐ | |
| | Facility improvements to better prepare for climate change threats | ☐ | ☐ | ☐ | |
| Greenhouse Gas Mitigation | Climate action plan to reduce GHG emissions | ☐ | ☐ | ☐ | |
| | Requirement to consider GHG emissions in decision-making | ☐ | ☐ | ☐ | |
| | Education/outreach about GHG reduction efforts | ☐ | ☐ | ☐ | |
| | Climate change advisory group | ☐ | ☐ | ☐ | |
| | Energy efficiency regulations for buildings | ☐ | ☐ | ☐ | |
| | Incentives for renewable energy sources | ☐ | ☐ | ☐ | |
| | Programs or facility upgrades to reduce GHG emissions, transition toward alternative transportation, or reduce waste | ☐ | ☐ | ☐ | |
| Green Energy Supply | Plan or policy to advance alternative/renewable energy sources | ☐ | ☐ | ☐ | |
| | Zoning/regulations promoting renewable energy/alternative fueling systems | ☐ | ☐ | ☐ | |
| | Partnerships with energy providers and consumers to match renewable energy sources with needs | ☐ | ☐ | ☐ | |
| | Renewable portfolio standard for utilities | ☐ | ☐ | ☐ | |
| | Incentives for renewable energy/alternative fuel infrastructure | ☐ | ☐ | ☐ | |
| | Net-metering program encouraging small-scale renewable energy | ☐ | ☐ | ☐ | |
| | Electrify truck stops for reduced idling | ☐ | ☐ | ☐ | |
| | Infrastructure improvements to support renewable energy investments | ☐ | ☐ | ☐ | |
| Industrial Resource Efficiency | Plan to improve resource efficiency of industrial sector | ☐ | ☐ | ☐ | |
| | Regulation to reduce energy and water use | ☐ | ☐ | ☐ | |
| | Policies and partnerships to improve and promote data collection of emissions and mitigation efforts | ☐ | ☐ | ☐ | |
| | Targets, trainings, or other programs for reducing industrial energy/water use | ☐ | ☐ | ☐ | |
| | Financial incentives for industrial resource efficiency | ☐ | ☐ | ☐ | |
| | Infrastructure development to support greater industrial resource efficiency | ☐ | ☐ | ☐ | |
| Resource Efficient | Plan for energy/water efficiency of commercial, residential, and institutional buildings | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| Buildings | Building codes include water/energy efficiency standards for new/renovated buildings and are enforced by trained inspectors | ☐ | ☐ | ☐ | |
| | Ordinance requiring energy/water users to disclose consumption levels | ☐ | ☐ | ☐ | |
| | Education/outreach engaging citizens/businesses in energy/water efficiency | ☐ | ☐ | ☐ | |
| | Committee(s) addressing resource efficiency in buildings | ☐ | ☐ | ☐ | |
| | Sub-metering programs with utilities | ☐ | ☐ | ☐ | |
| | Incentives to encourage upgrades and resource efficient certified buildings | ☐ | ☐ | ☐ | |
| Public Infrastructure Resource Efficiency | Targeted strategies, codes, or standards to improve resource efficiency of public infrastructure | ☐ | ☐ | ☐ | |
| | Require consideration of resource consumption in planning efforts | ☐ | ☐ | ☐ | |
| | Partnerships with state/regional agencies for resource reduction | ☐ | ☐ | ☐ | |
| | Public works/infrastructure managers voluntarily report GHGs | ☐ | ☐ | ☐ | |
| | Training for infrastructure operators on efficiency techniques | ☐ | ☐ | ☐ | |
| | Specific upgrades to increase efficiency | ☐ | ☐ | ☐ | |
| **ECONOMY AND JOBS** | | | | | |
| Business Retention and Development | Project labor, community benefit, or local hiring agreements for projects using public funds | ☐ | ☐ | ☐ | |
| | Formal engagement with business community on regular basis | ☐ | ☐ | ☐ | |
| | Advisory board representing the business community | ☐ | ☐ | ☐ | |
| Green Market | Policies, strategies, or regulations to increase market demand for green products, services, buildings, and materials | ☐ | ☐ | ☐ | |
| | Zoning codes encourage green businesses | ☐ | ☐ | ☐ | |
| | Policy for city/county's energy supplies to come from renewable/alternative sources | ☐ | ☐ | ☐ | |
| | Community partnership to strategically develop green products/services | ☐ | ☐ | ☐ | |
| | Education/outreach to foster green businesses, jobs, and practices | ☐ | ☐ | ☐ | |
| | Purchasing program to promote internal procurement of environmentally responsible products | ☐ | ☐ | ☐ | |
| | Assist businesses transitioning to green practices | ☐ | ☐ | ☐ | |
| Local Economy | Plan to increase local production for local consumption/export | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| | Campaign to bank/buy locally, or from small, independent businesses | ☐ | ☐ | ☐ | |
| | Incentives for businesses to source materials and sell products within region | ☐ | ☐ | ☐ | |
| | Connect business owners with investors to facilitate local investments | ☐ | ☐ | ☐ | |
| | Import substitution strategies for key sectors of the local economy | ☐ | ☐ | ☐ | |
| Quality Jobs and Living Wages | Living wage policy for all employees and contractors | ☐ | ☐ | ☐ | |
| | Family-friendly workplace policies for employees and contractors (paid sick days, flexible scheduling, family leave, etc.) | ☐ | ☐ | ☐ | |
| | Policy strategies to raise income/assets and remove upward mobility barriers for working poor and low-income families | ☐ | ☐ | ☐ | |
| | Support living wage and/or economic self-sufficiency campaigns | ☐ | ☐ | ☐ | |
| | Recognize local businesses supporting employees and families | ☐ | ☐ | ☐ | |
| | Collective bargaining relationships with public employee labor organizations | ☐ | ☐ | ☐ | |
| | Training for businesses, employers, and employees to promote family-friendly and living wage practices | ☐ | ☐ | ☐ | |
| Workforce Readiness | Alignment of economic development strategies with workforce development programs | ☐ | ☐ | ☐ | |
| | Requirement for government contractors and entities receiving financial incentives to prioritize local hiring | ☐ | ☐ | ☐ | |
| | Data sharing agreement with private sector to promote economic and workforce development planning | ☐ | ☐ | ☐ | |
| **EDUCATION, ARTS, AND CULTURE** | | | | | |
| Arts and Culture | Percent-for-art ordinance requiring public art installations for major new developments | ☐ | ☐ | ☐ | |
| | Zoning encouraging clusters of creative industries and integration with neighborhoods | ☐ | ☐ | ☐ | |
| | Financial/logistical support to local arts, festivals, etc. | ☐ | ☐ | ☐ | |
| | Hiring local artists to create artwork, sculptures, or perform in public spaces, and protect/maintain public artwork and cultural resources | ☐ | ☐ | ☐ | |
| Community | Plans and partnerships with neighborhoods to guide future development, addressing neighborhood-specific issues | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| Cohesion | Zoning/regulations that support or incentivize farmers markets, community gardens, urban agriculture | ☐ | ☐ | ☐ | |
| | Access to information serving non-English speaking residents | ☐ | ☐ | ☐ | |
| | Agency department and/or staff work as liaisons with neighborhoods | ☐ | ☐ | ☐ | |
| | Financial/logistical support for neighborhood venues, public events, and programming | ☐ | ☐ | ☐ | |
| Historic Preservation | Historic preservation plan | ☐ | ☐ | ☐ | |
| | Land use, design, or other regulations to support character in historic areas and promote compatible infill development | ☐ | ☐ | ☐ | |
| | Support local events/programs that celebrate and leverage historic resources | ☐ | ☐ | ☐ | |
| | Certified Local Government status recognized by National Park Service | ☐ | ☐ | ☐ | |
| | Demolition by neglect ordinance for older buildings | ☐ | ☐ | ☐ | |
| | Incentives or assistance for rehabilitation/maintenance of historic buildings and reinvestment in historic areas | ☐ | ☐ | ☐ | |
| | Technical assistance to property owners seeking listing on historic national or state register | ☐ | ☐ | ☐ | |
| Social and Cultural Diversity | Assessment of community's social/cultural diversity that informs government actions | ☐ | ☐ | ☐ | |
| | Use Diversity Index to assess effectiveness of policies, programs, services, and infrastructure investments | ☐ | ☐ | ☐ | |
| | Policy to encourage diversity in government appointments | ☐ | ☐ | ☐ | |
| | Equity and diversity training for staff | ☐ | ☐ | ☐ | |
| | Office to ensure access, equity, and inclusion in policies, programs, and services | ☐ | ☐ | ☐ | |
| | Training to support representation on boards/commissions reflective of community | ☐ | ☐ | ☐ | |
| | Financial/logistical support for programs/events that celebrate and deepen understanding of community diversity | ☐ | ☐ | ☐ | |
| **EQUITY AND EMPOWERMENT** | | | | | |
| Civic Engagement | Guidelines/training to aid employees in successfully engaging residents | ☐ | ☐ | ☐ | |
| | Regular, ongoing opportunities for elected officials/staff to answer questions/concerns of residents | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| | Volunteer program for residents to assist government events, services, operations | ☐ | ☐ | ☐ | |
| | Support and resources for local community groups | ☐ | ☐ | ☐ | |
| Civil and Human Rights | Policies protecting civil and human rights of all residents | ☐ | ☐ | ☐ | |
| | Office and/or independent commission to ensure civil and human rights and investigate complaints | ☐ | ☐ | ☐ | |
| | Education/outreach regarding civil and human rights | ☐ | ☐ | ☐ | |
| | Language translation/interpretation services to ensure residents' access to information | ☐ | ☐ | ☐ | |
| Environmental Justice (EJ) | Collaborative EJ Group to assess risk/exposure, set targets, implement projects, and monitor improvements | ☐ | ☐ | ☐ | |
| | Assessment of EJ sites, plan for reduction/remediation, and/or monitoring and enforcement of environmental regulations for facilities impacting sites | ☐ | ☐ | ☐ | |
| | EJ criteria/priorities in planning, zoning, permitting, and new development policies | ☐ | ☐ | ☐ | |
| | Internal working committee to support EJ activities | ☐ | ☐ | ☐ | |
| | Projects to reduce exposure/risks associated with EJ sites | ☐ | ☐ | ☐ | |
| Equitable Services & Access | Equity plan evaluating current conditions and setting targets to improve equitable access to community services | ☐ | ☐ | ☐ | |
| | Policy committing equity in decision-making, activities, and investments | ☐ | ☐ | ☐ | |
| | Outreach on efforts to improve equitable access to community facilities, services | ☐ | ☐ | ☐ | |
| | Community partnerships to advance equitable access to community facilities, services | ☐ | ☐ | ☐ | |
| Poverty Prevention and Alleviation | Community-wide plan to reduce poverty | ☐ | ☐ | ☐ | |
| | Government team to work with community organizations on services and poverty reduction | ☐ | ☐ | ☐ | |
| **HEALTH AND SAFETY** | | | | | |
| Active Living & | Standards or incentives for bicycle/pedestrian amenities in new major developments | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| Community Health | Guidelines for incorporating features promoting active lifestyles in new buildings | ☐ | ☐ | ☐ | |
| | Advisory board for government issues affecting active living in community | ☐ | ☐ | ☐ | |
| | Support programs encouraging active living for adults, kids | ☐ | ☐ | ☐ | |
| | Program systematically improving bicycle/pedestrian amenities community-wide | ☐ | ☐ | ☐ | |
| | "Health in all policies" statement or policy commitment for decision-making | ☐ | ☐ | ☐ | |
| Food Access & Nutrition | Zoning/development regulations specifically allowing farmers markets, community gardens, and urban agriculture | ☐ | ☐ | ☐ | |
| | Zoning/regulations that limit/prohibit sale of unhealthful foods | ☐ | ☐ | ☐ | |
| | Menu-labeling regulations to discourage/tax/prohibit sale of unhealthful foods/beverages | ☐ | ☐ | ☐ | |
| | Outreach about food, nutrition, gardening, or food assistance programs | ☐ | ☐ | ☐ | |
| | Program to purchase and sell healthful foods at government-owned/operated facilities | ☐ | ☐ | ☐ | |
| | Incentives for healthful retail food outlets to locate in underserved areas | ☐ | ☐ | ☐ | |
| Indoor Air Quality | Smoking ban in multi-family buildings, housing authority residential buildings, or an ordinance allowing landlords to establish smoke-free rental units | ☐ | ☐ | ☐ | |
| | Requirement for new/substantially renovated government buildings to have advanced ventilation standards | ☐ | ☐ | ☐ | |
| | Grant/loan program to remediate indoor air pollution problems in low-income or affordable residences | ☐ | ☐ | ☐ | |
| Natural and Human Hazards | All-hazard vulnerability assessment informing a hazard mitigation action plan or integrated into comprehensive plan | ☐ | ☐ | ☐ | |
| | Post-disaster plan addressing long-range redevelopment issues (e.g., land use, economic development, etc.) | ☐ | ☐ | ☐ | |
| | Education/outreach about natural hazards | ☐ | ☐ | ☐ | |
| | Insurance/incentives to equitably remove residents from hazardous situations | ☐ | ☐ | ☐ | |
| | Build/renovate local public facilities to meet code standards to be used as shelters/command centers | ☐ | ☐ | ☐ | |
| Safe | Community survey conducted about perceptions of safety | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| Communities | Safe communities strategic plan adopted, with education/outreach efforts, community partnerships, and coordinated cross-agency implementation | ☐ | ☐ | ☐ | |
| | Ongoing data collection and evaluation from various agencies to identify trends and needs | ☐ | ☐ | ☐ | |
| | Violence prevention, suppression, and enforcement programs and strategies | ☐ | ☐ | ☐ | |
| | Comprehensive, monitored reentry program for ex-offenders | ☐ | ☐ | ☐ | |
| **NATURAL SYSTEMS** | | | | | |
| Green Infrastructure<br>*Green infrastructure provides environmental services, such as sustaining clean air and water or providing habitat benefits. Though green infrastructure may also decrease resource consumption, it is not a necessary characteristic.* | Community-wide green infrastructure plan with a monitoring program | ☐ | ☐ | ☐ | |
| | Design criteria/codes requiring green infrastructure in new developments, and relevant departmental review of proposed developments to ensure standards are met and environmental protections put in place | ☐ | ☐ | ☐ | |
| | Partnership with community groups to ensure appropriate green infrastructure use | ☐ | ☐ | ☐ | |
| | Incentive program to encourage landowners to implement green infrastructure | ☐ | ☐ | ☐ | |
| | Investments in green infrastructure, increasing over time | ☐ | ☐ | ☐ | |
| | Upgrade public buildings/spaces to incorporate best green infrastructure practices and provide for ongoing maintenance | ☐ | ☐ | ☐ | |
| Invasive Species | Ensure government buildings use native plants or non-invasive species in landscaping | ☐ | ☐ | ☐ | |
| | Ordinance requiring control of listed priority invasive species or native plant ordinance for private and public landscaping | ☐ | ☐ | ☐ | |
| Outdoor Air Quality | Evaluation of health impacts of exposure to outdoor air pollutants in community | ☐ | ☐ | ☐ | |
| | Collaboration with industries to reduce release of noxious odors | ☐ | ☐ | ☐ | |
| | Promote rideshare programs/incentives for commuters to use alternative modes of transportation | ☐ | ☐ | ☐ | |
| | Anti-idling and/or burning regulations | ☐ | ☐ | ☐ | |
| | Traffic signal timing improvements or intersection upgrades to relieve congestion | ☐ | ☐ | ☐ | |

| | | Doing it now | Thinking about it | Not doing it | Notes |
|---|---|---|---|---|---|
| | Increased mileage of sidewalks and dedicated bicycle infrastructure, aimed at connecting key locations | ☐ | ☐ | ☐ | |
| | Tree canopy planting/protection program | ☐ | ☐ | ☐ | |
| | Clean products promotion program for residents | ☐ | ☐ | ☐ | |
| Water in the Environment | Incentive programs for residents/developers to protect/restore critical watershed protection areas | ☐ | ☐ | ☐ | |
| Working Lands | Partnerships with owners/operators to promote sustainable harvesting practices | ☐ | ☐ | ☐ | |
| | Education/outreach to owners, operators, and residents about BMPs and sustainable harvesting | ☐ | ☐ | ☐ | |
| | Programs to facilitate implementation of BMPs or promote conservation easements | ☐ | ☐ | ☐ | |
| | Financial strategies to help owners/operators transition to better practices | ☐ | ☐ | ☐ | |

# **Chapter 3:** Communities and Neighborhoods

*Jon Souder - Coos Watershed Association*

Photos: Downtown Coos Bay from the water (Top) and aerial of North Bend, looking north (Bottom). Credits: Coos Bay Net and Tim Palmer

*Summary:*

- *Community identity is one of the most significant sources of social capital within the project area.*
- *Ideally, community is what links residents to a geographic location, as well as to a common set of experiences.*
- *Maintaining community social capital has become increasingly difficult in the project area as immigration and work patterns have expanded and traditional links have broken.*

**Introduction**

Humans have always organized themselves into communities. Originated as extended family groupings, communities evolved into groupings around common belief systems, locations to provide services to travelers, and as a result of place-based employment. Today, communities are increasingly fractionalized into groups of people with similar interests and outlooks, and through improved communication networks, these communities have expanded beyond a local or regional focus. Integral to the idea of community is the identity that aggregates individuals into the group; having a common identify should allow group decisions to be made more expeditiously with a higher likelihood of continuity over time.

Our coverage will distinguish among different levels of communities, focusing on geographic connections within the project area. This is an arbitrary choice, given that community identity could originate from larger realms (the United States, Pacific Northwest, Oregon, or the Southern Oregon Coast). However, focusing on the project area should allow for greater depth in analysis, discussion, and links to other chapters. In this context, we will distinguish between “communities” and “neighborhoods”:

> Communities are outlying populated areas surrounded by forests and fields.
>
> Neighborhoods exist as sub-divisions within urbanized areas, generally within incorporated cities or adjacent to them.

These—and others—can be considered “communities” in the social sense, but there are different levels of government between communities and neighborhoods in the geographic context. More recently, there are social media “communities” that are not necessarily place-based, but are interest-based. There are many of these in the project area, but are too transitory to be addressed here.

- International (Treaty)
  - Federal (United States)
    - Tribal (Coos & Coquille)
    - State (Oregon)
      - Multi-county Special Districts
      - County (Coos)
        - Voting Precincts
        - County Special Districts
          - Public School Districts
          - Port & Airport Districts
          - Drainage & Diking Districts
          - Library District
          - Urban Renewal Districts
          - Road Improvement Districts
        - City (Coos Bay & North Bend)
          - CB/NB Water Board
          - Urban Renewal Districts
        - County Land Use Designations
          - Zoning Classification System
          - Urban Unincorporated
          - Rural Unincorporated
          - Rural Service Center
          - Estuary Management

Figure 1: The hierarchy of governmental units.

Superimposed upon the social considerations of “community” is a hierarchy of governmental units with varying effects. Under the system of government in the United States, laws and regulations established at higher levels of government usually provide an umbrella over those at lower levels. Figure 1 shows this hierarchy, with particular emphasis on those at the county level and finer. In this chapter we will focus on those that define “community” in the governmental sense; however, these levels of government will play important roles in subsequent chapters and discussions.

**Communities in the Project Area**

Settlement in the Coos Bay region—whether by Native Americans or Anglo-Americans—was usually situated based on access to resources and travel patterns. Native American villages where commonly established around Coos Bay in the vicinity of stream mouths and other locations that had easy access to fish and shellfish and game. Similarly, when Anglo-American settlement began in the mid-19th Century, communities were first located adjacent to convenient ocean-based transportation (i.e., Empire), and subsequently often grew around sites where modes of transportation changed, such as Allegany and Sumner, where overland wagon roads ended at the heads-of-tide and passengers switched to boats to continue their journey (or vice-versa). Communities also grew up around logging camps, especially when families began to arrive with their need for schools, churches, and post offices. Figure 2 shows the majority of the distinct populated communities within the project area, including those from early settlement that have subsequently died out.

As transportation networks expanded and changed, a community’s importance and size also changed. For example, the end of the Coos Bay Wagon Road from Roseburg was originally Sumner, where passengers transferred to boat to continue on to Marshfield (Coos Bay); and because of this, hotels, restaurants, and bathhouses were built there to serve travelers. When the road was continued to Coos City, access to Marshfield through Isthmus Slough proved quicker and the need for services in Sumner died. Sub-

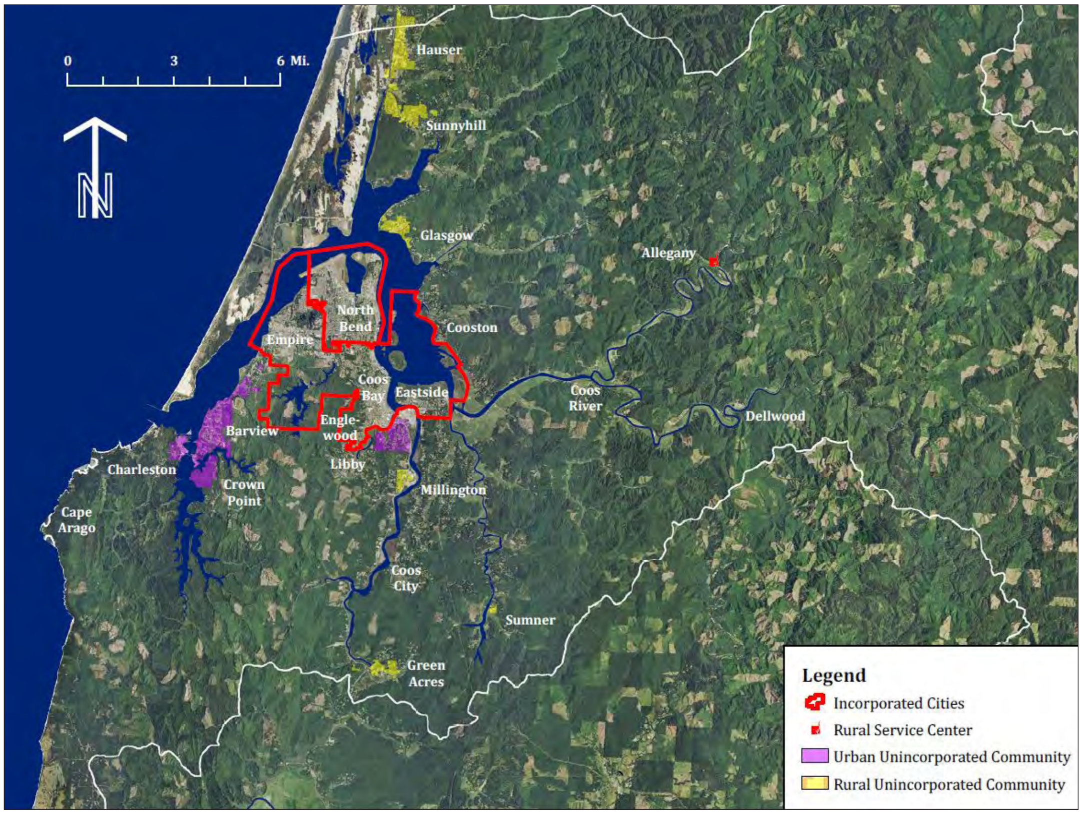



Figure 2: Communities and populated places in the project area.

sequently, once a ferry was installed at Coos City (and later a bridge) to meet the railroad and highway, passengers continued on to Marshfield, and Coos City became a ghost town.

Some communities continued to expand and develop because they were adjacent to logging camps. Allegany provides perhaps the best example of this: in the late 1890s and through the early decades of the 20th Century, timber along Marlow Creek was being logged. A logging camp at the mouth of Marlow Creek supported the community of Allegany, which was also a turnaround for boat traffic and a transfer site to the wagon road to Scottsburg. As logging in Marlow Creek died out, Weyerhaeuser Timber Co. began to access its timber in the East Fork Millicoma basin and established its logging camp on the other side of the Millicoma River. As transportation improved, residents in outlying communities could more easily access better schools and work opportunities in the cities of Coos Bay and North Bend, thus leading to the closure of many community institutions (schools and post offices) as residents began commuting to the larger cities rather than living and working locally. Currently, commutes from outlying communities are relatively short compared to state-wide averages and big cities (see Table 1).

*Community Descriptions*

Contemporary communities shown in the map on Figure 2 have all evolved over time, but their identity is often based on their origin and events that have occurred in the past. Knowing these origin stories is important in understanding community identity. Short descriptions of these communities are based on *Oregon Geographic Names, A Century of Coos and Curry Counties*, and the *Coos County Comprehensive Plan*, and descriptions provided by Brooke Yussim of Oregon Bay Properties, LLC. Full citations are provided at the end of this chapter.

| Community | Distance (mi.) | Time (min.) |
|---|---|---|
| Allegany | 18.5 | 39 |
| Barview | 3.2 | 6 |
| Charleston | 7.3 | 14 |
| Cooston | 9.8 | 21 |
| Dellwood | 17.1 | 35 |
| Glasgow | 5 | 10 |
| Green Acres | 13.3 | 21 |
| Hauser | 9.2 | 15 |
| Libby | 5.1 | 11 |
| Millington | 6.6 | 13 |
| Sumner | 9.1 | 16 |
| Sunnyhill | 10.2 | 19 |

Table 1: Commuting distances and times to/from various communities. Distances and times are based on AAA TripTik® routings from a central point in the community to the junction of Newmark Ave. and Broadway/Woodland.

Allegany: Originally called "The Forks" because of its location at the confluence of the East and West Forks of the Millicoma River (also called the North Fork of the Coos River), the Allegany Post Office was established in 1893, and remains open with its own ZIP code (97407) (Figure 3). There is a store, a church, and a few residences. Currently, the old Allegany School serves as a community center, and there is an active group of supporters in the Allegany Parks and Recreation District and a community newsletter, "Millicoma Ripples." Allegany provides access to the southern end of the Elliott State Forest, Golden and Silver Falls State Park, and Nesika County Park, as well as to the north end of Weyerhaeuser Timber Company's Millicoma Tree Farm.

This community is primarily a Rural Service Center with very few residences. Zoning is Rural Center (RC), with some surrounding areas as RR-2 and the remainder Agriculture and Forestry. (CCCP) There are more extensive residential developments along the West Fork Millicoma Road and the Coos River Highway above Allegany on the East Fork Millicoma River and Glenn Creek.

Barview: Most likely named for its location opposite the opening of Coos Bay into the Pacific Ocean. Barview is a long, linear community that has developed on the southeast side and adjacent to the lower end of Coos Bay. It is primarily residential with a small amount of commercial use scattered along Cape Arago State Highway. Residential uses are a mixture of nice quality homes west of the highway and sited on the bay, smaller homes on very small lots, and manufactured homes and recreational vehicle parks. There are also a few very nice historic homes throughout the area.

Barview is a Census Designated Place (CDP) for reporting purposes (Figure 4A). Most of the community is zoned Urban Residential-2 (UR-2); residences west of the highway are all zoned Urban Residential-1 (UR-1), and there is a small area zoned Urban Restidential-Multi Family (UR-M). Two small areas are zoned for controlled, commercial development on five acre lots (CD-5).

Bunker Hill: Named as a result of the coal bunkers nearby, principally on the east on Isthmus Slough (although some bunkers were on Coalbank Slough). These facilities were built for shipping coal from the Bunker Hill Mine and the other Newport mines via ocean-going vessels. Bunker Hill was platted in 1906 for homes by the Flanagan estate. A post office called "Bunker Hill" was established in 1936 and operated until 1949. There is a school called Bunker Hill (presently closed), and the district offices of the Oregon Department of Forestry are currently located in Bunker Hill. Water is provided by the Coos Bay/North Bend Water Board, and sewage disposal is managed by the Bunker Hill Sanitary District, which contracts with the City of Coos Bay to treat its effluent.

Bunker Hill is a Census Designated Place (CDP) (Figure 4B). It is primarily residential to the south and east of U.S. 101, with zoning as Urban Residential Single Family (UR 1); Urban Residential Mobile Homes, Duplexes, or Planned Unit Development (UR-2); or Urban Residential Multi-family (UR-M). About 50% is zoned UR-1. Commercial uses along U.S. 101 are zoned Commercial (C-1), and Industrial

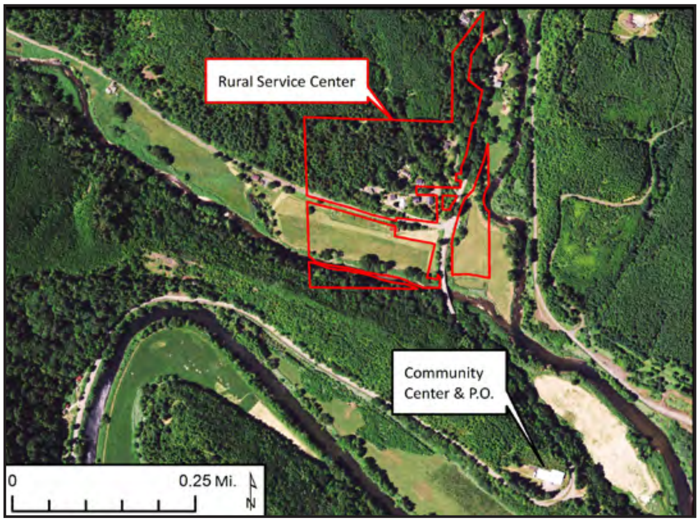



Figure 3: Allegany Rural Service Center (RSC) and surrounding community, including the community center and post office.

(IND). North of U.S. 101 and between the IND zoned areas is land zoned Control Development-5 (CD-5), although most are small lots with residences.

Charleston: Charleston is a small fishing community located southwest of Coos Bay on both sides of Cape Arago State Highway 240, at the confluence of South Slough and the Coos Bay estuary close to its exit into the Pacific Ocean (Figure 4C). Charleston provides access to Cape Arago, Sunset Bay, and Shore Acres State Parks, as well as to Bastendorff County Park. The community was named for Charles Haskel, who is said to have taken up a claim at the mouth of South Slough in 1853. The Charleston Post Office was not established until 1924, but continues to operate under the Coos Bay ZIP code (97420). Charleston previously had an elementary school, but this was closed in the summer of 2002 and subsequently sold to private individuals; however, the gymnasium is still used for community events such as Octoberfish. The densely populated areas of Charleston are served by the Coos Bay/North Bend Water Board; the Charleston Sanitary District provides sewage service.

The commercial and most of the industrial areas of Charleston are zoned Commercial (C-1). The remainder of the community is zoned Urban Residential (UR-2) (CCCP). Much of the property in Charleston is publicly-owned by The Oregon International Port of Coos Bay, the U.S. Coast Guard, and the University of Oregon. The Port operates the Charleston Marina, serving commercial and sport fishing vessels, including docks, launch ramps, an ice facility, an RV Park, and storage units. The Charleston Shipyard hosts three boat builders (Giddings Marine, Tarheel Aluminum, and Skallerud Marine), as well as a repair yard and dry storage. The University of Oregon's Institute of Marine Biology (OIMB) was built on the former site of the housing for workers constructing the jetties at the mouth of Coos Bay, and provides facilities for seven research faculty, graduate students, and visiting scientists. OIMB also provides graduate, undergraduate, and summer courses and has two research vessels, a library, laboratories, and housing. The Coast Guard presence in Charleston consists of two units: the *Aids To Navigation* team of 9 personnel and 1 reservist, that covers 240 miles of the Oregon coast and includes 5 lighthouses, 18 primary buoys, 43 secondary buoys, and 156 other lights, day beacons, and fog signals; the *Motor Life Boat Station Coos Bay* that has provided search and rescue operations from Coos Bay to Cape Blanco for over a hundred years (an older life boat facility constructed in 1915 is now owned by OIMB [known as the "Boathouse"] and is used for public presentations). The current Motor Life Boat Station was constructed in 1968, and is currently supported by 39 personnel and hosts two 47' and one

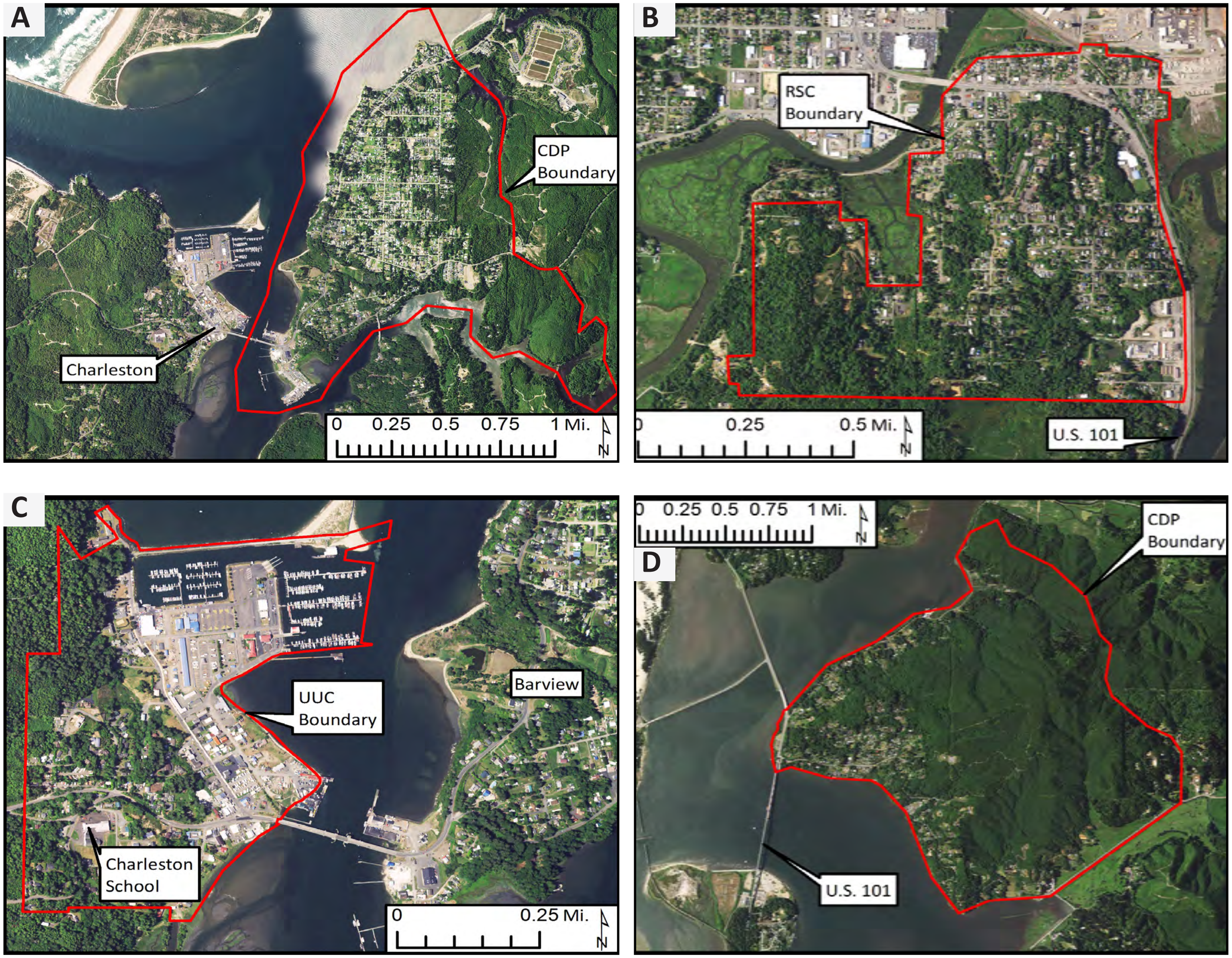



Figure 4: Census Designated Place (CDP) boundaries for the Barview (A), Bunker Hill (B), and Glasgow (D) communities, and Urban Unincorporated Boundaries for the Charleston community (C).

52’ vessels (the *Intrepid* motor life boats). The Coast Guard also owns an 8-plex and duplex housing facility in Charleston for their North Bend Sector personnel.

Glasgow: A small community on the north side of Coos Bay, Glasgow was started by speculators in the 1890s and then languished for 30 years until the construction of the Oregon Coast Highway, at which point it became the northern terminus of the Coos Bay ferry. The original promoters were the Pacific Coal & Transportation Co. Once the McCullough Bridge was opened in 1936, Glasgow became a suburban community to the cities of North Bend and Coos Bay. Glasgow retains its historic Grange Hall, a fire station, and a small grocery store with a gas pump. Glasgow is provided with drinking water by the Coos Bay/North Bend Water Board, but all residences and businesses use individual on-site septic systems for sewage disposal.

Glasgow is a Census Designated Place (CDP) for reporting purposes (Figure 4D). Approximately one-third of the central part of the community is zoned Rural Center (RC). The motel and restaurant are zoned Commercial and the remainder of the community is zoned rural Residential-2 (RR-2).

Green Acres: Green Acres is a small community between Coquille and Coos Bay, east of State Highway 42 and the railroad tracks, where Noble Creek broadens into Isthmus Slough (Figure 5). The area that is now Green Acres was originally a 700-acre farm homesteaded by master shipbuilder John Kruse, a Danish immigrant, in the late 19th century. Today the community has a Grange Hall, a volunteer fire department, and a community church. The community formerly had a school in the Coos Bay School District that closed in 1985. Green Acres is also home to the Noble Creek Fish Hatchery, operated by the Coos River Salmon Trout Enhancement Program (STEP).

Existing residential uses are on small to one-acre parcels adjacent to the school and the other public and industrial uses, which are all within the Rural Center (RC) zone. Adjacent residential areas are zoned Rural Residential-2 (RR-2). The community boundary includes all lands currently zoned Rural Center (RC), Rural Residential-2 (RR-2), and tax lot 800 zoned Industrial (IND) east of OR 42. (CCCP)

Hauser: Originally called “North Sough,” the name was changed to Hauser because the old name suggested “miasmatic surroundings” (i.e., morasses, swamps, or bad drainage that was thought in the late 1800s and early 1900s to change the electrical condition of

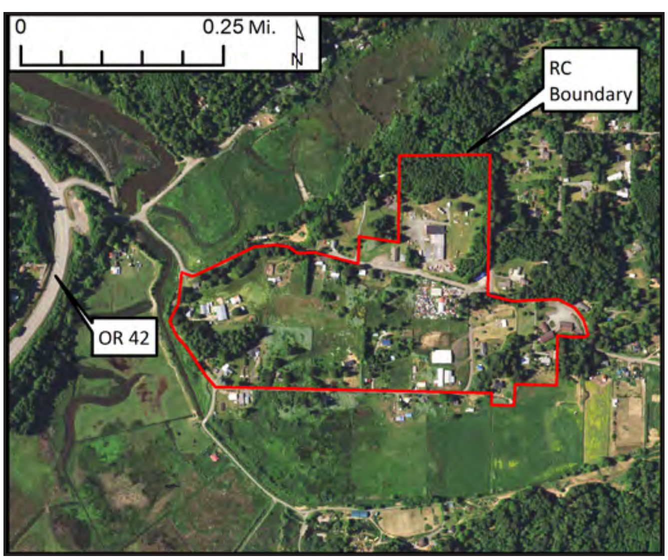
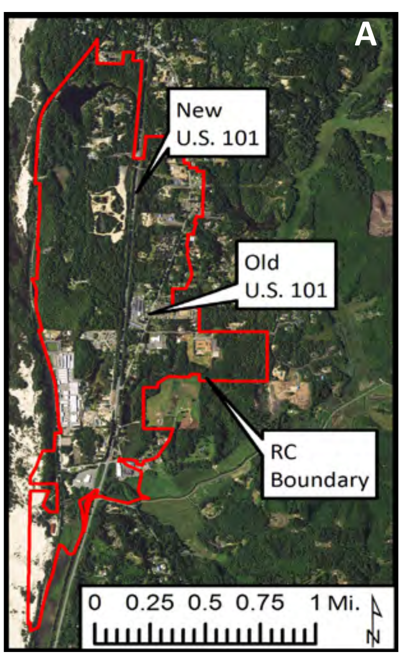



Figure 5: Green Acres Rural Community (RC) comprising residential, commercial and industrial properties.

the surrounding atmosphere, causing fevers). Established as a station north of Coos Bay on the Southern Pacific railroad, it is named for Eric V. Hauser of Portland, who had a construction contract for the railroad around 1914. The Hauser Post Office opened in 1915 and closed in 1957. The first known cranberry bog on the West Coast, built in 1885 by Charles D. McFarlin of Massachusetts, was in Hauser. The North Bay Elementary School of the North Bend School District is located in Hauser, as is the Hauser Rural Fire District and the Hauser Community Church. Hauser has a number of businesses catering to the Oregon Dunes National Recreation Area, and Riley Ranch County Park is just north. Industry in Hauser consists of the Coos Head and Conrad wood preservation treatment facilities.

Hauser is a linear, primarily residential community that evolved along Old Highway 101 and is comprised of a range of lot sizes (Figure 6A). Approximately three-quarters of the land along Old Highway 101 is zoned Rural Center (RC). The northern one-quarter and the lands east of the Rural Center designation are zoned Rural Residential-2 (RR-2). The land east of the current Highway 101 paralleling the Rural Center designation is zoned Industrial. All of the land between old Highway 101 and new Highway 101, including the lands designated Industrial (IND), are in the proposed community boundary, including the developed portions of the land zoned Rural Residential-2 (RR-2). The Myrtlewood Factory west of Highway 101 is also included.

<u>Millington:</u> Originally called "Flag Pole," Millington is primarily a residential area developed at urban densities immediately south of Bunker Hill and the City of Coos Bay (Figure 6B). Millington once had a school (Coos County School District 18), and presently has a Rural Fire Department. In addition to the residential areas, there are two existing commercial enterprises and a fire station on the west side of U.S. 101. There are two wood products facilities on the east side of U.S. 101, as well as two construction companies, a concrete batch facility, and storage areas for logs and log trucks. Most of Millington is zoned Urban Residential-2 (UR-2). Two areas east of U.S. 101 are zoned industrial, and several small areas are zoned Commerical-1 (C-1) on the west side of US. 101. There is also a large area zoned Exclusive Farm Use (EFU) that is currently vacant and undeveloped; a large area outside of the existing Urban Area Boundary, and west of the community is zoned RR-2.



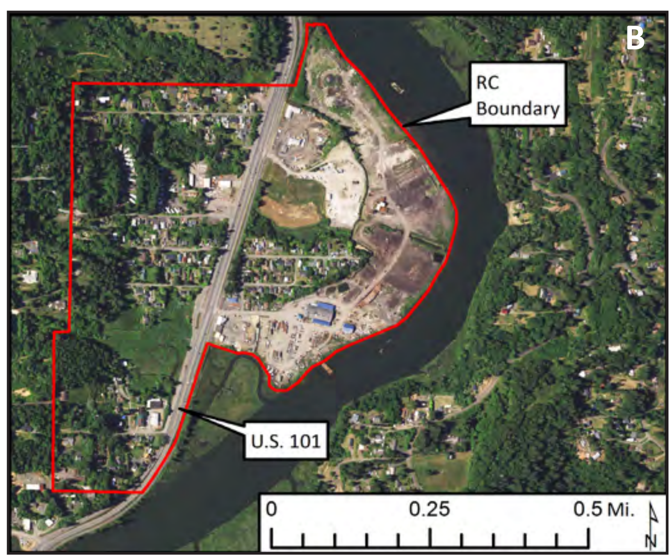




Figure 6: Rural Communities of Hauser (A, left) and Millington (B, above). Hauser runs alongside U.S. 101 in the northern end of the project area while Millington follows U.S. 101 in south of the City of Coos Bay.

Sumner: Located on the Coos Bay Wagon Road (Figure 7), which at one point was its terminus where passengers shifted to boats to reach the city of Coos Bay (Marshfield) via Catching Slough, Sumner was allegedly founded in 1888 by John B. Dalley and named for Charles Sumner (1811-1876), an antislavery politician and Massachusetts senator. The Sumner Post Office was established in 1874, with Dalley as the first postmaster, and closed at the end of 1961. Sumner had an elementary school that closed in 1985 as a result of budget difficulties in the Coos Bay School District. There is a private water system (Sumner Water Co-op) that serves an estimated 24 people using a spring for its source. Sewage is treated on-site by individual property owners. The Sumner Rural Fire District provides fire protection.

All Sumner lands are currently zoned Rural Center (RC) or Rural Residential-2 (RR-2) (CCCP).

Sunny Hill: Predominantly a residential community beginning on the east side of U.S. 101 immediately south of Hauser, the Sunny Hill community is spread out in a southeasterly direction over a series of rolling hills along North Bay Drive, a section of the original Oregon Coast Highway (Figure 8). Sunny Hill had an elementary school in the North Bend District, which is now a day-care center with space for community events. There is also a privately-owned airplane landing strip, built in 1970 and owned by Gary Femling and John Carr.

Sunny Hill is all zoned Rural Residential-2 (RR-2) with the exception of two areas zoned for industrial use, one at the northern end and one at the southern end. There are a few smaller commercial, industrial, and public uses along North Bay Drive (and the Conrad wood treatment facility might be within the designated community).

*Communities in Land Use Planning*

The State of Oregon gained oversight of local land use planning and zoning with passage of Senate Bill 100 in 1973; ultimately, counties and cities were required to create comprehensive plans to meet a set of 19 state-wide goals. The logic underlying the land use plans was—in the words of then-governor Tom McCall—to prevent "sagebrush subdivisions, coastal condo-mania, and the ravenous rampages of suburbia." This was to be done by protecting agricultural lands (Goal 3) and forest lands (Goal 4) from urbanization (Goal 14) through the creation of Urban Growth Boundaries to contain development.

County Comprehensive Plans separated populated areas outside incorporated cities into

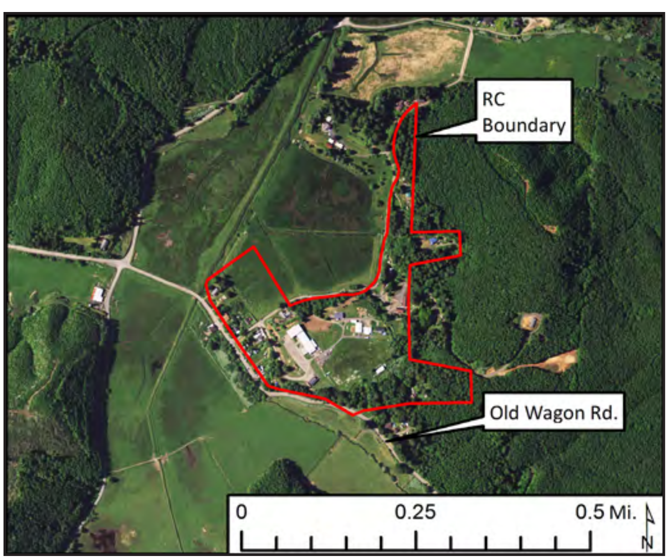



Figure 7: The Sumner Rural Community (RC) at the head of Catching Slough.

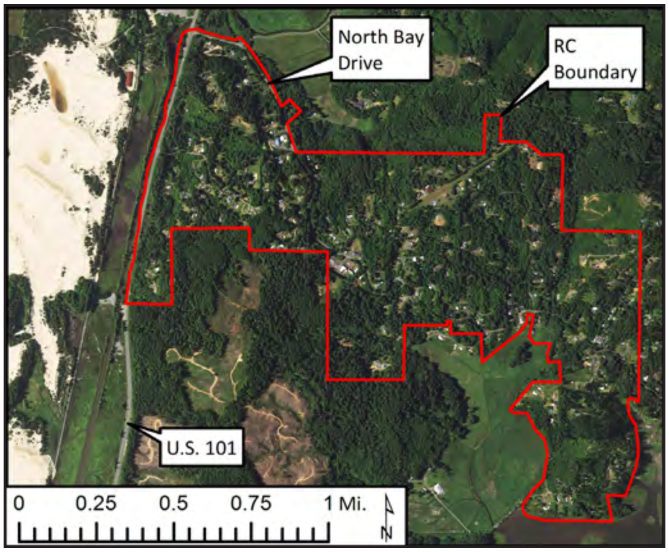



Figure 8: The Sunny Hill Rural Community (RC) between Glasgow and Hauser.

two major types, Unincorporated Communities and Urban Unincorporated Communities using definitions found in OAR 660-022-10:

> “Unincorporated Community” means a settlement with all of the following characteristics:
>
> (a) It is made up primarily of lands subject to an exception to Statewide Planning Goal 3, Goal 4 or both;
>
> (b) It was either identified in a county’s acknowledged comprehensive plan as a “rural community,” “service center,” “rural center,” “resort community,” or similar term before this division was adopted (October 28, 1994), or it is listed in the Department of Land Conservation and Development’s January 30, 1997, “Survey of Oregon’s Unincorporated Communities”;
>
> (c) It lies outside the urban growth boundary of any city;
>
> (d) It is not incorporated as a city; and
>
> (e) It met the definition of one of the four types of unincorporated communities in sections (6) through (9) of this rule [Resort Community, Urban Unincorporated Community, Rural Community, and Rural Service Center], and included the uses described in those definitions, prior to the adoption of this division (October 28, 1994).
>
> “Urban Unincorporated Community” is an unincorporated community which has the following characteristics:
>
> (a) Include at least 150 permanent residential dwellings units;
>
> (b) Contains a mixture of land uses, including three or more public, commercial, or industrial land uses;
>
> (c) Includes areas served by a community sewer system; and
>
> (d) Includes areas served by a community water system.

Of the four categories of Unincorporated Communities found in (e) above, Coos County has designated three types; the fourth, Resort Communities, that would usually apply to developments such as Bandon Dunes is not used in the Comprehensive Plan because it was approved as an “Exception” with its own zoning system.

"Rural Service Center" is an unincorporated community consisting primarily of commercial or industrial uses providing goods and services to the surrounding rural area or to persons traveling through the area, but which also includes some permanent residential dwellings.

"Urban Unincorporated Community" is an unincorporated community which has the following characteristics:

(a) Include at least 150 permanent residential dwellings units;

(b) Contains a mixture of land uses, including three or more public, commercial, or industrial land uses;

(c) Includes areas served by a community sewer system; and

(d) Includes areas served by a community water system.

"Rural Community" is an unincorporated community which consists primarily of permanent residential dwellings but also has at least two other land uses that provide commercial, industrial, or public uses (including but not limited to schools, churches, Grange halls, post offices) to the community, the surrounding rural area, or to persons traveling through the area.

These community designations were used in the original Coos County Comprehensive Plan, approved in 1984. The latest version of the plan (updated through 1997) identifies Barview, Bunker Hill, and Charleston as "Urban Unincorporated Communities"; Glasgow, Green Acres, Hauser, Millington, Sumner and Sunny Hill are classified as "Rural Unincorporated Communities"; and Allegany is considered a "Rural Service Center." The present-day (circa 2010) situation in each of these communities, based on the OAR 660-022 criteria, is shown in Table 2.

| Community[1] | Residential Buildings[2] | Est. 2010 Population[3] | School | Church | Store | Service Station | Grange | Water | Sewer | RFPD |
|---|---|---|---|---|---|---|---|---|---|---|
| Allegany | 7 | 11 | | X | | | X | | | |
| Barview | 839 | 1,763 | | X | X | | | X | X | X |
| Bunker Hill | 397 | 871 | X | X | X | | | X | X | |
| Charleston | 204 | 367 | | X | X | w/ store | | X | X | X |
| Glasgow | 147 | 268 | | | X | w/ store | X | X | | X |
| Green Acres | 37 | 83 | | X | | | X | | | X |
| Hauser | 133 | 300 | X | X | X | | | | | X |
| Millington | 112 | 244 | | | | X | | X | | X |
| Sumner | 6 | 14 | | | | | | X | | X |
| Sunnyhill | 111 | 258 | | | | | | | | X |

Notes: 1. Communities designated in the Coos County Comprehensive Plan under OAR 660-022 criteria.

2. Based on Property Improvement Codes indicating residences (including mobile homes; duplexes, etc.; and apartments) in the Coos County Assessor's database for properties identified in the Coos Co. Planning Department GIS layer for Rural Service Centers, Rural Communities, and Urban Unincorporated Communities. These are not synonymous with the Census Bureau's housing units where multiple units are within a single building (i.e., duplexes; apartments).

3. Calculated by determining the total housing units within 2010 Census Blocks that intersect with the County-designated parcels to determine an average number of persons per housing unit. This average was then multiplied by the number of residences within the community designation to estimate the population.

Table 2: Community characteristics used to determine status under OAR 660-022.

## Neighborhoods in the Project Area

Just as outlying communities within the project area have identities, so do neighborhoods within, and adjacent to, the cities of Coos Bay and North Bend. Nowhere has this identity been more apparent than in the debates surrounding consolidation among the cities of Marshfield, Empire, Eastside, and North Bend (Whitty 2012). In 1943, when the first consolidation vote to combine Marshfield and North Bend into a new City called Coos Bay failed to pass in North Bend, the city of Marshfield unilaterally renamed itself Coos Bay in 1944. Similar consolidation votes (and results) occurred in 1962, 1967, 1983, and 2004, with North Bend failing to approve consolidation each time. After the 1962 vote, Empire merged with Coos Bay in 1965; and Eastside decided to merge with Coos Bay as well after the 1983 vote.

Here, we consider neighborhoods as geographically-specific areas within urbanized areas, whether within or outside of incorporated city limits. Our investigations determined that there was no officially-designated set of neighborhoods. One local real estate company, Oregon Bay Properties, has developed descriptions for these neighborhoods that we used as a starting point; we appreciate Brooke Yussim's willingness to share their work. These were then reconciled with the 2010 U.S. Census blocks so that detailed neighborhood-specific, demographic information can be provided. Thus, these neighborhoods provide the basic reporting unit in subsequent chapters.

Figure 9 displays a map with our neighborhood determinations. Neighborhood map shows the various urbanized areas, with the boundary of the cities (which is also the urban growth boundary). Descriptions of these neighborhoods are provided below.

### *North Bend and its Neighborhoods*

The town of North Bend, incorporated in 1903, is named for the position its land plat holds in the Coos Bay waterway. Its population of nearly 10,000 residents enjoys the mild climate of the Southern Oregon Coast, as well as its beautiful sunsets and outdoor recreational opportunities. Fiercely independent in its identity separate from its close neighbor, Coos Bay, the city revels in its founding every year during its July Jubilee festivities, celebrating more than 100 years of vibrant history.

The abundant natural resources (chiefly lumber, coal, and fish) drew ambitious entrepreneurs to the area in the mid-1800s, which quickly established the town's industrial beginnings. What started as a rowdy, blue collar town with saloons and brothels had been tamed by the turn of the century by the presence of families, social clubs, and churches. While logging and fishing remain important industries, their declines have made room for other draws to this area, such as RV-ing, dune riding (ATVs), shopping, and the casino industry. North Bend neighborhoods are shown in Figure 10.

<u>Airport Heights:</u> This neighborhood is named for its location near the Southwest Oregon Regional Airport (originally named North Bend Airport), established in 1940. The neighborhood is roughly bordered on the south by Virginia Avenue, the north and east by the airport and a U. S. Coast Guard Air Station, and the west by the city limits (just beyond Channel Street).

The neighborhood is within easy walking distance of North Bend's main shopping district, which includes the Pony Village Mall. Some highlights of Airport Heights include a neighborhood market (Airport Heights Market), Airport Heights Park, North Bend Senior Activity Center, and a paved walking path (near the Bureau of Land Management Offices). Coos Bay and the McCullough Bridge make for beautiful views from many areas in this neighborhood. The oldest homes in this area are located primarily in the north central portion of the neighborhood and later construction fanned out south, east, and west, with the newest construction in the southern and western portions. Most homes are of wooden construction, but there are a small number of newer (1995 and later) manufactured homes, as well.

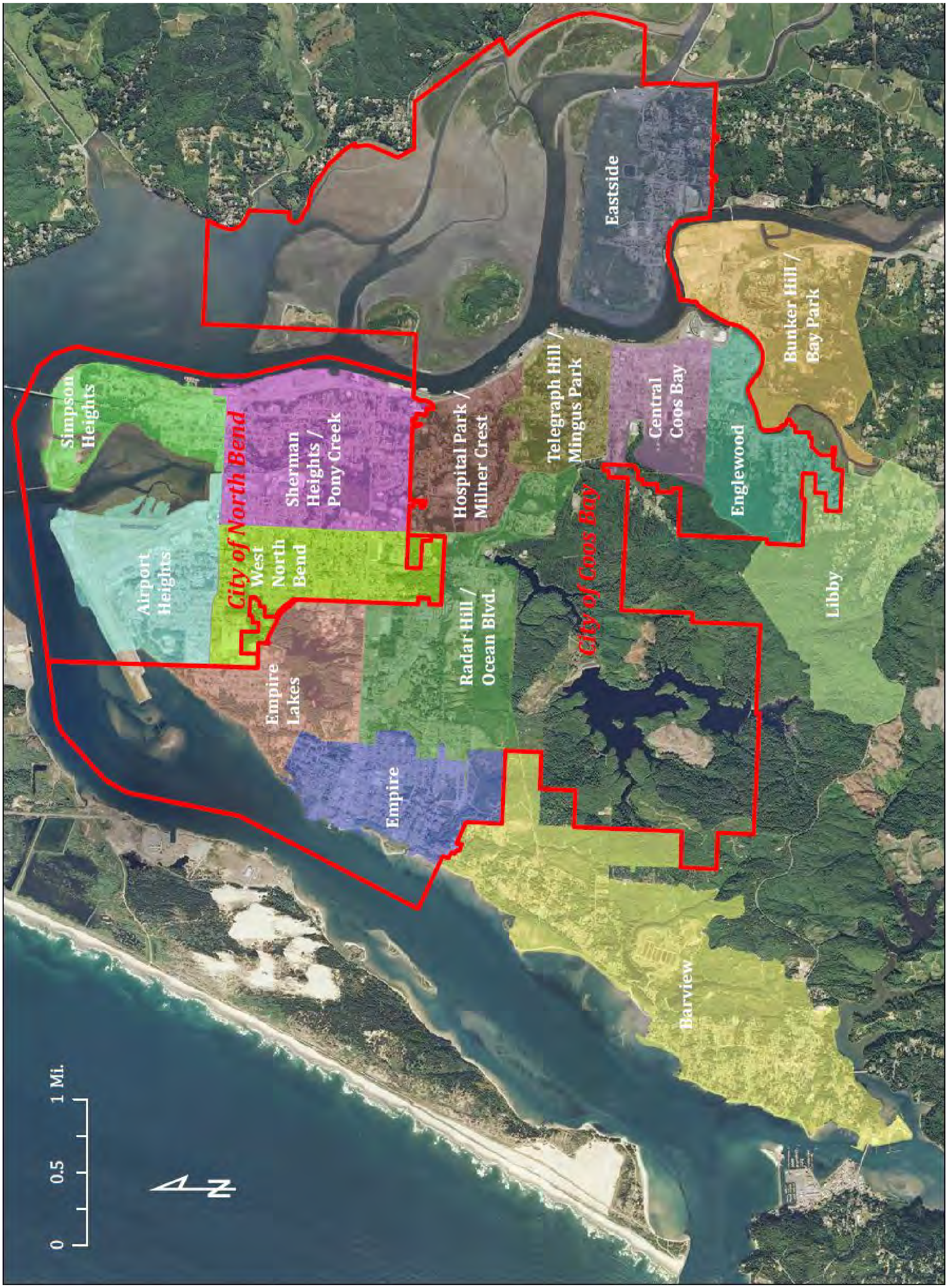



Figure 9. Neighborhoods within the cities of Coos Bay and North Bend.


Figure 10: The North Bend neighborhoods of Airport Heights, Sherman Heights/Pony Creek, Simpson Heights, and West North Bend.

Sherman Heights/Pony Creek: The Sherman Heights/Pony Creek area comprises the heart of North Bend as it consists of a good portion of the downtown area as well as the primary shopping district. Covering the southeast quadrant of the city, including the Edgewood Subdivision, the neighborhood is bordered by the bay on the east, Virginia Avenue to the north, Broadway Avenue on the west, and the city limits (just north of Thompson Rd.) on the south.

In the 1950s and 1960s, and the early 1970s, the wetlands and tidal areas along Pony Creek were filled in and developed, providing land to build the North Bend High School and Middle School, as well as the Pony Village Mall. Pony Village Mall is the largest indoor mall on the Oregon coast, built in 1960. All but one North Bend School is within this neighborhood, as are the greatest number of arts and entertainment options (Pony Village Cinema, Little Theater on the Bay, and North Bend Lanes, to name a few). Most of the city's churches and restaurants are also located here.

The homes in the Sherman Heights area were built primarily in the first half of the 20th Century, with a few exceptions. In and around the Pony Creek area and the Edgewood Subdivision, the homes are latter 20th Century vintage with a scattered few constructed in the last 10 years. Most homes are of wooden construction, and vary widely in style, depending greatly upon the year constructed.

Simpson Heights: What started as the original Simpson Company town site, with a lumber mill and a shipyard (dating back to 1857 and 1858, respectively), is now a quiet neighborhood with beautiful homes, many of which command spectacular bay views. The neighborhood is bordered on the north and east by the north bend of the Coos Bay, the west by Pony Slough, and the south by Virginia Avenue. The neighborhood boasts three parks, and one of only a few neon signs still allowed to span a state highway ("Welcome to North Bend" – installed in 1936), as well as the North Bend Information Center. There is a scenic walking trail that extends from Ferry Road Park to Simpson Park, a boat ramp, and the North Bend Boardwalk. A neighborhood market and meat processor (Ashworth's) also serves the residents of this area.

The homes in this area were built primarily in the first half of the 20th Century, with few exceptions. Most homes are of wooden construction, with a distinctly craftsman or Victorian style evident in homes built in the early 1900s. Another high concentration of construction occurred from the mid-1940s to the mid-1950s, and reflecting the bungalow or ranch styles.

West North Bend: The lumber boom in the 1970s caused a significant growth for North Bend, spurring construction of many new homes in the West North Bend neighborhood. Covering the southwest quadrant of the city, between Pony Slough and the Empire Lakes area, the neighborhood is roughly bordered by the city limits on the south (just south of Lynne Drive), the city limits on the west (which skirts the Empire Lakes area along Fir St., then juts further west towards Crocker St., north of the lakes), Virginia Avenue to the north, and Broadway Avenue on the east.

The homes in this neighborhood were constructed as early as the 1930s, with the most prolific construction period occurring during the lumber boom of the 1970s. However, most of the newest developments in North Bend are in this western part of town, as well. Most homes are of wooden construction, although manufactured homes started making an appearance in the 1990s and comprise a small percentage of the homes in this area. A secondary retail district with several restaurants is located on the southern portion of this neighborhood along Newmark Avenue. Also located in this area are several churches, two parks, one private school, and the town's Community Center, chiefly along either Broadway or Newmark Avenues.


Figure 11: The Coos Bay neighborhoods of Central Coos, Eastside, Empire, and Empire Lakes.

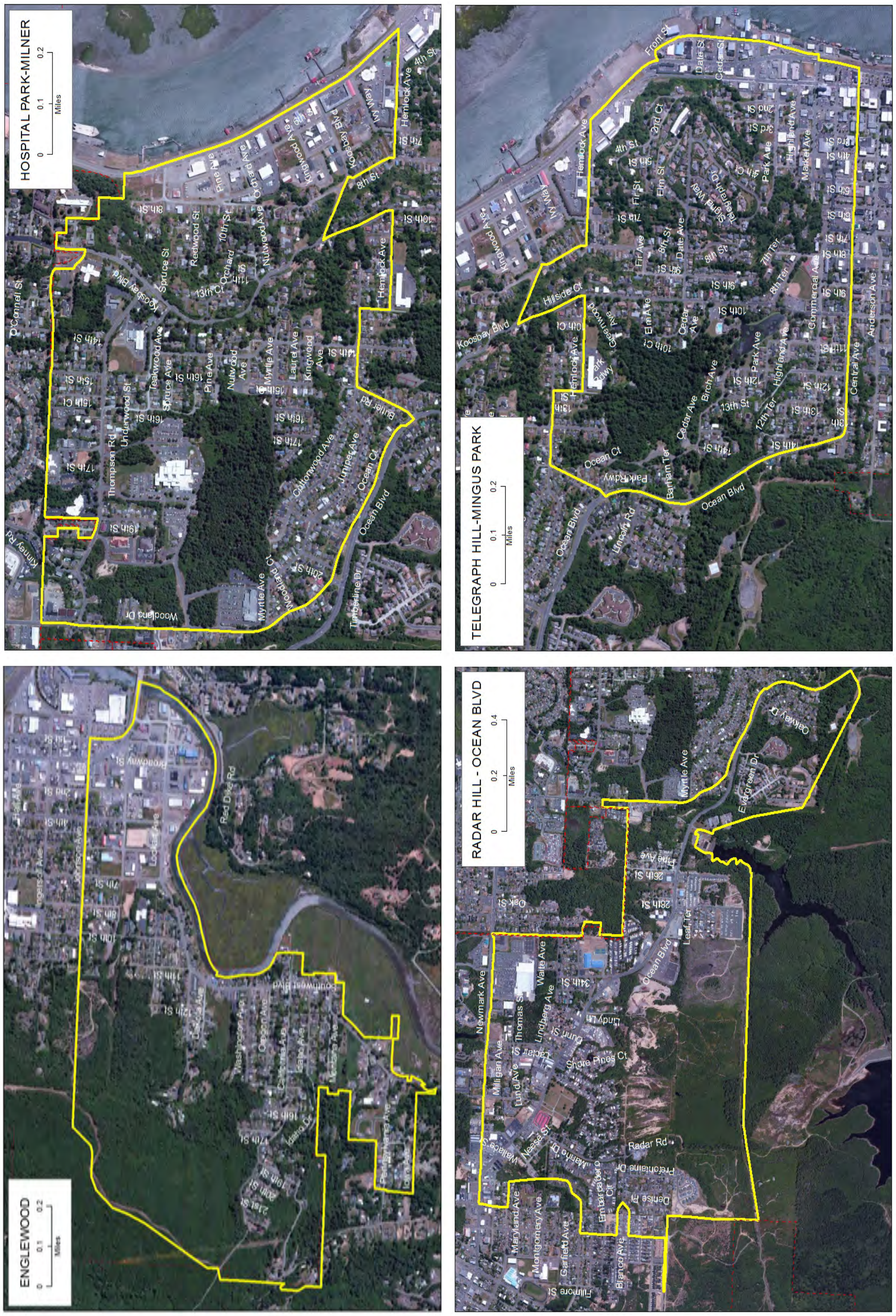



Figure 12: The Coos Bay neighborhoods of Englewood/Libby, Hospital Park/Milner Crest, Radar Hill/Ocean Blvd, and Telegraph Hill/Mingus.

*Coos Bay and its Neighborhoods*

The town of Coos Bay is named after the body of water along which it lies. Formerly known as Marshfield (after the Massachusetts home town of its founder), this community was established in 1853 and officially renamed in 1944. The region saw significant growth in its population from 1910 through the 1930s. However, it was the lumber boom of the late 1960s to early 1970s that nearly doubled the population. The area's more diversified industries now include tourism, retail and service providers (especially health care), and technology. Coos Bay neighborhoods are shown in Figures 11 and 12.

<u>Central Coos Bay:</u> This neighborhood comprises downtown Coos Bay and the majority of the original residential area of what was once known as Marshfield. Central is the main business and retail area of Coos Bay, and as such, includes many restaurants and public buildings. The neighborhood is bordered on the north by Central Avenue, on the east by the bay, on the south by Johnson Avenue, and the west by Anderson Avenue.

Most of the original commercial buildings in downtown Coos Bay were built at the turn of the 20th Century (late 1800s/early 1900s). The downtown area, originally located on Front Street (the waterfront), rapidly began expanding westward following the construction of the Chandler Hotel in 1909. By the mid-1920s, the heart of downtown Coos Bay was finally centered three blocks west of its original location, due in part to a devastating fire in July 1922 that destroyed most of the wood frame (as well as some of the brick) structures along Front Street. Homes in this neighborhood were built from the 1890s to the 1950s, and range from the more modest 1920s or 1930s bungalow, to the early 20th Century traditional style and to the mid-20th Century ranch style home.

<u>Eastside:</u> The Eastside neighborhood was once known as East Marshfield for its position on the east side of the bay. The East Marshfield Post Office was established in 1891 and operated intermittently until 1908. The community of Eastside merged with the town of Coos Bay in 1983. Eastside is surrounded by water on three sides (Coos Bay – the Marshfield Channel to the north, Catching Slough to the east, and Isthmus Slough to the west). The southern border of Eastside is the city limits, which follows I Street.

Eastside is a small community, served by a couple of restaurants and churches, and a convenience store. The Eastside district has a large residential area with water and city views from many of the properties. The majority of the homes in this neighborhood were built in the traditional or ranch style in the mid-20th Century. More custom and contemporary designs started showing up in the late 1970s, and some newer manufactured homes are present, as well. There are two parks (Eastside Park and Windy Hill Park), and a public boat ramp is located at the west end of D Street. There are an elementary and a middle school; Eastside is also the current home of the Pacific School of Dance, which focuses on ballet.

<u>Empire:</u> When Coos Bay Company settlers came to the area in 1853 they used the Indian village of Hanasitc as a town site and named it Empire City. It served as the County seat until 1896 when the citizens of Coos County voted to move the seat to the town of Coquille. Empire City was the site of the first Post Office (established in 1858) to serve the Coos County area. In 1894, Empire City changed its name to simply Empire; it was incorporated into the town of Coos Bay by popular vote in 1965. The neighborhood is bordered on the north and west by the bay, the east by Schoneman Street, on the south by the Coos Bay city limits that include the Bay Way Trailer Park just south of Wisconsin Ave/Cameron Rd.

Empire has its own public boat ramp, several RV parks, a small neighborhood park with playground (Taylor/Wasson), and elementary and middle schools. The future site of The Hollering Place Development (a project of the Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians) is located on the bluff above the channel, and will radically change the area if it comes to fruition. Homes existing in this area were built primarily between 1945 and 1955, and are of modest construction reflecting the ranch or bungalow style. Another burst of construction occurred in the late 1970s, and manufactured homes began to show up about that time, too. There are a handful of homes from the late 19th Century that also remain.

Empire Lakes: The Empire Lakes neighborhood encompasses a residential area (to the north and south), the local community college campus (on the east side), and the large John Topits Park that contains three lakes (one, "Upper Empire Lake," is the northernmost arm of "Middle Empire Lake"). The neighborhood is bordered on the north by the bay, on the west by Schoneman and Taylor Streets, on the south by Newmark Avenue, and on the east by Fir Street alongside the park, and Crocker Street north of the park.

A central feature of Empire Lakes, Southwestern Oregon Community College was established in 1959, and is the oldest community college in the State of Oregon. The homes in this area were built primarily in the 1970s and 1980s in the ranch style. However, some homes bordering the north side of the park date back to the 1950s. There are also small pockets of newer construction built in the last 15 years, as well as a few newer manufactured homes.

Englewood/Libby: This neighborhood is located south and west of the Coos Bay town center. The name Libby is said to have come from the daughter of a Coos Indian headman that once lived in the area. The original town of Libby grew through benefit of the coal mines in the area, particularly the Eastport mine. The Englewood/Libby neighborhood is bordered on the north by Johnson Avenue, the east and south by Coalbank Slough and its tributaries, and the west by Nichols Road.

There is a largely industrial area in the western portion of the neighborhood, with vehicle repair, RV sales, warehouses, trucking distribution centers, and small machine retailers, as well as plumbing, heating, and electrical companies. Commercial establishments also include the local Department of Motor Vehicles and major grocery retailers. The neighborhood's main residential area has a decidedly rural backdrop of views of the slough and lowlands to the east, and gradually climbing, wooded hills to the south and west. Lots are generally larger than the standard 50 X 100' city size, with many homes on parcels of an acre or more. Homes in this neighborhood are modest in style and size, with the early 20th Century bungalow and cottage styles common, as is the day ranch style (due to the hilly terrain).

Hospital Park/Milner Crest: This neighborhood is where the majority of Coos Bay and North Bend's current medical facilities are located, with Bay Area Hospital (opened in 1974) being the centerpiece. Milner Crest refers to the crest of an elevated portion of the neighborhood overlooking the Coos Bay. The neighborhood is bordered on the north by the city limits just north of Thompson Road, on the east by Highway 101, on the south by Greenwood Avenue, and on the west by Woodland Drive and Ocean Boulevard.

Besides being the home of numerous clinics, labs and medical offices, this neighborhood also has many stores and offices along Woodland Boulevard below the Hospital. The Milner Crest area is a highly desirable residential area filled with quiet streets and some bay view homes. The majority of the homes in this neighborhood were built in the mid-20th Century; architectural styles range from 1940s traditional to 1950s rambler to 1950-1960s ranch or day ranch.

Radar Hill/Ocean Blvd: This neighborhood is largely dominated by the Pony Creek Reservoir and Merritt Lake. The residential area in this neighborhood forms a loose horseshoe shape to the north and is bordered on the north by Newmark Avenue, to the east by Fir Street, Woodland Drive, and Ocean Terrace, to the south by Ocean Boulevard, and to the west by Fillmore and Schoneman Streets. The office and clinic of the Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians is in this neighborhood.

There are several mobile home parks in this area; all but one are for residents aged 55 and older. Additionally, there are a couple of assisted living facilities, as well as a nursing home, and The Boys & Girls Club of Coos Bay is located just north of Ocean Boulevard. Businesses in this area are located along Ocean Boulevard and Newmark Avenue. The Radar Hill residential area comprises the western leg of the horseshoe and features bay and ocean views from many of the homes. Existing homes in this neighborhood were constructed from 1950 to 1990, with manufactured homes on land beginning to appear in the late 1990s. Recent construction has materialized in the Radar Hill area largely in two separate developments. The Pacific Crest, at the top of the hill, offers contemporary style homes; while Lighthouse Estates, at the base of Radar Hill, is comprised of more moderately priced, craftsman style homes on smaller lots.

Telegraph Hill/Mingus Park: This neighborhood is the smallest in Coos Bay and has Mingus Park at its center. Mingus Park was originally called Marshfield Park; it was established in 1925 and renamed in 1937 to honor Dr. Everett Mingus, a local resident responsible for the park's further development. Telegraph Hill is a summit overlooking the Coos Bay with a peak elevation of 282' above sea level. This neighborhood is bordered on the north by Greenwood Avenue, the east by Bayshore Drive, the south by Central Avenue; the western border is located just west of and follows Ocean Boulevard.

Spectacular bay views dominate to the east, city views stretch out to the south, and pastoral views of the park roll out to the west. The neighborhood also offers several lodging options, a bistro, and The Marshfield Sun Printing museum on the frontage to U.S. 101, and the new Coos History Museum is planned for the waterfront at the northeast corner of this neighborhood. Most of the homes in this neighborhood were built in the 1950s, 1960s and 1970s and are of a ranch or custom design. Homes that were built in the early 20th Century border Mingus Park, along with some homes of contemporary design built in the 1990s that overlook the Park and downtown.

**Summary**

Communities in the project area developed as a result of their locations vis-à-vis natural resources, industry, or where changes in modes of transportation occurred (i.e., from stagecoaches to boats at the heads-of-tide). Communities waxed and wanted as these resources and industries played out, and as advances in transportation made traveling easier. Yet, these communities still retain their own history, character, and identity: when asked where they live, most residents readily name their community or neighborhood, oftentimes adding where they grew up as well.

Improvements in transportation expanded the tolerable distance between housing and work, schools, shopping, and other services. Changes in transportation, along with increased populations, contributed to the growth of the cities of Marshfield and North Bend. The merging of Marshfield, Empire and Eastside into the City of Coos Bay provided further consolidation into a single urbanized area. These original, independent, communities and cities became the basis for many of the neighborhoods discussed in this chapter; while other neighborhoods grew through land platting and development.

The project area is diverse and heterogeneous, both within neighborhoods as well as between them. This diversity will be highlighted in *Chapter 4: Community Demographics*, relying upon the 2010 U.S. Census demographic and housing information reported at the Block level, aggregated by neighborhood. Neighborhoods will also be the primary reporting unit for *Chapter 5: Zoning and Land Use* as well. Finally, in *Chapter 7: Schools and Education* we will see the pattern of local community schools consolidating into larger, unified school districts as evidence of how transportation has affected the socio-economic context of the project area.

**References**


Coos County Planning Department. *Coos County Comprehensive Plan*. Vol. 1, Part 2, §5.5.

McArthur, L.A. and L.L. McArthur. 2003. *Oregon Geographic Names*. Oregon Historical Society Press. 581 pp.

Peterson, E. and A. Powers. 1952. *A Century of Coos and Curry: History of Southwest Oregon.* Coos-Curry Pioneer and Historical Association. 599 pp.

Whitty, J. 2012. *The Coos Bay Area from 1940 to 2012.* Prepared for Leadership Coos, Bay Area Chamber of Commerce, September 11, 2012

# **Chapter 5:** Zoning and Land Use

*Jon Souder - Coos Watershed Association*


**Top: Aerial of Coos Bay and North Bend, Credit: Coos Bay Properties**
**Bottom: Boundaries of the Coos Bay Estuary Management Plan**

*Summary:*

- *In the project area, the greatest land use is private forestry (53%), with government using another 33%, agriculture 6% and residential, commercial, and industrial, combined using 7%.*

- *As the local economy has changed in the thirty years since the adoption of the Coos County Comprehensive Plan, the constraints imposed by landuse allocations made in the early 1980s—reflecting economic conditions and knowledge available at that time—may no longer best meet the community's emerging needs.*

- *The estuary plays a significant role in existing and prospective land uses.*

**Introduction**

This chapter provides an overview of land uses and zoning, highlighting the diversity reflecting the urban to rural to wildland nature of the area.

Zoning defines the allowable use(s) on a parcel of property, be it raw land, residential, commercial or industrial; while "land use" identifies what is currently on the parcel. Zoning looks prospectively at desirable uses of land, identifying outright permissible uses, uses conditioned upon meeting certain criteria, as well as potentially a host of criteria regulating features such as height, setbacks, parking requirements, etc. In contrast, land uses are indicative of the history of the piece of property as reflected in its current usage. In many cases, these historic uses would not necessarily be allowed under the current zoning codes—they are termed "legal non-conforming"—because they were established prior to zoning or permitted under previous zoning ordinance. We will divide our discussion between zoning designations and current land uses. Additional information on land use as related to housing will be provided in *Chapter 4: Community Demographics*. In addition, Land Cover for the project area is described in *Chapter 8: Physical Description of the Coos Estuary and Lower Coos Watershed*.

**Zoning in the Project Area** The Coos County Comprehensive Plan (CCCP) is the local ordinance that implements the state's planning system for areas outside the incorporated cities. The CCCP was first approved by the county commissioners in March, 1985, and was intended to govern the management of land and water areas in unincorporated areas outside the area covered by the two estuary plans (Coos Bay and Coquille River), i.e. the "balance of county," for the period from 1980 to 2000 (Coos County Planning Department 1985b). Periodic review was completed in 1999 but some of the inventories were not updated due to lack of growth and the expense involved with a comprehensive update of the CCCP, its duration has been extended through the present time.

Each land parcel is classified for one or more uses. Both the county and the two cities have general zoning maps with boundaries generally corresponding to the land parcels; however, in some cases, a property will be "split-zoned" where a portion has one allowable use while the remainder has another. This is most common with parcels split-zoned for forestry/agriculture. There are also significant numbers of parcels where the existing uses are "non-conforming" with the zoning classification because the zoning classification was applied. There are several non-conforming legal parcels as the land was platted in anticipation of rural development but due to soils classifications or pattern of residential uses the land was not zoned for residential use.

Zoning is generally broken into seven general categories as shown in Figure 1. It's obvious in from the percentages and Table 1 that the project area is largely rural, with resource land (forestry and agriculture) predominating (82%), with the next most common category being the zoning overlay for the Coos Bay Estuary Management Plan (7%). Parks and open space contribute another 5% of zoned lands within the project area. Zoning for more intensive land uses of residential (5.1%), mixed use (0.2%), commercial (0.3%), and industrial (0.9%), represents a relatively minor percentage of the overall project area, but is concentrated around the bay and streams and rivers.

Examining Table 1, it is apparent that the largest number of parcels—and the smallest parcel sizes—are in those zoning categories that represent more intensive, dense uses such as residences and commerce. The average number of parcels per acre for residences

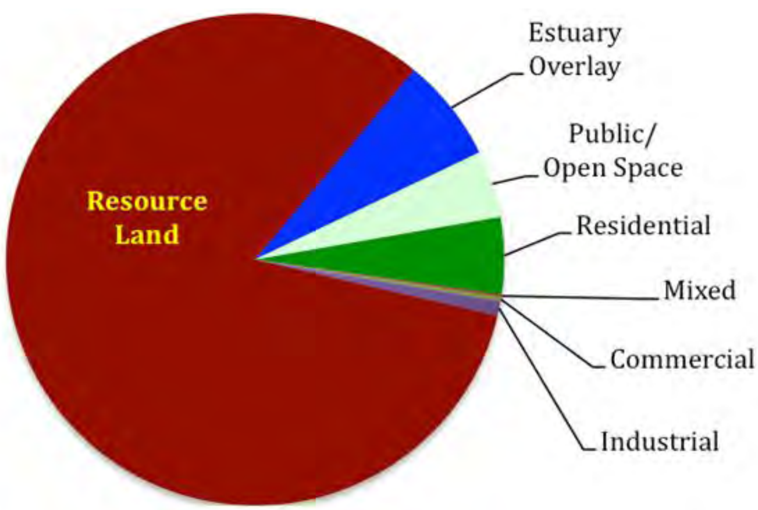



Figure 1: Zoning category proportions.

| Zoning Category | Coos Bay | | North Bend | | County | | Totals | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Parcels | Acres | Parcels | Acres | Parcels | Acres | Parcels | (%) | Acreage | (%) |
| Residential | 5,604 | 2,228 | 3,961 | 1,462 | 7,998 | 13,016 | 17,563 | 59.80% | 16,706 | 5.10% |
| Mixed | 264 | 75 | 45 | 17 | 582 | 456 | 891 | 3.00% | 548 | 0.20% |
| Commercial | 794 | 460 | 366 | 274 | 224 | 151 | 1,384 | 4.70% | 885 | 0.30% |
| Industrial | 374 | 473 | 214 | 1,473 | 269 | 1,184 | 857 | 2.90% | 3,130 | 0.90% |
| Resource Land | 0 | 0 | 0 | 0 | 4,712 | 271,547 | 4,712 | 16.10% | 271,547 | 82.40% |
| Estuary Overlay | 456 | 3,962 | 35 | 882 | 3,025 | 17,597 | 3,516 | 12.00% | 22,441 | 6.80% |
| Public/Open Space | 111 | 2,025 | | | 324 | 12,424 | 435 | 1.50% | 14,450 | 4.40% |

Table 1: Zoning categories, parcels, and areas within the various jurisdictions.

is roughly the same for those located in the cities of Coos Bay and North Bend (2.5 and 2.7, respectively), but they are significantly larger in the rural areas outside the UGB (0.6 parcels, or about one and two-thirds acres per parcel). Comparatively denser are parcels in the mixed, or transitional category, representing the conversion of residential areas to commercial; and these transitional parcels are even more dense than those currently zoned for commercial use. Industrially-zoned land tends to be in larger parcels than those zoned for either residential or commercial use.

Each specific zoning jurisdiction has their unique codes and definitions for specific uses allowed within sub-categories of the seven broader uses. Figure 2 shows how these are arranged outside incorporated city boundaries; and Figure 3 shows general zoning categories for the cities of Coos Bay and North Bend. Appendices 1 and 2 show the official zoning maps for the cities of Coos Bay and North Bend, respectively. Appendix 3 provides the number of parcels and aggregate areas by specific zoning classification for the areas outside the UGB and both cities.

The general patterns outside the UGB is that the resource lands are zoned for forestry in the upper watershed area, and similarly along the ridgetops extending down to the bay. Agricultural uses (i.e., Exclusive Farm Use) occur in the valleys, principally in the broad floodplains of the Coos, South Fork Coos, and Millicoma rivers and along diked areas such as Catching and Isthmus Sloughs. Rural residential zoned lands surround the east and north bay outside the UGB, along ridgetops and adjacent to streams and rivers where county roads provide access.

Patterns within the UGB (Figure 3) mirror those usually found in cities: industrial sites are concentrated along major thoroughfares, and/or adjacent to railroads or harbor facilities. Similarly, commercial enterprises typically front major streets; higher density residential zoning is in these same areas, while lower density residential zoning are buffered from the larger populated hubs. North Bend residential areas have different zoning classifications based on their lot sizes (R-7 and R-10), whether they can have duplexes (R5, R-6), and multi-family housing (R-M). About half of the residentially-zoned parcels in North Bend can have duplexes; while slightly over a quarter are solely for single-famiy residents, and slightly under a quarter are multi-family (Appendix 4).

Coos Bay's residential zoning pattern differs substantially from North Bend's. Of the approximately 5,600 parcels zoned for residential use (Appendix 4), almost three-quarters are zoned for single family residences and duplexes, while only about 8% are solely for single family residences. In fact, the City of Coos Bay currently (8/2015) is considering ordinance amendments that would change some of the zoning classifications. Coos Bay also has a higher number of parcels zoned for multi-family use than does North Bend (906 versus 768, respectively), as well as 48 parcels, covering 268 acres specifically zoned for certified manufactured houses, either in parks (R-5) or in a classification that allows for single-family residences, duplexes, and

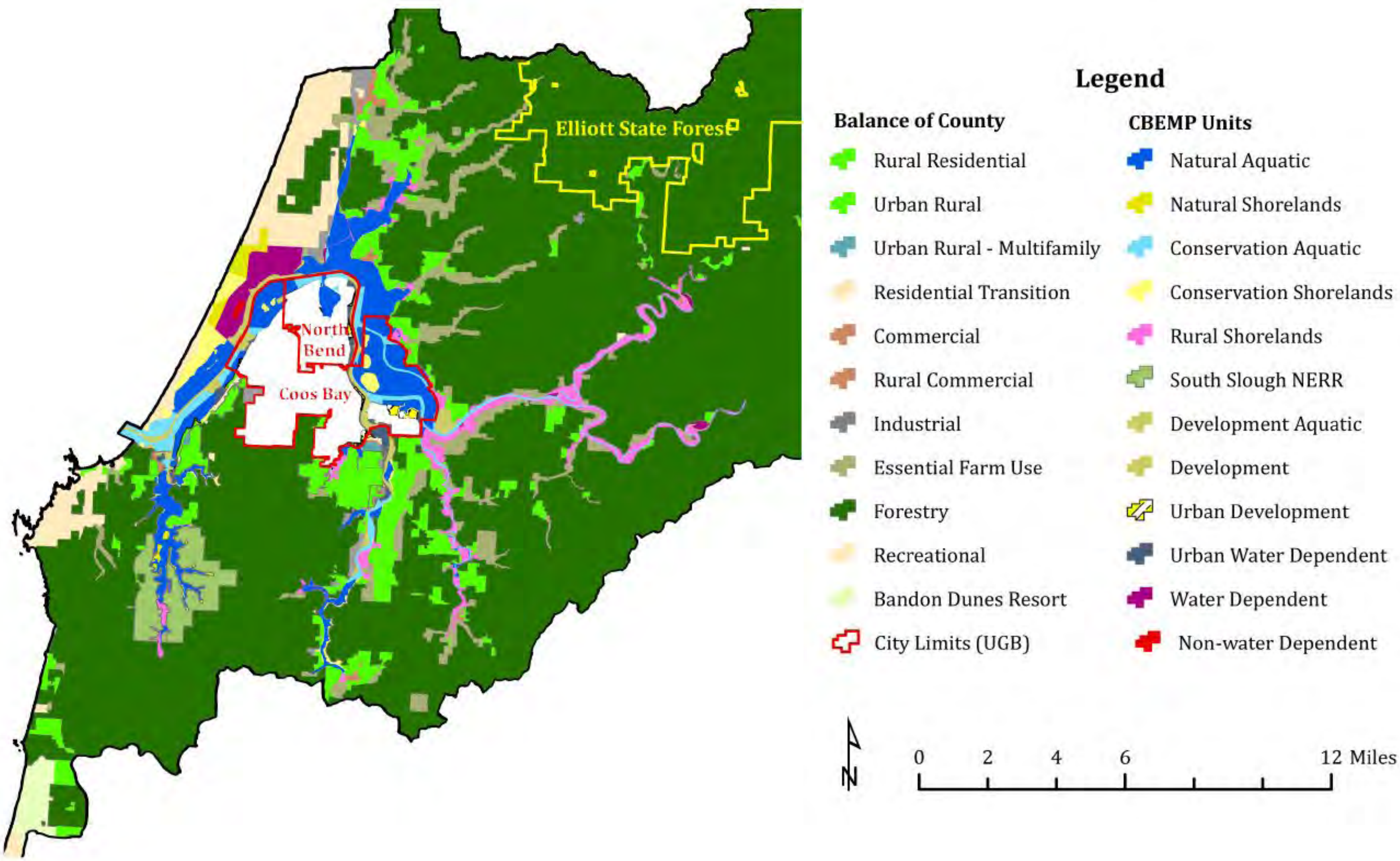



Figure 2: Zoning classifications for areas outside the urban growth boundary (UGB).

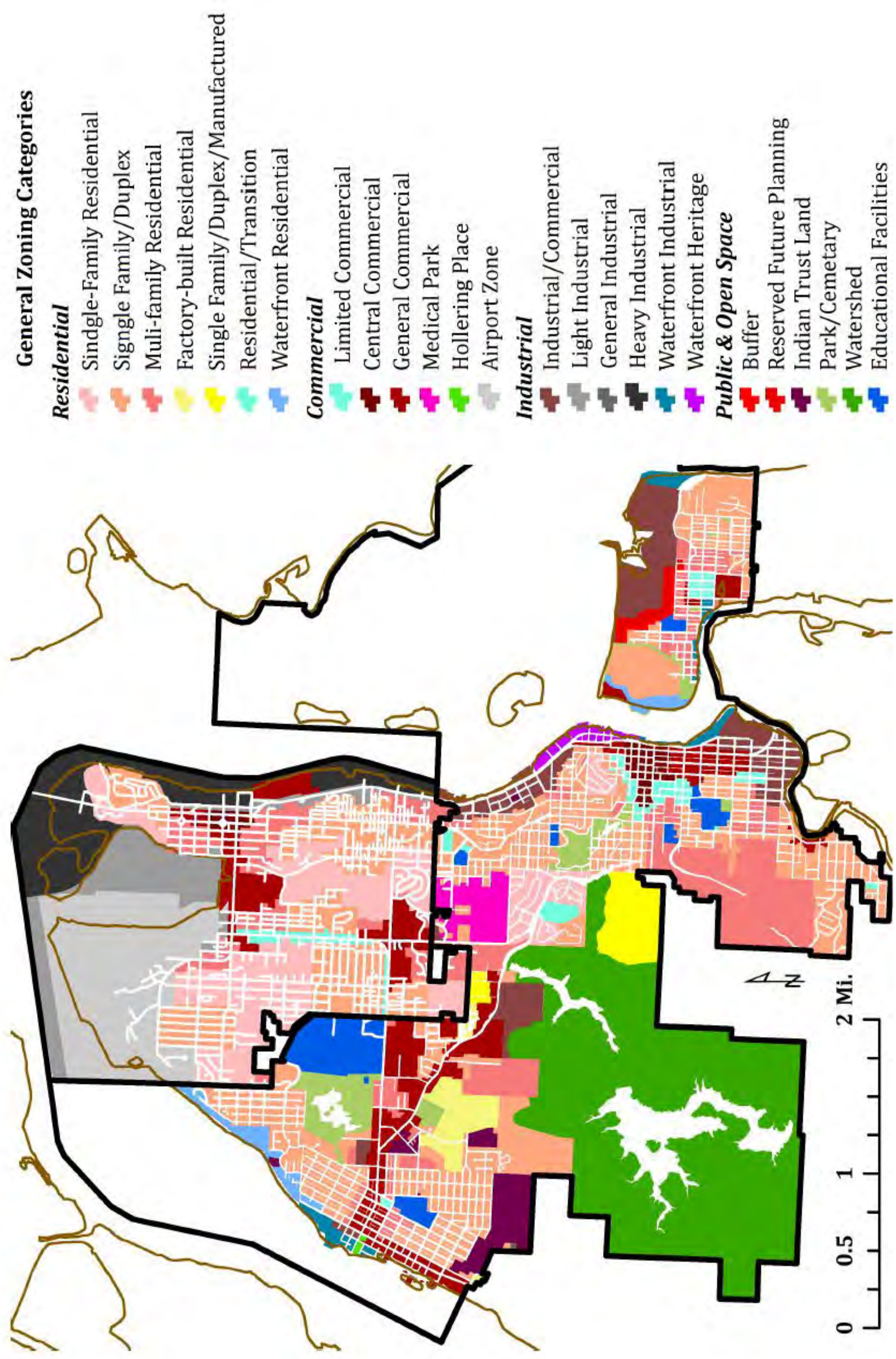



Figure 3: General zoning map for the cities of Coos Bay and North Bend.

the manufactured homes (R-6). There are two areas with the parks, both off of Ocean Blvd., one on the north side Ocean at the junction of 34th Street and Pacific Loop; and a second, larger area south of Ocean in the Shore Pines development that is specifically for senior housing.

Coos Bay also has a distinct classification for waterfront residences (R-W), the first of which is located along the Coos Bay channel north of Newmark Avenue in the Empire Lakes neighborhood. Generally the district includes parcels fronting the channel, and extending inland to the first major street. A second R-W district is in Eastside, and located in the dredged material disposal area to the north of the boat launch ramps, along the opposite of the Coos Bay waterfront. The City of Coos Bay development ordinance (Ch. 17.60) says the intent of the zoning is to protect the area, maintain access, and "encourage excellence of design" through clustering or other arrangements to protect open space. Almost any residential use (up through multi-family) is allowed, as are commercial uses that are residential in appearance and maintain the character of the area. Any uses other than single family residences require a site plan and architectural review.

Both cities also have zoning for other, unconventional, classifications. In North Bend there are three residential-transitional (R-T) areas that allow for commercial uses: both sides of Broadway between Lewis and 17th); the south side of Newmark between Broadway and College; and a small area centered at Florida and Union. Coos Bay's zoning includes residential-professional classification (R4-P) used for the Ocean Ridge Assisted Living facility off Ocean Blvd., many blocks on the periphery of the Central Business District, and two blocks south of Newmark between S. Main Street and S. Cammann in Empire. The Bay Area Hospital and surrounding parcels are zoned as Medical Park (MP), designated for medically-related uses.

Finally, Coos Bay also zoned areas of unique cultural significance: the Hollering Place proposed development in Empire, and the Waterfront Heritage (WH) area between Bayshore (northbound US-101) and the Coos Bay channel, extending north from Commercial Street to Ivy Ave. This includes the historic buildings along Front Street, and the first block back from the waterfront. To the south of this, also between Bayshore and the channel—and extending south to the mouth of Coalbank Slough—is zoned waterfront-industrial (W-I) zoning to reserve the area for water-dependent and water-related uses. This area includes the Coos Bay Boardwalk and the rail yard, as well as the Lucky Logger and Edgewater Inn commercial areas.

**Coos Bay Estuary Management Plan Zoning**

The Coos Bay Estuary Management Plan (CBEMP) is the implementation mechanism for goals 16 and 17 in the Coos County Comprehensive Plan. There are twelve different management types, equivalent to zoning classifications, listed in Table 2 and described more fully in Appendix 4 and in the Oregon Estuary Plan Book (DLCD n.d.). The primary differentiation is between aquatic units (below mean higher high tide), of which there are a total of 13,267 acres; and shoreland units (above mean higher high tide), of which there are total of 9,301 acres. Figure 4 provides a map of the management units within the CBEMP.

The area covered by the CBEMP is divided geographically into management areas, of which there are a total of 124, divided among those in the County (84) and the cities of Coos Bay (30) and North Bend (9). The City of Coos Bay has more management areas because its city limits extend across the upper bay, in contrast to North Bend whose city limits extend into the bay in but in a much smaller geographical area.

Each of the 124 management areas may have a unique management type (one of the twelve listed in Table 2), or it may be sub-divided into multiple, different management classifications (Appendix 5). The results of this sub-division result in 182 individual management units; and some management areas contain multiple polygons. While most management units only have one polygon, some—especially the urban water-dependent and rural shorelands—have multiple such that there are 279 unique polygons delineated in the CBEMP. Figure 4 shows a map of the polygons, with a sub-set of the specific polygons labeled. The management area numbering system starts at the mouth of the Bay, on the north jetty, and increases clockwise ending at the extreme southern units in South Slough (Figure 4).

Within the CBEMP, management units are designated according to the criteria described previously; for each unit there is a narrative description of its boundaries, and a management objective is identified, such as "this unit shall be managed to allow the continuance of shallow-draft navigation while protecting the productivity and natural character of the aquatic area" (CBEMP, Aquatic Unit 13A). Following the management class and objective, there is a list of different potential uses and types of activities that vary depending on the management unit and segment. Table 3 provides a list of these uses and activities. Each of these has a determination about whether it is allowed outright, allowed through an administrative conditional use, or prohibited. Each management area also has general conditions that apply to all uses and activities (e.g. "inventoried resources requiring mandatory protection in this unit are subject to Policies #17 and #18), and special conditions that relate to a specific activity or use. These special conditions are chosen from among a suite of policies.

| Code | Management Type | Area (ac.) |
|---|---|---|
| | ***Aquatic Units*** | |
| NA | Natural | 8,928 |
| CA | Conservation | 2,700 |
| DA | Development | 1,639 |
| | ***Aquatic Unit Totals*** | **13,267** |
| | ***Shoreland Units*** | |
| NS | Natural | 762 |
| CS | Conservation | 1,737 |
| RS | Rural Shorelands | 4,037 |
| | Sub-total | 6,536 |
| *Development – Outside UGB* | | |
| D | Development | 384 |
| WD | Water Dependent | 1,528 |
| NWD | Non-water Dependent | 52 |
| | Sub-total | 1,964 |
| *Development – Inside UGB or Urban Unincorporated Communities (UUC)* | | |
| UD & UDS | Urban Development | 257 |
| UW | Urban Water- dependent | 514 |
| UNW | Urban, Non-water | 30 |
| | Sub-total | 801 |
| | ***Shoreland Unit Totals*** | **9,301** |

Table 2: Management units in the CBEMP. Data Source: Coos County Planning Department n.d.a

Included within each management unit is an identification of any designated mitigation areas, as well as their priority: (1) high priority sites that shall be protected, i.e., no pre-emptory uses or activities are allowed; (2) medium priority sites that have realistic potential for mitigation, and therefore pre-emptory uses or activities are also not allowed; and (3) low priority sites that have questionable potential for mitigation, and are thus not protected from pre-emptory uses or activities that are otherwise permitted in the management unit (CBEMP, Vol. II, Part 1, §7.3).

There are 81 designated mitigation sites in the Coos Bay Estuary Management Plan. Figure 5 shows these mitigation sites, color-coded by their priority. Of these 81 sites, 15 are designated as High Priority, totaling about 320 acres; 37 are Medium Priority, covering about 485 acres; and 29 are designated as Low Priority, containing about 530 acres. Within these 81 sites there are 390 tax lots (although some may be slivers resulting from mis-alignment of data layers), with 188 owners. The relationship between the number of tax lots and owners is shown in Figure 6. Detailed information on tax lots and ownership (as of February, 2014) for each mitigation site is provided in Appendix 6 for those tax lots greater than 0.05 acre.

The practicality of a site for use as mitigation is affected by its number of taxlots and owners; as this number increases, so does the difficulty of its use as mitigation. As can be seen in Figure 6, most areas designated for mitigation contain multiple taxlots. More important is the number of unique owners: about a third of the mitigation sites have a

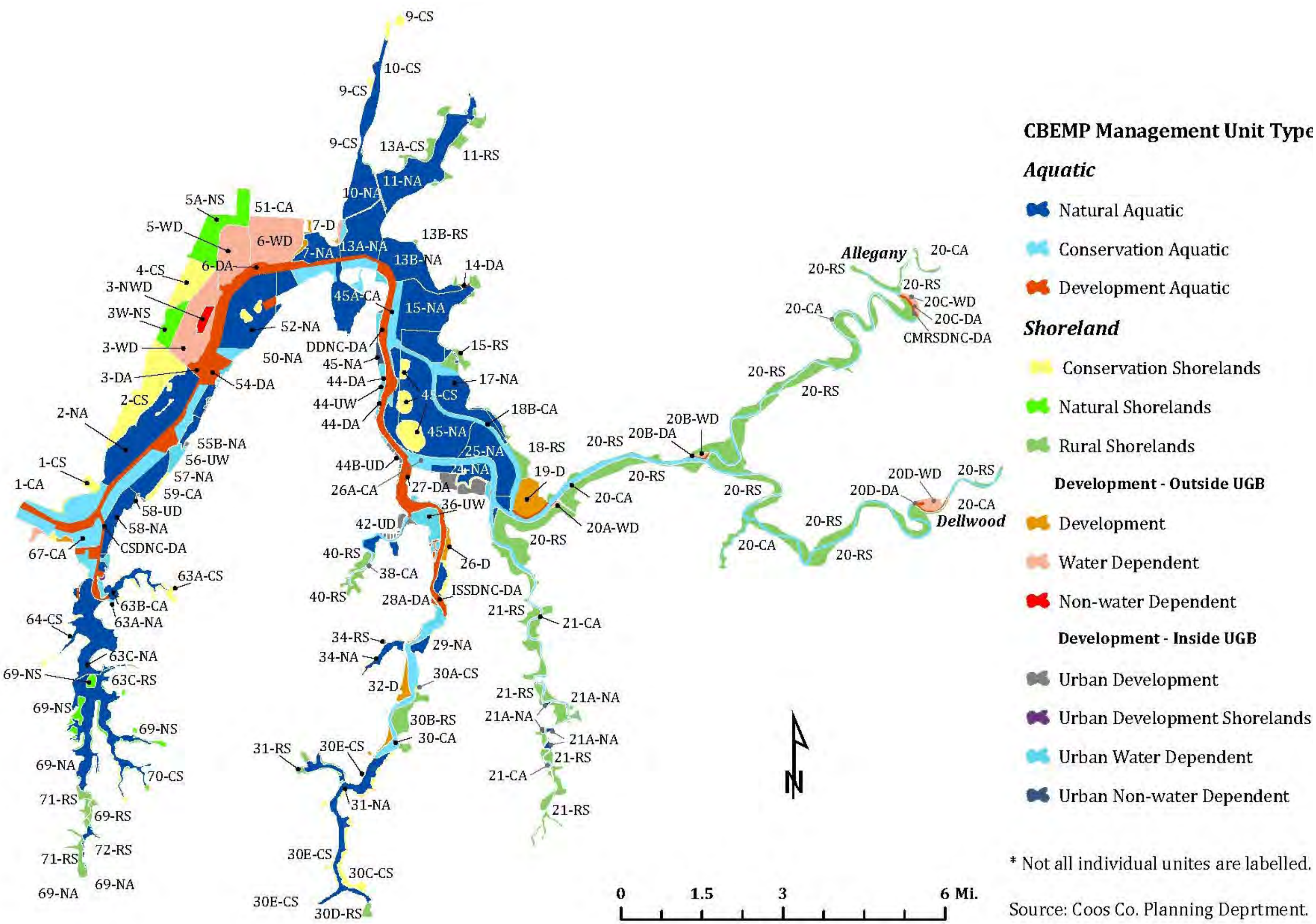



Figure 4: Management unit types within the Coos Bay Estuary Managment Plan. Not all individual units are labelled. Data Source: Coos County Planning Department 1985a.

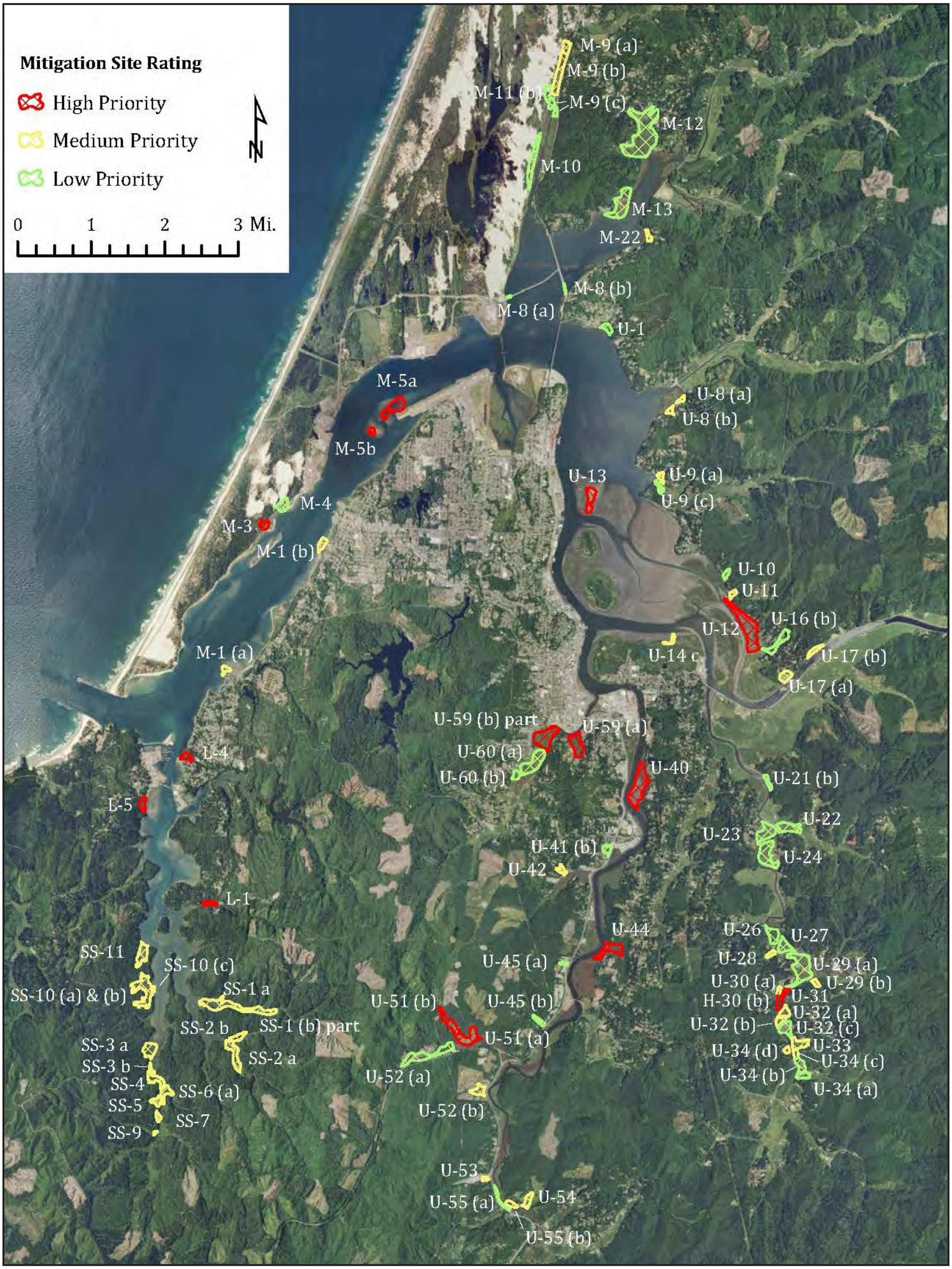


Figure 5: Mitigation sites deisgnated in the Coos Bay Estuary Management Plan.

single owner, while another third have two owners. The remaining third of sites have more than two owners, with nine having six or more.

About 63% of mitigation sites are within private ownership or ownerships. Government entities own about 37% of the designated mitigation sites, with 28.9% owned by the State of Oregon, and as such cannot be used for mitigation. This includes all the South Slough “Medium” priority sites. The Oregon International Port of Coos Bay owns the majority of High Priority sites (M3, U13), Medium Priority (U-14), and Low Priority (M-4) for almost 40 acres.

A site designated as mitigation in 1985 doesn’t necessarily have much relevance to its potential use in 2015. A site could have been developed since then; or it may have naturally reverted to wetlands so that their utility for mitigation is minimal. While we have not systematically evaluated all the sites, it’s obvious from even a cursory examination of Figure 5 that many of these sites would no longer qualify for mitigation.

**Land Use in the Project Area**

While zoning determines allowable future land uses (in the absence of re-zones), land use describes what is presently in place. Current land uses are the embodiment of the past development of communities, neighborhoods, and rural areas. As discussed previously in the *Chapter 3: Communities and Neighborhoods*, the Coos Bay area has gone through cycles of development (and abandonment) since settlement by Euro-Americans. Land that was once cleared for farms and pastures has changed into town lots or may have re-grown back into forest; historic wetlands were drained, diked and filled, have now become shopping centers, or—in some cases—reverted back to wetlands.

This section will describe how lands within the project area are currently classed into their “highest and best” use by the Coos Co. Assessor’s Office, based on 3-digit property codes with procedures established by the Oregon Department of Revenue (ODOR 2007). The general structure of these codes is shown in Table 3, with all the categories listed in Appendix 6. We will start with the overall patterns, then look more closely at major categories of use. Residential uses will be covered here, and in greater detail in the *Chapter 4: Community Demographics*.

*General Patterns*

Even though the Coos Bay estuary is the largest urban area on the Oregon coast, the surrounding watersheds and communities are still predominantly rural. Figure 7 shows the relative proportions of different land uses, highlighting that over half (53%) is still in private forest, and that much of the rest (33%)

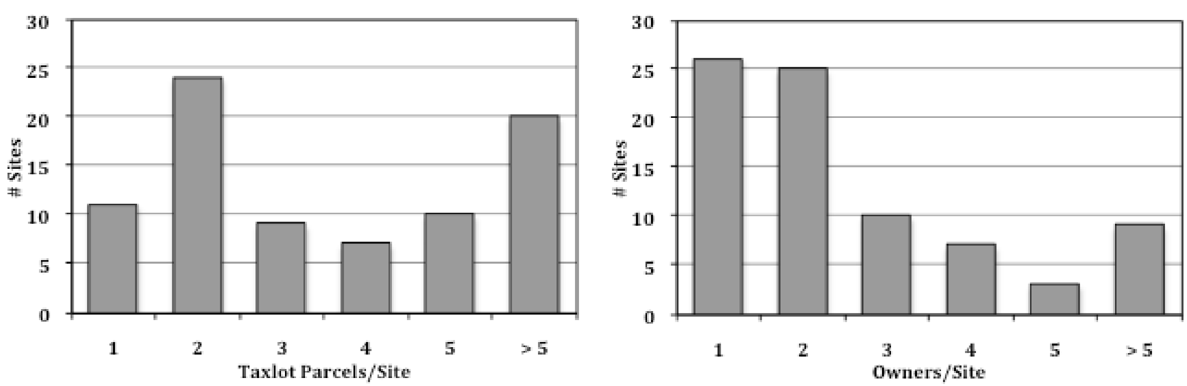



Figure 6: Frequency distribution of taxlots (left) and owners (right) in the CBEMP mitigation sites.
Data Source: Coos County Planning Department, n.d.b; Coos County Assessor 2014.

| First Digit | | Second Digit | | Third Digit | |
|---|---|---|---|---|---|
| 0 | Miscellaneous | 0 | No significance | 0 | Vacant |
| 1 | Residential | 1 | Residential zone | 1 | Improved (typical) |
| 2 | Commercial | 2 | Commercial zone | 2 | Condominium |
| 3 | industrial | 3 | Industrial zone | 3 | State responsibility |
| 4 | Tract | 4 | Unzoned farm land | 4 | Partially exempt |
| 5 | Farm | 5 | Exclusive farm use | 5 | Taxable leased |
| 6 | Forest | 6 | Small trace Forestland | 6 | Waterfront |
| 7 | Multi-Family | 7 | Disqualified permanent FU | 7 | Mobile home parks |
| 8 | Recreation | 8 | Multiple special | 8 | [Left blank] |
| 9 | Exempt | 9 | Potential development | 9 | Manufactured structure |

Table 3: Property class code system. Data Source: ODOR 2007, 3-1 based on OAR 150-308.215

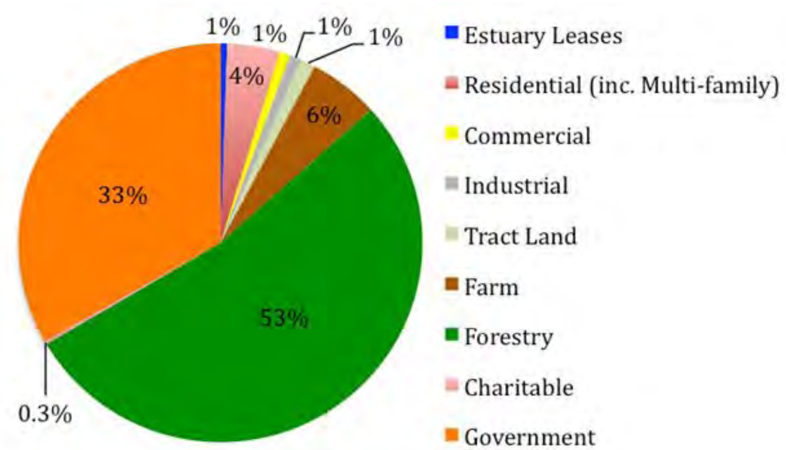



Figure 7: Principle land uses in the project area. Data Source: Coos County Assessor 2014, aggregated by PCLS variable.

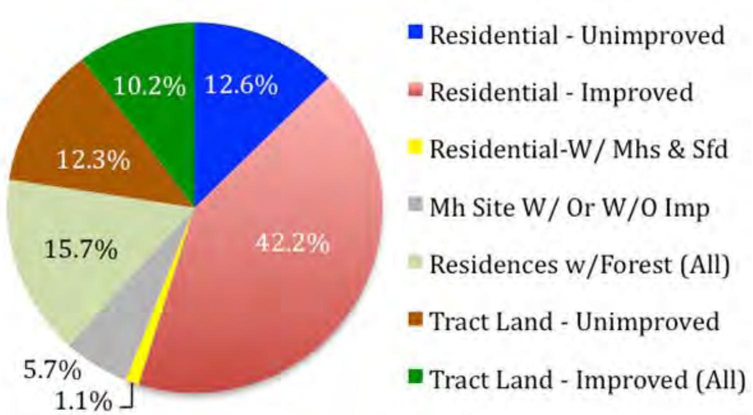



Figure 8: Single-family residential uses. Data Source: CCoos County Assessor 2014, PCLS codes in the 100 and 400 series.

is owned by the government, often as forest, park, or other open space. Of the remaining land uses, agriculture (6%) has the greatest proportion; residential uses (4%) follow, which if Tract lands (1%) are included almost equal agriculture. Commercial and industrial uses are only 1% each, with an additional 1% of the estuary leased for oyster beds and tidelands. However, each of these principal land uses can be further divided by specific type of use.

<u>Residential:</u> Single and multi-family residence uses have great diversity, but can be divided into four major categories: unimproved residential land (i.e., no buildings); traditional residences and mobile homes on lots; residences (traditional and mobile home) that are located on forest lands; and multi-family residences (condos, duplexes, apartments, etc.). Figure 8 shows the proportions of these various types for single-family uses, and Figure 9 shows the proportions for multi-family residences.

The majority of improved single-family residential use is in traditional stick framed houses (42.2%, 11,489 taxlots on 6,834 acres). Manufactured housing (7.5%, 1,013 taxlots on 1,219 acres) represents roughly one-sixth of the traditional housing. Approximately 16% of all single-family residences are located on taxlots also designed for forest use in one form or another. Of particular note Figure 8 is the amount of unimproved lands, either in residential use (12.6%, 2,065 acres) or in tract lands (22.5%, 3,662 acres). "Tract lands" are defined as "parcels of various sizes where the highest and best use is for development to a suburban or rural homesite, but the land is not divided into urban type lots" (ODOR 2007, 3-2).

Five different categories of multi-family residential uses are shown in Figure 9, totaling an area of 669 acres. The vast majority (57%) is used for mobile home parks, of which 48 acres are in taxlots also designed as forest. One of the uses, two houses or a house with a basement or attic apartment, is relatively minor (7%) in the total area of multi-family uses, but includes almost 20% of the taxlots. The greatest frequency by the proportion of taxlots is the duplex through fourplex category, with 55% of the taxlots. Larger housing complexes, i.e., five or more units, are relatively scarce, both as a percentage of the area of multi-family residences (10%), but also as a proportion of the taxlots (about 14%). However, this category—along with mobile home parks—has a larger average parcel size (0.53 acres/tax lot for five or more units; 5.3 acres/tax lot for mobile home parks). Of the 669 acres identified as having the highest and best use for multi-family residences, 9.2% (61 acres) is unimproved, consisting of 30 taxlots. However, although almost two-thirds is located on one tax lot of almost 40 acres on designated farm land, located behind Gib's RV south of Ocean Blvd.

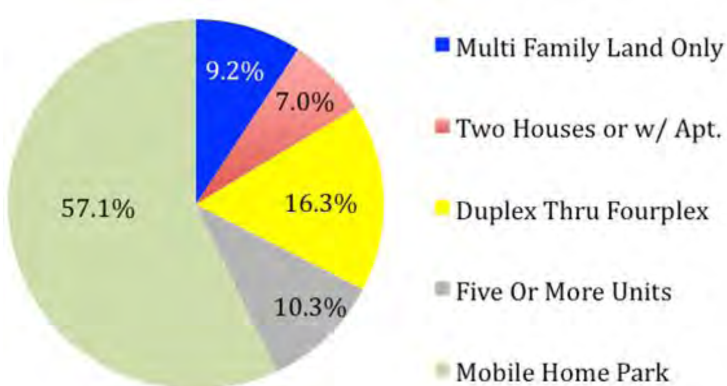



Figure 9: Multi-family residential uses. Data Source:Coos County Assessor 2014, PCLS codes in the 700 series.

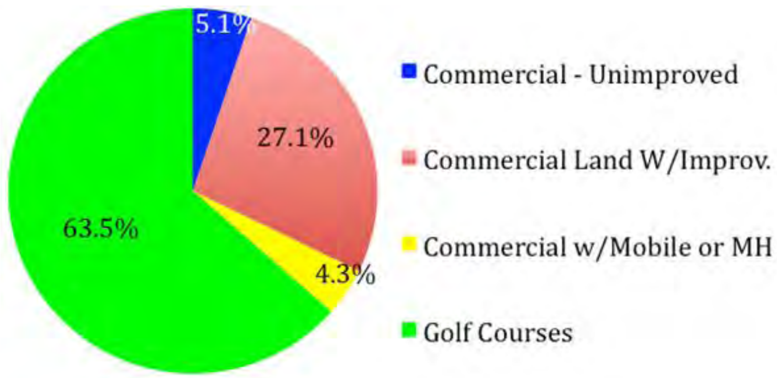



Figure 10: Area of various commercial uses. Data Source: Coos County Assessor 2014, PCLS codes in the 200 series.

Commercial: Commercial uses provide services to residents, workers, and visitors to the project area. While commercial uses cover 2,707 acres—a relatively minor 1% of the area—they provide critical support to the economy and community. Figure 10 shows the proportions of five different categories of commercial uses. Almost two-thirds (63.5%) of commercial uses are for golf courses, most of which is located in the Bandon Dunes complex that also includes housing and dining facilities. The bulk of activities are conducted in the about 27% of the commercial area that has improvements, containing 901 taxlots that cover almost 800 acres. Another 24 parcels (5 acres) have non-conforming uses for commercial areas; and 2 sites are designated historic commercial. An additional 22 parcels, covering 126 acres, have commercial uses as well as a manufactured house on the site. There are 283 taxlots that are zoned for commercial use, but that do not have improvements, i.e., vacant; these cover 152 acres (5.6%) of commercially-zoned lands.

Industrial: While industrial zoned and used lands cover a minor proportion (1%) of the project area, they are largely concentrated along the estuary's waterfront and waterways . Similar to the zoning categories described previously, industrial uses can be divided into four categories: lighter versus heavier, with mobile or manufactured homes, and improved versus unimproved or vacant. Figure 11 shows the relative proportions of these categories. There are 414 taxlots covering 3,030 acres classified for industrial uses in the project area. In contrast to the other major uses, unimproved or vacant industrial parcels represent the greatest percentage (43.2%) of this use: 187 taxlots in 1,308 acres. Slightly less in area, industrial zoned lands with improvements cover about 42% of the industrial uses, and include 198 taxlots with a total area of 1,280 acres (or two square miles). In addition, there are 20 taxlots classified as heavy industrial use, covering 343 acres. (the Jordan Cove LNG project site on the North Spit and Weyerhaeuser's Northwest Hardwood's chip

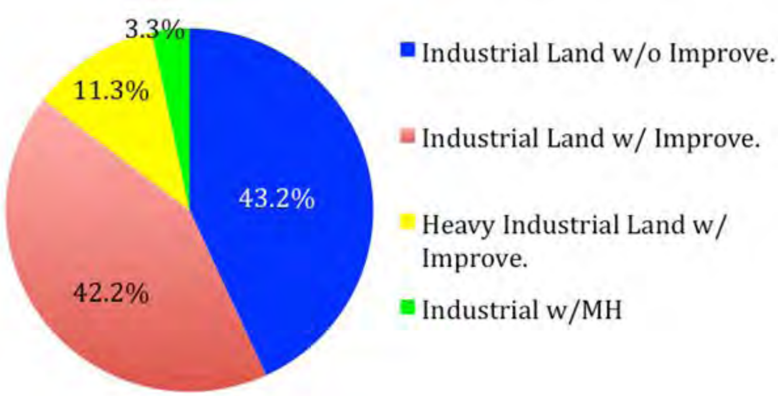



Figure 11: Area of various industrial uses. Data Source: Coos County Assessor 2014, PCLS codes in the 300 series.

facility at Coos City on Isthmus Slough are two of these sites). Another 9 taxlots covering 100 acres are classified as industrial but have either a mobile or a manufactured home on the parcel. Of the industrial parcels, 36 taxlots, covering almost 600 acres have some sort of forest designation.

Historically, lumber and pulp mills, and ship yards, provided the industrial base for the Coos Bay estuary. This has changed as some industries have declined, while others have expanded or become established. There are a wide range of uses presently classified as "industrial." These include what would be considered classic uses such as the Georgia-Pacific Lumber mill, the wood treating plants in Hauser, historic log dumps and rafting sites at Allegany and Dellwood, the quarries up Kentuck, and the fish plants and shipyards of Charleston. Transmitting towers for radio, television, and cell phones are newer uses also categorized as industrial. Included are two Enterprise zones—the Southport Lumber mill on the North Spit, and the Oregon Resources mineral sands processing facility in Bunker Hill.

Agriculture: "The Legislative Assembly recognizes that agriculture and related land uses contribute significantly to Oregon's character and economy and is in the interest of all citizens of this state" (ORS 308A.050, cited in ODOR 2013). While less than 6% of the project area is used for farm use, there is a wide variety of different uses—ranging from improved pastures, cranberry bogs, dairy farms, and small woodlots—in the 510 taxlots covering 18,010 acres. Most of this use occurs in diked areas along streams tributary to the Coos Bay estuary, in narrow valleys above what had been the historic heads of tide of these streams, and in the broad, perched, floodplain along the Coos, South Fork Coos, and Millicoma Rivers. Because of the narrowness of lands suitable for farming, many of the taxlot parcels also combine various designated forest uses; and reflecting settlement patterns discussed in *Chapter 3: Communities and Neighborhoods*, many of these taxlots also contain residences.

Figure 12 shows the relative proportion of various categories of farm uses. The 16 different property class categories have been aggregated into four for ease of display and discussion. Of the major categories, farm land can be designated for Exclusive Farm Use (EFU), called "Zoned" where agriculture is presumed to be the highest and best use, or it can be unzoned, but designated for farm use by application to the County (ODOR 2014). As noted in the previous paragraph, many farms and ranches have pastures in their valleys and floodplains, and forests on their hillsides, giving rise to a combined "farm and forest" property classification. Included in this mixed category in Figure 12 are woodlots of up to 20 acres in farm used taxlots (ORS 308A.056(3)(h)). Finally, farms having cranberry bogs are specifically broken out due to their infrastructure investments and comparatively high crop values. In contrast to other types of uses, the existence of improvements (such as

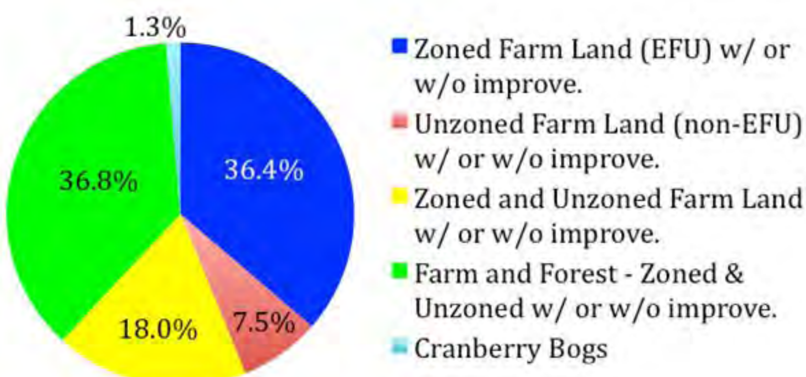



Figure 12: Area of various agricultural uses. Date Source: Coos County Assessor 2014, PCLS codes in the 500 series.

residences, barns, fences, etc.) in farm zones is presumed, and as such the property classes do not differentiate between those with improvements and those without.

Of the 510 farm use taxlots in the project area, over half (266) are exclusively classified as EFU covering slightly more than one-third of the farm use area (6,549 acres). Another quarter of the area is comprised of either un-zoned farm uses (7.5%, 92 taxlots, 1,356 acres), or a combination of EFU and non-EFU uses (18%, 64 taxlots, 3,237 acres). Over another third is mixed farm and forestry, about half of this is EFU (54 taxlots, 3,582 acres), a quarter is non-EFU (14 taxlots, 1,706 acres), and the other quarter is mixed (16 taxlots, 1,341 acres). Included in the forest classifications are woodlots, Small Forest Tracts (SFT), and regular commercial forest uses. Cranberry bogs comprise four taxlots covering 238 acres, including one in Hauser (the first site in Oregon), and three in the Seven Devils area. Not included are the organic cranberry bogs that the Coquille Indian Tribe has in their Kilkich Tribal Community development off Cape Arago highway in Barview.

<u>Forestry</u>: Forestry land uses cover over half (53%) of the project area (Figure 7), about 169,000 acres in total. There are 11 different property classes that the Assessor's office for employes for lands whose primary use is forestry. We can aggregate these 11 classes into four major categories: (a) Forestlands where the owner has over 5,000 in holdings; (b) designated forestlands owned by smaller holders; (c) land with tree cover but not designated as forest; and (d) lands enrolled in the Small Tract Forestland (SFT) special assessment program. Figure 13 shows that large "industrial" timberland owners hold over five-sixths land primarily used for forestry in the project area; this use consists of 663 taxlots, covering 146,664 acres with an average taxlot size of about 220 acres. Designated forest use lands of smaller holders comprises 7.2% of the area; 592 taxlots covering 12,206 acres with an average taxlot size of about 20 acres, or one-tenth as large as the industrial timberland owners' taxlots. "Tract" forests are typically rural properties of at least 40 acres, but are not designated nor participating in the STF program

"Designation" as forestland, either under the general category or as SFT, provides significant advantages to landowners through special tax assessment provisions (ODOR 2013). A distinction is made between forestland whose owners hold more than 5,000 acres total (Q in the property class description), and thus are considered as "industrial" timberland owners. This distinction is important because only owners holding less than 5,000 acres are qualified to participate in the Small Tract Forestland (STFL) tax deferral program (ORS 321.700-754). Landowners with at least 10—but less than 5,000—acres of forestland can apply for STFL designation, and if approved, their land is assessed at 20% of its value with the requirement to pay severance and a forest products harvest taxes when the timber is harvested (ODOR 2013).

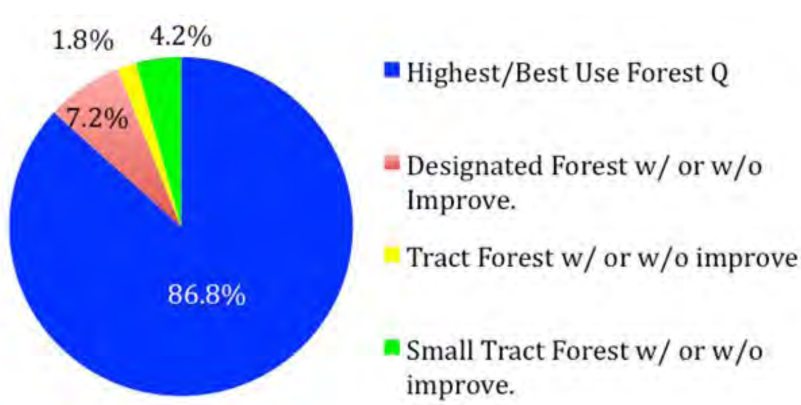



Figure 13: Area of various forest uses. Data Source: Coos County Assessor 2014, PCLS codes in the 600 series.

There are about 8,900 acres, containing 281 taxlots, in the forest use Tract category (not including almost 1,200 acres held by industrial timberland owners). These Tract uses can be divided into four categories depending upon whether the forest is designated through a special tax assessment process (either general or STF): there are designated Tract forestlands; Small Tract Forestland designations, with and without residences or other improvements; and undesignated forestland with residences. In the case of Tract forest use with residences, the number of taxlots is reasonably equivalent to the number of residences: there are 65 (1,747 acres) on designated forest use tracts that have manufactured homes; 15 (561 acres) that are non-designated, but have manufactured houses; and 60 (1,734 acres) that have residences and participate in the STF program. According to the Assessor's office, there is an effort to combine all the Tract classifications into the forestry series.

Charitable and Open Space: The project area has a wealth of charitable non-profit organizations to support critical community needs such as food pantries, social welfare, and fraternal organizations. While this sector doesn't own significant amounts of property, they have their own property classes because they can request exemption from taxes. The charitable property classes represent 265 taxlots covering 816 acres (Figure 14). The vast proportion of lands in this class are represented by various types of open space, including common areas for townhouse developments, cemeteries, and the ocean shore. Utilities, including the County's LNG pipeline right-of-way and the Whiskey Run oceanic fiber optic cable crossing facility, are also in this tax exempt class because they are assessed differently. The Coos Head property owned by the Confederated Tribes is included in this category. There are 76 taxlots owned by churches, cover a total of 87 acres.

Government: Over 105,000 acres within the Coos watershed are owned by governments at all levels: local, state, and Federal, not including the area of streets, highways, or the beds and banks of navigable streams. Figure 15 shows a breakdown of these ownerships by type. The majority of the State of Oregon ownership is in the Elliott State Forest, divided between lands owned by the Common School Fund and those owned by the Board of Forestry. The South Slough National Estuarine Research Reserve (SSNERR) south of Charleston is Common School Fund land as well. Federal ownership is predominantly in lands managed by the Bureau of Land Management (BLM), including three different categories: Coos Bay Wagon Road revested; Oregon and California Railroad revested land; and public domain lands. Each of these three categories have different legal mandates that determine their uses. Other Federal ownership includes lands managed by the Corps of Engineers, including the jetties at the mouth of Coos Bay

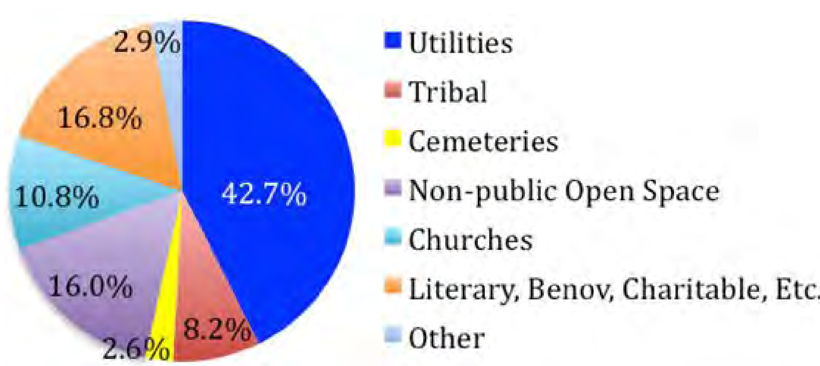



Figure 14: Area of County tax exempt uses. Data Source: Coos County Assessor 2014, PCLS codes in the 983- 993 series.

that extend into the Pacific Ocean; the Coast Guard stations in Charleston; and remnants of the old Coos Head facility that are still used by the Navy.

A multitude of different local governments own lands that are used for a large variety of uses. The largest local government land-owner, Coos County, has a County Forest with units located in the upper South Slough watershed and in Daniels Creek along Blue Ridge. There are also County Parks, including boat launches; the largest are Bastendorf Beach outside Charleston, and Riley Ranch near Hauser. The cities of Coos Bay and North Bend own parks, libraries, and municipal government buildings, while the City of Coos Bay owns part of its municipal watershed in Pony Creek. The two largest special district landowners are the Coos Bay-North Bend Water Board for the remainder of the municipal watershed not owned by the City of Coos Bay; and the Oregon International Port of Coos Bay that owns 59 parcels covering 1,767 acres, located in Charleston (the marina and shipyard), as well as land along the margin of the Bay and the spoil islands and dredged material disposal areas located in the upper Bay. Smaller parcels owned by special districts include rural fire stations, sanitary district pump stations, the Southwest Oregon Regional Airport in North Bend, and the Bay Area Hospital.

**Background**

Oregon's land use planning system has been widely praised—as well as cursed—since it's inception in 1969, and approval in 1973. It's supporters point out that it has controlled urban sprawl, and as a result maintained a land base suitable for agriculture and forestry; it's opponents cast it as failing to protect private property rights, and were successful in 2004 in passing Measure 37, and initiative that allowed uses permitted prior to the passage of the 1973 law to be continued if the current owner had owned the property since that time; however, the Legislature submitted Measure 49 to the voters in November, 2007 that limited the applicability of Measure 37 (DLCD 2007). The of this history of planning and zoning can be seen in the County's plat maps and the accompanying Coos County and City zoning and land use maps; these are the primary resources that we will rely upon for this discussion.

Oregon has 19 different goals in its state-wide system of land use planning (see Table 4). The goals provide a structure for local plans at the county level: they define specific processes, criteria, and outcomes that these plans must meet (DLCD 2010). The goals have legislative authority (ORS 197 and 215), and contain specific implementing provisions outlined in rules (OAR 660-015-0000). Of specific interest for this project are the goals related to the preservation of agricultural and forest lands (goals 3 and 4, respectively); the importance of protecting natural areas (goal 5); and

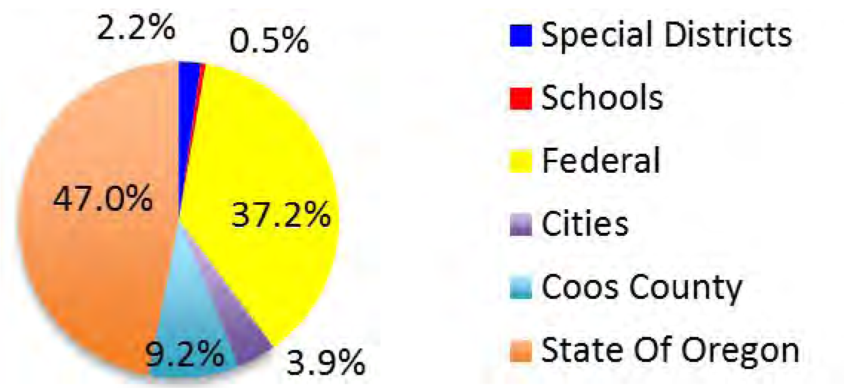



Figure 15: Government land ownership. Data Source: Coos County Assessor 2014

specifically, the planning of land uses in the State's estuaries (goal 16). Economic development (goal 9) provides a structural focus for comprehensive planning urban areas, specifically for commercial and industrial developments; while goal 10 governs the provision of adequate housing; goal 11, public facilities and services; and goal 12, transportation. The expansion of urban communities into surrounding rural areas is governed by goal 14, urbanization, provides criteria for the orderly expansion of urban growth boundaries (UGB), and constrains the provision of public services such as water and sewers outside the UGB. In addition, goal 16 provides standards and criteria specific to Oregon's estuaries, while goal 17 covers adjacent shorelands to insure access for water-dependent and water-related uses.

Goal 16 (OAR 660-017-0010) classifies the estuary into distinct water use management units taking into account the resources, values, and benefits of estuary. Beyond the inventories, there are four elements that are considered: adjacent upland characteristics and existing land uses; compatibility with adjacent uses, energy costs and benefits; and the extent to which the limited water surface area of the estuary shall be committed to different surface uses (Good et al. 2008). All of these elements are taken into consideration in developing the following management units:

(1) Natural – in all estuaries, areas shall be designated to assure the protection of significant fish and wildlife habitats, of continued biological productivity within the estuary, and of scientific, research, and educational needs. These shall be managed to preserve the natural resources in recognition of dynamic, natural, geological, and evolutionary processes. Such areas shall include, at a minimum, all major tracts of salt marsh, tideflats, and seagrass and algae beds.

(2) Conservation – in all estuaries, except those in the overall Oregon Estuary Classification which are classed for preservation, areas shall be designated for long-term uses of renewable resources that do not require major alteration of the estuary, except for the purpose of restoration. These areas shall be managed to conserve the natural resources and benefits. These shall include areas needed for maintenance and enhancement of biological productivity, recreational and aesthetic uses, and aquaculture. They shall include tracts of significant habitat smaller or of less biological importance than those in (1) above, and recreational or commercial oyster and clam beds not included in (1) above. Areas that are partially altered and adjacent to existing development of moderate intensity which do not possess the resource characteristics of natural or development units.

(3) Development – in estuaries classified in the overall Oregon Estuary Classification for more intense development or alteration, areas shall be designated to provide for navigation and other identified needs for public, commercial, and industrial water-dependent uses, consistent with the level of

| | |
|---|---|
| 1. | Citizen Involvement |
| 2. | Land Use Planning |
| 3. | Agricultural Lands |
| 4. | Forest Lands |
| 5. | Natural Resources |
| 6. | Air, Water and Land Quality |
| 7. | Natural Hazards |
| 8. | Recreational Needs |
| 9. | Economic Development |
| 10. | Housing |
| 11. | Public Facilities |
| 12. | Transportation |
| 13. | Energy Conservation |
| 14. | Urbanization |
| 15. | Willamette Greenway |
| 16. | Estuarine Resources |
| 17. | Coastal Shore Lands |
| 18. | Beaches and Dunes |
| 19. | Ocean Resources |

Table 4: Oregon's Statewide Planning Goals. Data Source: DLCD 2007

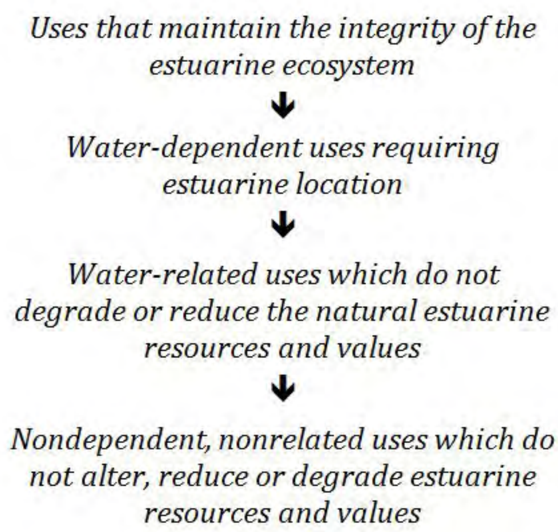



Figure 16: Hierarchy of estuary management priorities. Data Source: DLCD 2007

development or alteration allowed by the overall Oregon Estuary Classification. Such areas shall include deep-water areas adjacent or in proximity to the shoreline, navigation channels, subtidal areas for in-water disposal of dredged material and areas of minimal biological significance needed for uses requiring alterations of the estuary not included in (1) and (2) above.

Each one of these management units has permissible uses and these management units were used to development the management units in the Coos Bay Estuary Management Plan (CBEMP). The CBEMP applied the management units to the water as well as the upland that directly affects the water uses. The management units are defined as follows:

(1) CONSERVATION MANAGEMENT UNIT: In all estuaries, except those in the overall Oregon Estuary Classification which are classed for preservation, areas shall be designated for long-term uses of renewable resources that do not require major alteration of the estuary, except for the purpose of restoration. These areas shall be managed to conserve the natural resources and benefits. These shall include areas needed for maintenance and enhancement of biological productivity, recreational and aesthetic uses, and aquaculture. They shall include tracts of significant habitat smaller or of less biological importance then those in the "Natural" management unit, and recreational or commercial oyster and clam beds not included in the "Natural" management unit. Areas that are partially altered and adjacent to existing development of moderate intensity which do not possess the resource characteristics of natural or development units may also be included in this classification.

(2) DEVELOPMENT MANAGEMENT UNIT: In estuaries classified in the overall Oregon Estuary Classification for more intense development or alteration, areas shall be designated to provide for navigation and other identified needs for public, commercial, and industrial water-dependent uses, consistent with the level of development or alteration allowed by the overall Oregon Estuary Classification. Such areas shall include deep-water reas adjacent or in proximity to the shoreline, navigation channels, subtidal areas for in-water disposal of dredged material and areas of minimal biological significance needed for uses requiring alterations of the estuary not included in "Natural and Conservation" management units.

(3) NATURAL MANAGEMENT UNIT: In all estuaries, areas shall be designated to assurethe protection of significant fish and wildlife habitats, of continued biological pro-

ductivity within the estuary, and of scientific, research, and educational needs. These shall be managed to preserve the natural resources in recognition of dynamic, natural, geological, and evolutionary processes. Such areas shall include, at a minimum, all major tracts of saltmarsh, tideflats, and seagrass and algae beds.

The management units will be accompanied by a segment number and accompanied with letters to determine the management unit and if it is aquatic or shoreland. For example 1-CS means, segment 1-Conservation Shoreland. In the CBEMP there are two types of navigational channels Shallow and Deep:

(1) Natural estuaries that lack maintained jetties and channels, and have little residential or commercial developments;

(2) Conservation estuaries that also lack jetties and channels, but are within or adjacent to urban areas with developed shorelines;

(3) Shallow-draft development estuaries that have jetties, and whose channels are dredged to a depth of 22 feet or less; and

(4) Deep-draft development estuaries that have jetties and channels maintained to a depth greater than 22 feet.

Coos Bay is one of three deep-draft development estuaries in Oregon, with the other two being the Columbia River and Yaquina Bay. Each of these four types has an associated management goal (OAR 660-017-0025): for natural estuaries it is “preserve the natural resources and the dynamic natural processes”; for conservation estuaries it is to “manag[e] for long-term uses of renewable resources that do not require major alterations; and both shallow-draft and deep-draft development estuaries are to be “managed to provide for navigation and other identified needs for public, commercial, and industrial water-dependent uses,” while at the same time containing management units designated as “natural” and “conservation” where areas meet the criteria for those zones. Figure 16 shows the hierarchy of prioritized management and uses in estuaries, irrespective of their type.

Counties implement State-wide planning goals 16 and 17 within their comprehensive plan (OAR 660-015-0010(1)). For the purpose of planning, the area covered by goal 16 extends to the mean higher high water line, including sub-tidal (submerged) and inter-tidal zones, while Goal 17 extends into the uplands, and requires designation of sufficient areas to support water-dependent, water-related, and water-oriented uses. Part of the requirements for an estuary plan is a comprehensive inventory, including physical, biological, and socio-economic characteristics (DLCD 2010). The major outcome of the plan is a “zoning” of the plan area into management units, divided into two broad categories (aquatic and shoreland) then into the three different management classes (natural, conservation, and development), that are subsequently distinguished between urban and rural; and finally, for the development class, into water-dependent versus non-water-dependent uses. Descriptions of these estuary management types are found in Appendix 4.

**References**

Coos County Assessor. 2014. Coos County Assessor Database. ArcGIS shapefile dated 2/3/2014.

Coos County Planning Department. 1985a. "Coos Bay Estuary Management Plan." Volume II Part 1 of the Coos County Comprehensive Plan. Coquille, OR. 349 pp.

Coos County Planning Department. 1985b. Coos County Comprehensive Plan. Coquille, OR. http://www.oregon.gov/lcd/ocmp/docs/public_notice/coos_compplan_eps.pdf. Accessed 9/15/2015.

Coos County Planning Department. n.d.a CBEMP_34_OZM. ArcGIS shapefile.

Coos County Planning Department. n.d.b CBEMP_38_Selected_Mitigation_Restoration_Sites_9600. ArcGIS shapefile.

Good, J.W., J. Borberg, and A. Pakenham. 2008. "Goal 16: Estuarine Resources" Pp. 99 – 137 In: INR. 2008. The Oregon Land Use Program: An Assessment of Selected Goals." Draft Final Report. Prepared for Oregon Department of Land Conservation and Development. Corvallis, OR. 165 pp.

Oregon Department of Land Conservation and Development (DLCD). 2007. An Introductory Guide to Land Use Planning for Small Cities and Counties in Oregon. Salem, OR 52 pp.

Oregon Department of Land Conservation and Development (DLCD). 2010. Oregon's Statewide Planning Goals & Guidelines. 84 pp.

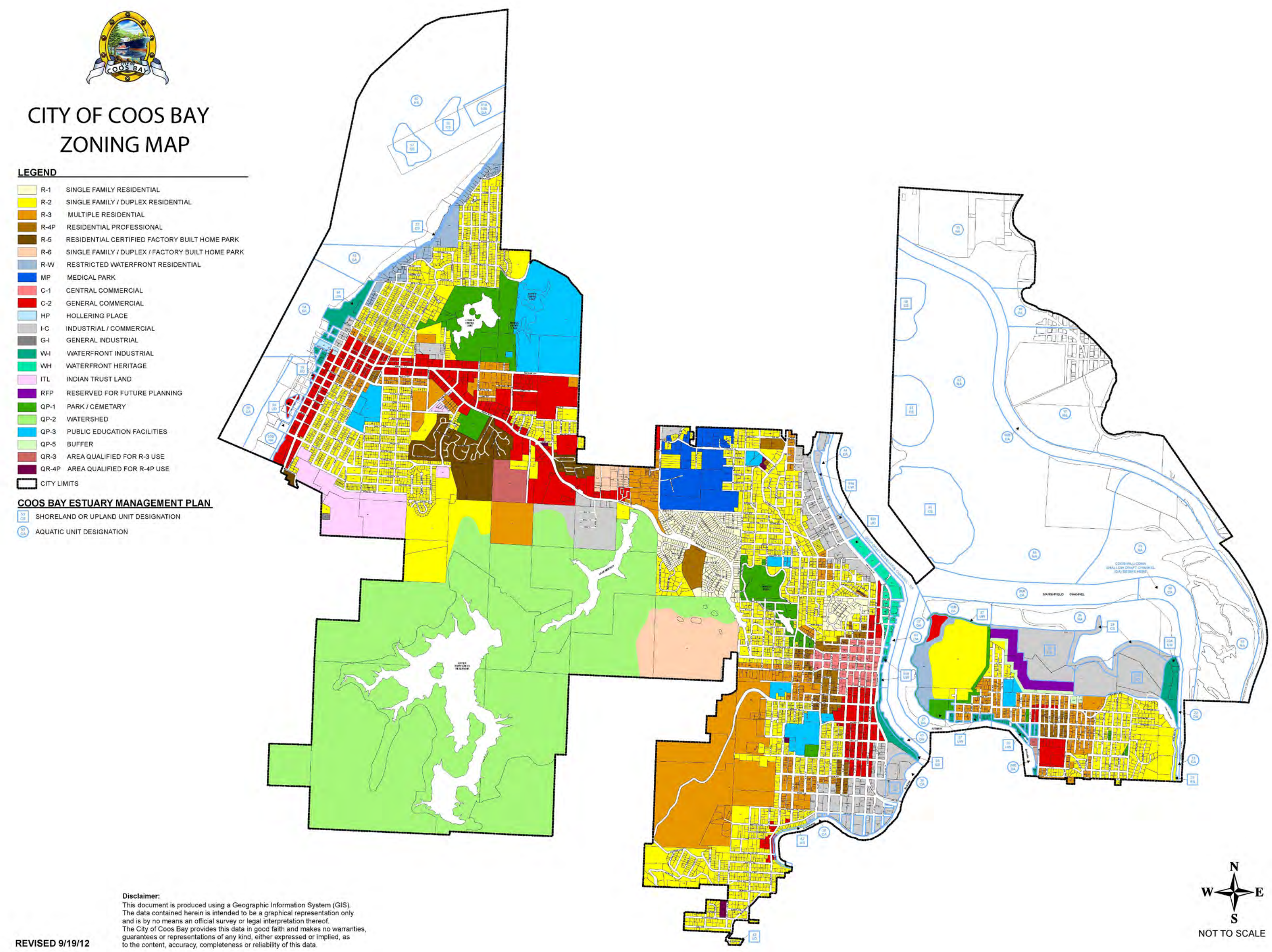
Oregon Department of Land Conservation and Development (DLCD). n.d. Oregon Estuary Plan Book. http://www.inforain.org/oregonestuary/. Accessed 9/15/2015.

Oregon Department of Revenue (ODOR). 2007. Assessor's Certified Ratio Study Procedures Manual. Publication 150-3-3-347, http://www.oregon.gov/dor/PTD/Pages/ratio_manual.aspx. Accessed 9/21/2015.

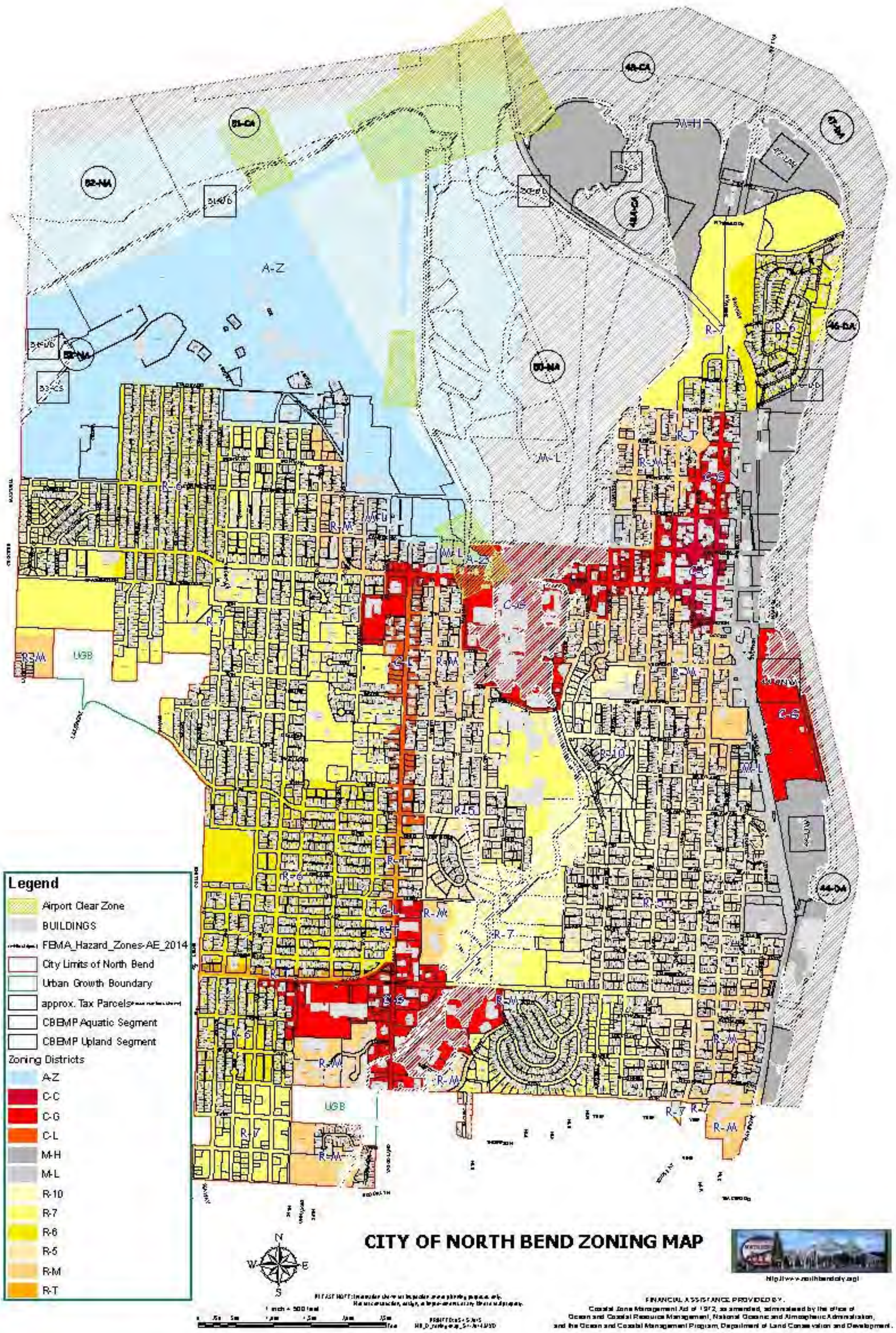
Oregon Department of Revenue (ODOR). 2013. Forestland Manual. Publication 150-303-424 (Rev. 05-13), http://www.oregon.gov/dor/TIMBER/docs/forestland-manual_303-424.pdf. Accessed 9/22/2015.

Oregon Department of Revenue (ODOR). 2014. Farm Use Manual. Publication 150-303-422 (Rev. 09-14), http://www.oregon.gov/dor/PTD/docs/farm-use-manual_303-422.pdf. Accessed 9/23/2015.

Appendix 1. City of Coos Bay Zoning Map



Appendix 2. City of North Bend zoning map



Appendix 3: Parcels and areas of different zoning categories in unincorporated Coos County, and the cities of Coos Bay and North Bend. Data Source: Coos County Planning Department and the Cities of Coos bay and North Bend.

| Coos Bay | | | North Bend | | | County | | |
|---|---|---|---|---|---|---|---|---|
| Zone | Parcels | Acres | Zone | Parcels | Acres | Zone | Parcels | Acres |
| Residential | | | Residential | | | Residential | | |
| Single-Family Residential District (R-1) | 445 | 106.7 | Residential (R-5) | 844 | 250 | Urban Residential-1 (UR-1) | 383 | 251.5 |
| Single-Family and Duplex Residential District (R-2) | 4,128 | 1,191.3 | Residential (R-6) | 1,148 | 330 | Urban Residential-2 (UR-2) | 2,496 | 1,483.4 |
| Multiple Residential District (R-3) | 906 | 585.4 | Residential (R-7) | 1,118 | 573 | Urban Residential- Multi Family (UR-M) | 260 | 106.1 |
| Residential Certified Factory-Built Home Park (R-5) | 14 | 119.7 | Residential (R-10) | 83 | 42 | Rural Residential-2 (RR-2) | 3,345 | 6,465.5 |
| Restricted Waterfront Residential (R-W) | 77 | 77.1 | Residential Multi-family (R-M) | 768 | 267 | Rural Residential-5 (RR-5) | 1,514 | 4,709.2 |
| Single-Family, Duplex Residential & Factory-Built Home District (R-6) | 34 | 148.2 | | | | | | |
| **TOTALS** | **5,604** | **2,228.4** | | **3,961** | **1,462** | | **7,998** | **13,016** |
| Mixed Residential | | | Mixed Residential | | | Mixed Residential | | |
| Residential/Professional District (R-4P) | 264 | 75.1 | Residential Transition (R-T) | 45 | 17 | (Urban) Controlled Development -5 | 278 | 111.5 |
| | | | | | | (Urban) Controlled Development -10 | 0 | 0.0 |
| | | | | | | (Rural) Rural Center - RC | 304 | 344.0 |
| **TOTALS** | **264** | **75.1** | | **45** | **17** | | **582** | **456** |
| Commercial | | | Commercial | | | Commercial | | |
| Medical Park District (MP) | 40 | 105.7 | Limited Commercial C-L | 74 | 26 | Commerical-1 | 224 | 150.8 |
| General Commercial District (C-2) | 612 | 318.1 | General Commercial C-G | 213 | 225 | | | |
| Central Commercial District (C-1) | 138 | 33.3 | Central Commercial C-C | 79 | 23 | | | |
| Hollering Place District (HP) | 4 | 2.9 | | | | | | |
| **TOTALS** | **794** | **460.0** | | **366** | **274** | | **224** | **150.8** |
| Industrial | | | Industrial | | | Industrial | | |
| Waterfront Industrial District (W-I) | 65 | 68.5 | Lht Industrial M-L | 128 | 326 | Industrial (IND) | 269 | 1,184.3 |
| Industrial/Commercial District (I-C) | 259 | 374.9 | Heavy Industrial M-H | 35 | 452 | Airport Operations (AO) | 0 | 0.0 |
| General Industrial District (G-I) | 3 | 1.9 | Airport A-Z | 51 | 695 | | | |
| Waterfront Heritage District (WH) | 47 | 27.6 | | | | | | |
| **TOTALS** | **374** | **472.9** | | **214** | **1,473** | | **269** | **1,184.3** |
| Resource Land | | | Resource Land | | | Resource Land | | |
| | | | | | | Forest (primary Forest) | 3,684 | 263,527.4 |
| | | | | | | Exclusive Farm Use (primary Farm) | 1,028 | 8,019.5 |
| **TOTALS** | | | | | | | **4,712** | **271,547.0** |
| Estuary Zoned/overlay | | | Estuary Zoned /overlay | | | Estuary Zoned | | |
| Aquatic | 183 | 3,372.0 | Aquatic | 18 | 739 | Aquatic | 1,270 | 9,031.1 |
| Shoreland | 273 | 590.0 | Shoreland | 17 | 143 | Shorelands | 1,755 | 8,566.2 |
| **TOTALS** | **456** | **3,962.0** | | **35** | **882** | | **3,025** | **17,597.4** |
| Public and Open Space | | | Public and Open Space | | | Public and Open Space | | |
| Park/Cemetery District (QP-1) | 51 | 184.2 | | | | South Slough (SS) | 102 | 3,301.1 |
| Watershed District (QP-2) | 34 | 1,611.5 | | | | Recreation (REC) | 184 | 7,759.0 |
| Public Educational Facilities District (QP-3) | 24 | 218.6 | | | | Bandon Dunes Resort (BDR) | 38 | 1,364.1 |
| Buffer District (QP-5) | 2 | 11.1 | | | | | | |
| **TOTALS** | **111** | **2,025.4** | | | | | **324** | **12,424.2** |

Appendix 4: Management units and descriptions within the CBEMP.

| Management unit type. | Description (Source: §3.5 of the CBEMP) |
|---|---|
| ***Aquatic Units*** | Boundary is mean higher high water (MHHW) |
| Natural (NA) | Managed for resource protection, preservation and restoration. Severe restrictions are placed on the intensity and types of uses and activities allowed. Natural Aquatic areas include all major tracts of salt marshes, mud-sand flats, seagrass and algae beds that, because of a combination of factors such as size; biological productivity; and habitat value, play a major role in the functioning of the estuarine ecosystem. Natural Aquatic areas also include ecologically important subtidal areas. |
| Conservation (CA) | Managed for low to moderate intensities of uses and activities. Emphasize maintaining the integrity and continuity of aquatic resources and recreational benefits. Minor alterations may be allowed in conjunction with approved uses as specified in each unit. Conservation aquatic areas include open water portions of the estuary and valuable salt marshes and mud-sand flats of lesser biological significance than those in the Natural Aquatic category. |
| Development (DA) | Managed for navigation and other water-dependent uses, consistent with the need to minimize damage to the estuarine system. Some water-related and other uses may be allowed as specified in each respective unit. Development Aquatic areas include areas suitable for deep or shallow-draft navigation (including shipping and access channels or turning basins), in-water dredged material disposal sites, mining or mineral extraction areas, and areas adjacent to developed or developable shorelines which may need to be altered to provide navigational access or create new land areas for water-dependent uses. |
| ***Shorelands Units*** | |
| Natural (NS) | Managed for the protection of natural resources, including the restoration of natural resources to their natural condition. Direct human influence in these areas will be minimal and primarily oriented toward passive undeveloped forms of recreation, educational, and research needs. Natural shoreland areas include major fresh-water marshes, significant wildlife habitat, and other special areas where a lesser management category would not afford adequate protection. |
| Conservation (CS) | Managed for uses and activities that directly depend on natural resources (such as farm and forest lands). While it is not intended that these areas remain in their natural condition, uses and activities occurring in these areas should be compatible with the natural resources of the areas. Conservation Shorelands include commercial forestlands, areas subject to severe flooding or other hazards, scenic recreation areas, specified public shorelines, and important habitat areas. |
| Rural Shorelands (RS) | Managed to maintain a rural character and mix of uses and activities. Management in these areas restricts the intensification of uses to maintain a rural environment and to protect the integrity of existing uses. Compatible rural uses and activities may be expanded in Rural Shorelands. Rural Shorelands include Exclusive Farm Use areas (including the farm and non-farm uses set forth in ORS 215), forestlands, rural centers, and low-intensity rural-residential development. |
| Development (D) | Managed to maintain a mix of compatible uses, including non-dependent and non-related uses. Development areas include areas presently suitable for commercial, industrial, or recreational development. Development Shoreland areas are always located outside of urban growth boundaries and satisfy needs that cannot be met within urban growth boundaries. |
| Urban Development (UD) | Managed to maintain a mix of compatible urban uses, including non-dependent and non-related uses. Urban Development areas include areas presently suitable for residential, commercial, industrial, or recreational development generally at intensities greater than would be found in rural areas. Urban Development areas are primarily within the urban growth boundaries of existing communities but may include other development areas. |
| Water Dependent (WD) | Managed for water dependent uses and some of these areas are suited for water-dependent development. Water-related and other uses are restricted to specific instances prescribed in unit management objectives. Water-Dependent Development Shoreland areas are always located outside of urban growth boundaries, and satisfy needs that cannot be met within urban growth boundaries. |
| Urban Water-dependent (UW) | Managed for water-dependent uses, since these areas are suited for water-dependent development. Water-related and other uses are restricted to specific instances prescribed in unit management objectives. |

Appendix 5: CBEMP management areas, zoning classifications, and their areas (ac.). Data Source: Coos County Planning Department n.d.a

| Management Unit | ***Aquatic Units*** | | | ***Shoreland Units*** | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Outside Urban Growth Boudary | | | | | | Inside UGB | | | | |
| | NA | CA | DA | NS | CS | RS | D | WD | NWD | UD | UDS | UW | UNW | |
| CB #1 | | 246 | | | 80 | | | | | | | | | 327 |
| CB #10 | 497 | | | | 8 | | | | | | | | | 505 |
| CB #11 | 631 | | | | | 225 | | | | | | | | 857 |
| CB #12 | | 3 | | | | 5 | | | | | | | | 8 |
| CB #13A | 390 | | | | 16 | | | | | | | | | 406 |
| CB #13B | 412 | | | | | 26 | | | | | | | | 438 |
| CB #14 | | | 4 | | | | | 1 | | | | | | 5 |
| CB #15 | 562 | | | | | 87 | | | | | | | | 649 |
| CB #16 | | 4 | | | | 45 | | | | | | | | 48 |
| CB #17 | 37 | | | | | 25 | | | | | | | | 62 |
| CB #18 | | | | | | 65 | | | | | | | | 65 |
| CB #18A | | 58 | | | | | | | | | | | | 58 |
| CB #19 | | | | | | | 195 | | | | | | | 195 |
| CB #19A | | 7 | | | | | | | | | | | | 7 |
| CB #19B | | | 9 | | | | | | | | | | | 9 |
| CB #2 | 748 | | | | 578 | | | | | | | | | 1,326 |
| CB #20 | | 532 | | | | 2,402 | | | | | | | | 2,934 |
| CB #20A | | | 1 | | | | | 4 | | | | | | 5 |
| CB #20B | | | 3 | | | | | 14 | | | | | | 17 |
| CB #20C | | | 3 | | | | | 32 | | | | | | 35 |
| CB #20D | | | 15 | | | | | 64 | | | | | | 78 |
| CB #21 | | 165 | | | | 600 | | | | | | | | 764 |
| CB #21A | 42 | | | | | | | | | | | | | 42 |
| CB #25 | 37 | | | | | | | | | | | | | 37 |
| CB #26A | | 3 | | | | | | | | | | | | 3 |
| CB #28 | | | | | | | 35 | | | | | | | 35 |
| CB #28A | | | 94 | | | | | | | | | | | 94 |
| CB #28B | | | 7 | | | | | | | | | | | 7 |
| CB #29 | 54 | | | | 33 | | | | | | | | | 86 |
| CB #3 | | 238 | 167 | | | | | 490 | 52 | | | | | 947 |
| CB #30A | | | | | 18 | | | | | | | | | 18 |
| CB #30B | | | | | | 147 | | | | | | | | 147 |
| CB #30C | | | | | 139 | | | | | | | | | 139 |
| CB #30D | | | | | | 24 | | | | | | | | 24 |
| CB #30E | | | | | 39 | | | | | | | | | 39 |
| CB #31 | 425 | | | | | 57 | | | | | | | | 482 |
| CB #32 | | | | | | | 96 | | | | | | | 96 |
| CB #34 | 70 | | | | | 13 | | | | | | | | 83 |
| CB #36 | | | | | | | | | | | | 195 | | 195 |
| CB #38 | | 17 | | | | | | | | 16 | | | | 33 |
| CB #39 | 61 | | | | 12 | | | | | | | | | 73 |
| CB #3W | | | | 159 | | | | | | | | | | 159 |
| CB #4 | | | | | 247 | | | | | | | | | 247 |
| CB #40 | | | | | | 104 | | | | | | | | 104 |
| CB #45 | 174 | | | | 19 | | | | | | | | | 193 |
| CB #45A | | 98 | | | | | | | | | | | | 98 |
| CB #5 | | | 53 | | | | | 363 | | | | | | 416 |
| CB #51 | | 9 | | | | | | | | | | | | 9 |
| CB #55 | | | | | | | | | | 9 | | | | 9 |
| CB #55A | | 59 | | | | | | | | | | | | 59 |

Appendix 5 Continued: CBEMP management areas, zoning classifications, and their areas (ac.). Data Source: Coos County Planning Department n.d.a

| Management Unit | ***Aquatic Units*** | | | ***Shoreland Units*** | | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Outside Urban Growth Boudary | | | | | | Inside UGB | | | | |
| | NA | CA | DA | NS | CS | RS | D | WD | NWD | UD | UDS | UW | UNW | |
| CB #55B | 51 | | | | | | | | | | | | | 51 |
| CB #56 | | | 69 | | | | | | | | | 63 | | 132 |
| CB #57 | 171 | | | | 28 | | | | | | | | | 199 |
| CB #58 | 175 | | | | | | | | | | | | | 175 |
| CB #59 | | 219 | | | | | | | | | | | | 219 |
| CB #5A | | | | 385 | | | | | | | | | | 385 |
| CB #6 | | | 71 | | | | | 512 | | | | | | 583 |
| CB #60 | | 3 | | | | | | | | | | 16 | | 19 |
| CB #60A | 23 | | | | | | | | | | | | | 23 |
| CB #61 | | | 46 | | | | | | | | 6 | 21 | | 73 |
| CB #63A | 118 | | | | 80 | | | | | | | | | 198 |
| CB #63B | | 6 | | | | | | | | 2 | | | | 8 |
| CB #63C | 496 | | | | | 30 | | | | | | | | 526 |
| CB #63C2 | | | 3 | | | | | | | | | | | 3 |
| CB #64 | | | | | 48 | | | | | | | | | 48 |
| CB #65 | | | | | | | | | | 4 | | | | 4 |
| CB #66 | | | | | | | | | | | | 39 | | 39 |
| CB #66A | | | 33 | | | | | | | | | | | 33 |
| CB #66B | | 33 | | | | | | | | | | | | 33 |
| CB #67 | | 255 | | | | | 17 | | | | | | | 272 |
| CB #67A | | | 6 | | | | | | | | | | | 6 |
| CB #68A | | | | | 12 | | | | | | | | | 12 |
| CB #68B | | | | | | | | 29 | | | | | | 29 |
| CB #69 | 671 | | | 218 | | 31 | | | | | | | | 920 |
| CB #7 | 189 | | | | | | 41 | | | | | | | 230 |
| CB #70 | | | | | 27 | | | | | | | | | 27 |
| CB #71 | | | | | | 125 | | | | | | | | 125 |
| CB #72 | | | | | | 24 | | | | | | | | 24 |
| CB #8 | | 17 | | | | | | 19 | | | | | | 36 |
| CB #9 | | | | | 66 | | | | | | | | | 66 |
| CB #CMRSDNC | | | 5 | | | | | | | | | | | 5 |
| CB #CSDNC | | | 30 | | | | | | | | | | | 30 |
| CB #DDNC | | | 507 | | | | | | | | | | | 507 |
| CB #ISSDNC | | | 52 | | | | | | | | | | | 52 |
| Coos Bay #15 | 218 | | | | | | | | | | | | | 218 |
| Coos Bay #16 | | 37 | | | | | | | | | | | | 37 |
| Coos Bay #17 | 315 | | | | | | | | | | | | | 315 |
| Coos Bay #18B | | 157 | | | | | | | | | | | | 157 |
| Coos Bay #20 | | 68 | | | | | | | | | | | | 68 |
| Coos Bay #21 | | 3 | | | | 3 | | | | | | | | 6 |
| Coos Bay #23 | | | 5 | | | | | | | | | | | 5 |
| Coos Bay #23A | | | | | | | | | | | | 18 | | 18 |
| Coos Bay #23B | | | | | | | | | | 75 | | | | 75 |
| Coos Bay #24 | 157 | | | | 22 | | | | | | | | | 179 |
| Coos Bay #25 | 372 | | | | | | | | | | | | | 372 |
| Coos Bay #26 | | | | | | | | | | 58 | | | | 58 |
| Coos Bay #26A | | 112 | | | | | | | | | | | | 112 |
| Coos Bay #26B | | 27 | | | | | | | | | | | | 27 |
| Coos Bay #27 | | | 62 | | | | | | | | | 20 | | 81 |
| Coos Bay #28 | | | | | | | | | | | | 11 | | 11 |

Appendix 5 Continued: CBEMP management areas, zoning classifications, and their areas (ac.). Data Source: Coos County Planning Department n.d.a

| Management Unit | *Aquatic Units* | | | ***Shoreland Units*** | | | | | | | | | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Outside Urban Growth Boudary | | | | | Inside UGB | | | | |
| | NA | CA | DA | NS | CS | RS | D | WD | NWD | UD | UDS | UW | UNW | |
| Coos Bay #28B | | | 12 | | | | | | | | | | | 12 |
| Coos Bay #38 | | 24 | | | | | | | | | | | | 24 |
| Coos Bay #42 | | | | | | | | | | 41 | | | | 41 |
| Coos Bay #43 | | | 15 | | | | | | | | | 5 | | 20 |
| Coos Bay #44 | | | 31 | | | | | | | | | | | 31 |
| Coos Bay #44a | | | | | | | | | | | | 16 | | 16 |
| Coos Bay #44b | | | | | | | | | | 23 | | | | 23 |
| Coos Bay #45 | 778 | | | | 220 | | | | | | | | | 998 |
| Coos Bay #51A-52A | | | 21 | | | | | | | | | | | 21 |
| Coos Bay #52 | 602 | | | | 35 | | | | | | | | | 637 |
| Coos Bay #53 | | 52 | | | 7 | | | | | | | | | 60 |
| Coos Bay #54 | | | 103 | | | | | | | | | 26 | | 128 |
| Coos Bay #55 | | 57 | | | | | | | | 9 | | | | 67 |
| Coos Bay #55B | 67 | | | | | | | | | | | | | 67 |
| Coos Bay #DEEP DRAFT | | | 79 | | | | | | | | | | | 79 |
| North Bend #44 | | | 74 | | | | | | | | | 62 | 30 | 166 |
| North Bend #46 | | | 20 | | | | | | | 9 | | | | 29 |
| North Bend #47 | | | 40 | | | | | | | | | 22 | | 62 |
| North Bend #48 | | | | | 4 | | | | | | | | | 4 |
| North Bend #48A | | 91 | | | | | | | | | | | | 91 |
| North Bend #50 | 291 | | | | | | | | | 0 | | | | 291 |
| North Bend #51 | | 99 | | | | | | | | 4 | | | | 104 |
| North Bend #52 | 95 | | | | | | | | | | | | | 95 |
| North Bend #53 | | | | | 1 | | | | | | | | | 1 |
| Grand Total | 8,928 | 2,700 | 1,639 | 762 | 1,737 | 4,037 | 384 | 1,528 | 52 | 251 | 6 | 514 | 30 | 22,568 |

Appendix 6: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **H-30 (b)** | 21-RS | **High** | 26S12W20TL0190000 | Hongell, John E., Jr. | 4.81 |
| | | | 26S12W20TL0190100 | Hongell, Roger A. & Debra A. | 4.29 |
| | | | | **H-30 (b) Total** | **9.10** |
| **L-1** | 63C-NA; 63C-RS | **High** | 26S14W13BTL0240000 | Elledge, Thomas W. & Robin L. | 1.59 |
| | | | 26S14W13BTL0240200 | Elledge, Thomas W. & Robin L. | 2.63 |
| | | | 26S14W13BTL0250000 | Oxford, James | 0.74 |
| | | | | **L-1 Total** | **4.99** |
| **L-4** | 60-UW | High | 26S14W01BCTL0670000 | Oregon Int'L Port Of Coos Bay | 0.06 |
| | | | 26S14W01BCTL0580000 | State Of Oregon | 2.02 |
| | | | 26S14W01BCTL0680000 | State Of Oregon | 2.11 |
| | | | 26S14W01BCTL0680100 | State Of Oregon | 2.39 |
| | | | | **L-4 Total** | **6.58** |
| **L-5** | 63C-NA | High | 26S14W11TL0050000 | Alvarado, Manuel | 0.53 |
| | | | 26S14W11TL0040000 | Coquille Indian Tribe Trust | 0.40 |
| | | | 26S14W11TL0060000 | Day, Taylor | 2.21 |
| | | | 26S14W11TL0030000 | State Of Oregon | 4.10 |
| | | | | **L-5 Total** | **7.25** |
| **M-1 (a)** | 57-NA; 58-NA | **Medium** | 25S14W36ACTL0060000 | Coos Bay Resort Llc; Etal | 2.15 |
| | | | 25S14W36ACTL0100000 | Jackson, Laurie E.; L/E | 0.93 |
| | | | 25S14W36ACTL0110000 | Windred, Richard K. | 0.17 |
| | | | | **M-1 (a) Total** | **3.28** |
| **M-1 (b)** | 55-UD | Medium | 25S13W19TL0050000 | City Of Coos Bay | 0.04 |
| | | | 25S13W19ADTL0220000 | Janice L. Wallenstein Revocable Trust | 0.31 |
| | | | 25S13W19ADTL0230000 | Janice L. Wallenstein Revocable Trust | 0.10 |
| | | | 25S13W19ADTL0350000 | Janice L. Wallenstein Revocable Trust | 0.59 |
| | | | 25S13W19ADTL0360000 | Janice L. Wallenstein Revocable Trust | 0.82 |
| | | | 25S13W19ADTL0370000 | Janice L. Wallenstein Revocable Trust | 0.82 |
| | | | 25S13W19DATL0410000 | Janice L. Wallenstein Revocable Trust | 0.29 |
| | | | 25S13W19TL0030000 | Janice L. Wallenstein Revocable Trust | 2.24 |
| | | | 25S13W19TL0040000 | Janice L. Wallenstein Revocable Trust | 0.06 |
| | | | 25S13W19DATL0420000 | Nelson, Gregory L.; Et Al | 0.12 |
| | | | | **M-1 (b) Total** | **5.40** |
| **M-3** | 2-CS | High | 25S13W19TL0020000 | Oregon Int'L Port Of Cb | 5.73 |
| | | | 25S14W24TL0010000 | U.S.A. | 1.47 |
| | | | | **M-3 Total** | **7.20** |
| **M-4** | 2-CS | Low | 25S13W18TL0010000 | Oregon Int'L Port Of Cb | 0.42 |
| | | | 25S13W19TL0020000 | Oregon Int'L Port Of Cb | 11.73 |
| | | | | **M-4 Total** | **12.16** |
| **M-5** | 52-NA; 52-CS | High | 25S13W08TL0010000 | Coos County Airport District | **8.53** |
| **M-8 (a)** | 10-NA | Low | | Unknown | **0.76** |
| **M-8 (b)** | 11-NA | Low | 24S13W35TL0020000 | Coos County | **0.17** |
| **M-9 (a)** | 9-CS | **Medium** | 24S13W15DTL0040000 | Lord, Louis & Julie | 3.52 |
| | | | 24S13W15ATL0090000 | Lord, Louis & Julie; Etal | 0.04 |
| | | | 24S13W15DTL0030000 | Lord, Louis & Julie; Etal | 0.24 |
| | | | 24S13W15DTL0010000 | Sand Dunes 101 Llc | 3.02 |
| | | | 24S13W15DTL0020000 | W.P.I. #3, Llc | 5.67 |
| | | | | **M-9 (a) Total** | **12.50** |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **M-9 (b)** | **10-CS** | **Medium** | 24S13W22TL0130000 | Albert & Marjean Lewis Trust | 0.63 |
| | | | 24S13W15DTL0060000 | Coos County | 6.15 |
| | | | 24S13W22TL0150000 | Coos County | 6.38 |
| | | | 24S13W22TL0140000 | Ebeling Family Trust; Etal | 3.14 |
| | | | 24S13W15DTL0040000 | Lord, Louis & Julie | 3.52 |
| | | | 24S13W15DTL0030000 | Lord, Louis & Julie; Etal | 0.24 |
| | | | 24S13W15DTL0050000 | Nguyen Living Trust | 9.34 |
| | | | | **M-9 (b) Total** | **29.41** |
| **M-9 (c)** | 10-NA | Low | 24S13W22TL0120000 | Shorewood Properties, Llc | 7.61 |
| | | | 24S13W22TL0130000 | Albert & Marjean Lewis Trust | 0.07 |
| | | | 24S13W22TL0160000 | U.S.A. | 9.45 |
| | | | | **M-9 (c) Total** | **17.13** |
| **M-10** | 10-NA | Low | 24S13W22TL0220000 | State Of Oregon Dept Of State Lands | 4.75 |
| | | | 24S13W27TL0090000 | U.S.A. | 11.42 |
| | | | | **M-10 Total** | **16.17** |
| **M-11 (b)** | 10-NA | Low | 24S13W22TL0160000 | U.S.A. | **9.45** |
| **M-12** | 11-RS | Low | 24S13W23TL0010100 | Antonia Rempelos Revocable Living Trust | 18.16 |
| | | | 24S13W24BTL0270000 | Colter, Cynthia A. | 0.44 |
| | | | 24S13W24CTL0100000 | Eickworth, Clara M. | 0.29 |
| | | | 24S13W24BTL0280000 | Graves, James R. | 0.14 |
| | | | 24S13W24CTL0110000 | Jensen, Marcia E. | 0.35 |
| | | | 24S13W23TL0080000 | Nix, Cecil & Nancy Lou | 33.62 |
| | | | 24S13W24CTL0120000 | Nix, Cecil J. & Nancy L. | 43.87 |
| | | | 24S13W24BTL0250000 | Partmann, John & Diane | 0.18 |
| | | | 24S13W24BTL0250100 | Partmann, John & Diane | 0.64 |
| | | | 24S13W23TL0010000 | Rempelos, John W. & Denise A. | 1.33 |
| | | | 24S13W24CTL0090000 | Richmond, Neil T. & Bonnie L. | 0.08 |
| | | | 24S13W26ATL0010000 | Rohrer, William L. & Maryann | 0.01 |
| | | | 24S13W24CTL0150000 | S.E. Wegfahrt Trust | 0.01 |
| | | | 24S13W24CTL0160000 | S.E. Wegfahrt Trust | 1.27 |
| | | | 24S13W24BTL0260000 | State Of Oregon | 14.64 |
| | | | | **M-12 Total** | **115.03** |
| **M-13** | 11-RS | Low | 24S13W26TL0050000 | Bank Of America, National Association | 4.83 |
| | | | 24S13W26ATL0050000 | Mangan, Larry S. & Sylvia A. | 4.36 |
| | | | 24S13W26TL0030000 | Mangan, Larry S. & Sylvia A. | 30.10 |
| | | | 24S13W26TL0050200 | Nanda, Rohit & Noelle J. | 1.31 |
| | | | 24S13W26TL0050400 | Paradise Point Holding Trust | 0.51 |
| | | | | **M-13 Total** | **41.12** |
| **M-22** | 11-RS | Medium | 24S13W36BTL0010000 | Blomquist, Hal D. & Donna J. | 0.12 |
| | | | 24S13W36BTL0030000 | Goodnature, Sonny S. | 1.16 |
| | | | 24S13W36BTL0040000 | Ingersoll, Mark D. & Annette M. | 0.57 |
| | | | 24S13W36BTL0050000 | Ingersoll, William J. & Shirley | 0.51 |
| | | | 24S13W36BTL0020000 | Mazzucchi, David M. & Diana A. | 1.56 |
| | | | 24S13W36BTL0070000 | Thompson, Donald J. & Carol L. | 0.44 |
| | | | | **M-22 Total** | **4.36** |
| **SS-1 a** | 69-NA | Medium | 26S14W00TL0010100 | State Of Oregon Dept Of State Lands | 7.30 |
| | | | 26S14W24TL0020000 | State Of Oregon Dept Of State Lands | 5.64 |
| | | | 26S14W24TL0050000 | State Of Oregon Dept Of State Lands | 22.82 |
| | | | | **SS-1 a Total** | **35.77** |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **SS-1 (b) part** | 69-NS; 69-NA | **Medium** | 26S13W19TL0060000 | State Of Oregon Dept Of State Lands | 15.86 |
| | | | 26S14W24TL0050000 | State Of Oregon Dept Of State Lands | 22.82 |
| | | | | **SS-1 (b) part Total** | **38.68** |
| **SS-2** | 69-NS; 69-NA | **Medium** | 26S14W25TL0010000 | State Of Oregon Dept Of State Lands | 27.26 |
| | | | 26S14W25TL0090000 | State Of Oregon Dept Of State Lands | 0.05 |
| | | | 26S13W30TL0030000 | State Of Oregon Dept Of State Lands | 1.51 |
| | | | 26S14W25TL0010000 | State Of Oregon Dept Of State Lands | 27.26 |
| | | | | **SS-2 Total** | **56.07** |
| **SS-3 a** | 69-NA | **Medium** | 26S14W00TL0010100 | State Of Oregon Dept Of State Lands | 7.30 |
| | | | 26S14W26TL0020000 | State Of Oregon Dept Of State Lands | 1.57 |
| | | | 26S14W26TL0150000 | State Of Oregon Dept Of State Lands | 2.81 |
| | | | 26S14W26TL0160000 | State Of Oregon Dept Of State Lands | 6.48 |
| | | | 26S14W00TL0010100 | State Of Oregon Dept Of State Lands | 7.30 |
| | | | 26S14W26TL0170000 | State Of Oregon Dept Of State Lands | 0.11 |
| | | | 26S14W26TL0180000 | State Of Oregon Dept Of State Lands | 1.75 |
| | | | | **SS-3 Total** | **27.28** |
| **SS-4** | 69-RS | **Medium** | 26S14W26TL0190000 | State Of Oregon Dept Of State Lands | 1.13 |
| | | | 26S14W26TL0200000 | State Of Oregon Dept Of State Lands | 11.11 |
| | | | 26S14W35TL0020000 | State Of Oregon Dept Of State Lands | 7.73 |
| | | | | **SS-4 Total** | **19.97** |
| **SS-5** | 72-RS | **Medium** | 26S14W35TL0020000 | State Of Oregon Dept Of State Lands | **7.73** |
| **SS-6 (a)** | 71-RS | **Medium** | 26S14W26TL0170000 | State Of Oregon Dept Of State Lands | 0.11 |
| | | | 26S14W35TL0010000 | State Of Oregon Dept Of State Lands | 7.44 |
| | | | 26S14W35TL0020000 | State Of Oregon Dept Of State Lands | 7.73 |
| | | | 26S14W36TL0030000 | State Of Oregon Dept Of State Lands | 0.23 |
| | | | 26S14W36TL0040000 | State Of Oregon Dept Of State Lands | 2.40 |
| | | | | **SS-6 (a) Total** | **17.93** |
| **SS-7** | 71-RS | **Medium** | 26S14W35TL0120000 | State Of Oregon Dept Of State Lands | **4.13** |
| **SS-9** | 71-RS | **Medium** | 26S14W35TL0130000 | State Of Oregon Dept Of State Lands | **1.27** |
| **SS-10 (a) & (b)** | 69-NA | **Medium** | 26S14W23TL0020000 | State Of Oregon Dept Of State Lands | 19.18 |
| | | | 26S14W23TL0110000 | State Of Oregon Dept Of State Lands | 1.05 |
| | | | 26S14W23TL0120000 | State Of Oregon Dept Of State Lands | 35.65 |
| | | | 26S14W23TL0130000 | State Of Oregon Dept Of State Lands | 1.22 |
| | | | 26S14W23TL0140000 | State Of Oregon Dept Of State Lands | 0.71 |
| | | | | **SS-10 (a) & (b) Total** | **57.81** |
| **SS-10 (c)** | 69-NA | **Medium** | 26S14W23TL0130000 | State Of Oregon Dept Of State Lands | **1.22** |
| **SS-11** | 69-NA | **Medium** | 26S14W23TL0020000 | State Of Oregon Dept Of State Lands | **19.18** |
| **U-1** | 13B-RS | Low | 25S13W02ACTL0250000 | Ann Collins Survivor'S Trust | 3.03 |
| | | | 25S13W02ACTL0220000 | Bicoastal Cb, Llc | 0.31 |
| | | | 25S13W02ACTL0260000 | Colangelo, Vincent | 0.05 |
| | | | 25S13W02ACTL0230000 | The Swallow Road Trust | 1.02 |
| | | | 25S13W02ACTL0230100 | The Swallow Road Trust | 2.71 |
| | | | | **U-1 Total** | **7.12** |
| **U-8 (a)** | 15-RS | **Medium** | 25S13W12ATL0150000 | Forbes, Paul E., Jr. & Shirley | 0.53 |
| | | | 25S13W12ATL0120000 | Gilfillan, Michael & Shelia | 0.53 |
| | | | 25S13W12ATL0130000 | Martin, Gayle J. | 1.92 |
| | | | | **U-8 (a) Total** | **2.98** |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **U-8 (b)** | 15-RS | **Medium** | 25S13W12TL0030000 | Beechly, R. Eric & C. Linnae | 1.69 |
| | | | 25S13W12TL0030100 | Lortie, Guy J. & Winnifred P. | 0.86 |
| | | | 25S13W12TL0020000 | Miriam W.J.Zomerschoe Rev Trst;Etal | 0.11 |
| | | | 25S13W12ATL0200000 | Stroud Family Trust | 0.96 |
| | | | | **U-8 (b) Total** | **3.61** |
| **U-9 (a)** | 15-RS | **Medium** | 25S13W13BDTL0010000 | Borthwick, Russell C. | 0.39 |
| | | | 25S13W13BDTL0040000 | Coos County | 0.27 |
| | | | 25S13W13BDTL0290000 | Dagata, Joseph | 0.26 |
| | | | 25S13W13BDTL0100000 | Finell Trust | 0.50 |
| | | | 25S13W13BDTL0280000 | Jerry W. White Trust 09-29-10 | 0.11 |
| | | | 25S13W13BDTL0380000 | Jerry W. White Trust 09-29-10 | 0.14 |
| | | | 25S13W13BDTL0320000 | Mark E. & Rebecca E. Ritchie Trust | 0.27 |
| | | | 25S13W13BDTL0300000 | Muenchrath, Matthew; Etal | 0.19 |
| | | | 25S13W13BDTL0330000 | Muenchrath, Matthew; Etal | 0.14 |
| | | | 25S13W13BDTL0340000 | Muenchrath, Matthew; Etal | 0.10 |
| | | | 25S13W13BDTL0350000 | Muenchrath, Matthew; Etal | 0.65 |
| | | | 25S13W13BDTL0360000 | Muenchrath, Matthew; Etal | 0.08 |
| | | | 25S13W13BDTL0370000 | Muenchrath, Matthew; Etal | 0.10 |
| | | | 25S13W13BDTL0050000 | Vader, Eldon C. | 0.14 |
| | | | | **U-9 (a) Total** | **3.33** |
| **U-9 (c)** | 16-WD; 15-NA | Low | 25S13W13BDTL0270000 | Jerry W. White Trust 09-29-10 | **1.34** |
| | | | 25S13W13CATL0010000 | Jerry W. White Trust 09-29-10 | **1.56** |
| | | | | **U-9 (c)2 Total** | **2.90** |
| **U-10** | 17-RS | Low | 25S12W19TL0050000 | Lilienthal, Carole A. | 4.12 |
| | | | 25S12W19TL0010000 | Weyerhaeuser Company | 0.20 |
| | | | | **U-10 Total** | **4.32** |
| **U-11** | 17-RS | **Medium** | 25S12W19TL0130000 | French, Ray L. & Diana L. | 0.07 |
| | | | 25S12W19TL0130200 | French, Ray L. & Diana L. | 2.67 |
| | | | 25S12W19TL0140300 | French, Ray L. & Diana L. | 0.23 |
| | | | 25S12W19TL0130300 | Meyer, Herbert | 0.91 |
| | | | | **U-11 Total** | **3.90** |
| **U-12** | 18-RS | **High** | 25S12W30DTL0150100 | Agri Pacific Resources, Inc. | 7.21 |
| | | | 25S12W30TL0020000 | Demers, Gregory M. | 33.32 |
| | | | 25S12W30TL0060000 | Demers, Gregory M. | 11.92 |
| | | | 25S12W30DTL0050800 | Kronsteiner, Kay A.; Etal | 2.87 |
| | | | 25S12W30TL0030000 | Weyerhaeuser Company | 4.52 |
| | | | 25S12W30TL0070000 | Weyerhaeuser Company | 1.99 |
| | | | | **U-12 Total** | **61.84** |
| **U-13** | 45-CS | **High** | 25S13W00TL0030000 | Oregon Int'L Port Of Cb | **18.25** |
| **U-14 c** | 24-CS | **Medium** | 25S13W25TL0010000 | Oregon Int'L Port Of Cb | **3.84** |
| **U-16 (b)** | Outside CBEMP | Low | 25S12W29CBTL0010000 | Barney, R. John & Lorna M. | 0.31 |
| | | | 25S12W30DTL0090000 | Craig, Steven J. & Debra A. | 4.36 |
| | | | 25S12W29CBTL0050000 | Crawford, Wayne R. & Donna L. | 0.73 |
| | | | 25S12W29TL0110000 | Donald E. Fisher 2012 Delaware Trust | 1.53 |
| | | | 25S12W29TL0120400 | Jaeggli, Nathaniel D. & Sally B. | 5.80 |
| | | | 25S12W29CBTL0040000 | Johnson, Guy L.; & Johnson, Barbara | 1.06 |
| | | | 25S12W29CBTL0020000 | Johnson, Robert D. & Wendy S. | 1.70 |
| | | | 25S12W29CBTL0030000 | Johnson, Robert Doran & Amy Joan | 0.95 |
| | | | 25S12W29CBTL0060000 | Mccarthy, Dennis C. & Joy L. | 1.59 |
| | | | | **U-16 (b) Total** | **18.04** |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **U-17 (a)** | **20-RS** | **Medium** | 25S12W29CTL0040000 | Douglas Family Trust | 1.46 |
| | | | 25S12W29CTL0070000 | Douglas Family Trust | 0.20 |
| | | | 25S12W32BTL0020000 | Mault, Jason & Brandy | 7.80 |
| | | | 25S12W29CTL0020000 | Saunders, Randy A. | 0.66 |
| | | | 25S12W32BTL0030000 | Weyerhaeuser Company | 0.65 |
| | | | | **U-17 (a) Total** | **10.77** |
| **U-17 (b)** | **20-RS** | **Medium** | 25S12W29CTL0020300 | Welsh, Joel & Julie | 0.40 |
| | | | 25S12W29TL0140000 | Weyerhaeuser Company | 4.66 |
| | | | | **U-17 (b) Total** | **5.06** |
| **U-21 (b)** | **21-RS** | **Medium** | 26S12W05TL0080100 | Morgan, David & Dena | 1.63 |
| | | | 26S12W05TL0080300 | Nelson, Kevin R. & Theresa R. | 2.54 |
| | | | 26S12W06ATL0070000 | Peck, Gayle L. & Sheila M. | 0.86 |
| | | | 26S12W05TL0080200 | Wright, Ron & Donna | 0.16 |
| | | | | **U-21 (b) Total** | **5.18** |
| **U-22** | **21-RS** | **Low** | 26S12W08TL0090000 | Hill, Jeffrey L. | 0.15 |
| | | | 26S12W08TL0100000 | Hill, Jeffrey L. & Gidgette N. | 0.98 |
| | | | 26S12W08BTL0030000 | Johnson Family Trust | 0.11 |
| | | | 26S12W08BTL0040000 | Johnson Family Trust | 0.32 |
| | | | 26S12W08BTL0010000 | Prugh, Michael; Etal | 7.66 |
| | | | 26S12W08BTL0070000 | Rapelje, Nikki S. & Rapelje, Brandon W. | 2.78 |
| | | | 26S12W08TL0110000 | Rode, Alvin & Lou Ann; L/E | 0.09 |
| | | | 26S12W08BTL0050000 | Szymik, John R. & Stacy | 8.06 |
| | | | | **U-22 Total** | **20.16** |
| **U-23** | **21-RS** | **Low** | 26S12W08BTL0100000 | Liles, Richard & Betty | 24.79 |
| | | | 26S12W06DTL0200000 | Rhonda Hill Revocable Trust | 0.12 |
| | | | | **U-23 Total** | **24.91** |
| **U-24** | **21-RS** | **Low** | 26S12W08BTL0120000 | Danielson, Ryan M. & Timony, Erin C. | 8.31 |
| | | | 26S12W08TL0160300 | Gunnell Family Trust | 3.63 |
| | | | 26S12W08TL0170000 | Pallin, Curtis J. & Melissa R. | 12.28 |
| | | | 26S12W08BTL0110000 | Post, Michael S. & Trina A. | 7.15 |
| | | | 26S12W08BTL0130000 | Robertson, Daniel M. & Mary K. | 0.82 |
| | | | | **U-24 Total** | **32.18** |
| **U-26** | **21-RS** | **Low** | 26S12W17CTL0030100 | Mast, Harold | 15.36 |
| | | | 26S12W17TL0050000 | State Of Oregon | 1.08 |
| | | | | **U-26 Total** | **16.45** |
| **U-27** | **21-RS** | **Low** | 26S12W17CTL0020000 | Cole, William C. & Ellen B. | 11.74 |
| | | | 26S12W17DTL0030000 | Hongell, Jan E. | 2.91 |
| | | | | **U-27 Total** | **14.65** |
| **U-28** | **21-RS** | **Medium** | 26S12W17CTL0060000 | Perrin, Peter E. & Leticia M. | **4.00** |
| **U-29 (a)** | **21-RS** | **Low** | 26S12W17DTL0070000 | Cole, William C. & Ellen B. | 33.10 |
| | | | 26S12W20TL0040000 | Koehler, Gary C. | 14.05 |
| | | | 26S12W17CTL0110000 | Penas, Mary K. | 0.71 |
| | | | 26S12W20TL0090000 | Purcell, Richard E. | 0.57 |
| | | | 26S12W20TL0070000 | Schad, Dennis | 0.84 |
| | | | 26S12W17TL0050000 | State Of Oregon | 1.08 |
| | | | 26S12W20TL0030000 | State Of Oregon | 0.13 |
| | | | | **U-29 (a) Total** | **50.51** |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **U-29 (b)** | 21-RS | Medium | 26S12W20ADTL0020000 | Johnson, Vivian Ocie | 0.17 |
| | | | 26S12W20TL0010000 | Wetlands Conservancy, Inc. | 3.74 |
| | | | | **U-29 (b) Total** | **3.91** |
| **U-30 (a)** | 21A-NA | Medium | 26S12W20TL0190000 | Hongell, John E., Jr. | 3.15 |
| | | | 26S12W20TL0090000 | Purcell, Richard E. | 0.21 |
| | | | | **U-30 (a) Total** | **3.35** |
| **U-31** | 21A-NA | High | 26S12W20TL0200000 | Schneider, Ruth A. | **3.21** |
| **U-32 (a)** | 21A-NA | Medium | 26S12W20TL0230000 | De Ronden-Pos, Lionel | 7.59 |
| | | | 26S12W20DTL0010200 | Wauer, David J. | 0.25 |
| | | | | **U-32 (a) Total** | **7.85** |
| **U-32 (b)** | 21-RS | Medium | 26S12W20TL0260000 | Bert, Diane A. | 2.87 |
| | | | 26S12W20TL0240000 | De Ronden-Pos, Lionel | 4.45 |
| | | | | **U-32 (b) Total** | **7.32** |
| **U-32 (c)** | 21-RS | Low | 26S12W20DTL0050000 | Deronden-Pos, Ronald J. | 0.22 |
| | | | 26S12W20TL0270000 | Wood, David R. & Caroll | 13.85 |
| | | | | **U-32 (c) Total** | **14.07** |
| **U-33** | 21-RS | Medium | 26S12W29TL0030000 | State Of Oregon | 3.20 |
| | | | 26S12W20DTL0160000 | The Petock Family Trust | 1.33 |
| | | | 26S12W29TL0010000 | The Petock Family Trust | 15.36 |
| | | | 26S12W20DTL0100000 | Tracy, Kenneth & Donna K. | 0.13 |
| | | | | **U-33 Total** | **20.01** |
| **U-34 (a)** | 21-RS | Low | 26S12W29TL0040000 | Fred Messerle & Sons, Inc. | 2.50 |
| | | | 26S12W29TL0100000 | R & B Brown Family Trust | 8.08 |
| | | | | **U-34 (a) Total** | **10.58** |
| **U-34 (b)** | 21-RS | Low | 26S12W29TL0040000 | Fred Messerle & Sons, Inc. | 2.50 |
| | | | 26S12W29TL0020100 | Lone Rock Timber Investments I, Llc | 5.59 |
| | | | 26S12W29TL0030000 | State Of Oregon | 2.93 |
| | | | | **U-34 (b) Total** | **11.02** |
| **U-34 (c)** | 21-RS | Medium | 26S12W29TL0040000 | Fred Messerle & Sons, Inc. | 1.00 |
| | | | 26S12W29TL0020100 | Lone Rock Timber Investments I, Llc | 0.24 |
| | | | 26S12W29TL0030000 | State Of Oregon | 3.20 |
| | | | 26S12W29TL0010000 | The Petock Family Trust | 15.36 |
| | | | | **U-34 (c) Total** | **19.79** |
| **U-34 (d)** | 21-RS | Medium | 26S12W29TL0050000 | Louie & Cecilia Evoniuk Trust | 1.04 |
| | | | 26S12W29TL0030000 | State Of Oregon | 3.20 |
| | | | | **U-34 (d) Total** | **4.24** |
| **U-40** | 21-RS | High | 26S13W01BTL00699Z0 | Division Of State Lands | 0.15 |
| | | | 26S13W01CTL00198Z0 | Division Of State Lands | 0.23 |
| | | | 26S13W01CTL00199Z0 | Division Of State Lands | 0.81 |
| | | | 26S13W01BTL0060000 | Hong, Fang-Yen & Chun-Mei | 15.85 |
| | | | 26S13W01CTL0010000 | Hong, Fang-Yen & Chun-Mei | 33.18 |
| | | | | **U-40 Total** | **50.22** |
| **U-41 (b)** | Outside CBEMP | Low | 26S13W11DATL0020000 | Slape, George W. | 0.14 |
| | | | 26S13W11DATL0010000 | State Of Oregon | 0.32 |
| | | | 26S13W11ADTL0480000 | Young, Carole K. | 0.14 |
| | | | 26S13W11ADTL0500000 | Young, Carole K. | 1.48 |
| | | | 26S13W11ADTL0560000 | Young, Carole K. | 0.63 |
| | | | 26S13W11ADTL0570000 | Young, Carole K. | 1.75 |
| | | | 26S13W11ADTL0580000 | Young, Carole K. | 0.26 |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| U-41 (b)(con't) | | | 26S13W11ADTL0590000 | Young, Carole K. | 0.22 |
| | | | 26S13W11ADTL0600000 | Young, Carole K. | 1.18 |
| | | | | **U-41 (b) Total** | **6.15** |
| **U-42** | 34-RS | Medium | 26S13W11CTL0240200 | Kuehn, Terry L. & Loretta M.; Etal | 0.08 |
| | | | 26S13W11CTL0240000 | Kuehn, Terry L.; Etal | 5.68 |
| | | | | **U-42 Total** | **5.75** |
| **U-44** | 30B-RS | High | 26S13W13CTL0050200 | Bracelin, Charles R. & Joanna J. | 0.08 |
| | | | 26S13W13CTL0051400 | Bracelin, Charles R. & Joanna J. | 1.08 |
| | | | 26S13W14TL0010000 | Bracelin, Charles R. & Joanna J. | 0.53 |
| | | | 26S13W14TL0010100 | Lyons, Barbara A. | 2.41 |
| | | | 26S13W13CTL0100000 | Trillium Land Group, Llc | 2.49 |
| | | | 26S13W13CTL0110000 | Trillium Land Group, Llc | 2.91 |
| | | | 26S13W13CTL0120000 | Trillium Land Group, Llc | 4.67 |
| | | | 26S13W14TL0020000 | Trillium Land Group, Llc | 8.60 |
| | | | | **U-44 Total** | **22.78** |
| **U-45 (a)** | Outside CBEMP | Low | 26S13W23BTL0020100 | Kronsteiner, David; Etal | 0.26 |
| | | | 26S13W23BTL0030000 | Kronsteiner, David; Etal | 0.49 |
| | | | 26S13W23BTL0040000 | Southern Oregon Marine, Inc. | 0.33 |
| | | | | **U-45 (a) Total** | **1.08** |
| **U-45 (b)** | 32-D | Low | 26S13W22TL0070000 | Enterprises Of Leahy & Kubli Mountain, L | 0.51 |
| | | | 26S13W23CTL0030100 | John W. Plott Trust | 4.62 |
| | | | | **U-45 (b) Total** | **5.13** |
| **U-51 (a)** | 31-NA | High | 26S13W27TL0100000 | Menasha Forest Products Corporation | 0.01 |
| | | | 26S13W28TL0010000 | Menasha Forest Products Corporation | 0.08 |
| | | | 26S13W28TL0010200 | Menasha Forest Products Corporation | 1.33 |
| | | | 26S13W27TL0100100 | State Of Oregon Dept Of State Lands | 21.65 |
| | | | 26S13W28TL0010100 | State Of Oregon Dept Of State Lands | 13.36 |
| | | | | **U-51 (a) Total** | **36.43** |
| **U-51 (b)** | 31-RS | High | 26S13W21TL0010000 | Menasha Forest Products Corporation | 7.47 |
| | | | 26S13W28TL0010000 | Menasha Forest Products Corporation | 0.08 |
| | | | 26S13W28TL0010200 | Menasha Forest Products Corporation | 1.33 |
| | | | 26S13W28TL0010100 | State Of Oregon Dept Of State Lands | 13.36 |
| | | | | **U-51 (b) Total** | **22.24** |
| **U-52 (a)** | 31-RS | Low | 26S13W28TL0010000 | Menasha Forest Products Corporation | 0.22 |
| | | | 26S13W28TL0010900 | Menasha Forest Products Corporation | 0.51 |
| | | | 26S13W28TL0030000 | Pacificorp | 0.98 |
| | | | 26S13W28TL0010300 | Statham, Michael L. & Jerri L. | 8.67 |
| | | | 26S13W28TL0010800 | Statham, Michael L. & Jerri L. | 23.44 |
| | | | | **U-52 (a) Total** | **33.81** |
| **U-52 (b)** | 30E-CS | Medium | 26S13W27TL0170000 | Fred Messerle & Sons, Inc. | **10.11** |
| **U-53** | 30E-CS | Medium | 27S13W03TL0010000 | Prather Family Trust | **2.42** |
| **U-54** | 30E-CS | Medium | 27S13W02TL0010000 | Siglin, Terry & Christy | **8.86** |
| **U-55 (a)** | 30E-CS | Low | 27S13W03ATL0030000 | Plum Creek Timberlands, L.P. | 3.19 |
| | | | 27S13W03ATL0120000 | Siglin, Terry M. & Christy | 0.08 |
| | | | 27S13W03DTL0010000 | Siglin, Terry M. & Christy | 0.06 |
| | | | | **U-55 (a) Total** | **3.33** |
| **U-55 (b)** | 31-NA | Medium | 27S13W03ATL0130000 | Coos County | 1.35 |
| | | | 27S13W03ATL0140000 | Siglin, Terry M. & Christy | 3.94 |
| | | | | **U-55 (b) Total** | **5.29** |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **U-59 (a)** | **39-NA** | **High** | 26S13W02BATL0050000 | Arney, Timothy L. | 0.32 |
| | | | 26S13W02BATL0370000 | Arney, Timothy L. | 0.20 |
| | | | 26S13W02BATL0170000 | Button Family Trust | 0.10 |
| | | | 26S13W02BATL0190000 | Campbell, Ronald D. | 0.07 |
| | | | 26S13W02BATL0040000 | Coos County | 0.13 |
| | | | 26S13W02BATL0060000 | Coos County | 0.19 |
| | | | 26S13W02BATL0210000 | Coos County | 0.53 |
| | | | 26S13W02BATL0210000 | Coos County | 1.05 |
| | | | 26S13W02BATL0220000 | Coos County | 0.52 |
| | | | 26S13W02BATL0310000 | Coos County | 0.47 |
| | | | 26S13W02BATL0350000 | Coos County | 0.26 |
| | | | 26S13W02BATL0360000 | Coos County | 0.20 |
| | | | 26S13W02BATL0080000 | Cuong & Lemai Ngo Trust | 0.61 |
| | | | 26S13W02BATL0070000 | Dohle, Isabel B. | 0.13 |
| | | | 26S13W02BATL0030000 | Donald Goossens Revocable Trust | 0.50 |
| | | | 26S13W02BATL0320000 | Dubisar, Vicki L. | 0.06 |
| | | | 26S13W02BATL0340000 | Dubisar, Vicki L. | 0.39 |
| | | | 26S13W02BATL0160000 | Engebretson, Frances J.; Etal | 0.08 |
| | | | 26S13W02BATL0400000 | Engebretson, Frances J.; Etal | 0.73 |
| | | | 26S13W02BATL0260300 | Frakes, Steven G. & Evette E. | 0.24 |
| | | | 26S13W02BATL0330000 | Frakes, Steven G. & Evette E. | 0.26 |
| | | | 25S13W35CDTL0120000 | Garcia, Raymundo V. & Rosalba M. | 0.58 |
| | | | 25S13W35CDTL0130000 | Garcia, Raymundo V. & Rosalba M. | 0.09 |
| | | | 25S13W35CDTL0140000 | Garcia, Raymundo V. & Rosalba M. | 0.35 |
| | | | 25S13W35CDTL0150000 | Garcia, Raymundo V. & Rosalba M. | 0.37 |
| | | | 26S13W02BATL0180000 | Gibson, Jessie M. | 0.90 |
| | | | 26S13W02BATL0200000 | Gibson, Jessie M. | 1.05 |
| | | | 26S13W02BATL0270000 | Karicofe, Steve & Vickie | 0.24 |
| | | | 26S13W02BATL0380000 | Miller, Rex E. | 0.20 |
| | | | 26S13W02BATL0390000 | Miller, Rex E. | 0.06 |
| | | | 26S13W02BATL0390100 | Miller, Rex E. | 0.07 |
| | | | 25S13W35CDTL0110000 | Powell, John A., Estate Of | 2.87 |
| | | | 26S13W02BATL0090000 | Rains, Vaughn Z.; & Warthen, Vicky | 0.24 |
| | | | 26S13W02BATL0100000 | Rains, Vaughn Z.; & Warthen, Vicky | 0.21 |
| | | | 26S13W02BATL0110000 | Rains, Vaughn Z.; & Warthen, Vicky | 0.07 |
| | | | 26S13W02BATL0300000 | Randle Bros Construction | 0.13 |
| | | | 26S13W02BATL0290000 | Randle Bros. Construction | 0.14 |
| | | | 26S13W02BATL0280000 | Randle, Shannon | 0.12 |
| | | | 25S13W35CDTL0160000 | Scott Family Trust | 0.81 |
| | | | 26S13W02BATL0230000 | Scott Family Trust | 0.26 |
| | | | 26S13W02BATL0240000 | Scott Family Trust | 0.53 |
| | | | 26S13W02BATL0250000 | Scott Family Trust | 0.02 |
| | | | 25S13W35CDTL0250000 | Tribes Of Coos, Lower | 2.08 |
| | | | 26S13W02BATL0070100 | Zar, Olga L. | 0.08 |
| | | | | **U-59 (a) Total** | **18.60** |
| **U-59 (b) part** | 39-NA | High | 26S13W02BBTL0160000 | Bouchet, Mardeane D. | 0.36 |
| | | | 25S13W35CCTL0180000 | Coos County | 0.23 |
| | | | 25S13W35CCTL0080000 | Kathryn F. Anthony Trust | 0.14 |
| | | | 25S13W34DDTL0610000 | Seven Hounds Trust 1-5-2012 | 13.47 |
| | | | 25S13W35CCTL0070000 | Seven Hounds Trust 1-5-2012 | 7.07 |
| | | | 26S13W03AATL0010000 | Seven Hounds Trust 1-5-2012 | 12.40 |

Appendix 6 Continued: Designated mitigation sites and their owners with the Coos Bay Estuary Managment Plan (CBEMP)

| Site | CBEMP Unit | Mitigation Priority | TLID | Owner (as of 2/2014) | Parcel Acres* |
|---|---|---|---|---|---|
| **U-59 (b) part (con't)** | | | 26S13W02BBTL0530000 | Souza, Bryan A. | 0.31 |
| | | | | **U-59 (b) part Total** | **34.06** |
| **U-60 (a)** | 40-RS | Low | 26S13W03AATL0220000 | Brown, Samuel A. & Cynthia L. | 0.56 |
| | | | 26S13W03AATL0310000 | Casey, Paula K. | 4.90 |
| | | | 26S13W03ADTL0010000 | Casey, Paula K. | 4.17 |
| | | | 26S13W03AATL0200000 | Gollihur, Thomas R. & Sue A. | 0.07 |
| | | | 26S13W03ACTL0050000 | Harrison, Petrona M. | 2.42 |
| | | | 26S13W03ACTL0050100 | Harrison, Petrona M. | 1.34 |
| | | | 26S13W03ADTL0020000 | Harrison, Petrona M. | 5.59 |
| | | | 26S13W03ADTL0020100 | Harrison, Petrona M. | 4.34 |
| | | | 26S13W03ACTL0400000 | Hoeger, Georgeann M. | 0.95 |
| | | | 26S13W03ACTL0440000 | Hoeger, Georgeann M. | 1.82 |
| | | | 26S13W03ACTL0450000 | Hoeger, Georgeann M. | 1.53 |
| | | | 26S13W03ADTL0040000 | Hoeger, Georgeann M. | 0.47 |
| | | | 26S13W03DBTL0070000 | Hoeger, Georgeann M. | 2.79 |
| | | | 26S13W03AATL0210000 | Walker, Lee Roy G. & Jean K. | 3.75 |
| | | | | **U-60 (a) Total** | **34.70** |
| **U-60 (b)** | 40-RS | Low | 26S13W03DBTL0110000 | City Of Coos Bay | 0.31 |
| | | | 26S13W03ACTL0390000 | Hoeger, Georgeann M. | 0.88 |
| | | | 26S13W03ACTL0400000 | Hoeger, Georgeann M. | 0.95 |
| | | | 26S13W03DBTL0070000 | Hoeger, Georgeann M. | 2.79 |
| | | | 26S13W03DBTL0090000 | Wright, Duane E. & Joyce L. | 0.09 |
| | | | 26S13W03DBTL0100000 | Wright, Duane E. & Joyce L. | 0.10 |
| | | | | **U-60 (b) Total** | **5.12** |
| | | | | **Grand Total** | **1,337.49** |

* Taxlot parcels < 0.05 acres are not listed. Therefore, parcel areas may not sum to the site total acres.

# **Chapter 7:** Schools and Education in the Coos Bay Area

*Jon Souder - Coos Watershed Association*



*Summary:*

- *Students can get a good education in project area schools. However, despite the best efforts of the school districts, the local educational system is not working well for a number of segments of the community.*
- *The state of educational infrastructure in the project area is a deterrent to effective education.*
- *In recent years, student numbers have been declining in the project area.*
- *The distance and time required for students from outlying areas to be bussed to centralized schools is leading to the creation of "home-schooling cooperatives."*

**Introduction**

One of the most important decisions that residents of the project area make is where to live. Multiple factors usually enter into this decision, but if the family has children—or expects to in the near future— what school their kids will attend often outweighs any other single criteria. Schools also play an important role in civic engagement within the community: teachers and staff are often recruited into the community; parents become involved in their children's sports and other activities; and parents often join Parent

Teacher Associations (PTAs), advisory groups, or run for the school board. Schools often host facilities such as playing fields, theatres, libraries, and meeting rooms that are open to the public outside of school hours. Thus, the condition of the educational system in the community reflects, and is reflected by, the public's support and involvement.

This chapter will examine the state of the schools in the project area (Figure 1). We will begin by describing the composition of schools in the area, including public, charter, and private schools. Because public schools are financed based on the number of students, changes in attendance over time (as well as local school levies) significantly affect their operations. One of the outcomes of the No Child Left Behind law was testing students and assessing school performance; Oregon provides annual district and school report cards that allow for comparison among districts and schools within the project area, as well as comparisons with districts and schools state- wide that have similar demographics. Finally, there has been a history of school district consolidations—and school closures—within the project area that have resulted in impacts to both students and local communities.

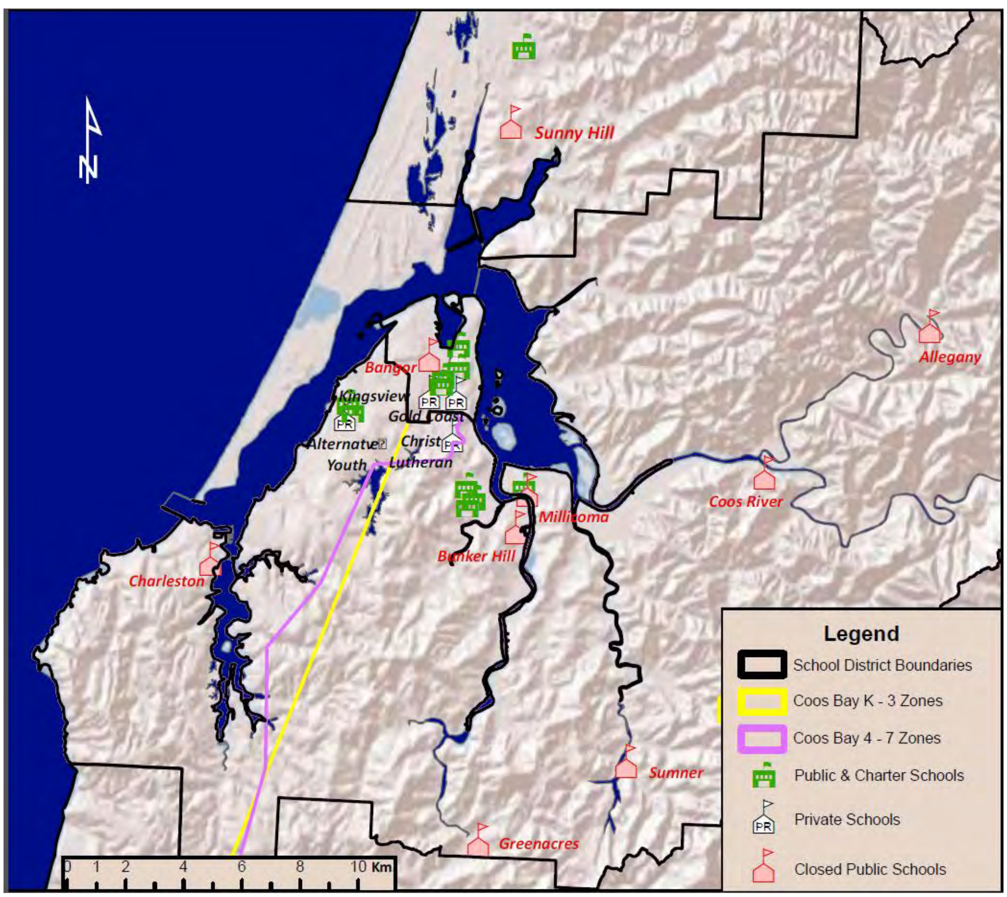



Figure 1. Districts and schools (open and closed) in the project area.

## Project Area Schools

The project area provides an array of school choices to residents: standard public schools that enroll the vast majority of students; public charter schools that offer alternative approaches to education; and private schools (primarily religious) whose instruction reflects their values (Table 1). These options are available for the entire range of formal schooling, from kindergarten through high school. Within these choices, about 83% of children attend public schools, 13% attend chater schools, and 4% are enrolled at private schools (these percentages are inexact because they include the entire student population for the Bandon and North Bend schools, some of whose students reside outside of the project area). In addition, approximately 250 school-aged children in the project area are homeschooled (2014-2015).

| School | Grades | Teacher FTE | Pupils |
|---|---|---|---|
| ***Bandon*** | | | |
| Ocean Crest | K - 4 | | 264 |
| Harbor Lights | 5 – 8 | | 227 |
| Bandon H.S. | 9 - 12 | | 242 |
| | | ***total Bandon*** | ***733*** |
| ***Coos Bay*** | | | |
| Blossom Gulch | K - 3 | 19.0 | 518 |
| Madison | K – 3 | 15.0 | 415 |
| Millicoma | 4 – 7 | 19.0 | 464 |
| Sunset | 4 – 7 | 18.0 | 434 |
| Marshfield H.S. | 8 – 12 | 37.0 | 955 |
| | | ***total Coos Bay*** | ***2,786*** |
| ***North Bend*** | | | |
| Hillcrest | K – 4 | 27 | 549 |
| North Bay | K – 5 | 11 | 257 |
| N.B. Middle | 5 – 8 | | 377 |
| N.B. Senior | 9 – 12 | | 417 |
| | | ***total North Bend*** | ***1,600*** |
| ***Charter Schools*** | | | |
| Destinations (CB) | K – 12 | 3.5 | 91 |
| Resource Link (CB) | K – 12 | 3.5 | 65 |
| Lighthouse (NB) | K – 8 | 13 | 205 |
| Or. Coast Technology (NB) | 6 – 12 | | 443 |
| | | ***total Charter Schools*** | ***804*** |
| ***Private*** | | | |
| Christ Lutheran | PK - 8 | 3.6 | 69 |
| Kingsview Christian | PK - 8 | 8 | 137 |
| Gold Coast 7th-Day Adventist | 2-4, 6-7 | 1 | 14 |
| Alternative Youth Activities | 7 – 12 | 5.0 | 28 |
| | | ***total Private*** | ***248*** |

Table 1. School characteristics in the project area. FTE: Full Time Equivelant, in that 1.0 is a full time employed teacher and 0.5 is a half-time employed teacher. Source: ODE 2013a.

<u>Public Schools</u>

There are three public school districts that serve students within the project area. Bandon School District #54 serves students living at the extreme southern end of the project area in neighborhoods along Seven Devils Road and surrounding the Bandon Dunes Golf Resort (Figure 1). Coos Bay School District #9 serves students in the center of the project area, covering the communities of Allegany, Charleston, Cooston, Empire, Eastside, Greenacres, and Sumner as well as those students within the Coos Bay city limits. The North Bend School District serves the city of North Bend, the East and North Bay neighborhoods, Glasgow, and Hauser within the project area. The Coos Bay School District covers the greatest percentage of the project area (76%), followed by North Bend (19%), and finally Bandon (5%). Similarly, in the 2012-2013 school year, Coos Bay had the highest enrollment (2,786 in its standard schools, with another 156 in two charter schools); North Bend enrolled 1,600 students in its standard schools, and another 648 students in two charter schools; while Bandon had 733 students in its three schools.

There are differences among the three districts in how they configure their classes (Table 1), and these configurations are constantly changing as the districts grapple with changing enrollment numbers in various classes and outdated infrastructure. Bandon follows the traditional model of K-4 grades in its elementary school, grades 5-8 in Harbor Lights Middle School, and grades 9-12 in the high school. North Bend modifies this traditional approach with its elementary schools covering K-4 in one school (Hillcrest) and K-5 in the other (North Bay), its middle school covering grades 5-8, and its high school grades 9-12. In contrast, Coos Bay has its two elementary schools cover K-3, its two intermediate schools cover grades 4-7, and the high school covers grades 8-12.

The Coos Bay school attendance boundaries (Figure 1) differ between their elementary and intermediate schools. Elementary grade students living to the west of Pony Creek attend Madison Elementary while those living to the east and south attend Blossom Gulch. This boundary changes for the middle/intermediate school attendance zones: those living in the neighborhoods west of Koos Boulevard and 10th Street, extending south to Juniper Avenue, then southeast to Ocean Boulevard and then west to Pony Creek attend Sunset Middle School, while those to the east and south of this line attend Millicoma Intermediate School. Students from the entire district attend Marshfield High School.

Attendance zones in the North Bend School District are more straightforward. Students attending the standard curriculum schools who live north or east of the McCullough Bridge attend North Bay Elementary; those living south attend Hillcrest Elementary. Students who attend the Lighthouse Charter School can live within Coos County or as far north as Reedsport; those living within the North Bend School District are provided transportation to the school. The remaining grades at North Bend all attend schools within a larger complex in the city of North Bend that includes a middle school, high school, and a technology center that supports the Oregon Coast Technology Charter School.

## Charter Schools

The Oregon Public Charter School Act (Oregon Revised Statutes, Chapter 338), passed in 1999, allows a sponsoring group such as parents, teachers and/or community members to form a semi-autonomous school under the umbrella of a public school district. The school district must approve the “charter” for the school under the provisions of ORS Ch. 338, or their decision can be appealed to the State Board of Education for certification. Charter schools are given more freedom in their operations (and at least initially more funding) than comparable standard public schools. As a result, a number of smaller school districts in the region (Reedsport, Elkton, Triangle Lake) have completely converted to charter schools. Other districts, such as Coos Bay and North Bend, have either allowed or opened charter schools to provide alternative educational opportunities. Depending upon whether the charter school is sponsored by the district or the State Board of Education (if a district refuses), charter schools are provided with, respectively, either 80% or 90% of state per student funding for kindergarten through 8th grades, and 90% or 95% of the per-student funding received for high school students (ORS 388.155). Districts may lose funding if independent schools are chartered; however, by opening their own charter schools they may keep more students enrolled, and thus retain more state support, while widening available educational opportunities.

The initial charter school in the project area (the Lighthouse School) was organized in 2002 by parents who were dissatisfied with the traditional educational model in the local public schools. The school enrolls about 200 students from kindergarten through the 8th grade. Lighthouse curriculum is inspired by the educational philosophy of Rudolf Steiner (1907) in his Waldorf Schools. The Waldorf approach for pre-adolescent students (K-8) is to develop their artistic and social capacities using both creative and analytical understanding. The second charter school in the North Bend School District is the Oregon Coast Technology School (ORCO Tech), created in 2003 as a "school within a school" located on the grounds of North Bend Middle and High Schools. The focus for the school is to use information technology as an organizing principle, developing students' interdependent knowledge in three areas: skills, concepts, and capabilities. ORCO Tech enrolls about 450 students from with those in the 6th through 8th grades attending classes in the North Bend Middle School, 9th and 10th graders in classrooms at the North Bend High School, and 11th and 12th graders in separate Technology Center on the campus.

The Coos Bay School District also sponsors two charter schools, housed in the Harding Learning Center on the campus of Marshfield High School. Destinations Academy is designed for students to work at their own pace in a community service approach that is project-based and appropriate for their academic level. Approximately 90 students are enrolled in grades 9-12, with four teachers and an educational assistant. The Resource Link Charter School provides services to K-12 grades, including home-schooled students. About 65 students were enrolled in its programs in 2013. Resource Link's educational strategy is that effective communication, academic relevance, and student voice and choice are fundamental to a student's success. The curriculum focuses on project based, individual learning. Students are required to meet with a teacher only one hour per week, although there are three classrooms with computers, and four teachers who are available to work with students.

<u>Private Schools</u>

Three out of the four private schools in the project area are religion-based, with the fourth focusing on alternative education (Table 1). Information is more difficult to obtain on these schools because they are not required to report to the Oregon Department of Education; most information in this section was derived from the schools' websites and independent web pages. Alternative Youth Activities (AYA) was founded in 1979 to serve students on the Oregon south coast from Florence to Brookings who are disconnected from their public schools. The school focuses on offering relationship-based learning experiences by developing connections, capability, and confidence with a particular emphasis in credit recovery so that students can return to their public school. About 30 students attend AYA, and are supported by 15 full- and part-time staff members.

The three religion-based, private schools are Christ Lutheran, Gold Coast Seventh-Day Adventist, and Kingsview Christian (Table 1). Christ Lutheran School serves about 70 students from pre-kindergarten through eighth grade. The school focuses on the spiritual welfare of the child, assisting parents in educating their children and providing an opportunity for Christian education, witness, and evangelism. Gold Coast Seventh-Day Adventist School serves a small number of students, about 14, in grades 2-7 with one teacher. The focus of the school is to develop the spiritual, mental, and physical powers of each student; preparing them for the joy of service in this life and for the higher joy of service in the life to come. Kingsview Christian School, established by the Bay Area Church of the Nazarene in 1979, serves about 140 students from pre-kindergarten through the 8th grade with eight teachers.

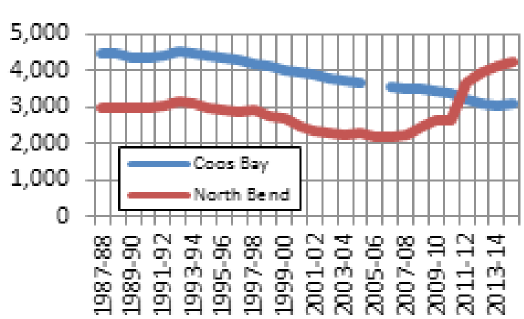



Figure 2. Patterns of school enrollment from 1987 – present. Source: National Center for Education Statistics 2015.

## Student Population and Demographics

The decline of the natural resource based economy, coinciding with demographic trends and cycles, resulted in an overall decrease in the number of students in the project area. The reduction in family wage jobs began in the 1980s led to significant outmigration (see *Chapter 4: Community Demographics*), and the Great Recession of 2008 has continued the process (Figure 2). Enrollment in recent decades topped during the 1992-93 school year, with a high of 4,517 students in the Coos Bay district and 3,140 in North Bend. Enrollment during the 2013-14 school year dropped to 3,068 in the Coos Bay School District (i.e., Coos Bay schools enrolled almost 50% more students at their peak); in the North Bend School District there are 2,423 students enrolled (not including their Virtual Academy), compared to about 30% more at their peak.

While student numbers have dropped over the last two decades, student diversity has increased (Figure 3). While the vast majority of students are white in both school districts (72% in Coos Bay and 76% in North Bend), there are significant numbers of Native American (5% in both districts) and Hispanic/Latino

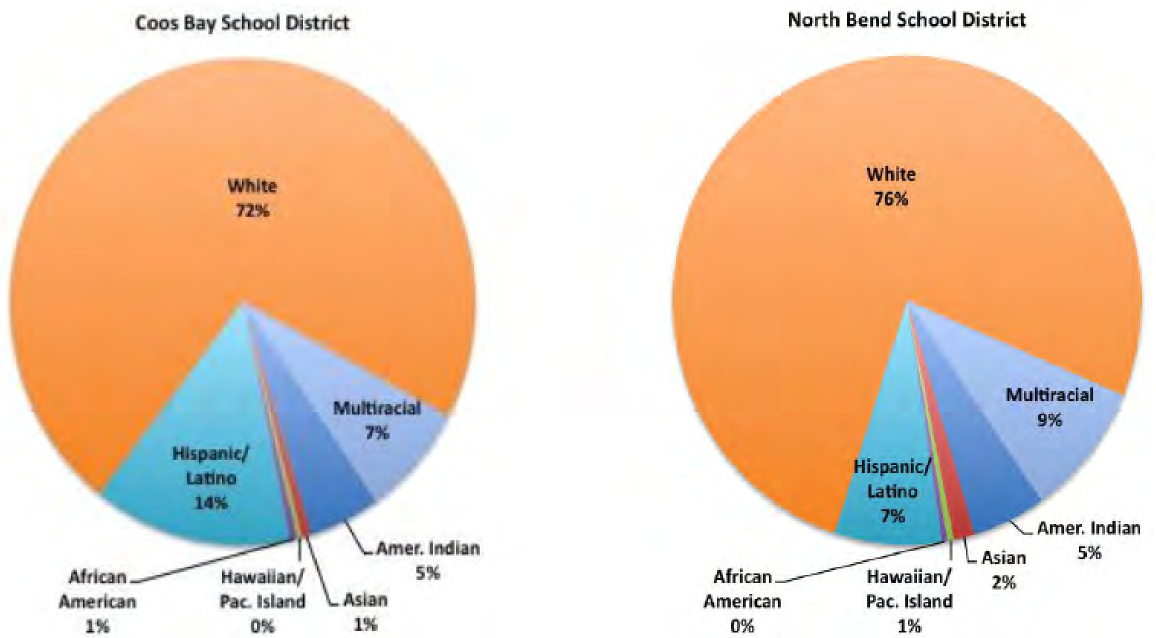



Figure 3. Demographic makeup of the Coos Bay (left) and North Bend (right) students. Source: ODE 2015.

students (14% in Coos Bay and 7% in North Bend); multiracial students comprise 7% and 9%, respectively, of the student bodies in Coos Bay and North Bend. The Native American and Hispanic/Latino students are aggregated into a category known as Underserved Races/Ethnicities in reporting required by the No Child Left Behind Act, as will be discussed below.

There are differences in student demographics between the North Bend and Coos Bay School Districts, as well as among the student populations in various schools (Table 2). While both Districts have substantial numbers of economically disadvantaged students (and thus the Title I designations), in general there are between 5% and 10% more disadvantaged students in the Coos Bay schools compared to North Bend, although the difference becomes slight between the two high schools. The attendance boundaries described previously affect student demographics; and the availability of North Bend's charter schools further exacerbates demographic differences within the North Bend School District. Similarly, Coos Bay enrolls more disabled students in comparison to North Bend, but these differences are not substantial except in the elementary grades where Coos Bay enrolls about a third more. Finally, English learners as a group are not a significant proportion of either district's students.

Coos Bay

Because of fixed attendance zones, student demographics largely reflect those of the neighborhoods and communities where they reside (see *Chapter 4: Community Demographics*, and Appendix 1). For Coos Bay elementary schools, there are almost

Table 2. Subgroup demographics for Coos Bay and North Bend schools. Source ODE 2013a.

| Subgroup and District | Grades K-3 | Grades 4-5 | Grades 6-8 | Grades 9-12 |
|---|---|---|---|---|
| ***Economically Disadvantaged*** | | | | |
| Coos Bay | 71% | 71% | 65% | 52% |
| North Bend | 60% | 54% | 55% | 50% |
| ***Students with Disabilities*** | | | | |
| Coos Bay | 16% | 21% | 17% | 15% |
| North Bend | 12% | 17% | 16% | 13% |
| ***English Learners*** | | | | |
| Coos Bay | 5% | 6% | <5% | <5% |
| North Bend | <5% | <5% | <5% | <5% |
| Source: ODE, 2013. District and School Report Cards. | | | | |

25% more disadvantaged students attending Madison Elementary (80%) compared to Blossom Gulch (64%); while there are relatively similar percentages of disabled students and under-served races and ethnicities, there are substantially more English learners at Madison compared to Blossom Gulch (the <5% at Blossom Gulch can go down to almost zero, in comparison with the 7% at Madison). Madison has a slightly higher percentage of minority students (20%) compared to Blossom Gulch (18%), but this gap increases to a 25% difference (22% versus 17%, respectively) at the middle school level at Sunset and Millicoma. Economic disparities continue at the middle school level as well: Sunset Middle School has almost a third more economically disadvantaged students compared to Millicoma Intermediate School. Coos Bay's Destinations Charter School serves almost 25% more economically disadvantaged students compared to Marshfield High School, as well as over one-third minority students.

North Bend

Demographic disparities among schools in North Bend are even greater than Coos Bay (Appendix 1). Students attending the standard curriculum elementary schools are largely similar, although Hillcrest Elementary (16%) has almost twice as many underserved races/ethnicities as does North Bay (8%).

The more substantial differences are between the demographics of the students attending the two charter schools compared to those in the standard curriculum schools. At the elementary level, Lighthouse Charter has only about half the percentage of economically disadvantaged students, half the proportion of disabled students and underserved races/ethnicities, and no English learners compared to the two standard elementary schools. The pattern of demographic disparities continues in the upper grades, as the Oregon Coast Technology School enrolls 39% economically disadvantaged students, compared to 71%

for the North Bend Middle School (almost twice as many), and compared to 49% at North Bend High School. As a proportion of total enrollment, ORCO Tech has fewer than a third of disabled students, less underserved races/ethnicities, and no English learners as compared to the North Bend Middle and High Schools.

**Educational Attainment**

The No Child Left Behind Act of 2001 (P.L. 107-110) significantly amended the Elementary and Secondary Education Act of 1965 (20 U.S.C. 6301 et seq.). It increased accountability for educational quality by emphasizing testing to evaluate whether all students are meeting performance goals in reading, math, writing, and science (Learning First Alliance 2002). Test (and metrics) results reported by various student demographics are compiled by the Oregon Department of Education and have been made publicly available since 2000 (by S.B. 1329) as School and District Report Cards. Data from these report cards are the primary source of information for this section; however, comparable testing/performance data are not available for the private schools, and we will provide more detailed information for the Coos Bay and North Bend School Districts (Appendix 1) because they cover the vast majority of the project area.

School Performance

The School and District Report Cards provide a summary performance level based on how a school ranks statewide, as well as compared to those schools with similar demographics. Five performance levels are designated, with a level being determined by an aggregate of five measures: (1) subject achievement rate; (2) subject achievement growth rate; (3) subgroup achievement growth rate; (4) graduation rate; and (5) subgroup graduation rate. These performance measures often incorporate multiple categories (such as math and reading assessment scores). Each performance measure is assigned a level based on a scale of 5; points are accumulated in each performance measure by a process of "earning" points, the calculation of which is outlined in ODE 2013b, and are generally described in Appendix 2. Performance measures often have a threshold required to attain a specific level, either in points or as a percentage of available points.

A school's or district's aggregate Performance Level is determined by the aggregate points it receives in the five measures, and then where it ranks compared to similar level schools in the State of Oregon. In order to control for the effects of socio-economic factors, an additional measure evaluates a school's performance compared to the closest 20 other schools in Oregon having similar demographics. Table 3 shows the performance ratings of schools in the project area for the last school year (2012-13) and the one previous to that (2011-12). About 55% percent of schools statewide have met state standards for educational attainment (and graduation, if a high school. Note that it is possible that a school stayed the same in its performance between the two reported years, while others in the state were improving (or deteriorating) at a comparatively higher (or lower) rate.

Only in the North Bend School District do all the elementary schools meet overall state targets for educational attainment and student growth. Neither Ocean Crest in Bandon, nor Madison or Blossom Gulch in Coos Bay, met state targets in 2012-13 (although Madison did in 2011-12). Middle or intermediate schools range in quality among districts and between schools. Harbor Lights Middle School in Bandon is among the top 5% of middle schools statewide in terms of its educational quality, and is designated a Model School under Title I of the Elementary and Secondary School Act because it achieves this quality while having a high percentage of economically disadvantaged students. In Coos Bay, Millicoma Intermediate had a good score in 2012-13, rising from not meeting state targets in 2011-12, while Sunset Middle School did not meet targets in 2012-13 (data were not available for 2011-12). The standard curriculum North Bend Middle School ranked in the worst 15% statewide for both 2012-13 and 2011-12, while the two charter schools within the North Bend School District both met state targets and were in the top 55% of schools statewide. Bandon High School met state targets in 2012-2013 after having failed them in 2011-12; North Bend High School did not meet state targets in either 2012-13 or 2011-12 (but was not in the worst 15%), while ORCO Tech did meet state targets; and Marshfield High School descended from not meeting state targets to being in the lowest 15% of high schools statewide from 2011-2012 to 2012-13.

| District & School | 2012 - 2013 | 2011 - 2012 | Similar Schools |
|---|---|---|---|
| ***Bandon*** | | | |
| Ocean Crest Elementary | Level 3 | Level 3 | Below Average |
| Harbor Lights Middle | M (Level 5) | Level 4 | Above Average |
| Bandon Senior H.S. | Level 4 | Level 3 | About Average |
| ***Coos Bay*** | | | |
| Blossom Gulch Elementary | Level 3 | Data not available | Below Average |
| Madison Elementary | Level 3 | Level 4 | About Average |
| Millicoma Intermediate | Level 4 | Level 3 | Above Average |
| Sunset Middle | Level 3 | Data not available | Below Average |
| Marshfield Senior H.S. | Level 2 | Level 3 | Below Average |
| Resource Link Charter | Level 3 | Data not available | Above Average |
| ***North Bend*** | | | |
| Hillcrest Elementary | Level 4 | Level 4 | About Average |
| North Bay Elementary | Level 4 | Level 4 | Above Average |
| Lighthouse Charter | Level 4 | Level 4 | About Average |
| North Bend Middle | Level 2 | Level 2 | Below Average |
| North Bend Senior H.S. | Level 3 | Level 3 | Below Average |
| Oregon Coast Technology | Level 4 | Level 4 | Above Average |

M = Model school: high poverty levels and top-tier results.
Overall ratings (2012-2013, and 2011-2012):
- Level 5 – Top 10% of schools statewide.
- Level 4 – Meet state targets but not in the top 10%.
- Level 3 – Do not meet state targets, but not in lower 15%.
- Level 2 – Bottom 15%, but not 5% of schools statewide.
- Level 1 – Bottom 5% of schools statewide.
- Data not available.

Comparable Schools Codes (compared with 20 similar schools):
- Above Average: Highest 33% of comparable schools.
- About Average: Middle 33% of comparable schools.
- Below Average: Lowest 33% of comparable schools.

Table 3. School performance in the project area. Source: ODE 2013a.

It could be argued that school performance in the project area is adversely affected by the overall economic climate and the preponderance of economically disadvantaged students that they serve (Appendix 1). However, the right- most column in Table 2 shows that this is not necessarily the case. Each school's performance was compared with 20 others in the state that had the closest demographic makeup, irrespective of whether they were larger or smaller, urban or rural. There is no consistent pattern among the schools, or among the districts, in the project area. Not surprisingly, Bandon's Harbor Lights Middle School was above average, but its elementary school was below average and its high school about average. Coos Bay has more schools rated below average in comparison to similar ones statewide, but Millicoma Intermediate is above average, as is its Resource Link Charter School. One might have thought that North Bend's charter schools would have outperformed similar schools statewide, which is the case with the Oregon Coast Technology School but not with the Lighthouse School. Neither of the standard curriculum high schools in Coos Bay and North Bend compared well with comparable schools statewide.

Academic Achievement

As outlined in Appendix 2, attainment of standards—as well as student growth from one year to the next— contribute to a school's performance rating. For the 2012-13 Report Cards, the Oregon Department of Education emphasized student growth in its weighting (ODE 2013a). Both attainment and growth are based on the results of assessment tests, called the Oregon Assessment of Knowledge and Skills (OAKS). Reading assessment tests are given in grades 3 - 8, and 11; math assessment tests are given in grades 3 - 8, and 11; science assessment tests are given in grades 5, 8, and 11; and writing assessments are given in grade 11 (writing was also assessed in grades 4 and 7, but this was discontinued in 2011 due to budget shortages). Coos Bay and North Bend standards attainment and growth by school and subgroup will be discussed in detail based on data provided in Appendix 1.

North Bend does a better job at teaching reading in the elementary schools, where about three-quarters of students meet state standards compared to less than two-thirds in the Coos Bay schools. Economically disadvantaged students have reading attainment rates that are largely comparable to those of non-economically disadvantaged students in elementary school in North Bend, but such reading rates are 12% less at Blossom Gulch in Coos Bay. Students with disabilities fared poorly in reading in elementary schools with an average of only about 50% meeting state standards, with the exception of Hillcrest; both Madison Elementary in Coos Bay, and North Bay in North Bend, did particularly poorly with disabled students' reading. Lighthouse Charter exceeded all the standard curriculum schools in reading, with 86% overall meeting standards, with little drop off for the subgroups. A similar pattern exists for elementary school math attainment: North Bend elementary schools do better than Coos Bay, in some cases substantially, but all subgroups do worse, particularly students with disabilities. For math, the Lighthouse School students are less proficient compared to Hillcrest Elementary in North Bend, but about equivalent to North Bay. However, Lighthouse does much more poorly with the subgroup performance in math when compared to the standard curriculum schools.

Once students enter middle/intermediate school, educational attainment switches between the standard curriculum schools in Coos Bay (which are better) compared to North Bend Middle School. About two-thirds of Coos Bay's Millicoma Intermediate School students met reading standards (but only 58% at Sunset), while only slightly over half did at North Bend. The reading performance of economically disadvantaged students dropped off more rapidly at North Bend compared to the Coos Bay middle schools, although only one-third of disabled students met reading standards at any of the three standard curriculum middle schools. That was not the case with the North Bend charter schools, both of which include the middle school grades: overall reading attainment was above 80% at both schools, and stayed high for Economically Disadvantaged students; Lighthouse did well in reading for the other subgroups (ORCO Tech had only 21% of its disabled students meet reading standards). In math, Coos Bay middle schools did better than North Bend, although almost three-quarters of ORCO Tech students (with the exception of those disabled) met math standards compared to less than two-thirds of Coos Bay middle school students.

At the high school level, North Bend High School (80%) and ORCO Tech (81%) students are quite a bit more proficient in reading compared to Coos Bay (67%); however, in math Coos Bay (52%) bettered North Bend (42%), while at ORCO Tech. 73% of students met Grade 11 standards in math. Economically Disadvantaged students match fairly well with overall attainment in math, but the drop off is higher in reading. Less than 10% of Disabled students in high school standard curriculum meet state math standards, and less than a quarter meet state reading standards (and only 16% and 21%, respectively, at ORCO Tech). Underserved Races/Ethnicities largely hold up with overall school performance, and even exceed them at North Bend High School.

Of particular interest is how well (or poorly) students are meeting state standards in science, when tests are given in the 5th, 8th, and 11th grades. Data are much more spotty compared to the reading and math assessment (Appendix 2): Sunset, Millicoma Intermediate and North Bend Middle School report scores; and all three high schools (Marshfield, North Bend, and ORCO Tech) report overall scores, but not for any subgroups. Attainment of state science standards is not high, even at ORCO Tech. Less than two-thirds of Sunset Middle students met standards while surprisingly on 46% met standards at Millicoma Intermediate, somewhat over half meeting them at North Bend Middle School level. Attainment rises with the Grade 11 tests: 65% of Marshfield students, 71% of North Bend students, and 81% of ORCO Tech students meet state standards.

Student Growth and Graduation Rates

Academic growth is calculated by evaluating an individual student's score on math and reading exams for the current and previous year, and then determining whether at that rate the student would be able to attain state standards within the next three years. For the 2012-13 school year, the Oregon Department of Education dramatically revised its School and District Report Cards to emphasize student growth in the determination of a school's performance, weighing it as 50% of the score for elementary and middle schools, with an additional 25% weight for subgroup growth (ODE 2013a, see also Appendix 2). For high schools, student academic growth counts less (20%, with an additional 10% weight for subgroup growth), while graduation rates influence the majority of a school's score (35% overall, with an additional 25% for subgroup graduation rates). Growth rates are not reported if too few students take exams two years in a row, which was the case at Blossom Gulch and Madison Elementary Schools in Coos Bay; in North Bend, no separate scores were reported for underserved races/ethnicities at North Bay and Lighthouse due to too few (<6) students taking the tests.

Not surprisingly, patterns in academic growth closely reflect those in academic achievement in both school districts. Generally, Coos Bay lags North Bend by almost 10%, while Lighthouse exceeds the two North Bend elementary schools by another 10%. However, in no case is academic growth exceptionally good: only 46% of Sunset middle students are making adequate progress to meet state standards in three years, while 54% of both North Bend standard curriculum schools, and 66% of Lighthouse students are on track to meet state standards in reading. For elementary school math, academic growth is higher than reading growth at Hillcrest (65%), and slightly lower at North Bay (51%). Drop off in academic growth for the subgroups is less than for academic achievement, but disabled students are 10% - 15% less likely to be making adequate progress compared to the regular students in the elementary schools (with the exception of the Lighthouse Charter School where progress is equivalent or even better for disabled students).

For the middle schools, Millicoma has the best record in the percentage of students on track to meet state standards in reading and math in three years. Even so, less than 60% of Millicoma students will meet standards in reading, and only slightly over half in math; for students in Sunset Middle School, only 46% will attain standards in reading and 40% in math. At North Bend Middle School, 46% of students are on track to meet standards in reading, and 43% in math; ORCO Tech does not much better in reading (49%)and only 59% of students will likely meet state standards in math over the next three years. There is some drop off in academic growth at Sunset Intermediate for disabled students in reading, while underserved races/ethnicities do well in reading but comparatively poor in math. Very little drop off in academic growth is seen in the subgroups at Millicoma Middle or North Bend Middle schools, but disabled students at the Lighthouse Charter School are only about half as likely to be able to meet state standards as other students in the school.

Academic growth at the high school level is more difficult to determine because students take the OAKS tests only in the 11th grade. North Bend does quite a bit better than Coos

Bay for high school students: at North Bend High School, 55% of students are on track in reading and 58% are on track in math; at ORCO Tech, only 49% are on track for reading, but 59% are on track for math; while at Marshfield, only 45% of students are on track for reading, and only 40% are on track for math.

Graduation rates may be as, or more, important as an indicator of school district performance. In Coos Bay, the Marshfield graduation rate is 63%, with 68% on track to graduate, and an overall completion rate (including GED and alternative diplomas) of 78%. North Bend's record is lower than Coos Bay's in a couple of measures: its graduation rate is 61%, though over 95% of students are on track to graduate, and 68% ultimately complete school in one form or another; in contrast, 95% of ORCO Tech students graduate with regular diplomas within five years, and over 95% are on track to graduate.

**School Finance**

Oregon public schools are funded through three basic sources: local property taxes, state contributions, and Federal contributions. The relative contribution of these sources to the total revenue available to the school districts has changed over time due to policy shifts that affected local property taxes, the shift of the majority of school funding to the State General Fund, and increases in Federal funds that became available with the No Child Left Behind Act. The cumulative effects of these changes are shown in Figure 4 for Coos Bay (left) and North Bend (right) for the period from the 1994-95 to 2012-13 school years. For Figure 4, revenues have been converted to a standard year (2010) based on the Consumer Price Index – Urban (CPI-U) to remove any effects of inflation (or deflation).

State Support

Oregon Ballot Measure 5 passed in 1990, amending the Oregon Constitution in ways that significantly affected educational financing. It capped local property tax rates, and shifted much funding previously received from these taxes to the state general fund (OSOS 1990). Figure 5 shows how funding sources, as statewide averages, have changed over time. Overall, pre-Measure 5, local property taxes contributed approximately two-thirds of school district revenues, state funds contributed about a quarter of the total, and the remaining was contributed by Federal and other sources. Post-Measure 5, state funds usually provide over half of funding for schools, local property taxes provide about a third, and Federal funds provide between 10% and 15% (in the recent years). One result of the Great Recession of 2008 and the resulting shortfalls in General Fund revenues is that state support for school funding was reduced from about two-thirds to about half (ODE 2013a).

State contributions to school districts are based on average daily membership (ADM), usually calculated as the number of students enrolled on October 1 of the school year (ORS 327.013). Under the statute, the Oregon state school fund contribution contains a number of additions to the ADM based on teacher experience, presence of charter schools, disabled and special education students, rural schools, early English learners, and poverty levels. Figure 2 shows the decline in students in the Coos Bay and North Bend Districts over time, and while Figure 4 shows the effect that these student declines have had on state contributions to the two school districts, although this is also co-mingled with declining per ADM support.

Local Property Taxes

While Measure 5 transferred much of the responsibility for local school finance to the Oregon state general fund, it also constrained the ability of local taxing districts to fund schools and other public purposes. Beginning with its implementation in the State fiscal year 1991-92, Counties were limited to a top tax rate of $25 per $1,000 of property valuation, with this amount decreasing to $15/$1,000 in 1996 and continuing at this level (Table 4). Measure 50, passed in May 1997, further constrained the ability to raise funds to support public schools: each taxing district was given a permanent property tax rate (which was 10% lower than it had previously received); the growth in a property's assessed value was limited to 3% per year (but then was not limit on decreases if property values dropped); voter approval was required for any taxes or bond obligations beyond the permanent rates, and votes that did not occur in general elections (November of even numbered years) were also required (until 2008) to have a "double majority" of yes votes and voters; and with the exception of some exempt capital bond levies, the resulting taxes still were required to be within the limits set

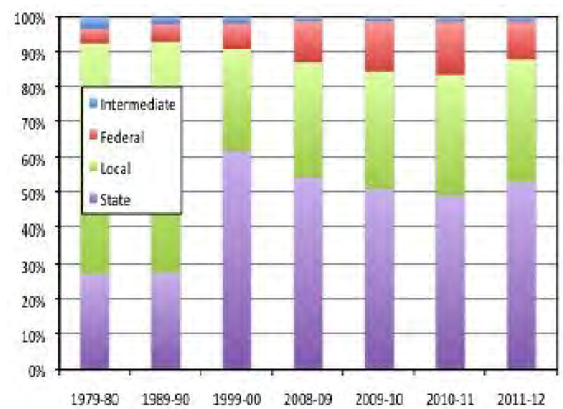
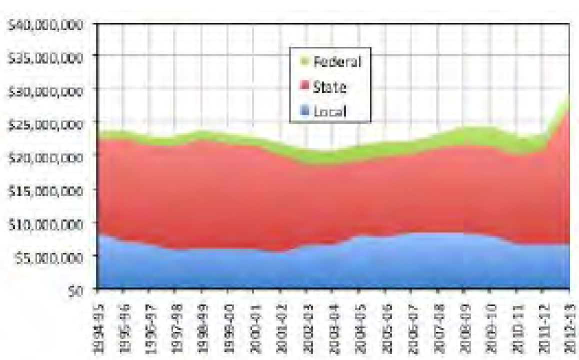



Figure 5. Sources of funding for schools pre-and post-Measure 5 in Oregon. Source: ODE n.d.



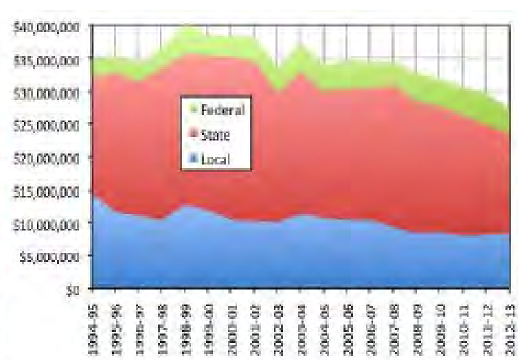




Figure 4. Sources of revenues (constant 2010$) for Coos Bay (left) and North Bend (right) School Districts. Source: USDOE 2011.

by Measure 5 (Legislative Revenue Office 1999). Table 4 shows the permanent tax levies for the three school districts, while Table 5 shows the results of bond and local option levy elections that have occurred since 1997. As can be seen in Table 5, the local electorate has not been supportive of local schools, at least to the point of providing them with adequate financial resources.

In an analysis of Oregon school finance, ECONorthwest (2002) presented a short case study of the situation of the Coos Bay School District found itself in with the passage of Measure 50:

*Coos Bay saw its student population steadily decline since 1994. Prior to Measure 5, the Coos Bay District was one of the lowest spending per-pupil districts in Oregon* (Figure 6).

Because of its low spending levels, when Measure 50 froze the property tax levy (and further reduced it by 10%), the Coos Bay District (as well as North Bend) was limited in its ability to raise funds locally (Table 4), and thus became more reliant on State and Federal revenues.

Table 4. Measure 5 maximum tax rates (per $1,000 valuation) and school district permanent tax levies. Source: Coos County Assessor 2013.

| | Measure 5 Limit | | Permanent School Levy | | |
|---|---|---|---|---|---|
| Year | Education | General Gov't. | Bandon | Coos Bay | North Bend |
| 1991-1992 | $15.00 | $10.00 | N/A | N/A | N/A |
| 1992-1993 | $12.50 | $10.00 | N/A | N/A | N/A |
| 1993-1994 | $10.00 | $10.00 | N/A | N/A | N/A |
| 1994-1995 | $7.50 | $10.00 | N/A | N/A | N/A |
| 1995-1996 | $5.00 | $10.00 | N/A | N/A | N/A |
| 1996-1997 | $5.00 | $10.00 | N/A | N/A | N/A |
| 1997-1998 | $5.00 | $10.00 | $3.9745 | $4.5315 | $4.1667 |
| 1998-on | $5.00 | $10.00 | $3.9702 | $4.5276 | $4.1626 |

Federal Support

As mentioned previously, there has been a significant growth in the proportion of school revenues obtained from the Federal government as a result of No Child Left Behind, but with these funds comes increased accountability and consequences. There are three significant sources of Federal funding that go to local school districts: (1) Title I funds provided based on the amount and types of disadvantaged students, and how an individual school district allocates its funds among schools; (2) support for students with disabilities through the Individuals with Disabilities Education Act (IDEA), Part B for school-aged children; and (3) support to provide free and reduced-cost school lunches for economically-disadvantaged students through the Federal School Meal and Federal School Commodity Acts (New America Foundation 2013). Figure 6 shows the average proportions for these sources of funding for the Bandon, Coos Bay, and North Bend School Districts; and the proportions are quite similar between Coos Bay and North Bend, even though North Bend receives about half as much Federal funding as Coos Bay. Because the Title I funds are the most noteworthy by being tied to student and school performance, our discussion will focus on them.

In Title I of the Elementary and Secondary School Act, funds are provided to schools serving high levels of students in poverty from birth through 12th grade (school districts receive funding for pre-kindergarten children through Title I even though they are not school-aged). Funds are distributed through four major formulas (New America Foundation 2013):

1. Basic Grants (≈ 45% of funds) go to districts on a per-student basis if there are more than 10 students living in poverty in the district;

2. Concentrated Grants (≈ 9% of funds) are provided on a per-student basis if the district has at least 15% or 6,500 students (whichever is less) living in poverty as a supplement to its Basic Grants;

3. Targeted Assistance Grants (≈ 23%) provides escalating per-student funding based on the percentage of students in a district living in poverty, so that a district having over 38.2% students living in poverty gets four times what a district having fewer than 15.6% students receives; and

4. Education Finance Incentive Grants (≈ 23%) target more aid to schools in states that (a) spend more per student; and (b), are high poverty schools where state aid is equitably distributed among all the districts' schools.

States and districts, in theory, are also required to remedy any imbalance in funding between Title I and non-Title I schools prior to receiving any Title I funds; in essence, the Title I funds are intended to supplement, not replace, usual expenditure levels.

In exchange for Title I funds, states agreed that schools would be required to meet Adequate Yearly Progress (AYP) towards the goal that 100% of students would attain state standards for reading, math, science, and writing. An increasing progression of penalties are prescribed for those schools failing to meet AYP: the first two years of not meeting AYP goals has no effect; but failing in year 3 requires a School Improvement Plan,

Table 5. History of school general obligation bond and local option levy elections. Source: OSBA 2015

| Election | District | Amount | Passed (Y/N) | % Yes | % Turnout | Type |
|---|---|---|---|---|---|---|
| 11/7/00 | Bandon | $1,690,000 | No | 38.1% | N/A | GOB |
| 5/15/01 | Bandon | $1,500,000 | Yes | 51.1% | 60.5% | GOB |
| 5/17/11 | Bandon | $1,500,000 | Yes | 59.5% | N/A | GOB |
| 11/3/98 | Coos Bay | $9,990,000 | Yes | 52.7% | N/A | GOB |
| 11/4/08 | Coos Bay | $59,950,000 | No | 34.4% | N/A | GOB |
| 5/16/00 | North Bend | $2,085,000 | No | 46.5% | 54.5% | LOL |
| 11/7/00 | North Bend | $25,400,000 | No | 38.8% | N/A | GOB |
| 11/6/01 | North Bend | $12,500,000 | Yes | 52.8% | 57.0% | GOB |

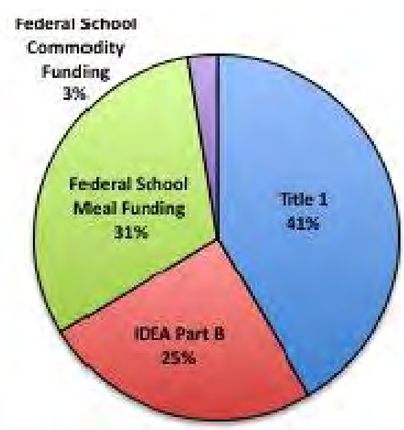



Figure 6. Types of Federal funds going to school districts. Source: New America Foundation 2013.

devoting at least 10% of their Title I funds to teacher development, and allowing parents to move their children to another school in the district; with failing year 4, the district is required to make interventions to restructure the school; if AYP is still not met in year 5, the district is required to reconstitute the staff (including leadership), change governance, convert the school to a charter school, allow for private management, or some similar major change. In 2012, Oregon obtained a waiver from the Adequate Yearly Progress accountability requirements in No Child Left Behind that removed the more onerous outcomes of No Child Left Behind, replacing them with "Achievement Compacts" between the districts and the state. However, Oregon has been notified by the U.S. Department of Education that it is at high risk of losing its exemption because of its failure to institute a single, statewide assessment system for teachers.

The amount of funds received by a specific school district is based on a complex set of factors, beginning with the overall Title I budget approved by the U.S. Congress. These funds are divided among the states, which then apportion them to the school districts using U.S. Census Bureau poverty data in a calculation that provides additional per-student funds as described above, as well as additional funding for homeless and neglected students. Figure 7 shows the trajectory of the funds that the U.S. Department of Education provides to the State of Oregon for the three school districts. The State of Oregon is allowed to deduct 1% of these funds for administrative expenses, and up to an additional 4% to place into a School Improvement Fund pool to provide additional assistance to the lowest 5% of performing schools. The funds shown in Figure 7 are reported in constant dollars (2010$) to remove any inflation effects.

It's clear from Figure 7 that Title I funds provided to the school districts (with the exception of Bandon) have been reduced in real terms since No Child Left Behind was passed in 2002. This is primarily due to stable or declining Federal funds, rather than a reduction in the number of qualifying students in a district. The American Recovery and Reconstruction Act ("Stimulus") provided significant additions to Title I funding for the 2009-2010 school year that allowed schools to retain teachers in the face of significant declines in state revenues caused by the Great Recession. However, this one-time supplement that did not reverse long-term patterns. (Figure 8).

As anticipated in the No Child Left Behind legislation, schools have focused their efforts on the early grades (Appendix 1). While neither the Coos Bay nor the North Bend School District explicitly breaks out Title I funds in their annual budgets, most of the individual school web pages identify staff who are funded by Title I, and often provide additional information on their programs. As intended, most emphasis is placed on improving reading and math performance using a combination of additional teachers, supplemental teachers aids, and activities to involve parents in the student's education. For example, at Hillcrest School in the North Bend district, the focus on reading is through blocking out specific

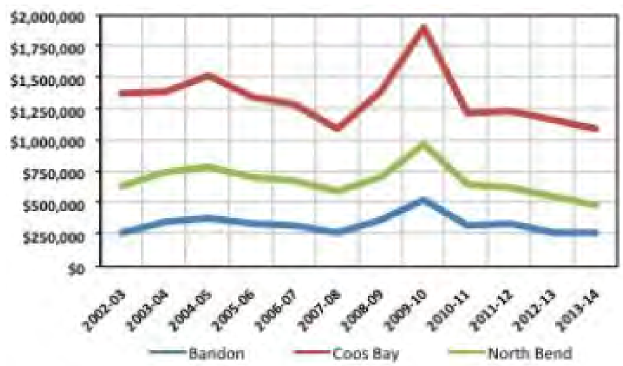



Figure 7. Amount of Title 1 funds received by Districts, 2002- 2013 (2010$).*
Source: USDOE n.d.

*Amount provided by the U.S. Dep't. of Education to the State of Oregon for the school districts. State may retain up to 5% for administrative and School Improvement Fund purposes.

time during the day, involving Title I teachers with specialized knowledge during this time, and providing an afterschool program for the neediest students. The only Title I middle school, Sunset in the Coos Bay District, provides additional assistance in math and reading through its Title I program.

**Facilities, School Closures, and Community**

In 1913, there were 91 school districts in Coos County; today, after many consolidations, there are six (Lansing 2008). In the project area, there were about 36 districts in 1913, and now, a hundred years later, there are only three. Consolidation of school districts arose due to improvements in transportation, an increase in student numbers with the post-WWII baby boom, and requirements for improved teaching and facilities to offer a wider range of courses. As part of the consolidations, rural schools were closed, and students were bussed (or "boated" earlier in earlier years) to schools closer to town. While there were many benefits to this consolidation, there were effects to communities when a local focus was lost, especially with the increased travel distance to residents' employment (see *Chapter 6: Jobs and Employment*).

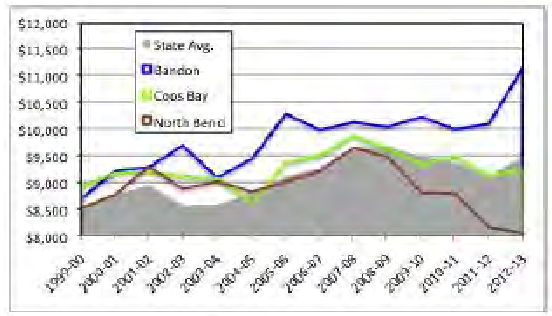



Figure 8. Per student expenditures (2010$).
Source: USDOE 2011.

<u>Facilities</u>

Just as the community's investment in education reflects its priorities, the investment in facilities that support education provides a daily reminder to students and teachers. The quality of facilities also affects the ability of students to learn and faculty to effectively teach. Both the Coos Bay and North Bend School Districts have facilities that encumber their effectiveness, and a number are at, or past, their useful life (Table 6). However, as discussed above, the two school districts are constrained in their ability to upgrade or replace their facilities due to the need for voter approval of general obligation bonds, and as seen in Table 4, this voter approval has not been forthcoming.

The newest, currently occupied, school in the Coos Bay district (Millicoma Intermediate) was constructed over 50 years ago (Table 6). Coos Bay's most recent building is Pirate Hall on the Marshfield High School Campus, finished in 2001, that houses science classes, a computer lab, and general 8th grade classes. Prior to that building, the most recent addition/upgrade was to Sunset Middle School in 1992, over twenty years ago. The District has an active Coos Bay Facilities Task Force that has been working with the DLR Group on a long-term strategic planning process to evaluate needs, and a proposal planned to be shared with the community in May, 2014. North Bend School District facilities are in a similar situation with respect to age and appropriateness. The North Bend School District is currently evaluating four options that would reconfigure the elementary schools so that each has the same grades (Table 1), full-day kindergarten would be provided, and the Middle School would have grades 6-8. Based on their proposals, the preferred option will likely be one that does not require additional construction or temporary buildings. Current (April, 2014) discussions include having the Lighthouse School move into the empty building owned by the Airport District that formerly housed the ACS call center.

Closed Schools and Community

Reductions in student numbers, aging infrastructure, increased expectations for a wider range of available classes, and improvements in transportation collectively pushed to consolidate schools, generally by closing those that were smaller, older, or in remote communities. Students at those schools are then bussed to schools in town, the exception being North Bay Elementary, which houses K-5 students as well as the Lighthouse Charter School. As can be seen in Figure 1, schools in the rural communities of Allegany, Coos River, Greenacres, Sumner, and Charleston were all closed within the last few decades, while four schools located within town (Milner Crest, Bunker Hill, Eastside, and Bangor) have been closed or repurposed. There is little economic disincentive to transporting these students for long distances because the state pays for 70% to 90% of the transportation costs. It could be that this lack of community interaction is having a significant detrimental effect on the project area's lack of capacity and willingness to improve its educational system.

Table 6. Status of facilities in the Coos Bay and North Bend School Districts. Source: DLR Group 2014.

| School | Built | Upgraded |
|---|---|---|
| *Coos Bay School District* | | |
| Blossom Gulch Elementary | 1952 | None |
| Madison Elementary | 1953 | '62, '68, '73, '77 |
| Millicoma Intermediate | 1962 | '74, '87 |
| Sunset Middle | 1949 | '92 |
| Marshfield High School | 1923 | '25, '38, '51, '61, '01 |
| Harding Learning Center | 1923 | '38, '51, '63 |
| Eastside (closed) | 1949 | '52, '60 |
| Bunker Hill (closed) | 1955 | '78, '96 |
| Milner Crest (admin.) | 1949 | '61, '03 |
| *North Bend School District* | | |
| Hillcrest Elementary | 1948 | '65, '02-'05 |
| North Bay Elementary | 1968 | |
| N.B. Middle School | 1960 | '64 |
| N.B. High School | 1949 | '52, '54, '66, '76, '02 |
| Technology Center | 2002 | |

**Southwestern Oregon Community College**

History

Founded in 1961, Southwestern Oregon Community College (Southwestern) is one of the oldest of the 17 public community colleges in the state. Its district includes all of Coos County, western Douglas County (primarily Reedsport), and all of Curry County (which was annexed into the district in 1995). The college offers full services throughout its district, primarily through the main campus in Coos Bay and with outlying Curry County sites in Port Orford, Gold Beach, and Brookings. There are no Southwestern-managed facilities in the western Douglas County area at this time.

Since its founding, enrollment has grown from 266 students to about 10,000 students, with about 3,350 FTE (full-time equivalent) student enrollment in 2012-2011 (Figure 9); full-time faculty have grown from 15 to about 60 and part-time instructors have grown from 11 to nearly 200. Southwestern enrollment in Curry County has tripled since it was annexed.

Construction of permanent buildings on the main campus began in 1963, and most of the current buildings were built between 1965 and 1969. A second building phase began in 1979 to add educational program facilities such as shops and laboratories; a third building phase beginning in 1994 added student services facilities and additional classrooms. Two new buildings have been added since: the Oregon Coast Culinary Institute and a Recreation Center, as well as additional outdoor athletic facilities. Southwestern's first set of dormitories, opened in 1997, were originally built primarily to accommodate international and out of state students. Although the numbers of international students have since declined because of tighter visa restrictions, today the expanded dorm facilities can house 400 students. A new 27,000 square foot college facility in Brookings began public use in January 2013, offering a full range of services to the southernmost part of the Oregon Coast. (Lansing 2011)

*Bill Lansing, in the epilogue to his* Remember When*, closes by observing:*

*The isolation that brought a small rural community together around a rustic school house for weekend dances, potluck socials, church or school plays has been replaced by modern roads and the information highway that connects in different ways. Computers, internet and travel opportunities offer many choices to families and individuals who may choose to gather in interest groups unrelated to their schools. … Centralized schools bring students and teachers together in modern facilities offering many advantages and technologies, but a lesser degree of community social interaction than in the past (Lansing 2008, 195).*

Although Southwestern experienced significant growth, in the first decade of this century, miscalculation of predicted revenues and expenses led to a major shortfall. (Lansing 2011) A rise in state-wide unemployment rates in the last part of that decade exacerbated the deficit by reducing the state revenue from 51% of the general fund budget (in 1999-2001) to 26% (in 2011-2013). Economic stress was further heightened by the college's relatively high proportion of administrators (from Oregon Department of Community Colleges and Workforce Development 2010 [Jan.])—with a high percentage of those at the more experienced, higher end of the pay scale. That shortfall was remedied, in part, by a reduction of part of the workforce and staff furlough. Too, some class offerings were trimmed, eliminating classes such as journalism and theatre.

Southwestern continues to work toward recovering from those economic challenges. The college's programs, attractive setting and location, and an active recruitment system serve to draw students from outside the college district.

Current Enrollment

In 2013-2014, 8,508 individual Southwestern students accounted for 3,150 FTE (full-time equivalent).

*Student Profile*

Currently, 83% of Southwestern students are Oregon residents; out-of-district students hail from 15 states and many countries. Southwestern students are 51% female, 42% male, and 7% undisclosed. While gender breakdowns have changed little since 2008-2009, there was a small shift in the age ranges of Southwestern students between 2008-2009 and 2011-2012: the percentages of students in all age ranges above 20 (20-24, 25-44, 45-64, and 65+) dropped 1-3% while the percentage of students in the two lowest age ranges (15 and under, 16-19) rose by 6%.

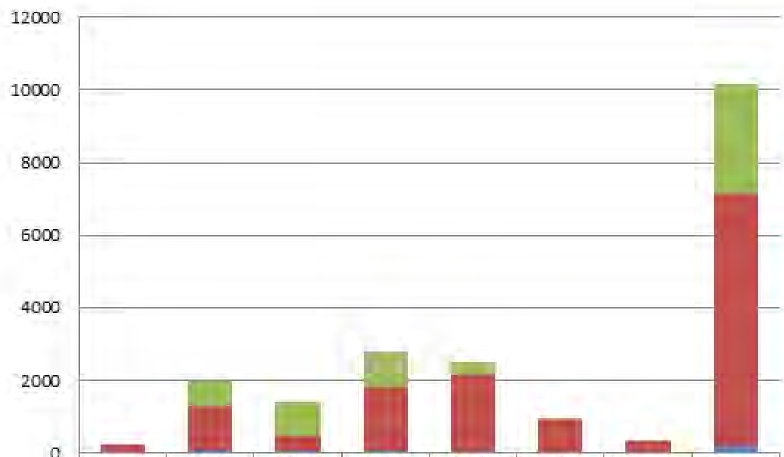
*Full-time equivalencies*

Reflecting the region's somewhat higher percentage of retirees (who are more likely to take college classes for recreation), Southwestern has a higher than state average of students in adult continuing education and noncredit courses (Figure 10 and 11). That skew is also reflected in the percentage of credit/noncredit classes since Southwestern's relatively high proportion of older students are somewhat more likely to take non-credit classes (Figure 9).

Degrees and Certificates

A variety of certificates and two-year degrees are currently available at Southwestern (see Appendix 3 for details):

- Associate of Arts Oregon Transfer (AA/OT)
- Oregon Transfer Module (OTM)
- Associate of General Studies (ASG)
- Associate of Applied Science (AAS)
- Associate of Science/Oregon Transfer in Business (AS/OT-BUS)
- Career Pathway Certificate of Completion
- One-Year Certificates of Completions
- Less than One-Year Certificates of Completion




| | <16 | 16-19 | 20-24 | 25-44 | 45-64 | >64 | Unknown | Total |
|---|---|---|---|---|---|---|---|---|
| Credit | - | 674 | 916 | 977 | 383 | 33 | 2 | 2,985 |
| Noncredit | 228 | 1,234 | 432 | 1,748 | 2,114 | 934 | 288 | 6,978 |
| Dev. Ed. | 2 | 47 | 51 | 56 | 19 | 1 | 1 | 177 |

Figure 9. Percentages and numbers of Southwestern students by credit, 2011-2012. Source: Oregon Department of Community Colleges and Workforce Development 2011.

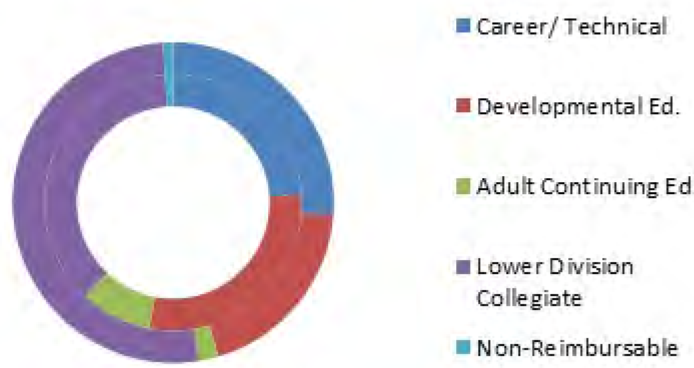



Figure 10. Percentages of Southwestern FTE by program area, 2011-201
Inner circle, Southweste
outer circle, total Orego
Community Colleges.
Source: Oregon Departn
of Community Colleges
Workforce Developmen
2011.

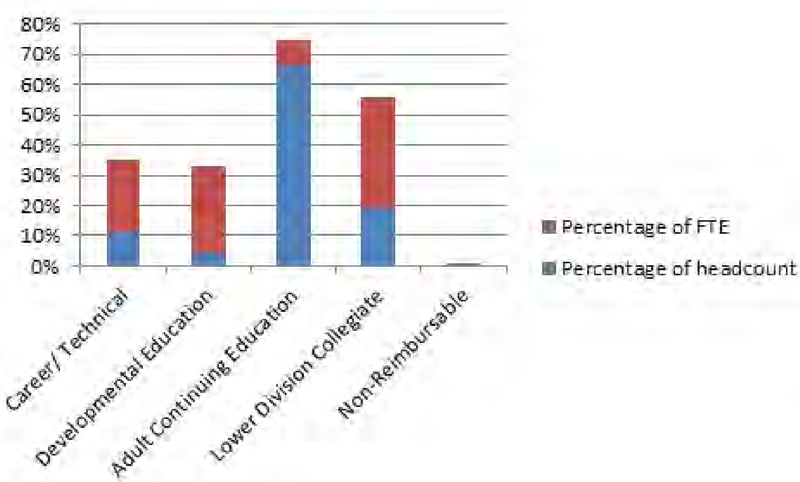



Figure 11. Comparisons of Southwestern FTE and headcount by program area, 2011-2012. Source: Oregon Department of Community Colleges and Workforce Development 2011.

Eleven new certificates were added in the last 10 years, while 26 certificates and degrees were terminated and two were significantly altered. Most of those changes appear to be coalesced or adapted career niches. Other program adaptations during that time included a nearly $2 million Department of Labor Employment Training Administration grant for Community Based Job Training to develop a mobile welding training lab. Particularly germane to this Project, half the AS Degrees offered are natural resource based: Forestry, Natural Resources, and Marine Biology. (As of this writing, Natural Resources is new and Marine Biology is expected to be complete soon.)

To provide that variety of service, Southwestern has four instructional units: Lower Division Collegiate and Developmental Education, Career and Technical Education, Extended Learning, and Student Services.

The Lower Division Collegiate unit is concerned primarily with transfer courses; key programs include Science/Math/Engineering, Humanities, and Social Sciences; Developmental Education helps students prepare for higher education and supports them in that pursuit, with services that include academic tutoring. Career and Technical Education are classic two-year degree and certificate programs—such as Allied Health/HPE/Emergency Services Training Programs, Nursing, Business and Technology, Culinary Arts, Family Studies and Childhood Education. Extended Learning provides community-based education, such as classes and services for the business community (through the Small Business Development Center in North Bend), corrections education, and ABE/GED classes. Student Services addresses enrollment and activities such as advising, counseling, testing, and internships.

*Accreditations*

Eight individual programs and program sections maintain special accreditation:

- Culinary Arts and Baking and Pastry Arts Program
- Early Childhood Education Degree (AS and AAS)
- Early Childhood Education Program
- EMT: Emergency Medical Technician Program
- Nursing Self-Study
- Oregon Small Business Development Centers
- Transitional Education: Self Study

<u>Related Programs, Resources, and Services</u>

Other Southwestern services and resources include the library (which is part of the Coos County Library Service District), computers and online student support, dining services (cafeteria), bookstore, sports, and student housing (with related services and activities).

Nine four-year Oregon universities and colleges participate in the *Southwestern Oregon University Center*, housed at Southwestern, giving students local access to over 40 different undergraduate and graduate degrees and over 25 different professional certificates. Current participating institutions are: Eastern Oregon University, Linfield College, Oregon Institute of Technology, Oregon State University, Portland State University, Southern Oregon University, University of Oregon, Western Oregon University, and Oregon Health & Science University.

Infrastructure

*Organizational Structure*

Southwestern policy is directed by a seven member board of directors through the college President. A Vice-president of Instructional and Student Services (Coos Campus) and the Executive Dean of Curry Campus report directly to the President. Reporting to the Vice-president are four Deans—Student Services, Extended Learning, Technical Education, and Lower Division Courses and Developmental Education—plus the Executive Director of OCCI and the Director of the Business Development Center, as well as staff in the Office of Instructional Services. Each Dean, in turn, directs a variety of programs through their administrative and support staff. The Executive Dean of Curry Campus oversees all key staff in that county directly. Several additional departments deal with infrastructure and support.

*Staffing*

Currently Southwestern has about 200 full-time employees and 180 part-time employees. Of the full-time employees, about 24% are faculty, about 18% are administrators, and about 58% are other support staff; most of the part-time employees are instructional staff. The percentages of types of employees have changed since 2008—notably, full-time faculty numbers have dropped (from about 70 to about 50) while other support staff have increased (from about 40 to about 120). Significant changes driving those changes include the addition of the Curry County campus and the acquisition of cafeteria management, as well as other institutional needs.

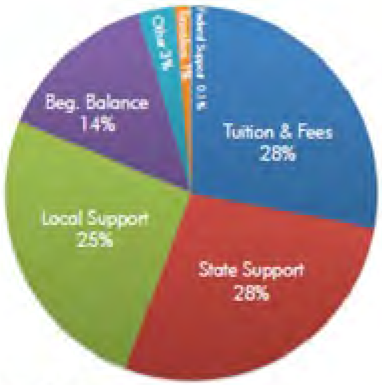
*Facilities*

Southwestern owns a total of 174 acres, with 83 of those acres developed; currently Southwestern owns and operates 44 buildings on those properties. See "History," above, for a summary of building construction and facility expansion. (See Appendix 4 for an annotated map of the main campus in Coos Bay.)

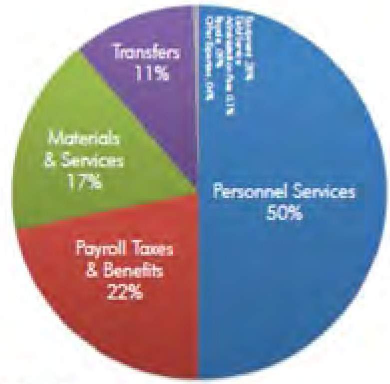
*Funding*

Southwestern's 2013-2014 budget actuals show total resources available of about $20 million and total expenditures of about $17 million. Just over 80% of those resources are about evenly divided among state support, tuition and fees, and local support. A little over 70% of the expenditures are personnel costs. (Figure 12) (Note that Southwestern is still paying down a debt incurred in the first decade of this century. See "History," above, for details.)

Further, Southwestern's Foundation manages holdings in excess of $3.6 million, making significant funds available to Southwestern students (Figure 13).




| RESOURCES | |
|---|---|
| State Support | $5,673,983 |
| Tuition and Fees | $5,632,951 |
| Local Support | $5,158,336 |
| Beginning Fund Balance | $2,853,980 |
| Other Income | $645,080 |
| Transfers from Other Funds | $276,327 |
| Federal Support | $16,333 |
| TOTAL RESOURCES AVAILABLE | $20,256,990 |




| EXPENDITURES | |
|---|---|
| Personnel Services | $8,600,976 |
| Payroll Taxes and Benefits | $3,738,823 |
| Materials and Services | $2,926,994 |
| Transfers to Other Funds | $1,825,869 |
| Equipment | $47,285 |
| Debt Service Administration Fees | $23,158 |
| Repairs | $15,598 |
| Other Expenses | $6,796 |
| TOTAL EXPENDITURES | $17,185,499 |
| ENDING FUND BALANCE | $3,071,491 |

Figure 12. Southwestern 2013-2014 budget actuals (unofficial). Source: Southwestern Oregon Community College 2014.

| | |
|---|---|
| Southwestern Foundation holdings: | $3,658,130 |
| Unrestricted Funds: | $1,597,411 |
| Restricted Funds: | $1,978,048 |
| Foundation Scholarships: | $95,389 |
| Outside Scholarships: | $497,072 |
| Gifts, Grants and Contributions: | $200,215 |
| Gifts to Endowments: | $16,793 |

Figure 13. Southwestern Foundations 2013-2014 budget actuals. Source: Southwestern Oregon Community College 2014.

## Conclusions

It is possible for students to get a good education in project area schools. However, despite the best efforts of the schools districts, the educational system is not working well for a number of segments of the community.

1. Based on the Oregon Department of Education's District and School Report Cards (Table 3), there are some schools serving students in the project area that provide better education than others, at least for the average student. For an involved and educated parent, it is possible to navigate through the various school options to increase the likelihood that your child will be successful. But this requires being proactive, and might necessitate moving among the three districts.

2. The combination of charter schools in the North Bend School District may provide the best pathway from kindergarten through high school for a student. Both standard curriculum elementary schools in North Bend are rated “above average” in comparison to other schools with similar demographics. However, test results from the Lighthouse School and ORCO Tech show they are superior, but rated as only “average” when compared to schools in their different demographic characteristic.

3. In many ways, the North Bend schools are segregated by class and ethnicity, with the more economically disadvantaged, disabled, and underserved minorities predominantly attending North Bend Middle School, and continuing into the High School, compared to the more advantaged students going from Lighthouse to ORCO Tech (Appendix 1). The Middle School is in the bottom 15% of schools statewide, with the High School rated in the lowest 45% percentile of all high schools in the state.

4. The situation with the Coos Bay schools is even more distressing: the only bright light in the 2012-2013 school performance measures was Millicoma Intermediate School, which as rated as above average, both statewide and compared to schools with comparable demographics. Marshfield High School, rated as a Level 3 (lowest 45%) can be considered as mediocre at best.

5. Neither Coos Bay nor North Bend adequately serves disabled students or underserved minorities, at least according to test scores. With few exceptions, disabled students are performing at the lowest level in virtually all areas at all grade levels compared to other schools in the State, even though IDEA Part B funds are distributed evenly on a per-student basis. Similarly, while underserved races/ethnicities are generally rated Level 2 (out of five, with higher better) on standardized tests, Hispanic/Latino students often fare worse at Level 1 (with the exception of Millicoma Middle School, where they perform as well or better than white students).

6. The state of educational infrastructure in the project area is a deterrent to effective education. The School Districts need to more successfully engage the community in order to gain the support they need to modernize.

7. The constant closing and realignments in both the Coos Bay and North Bend School Districts may be causing problems with parent involvement (with commitments made long-term to a specific school and faculty). Ultimately, this may affect parents’ willingness to support schools through volunteering as well as through tax levies.

8. The distance, and time required, for students from outlying areas to be bussed to centralized schools is leading to the creation of “home-schooling coopera-

tives." One of these is run by parents in Allegany, and others may exist. Some of these students may be connected with the school districts through Resource Link in Coos Bay, or the Virtual Academy in North Bend, but in many cases they may not be associated with any formal school system.

9. There is anecdotal evidence that the state of local schools is having adverse affects on local businesses, both through their inability to find trained (or trainable) employees, and in their ability to attract desirable employees to relocate to the Bay Area. *Chapter 6: Jobs and Employment* provides additional analysis of these potential effects.

**References**


Coos County Assessor. 2013. 2013-2014 Summary of Assessment and Tax Roll, Coos County, Oregon. Coquille, OR. 209 pp.

DLR Group. 2014. "What's Best For Students." Presentation, Coos Bay School District Facilities Planning Workshop, January 25, 2014, Marshfield High School.

ECONorthwest. 2002. "Comprehensive Analysis of K-12 Education Finance in Oregon." Prepared for the Oregon State School Board Association. ECONorthwest Consultants, Eugene, OR. 58 pp.

Lansing, William A. 2008. Remember When: Coos County Schools 1850 – 1940. Distributed by the Coos Historical and Maritime Museum, North Bend, OR. 199pp.

Lansing, William A. 2011. Fifty Years: Honoring Our Past, Lighting The Future. Southwestern Oregon Community College. Coos Bay, OR. 192pp.

Learning First Alliance. 2002. "Major Changes to ESEA in No Child Left Behind Act." Accessed 14 March 2014: http://www2.edmin.com/news/nclb/files/2_16.pdf

Legislative Revenue Office. 1999. "The New Direction of the Oregon Property Tax System Under Measure 50." Research Report #6-99. State of Oregon, Legislative Revenue Office, Salem, OR. 19 pp.

National Center for Education Statistics. 2015. http://nces.ed.gov/ccd/elsi/; for 2014-2015: http://www.ode.state.or.us/wma/data/schoolanddistrict/students/docs/fallmembershipreport_20142015.xls

New America Foundation. 2013. Federal Education Budget Project: Electronic data files: Coos Bay: http://febp.newamerica.net/k12/OR/4103660: North Bend: http://febp.newamerica.net/k12/OR/4108820

Oregon Department of Community Colleges and Workforce Development. 2010. Community College Profile 2010-2011 (Jan.). http://www.oregon.gov/ccwd/pdf/Profile/ORCCProfile10-11.pdf

Oregon Department of Community Colleges and Workforce Development. 2011. Community College Profile 2011-2012. Accessed 3 July 2015: http://www.oregon.gov/ccwd/pdf/Profile/ORCCProfile11-12.pdf

Oregon Department of Education (ODE). 2013a. Oregon Statewide Report Card, 2012–2013. Salem, OR. 83pp. Accessed 20 March 2014: http://www.ode.state.or.us/search/page/?id=1821

Oregon Department of Education (ODE). 2013b. Oregon School and District Report Card Policy and Technical Manual. Draft of June, 2013. Office of Assessment and Information Services, Oregon Department of Education, Salem, OR. 41 pp.

Oregon Department of Education (ODE). 2013c. Oregon Cohort Graduation Rate: Policy and Technical Manual. Draft. Office of Assessment and Information Services, Oregon Department of Education, Salem, OR. 29 pp.

Oregon Department of Education (ODE). 2015. "Fall Membership Report." Electronic data files: http://www.ode.state.or.us/search/page/?=3225

Oregon Department of Education (ODE). n.d. Budgeted Operating Revenue by Source. Compiled from: http://www.ode.state.or.us/sfda/reports/r0014Select.asp

Oregon School Boards Association (OSBA). 2015. Resources: Bond and Local Option Election Data. Accessed: http://www.osba.org/Resources/Article/Budget_and_Finance/Election-Recent_Bond-Local_Option_Election_Results.aspx

Oregon Secretary of State (OSOS). 1990. Oregon Voters' Pamphlet, November 1990 General Election. Accessed 20 March 2014: http://library.state.or.us/repository/2010/201003011350161/ORVPGenMari1990.pdf

Southwestern Oregon Community College. 2014. Annual Report.

Southwestern Oregon Community College. 2015. Degrees and Certificate Options. http://www.socc.edu/academics/degrees

U.S. Department of Education. 2011. National Center for Education Statistics, Common Core of Data (CCD), "Local Education Agency (School District) Universe Survey," "Survey of Local Government Finances, School Systems (F-33)." https://nces.ed.gov/ccd/pubagency.asp

U.S. Department of Education. n.d. ESEA Title I LEA Allocations—FY 2013: Electronic data files: http://www2.ed.gov/about/overview/budget/titlei/fy13/index.html

Appendix 1: School performance statistics for the Coos Watershed (2012-2013 School year). Source: ODE 2013a.

| Metric | Coos Bay SD#9 | | | | | | | North Bend SD#13 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Blossom Gulch | Madison Elementary | Sunset Middle | Millicoma Intermediate | Marshfield H.S. | Destinations Charter | Resource Link | Hillcrest Elementary | North Bay Elementary | Lighthouse Charter | North Bend Middle School | North Bend Senior H.S. | Or. Coast Tech. School | Or. Virtual Academy |
| **School Demographics** | | | | | | | | | | | | | | |
| Grades Enrolled | K-3 | K - 3 | 4 - 7 | 4 - 7 | 8 - 12 | K - 12 | K - 12 | K - 4 | K - 5 | K - 8 | 5 - 8 | 9 - 12 | 6 - 12 | K - 11 |
| Students Enrolled | 518 | 415 | 434 | 464 | 955 | 91 | 65 | 549 | 257 | 205 | 377 | 417 | 443 | 1,582 |
| Average Class Size | 22.9 | 23.9 | 20.9 | 21.6 | N/A | N/A | N/A | 26.6 | 25.8 | 20.1 | N/A | N/A | N/A | N/A |
| Attending 90% or More Days | 86% | 81% | 82% | 84% | 86% | > 95% | > 95% | 86% | 82% | 87% | 81% | 88% | 93% | 71% |
| % Economically Disadvantaged | 64% | 80% | 79% | 60% | 53% | 65% | 54% | 60% | 65% | 35% | 71% | 49% | 39% | 57% |
| % Students with Disabilities | 16% | 15% | 20% | 19% | 16% | 16% | 14% | 15% | 15% | 8% | 18% | 16% | 5% | 16% |
| % Underserved Races/Ethnicities | 18% | 20% | 22% | 17% | 19% | 22% | 14% | 16% | 8% | 7% | 15% | 13% | 10% | 10% |
| % English Learners | < 5% | 7% | 6% | 5% | <5% | < 5% | 0% | < 5% | < 5% | 0% | < 5% | < 5% | 0% | < 5% |
| Title I School | Yes | Yes | Yes | Yes | No | No | No | Yes | Yes | No | No | No | No | No |
| **Academic Achievement** | | | | | | | | | | | | | | |
| ***Reading*** (Met Standards) | 64% | 62% | 58% | 69% | 67% | 57% | 83% | 78% | 73% | 86% | 55% | 80% | 81% | 59% |
| Economically Disadvantaged | 52% | 58% | 55% | 65% | 61% | 67% | 90% | 74% | 74% | 79% | 49% | 66% | 76% | 52% |
| Students with Disabilities | 50% | 36% | 38% | 33% | 10% | N/A | N/A | 63% | 40% | 82% | 31% | 23% | 21% | 39% |
| Underserved Races/Ethnicities | 61% | 50% | 47% | 61% | 62% | N/A | N/A | 68% | 67% | 80% | 50% | 89% | 57% | 56% |
| ***Math*** (Met Standards) | 49% | 54% | 42% | 64% | 52% | 21% | 58% | 77% | 57% | 60% | 46% | 42% | 73% | 37% |
| Economically Disadvantaged | 42% | 51% | 40% | 60% | 47% | 33% | 46% | 74% | 54% | 49% | 39% | 39% | 66% | 28% |
| Students with Disabilities | 25% | 27% | 18% | 26% | 10% | N/A | N/A | 47% | 30% | 35% | 15% | < 5% | 16% | 21% |
| Underserved Races/Ethnicities | 39% | 59% | 33% | 57% | 46% | N/A | N/A | 66% | 44% | 20% | 36% | 22% | 57% | 28% |
| ***Science*** (Met Standards) | N/A | N/A | 63% | 46% | 65% | 36% | 75% | N/A | N/A | N/A | 56% | 71% | 81% | 53% |
| Economically Disadvantaged | N/A | N/A | 60% | 33% | N/A | N/A | N/A | N/A | N/A | N/A | 48% | N/A | N/A | N/A |
| Students with Disabilities | N/A | N/A | 43% | 21% | N/A | N/A | N/A | N/A | N/A | N/A | 30% | N/A | N/A | N/A |
| Underserved Races/Ethnicities** | N/A | N/A | 47% | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 48% | N/A | N/A | N/A |
| ***Writing*** (11th Grade) | | | | | 42% | < 5% | 57% | | | | | 34% | 59% | 45% |
| **Academic Growth***** | | | | | | | | | | | | | | |
| ***Reading*** | N/A | N/A | 46% | 58% | 45% | 39 | 55% | 54% | 54% | 66% | 46% | 55% | 49% | 34% |
| Economically Disadvantaged | N/A | N/A | 42% | 57% | 39% | 39% | 63% | 49% | 56% | 78% | 45% | 50% | 48% | 23% |
| Students with Disabilities | N/A | N/A | 34% | 57% | 26% | N/A | N/A | 44% | 25% | 81% | 39% | 40% | 28% | 16% |
| Underserved Races/Ethnicities | N/A | N/A | 49% | 54% | 60% | N/A | N/A | 40% | N/A | N/A | 44% | 70% | 44% | 25% |
| ***Math*** | N/A | N/A | 40% | 61% | 40% | 33% | 43% | 65% | 51% | 62% | 43% | 58% | 59% | 24% |
| Economically Disadvantaged | N/A | N/A | 39% | 61% | 39% | 35% | 37% | 65% | 47% | 58% | 42% | 57% | 55% | 17% |
| Students with Disabilities | N/A | N/A | 34% | 62% | 38% | N/A | N/A | 42% | 43% | 64% | 46% | 17% | 34% | 24% |
| Underserved Races/Ethnicities | N/A | N/A | 29% | 66% | 40% | N/A | N/A | 64% | N/A | N/A | 38% | 49% | 77% | 17% |
| **Other** | | | | | | | | | | | | | | |
| Graduation Rate | | | | | 63% | 23% | 36% | | | | | 61% | 95% | N/A |
| Post-Secondary Advancement ('10-'11) | | | | | 56% | 40% | 0% | | | | | 56% | 88% | N/A |
| On Track to Graduate | | | | | 68% | 60% | 29% | | | | | > 95% | > 95% | N/A |
| Completion Rate (GED, etc.) | | | | | 78% | 55% | 50% | | | | | 68% | 87% | N/A |
| Dropout Rate | | | | | 2.8% | 26% | 0% | | | | | 2.70% | 0% | 7.80% |

** Not aggregated in report card. Figure reported here is the average of the American Indian and Hispanic Latino percentages.

*** Academic Growth is progress towards meeting or maintaining standards over the next three years.

Appendix 2. Oregon K-12 performance measures, their weights, and how they are scored. Sources: ODE 2013b and 2013c

| Performance Measure | Weight %* | Definition | Determination |
|---|---|---|---|
| 1. Achievement Rating | 25% - 20% - 20% | Percentage of students who met state achievement standards on reading and math assessments in grades 3 – 8 and 11. | Up to 10 points awarded (5 for math and 5 for reading) based on cutoff thresholds determined annually. |
| 2. Growth Rating | 50% - 30% - 20% | Whether the typical student in a school is "on-track" to meet mathematics or reading achievement standards in the next three years. | Based on the change in math and reading OAKS test scores from one year to the next, compared to the progress rate needed to meet standards. Points assigned based on the median student growth scores. |
| 3. Sub-group Growth Rating | 25% - 15% - 10% | The Growth Rating as measured by four sub-groups: Economically Disadvantaged, Limited English Proficient, Students with Disabilities, and Underserved Races/Ethnicities | Calculated exactly the same as the Growth Rating. Based on percent of points earned by subgroup. Each Level has a cutoff threshold for percent of points earned. Subgroup requires at least 40 assessment tests from a minimum of 30 students. |
| 4. Graduation Rate | N/A - 25% - 35% | The Graduation Rate follows a cohort students who are first-time high school students in a particular year and determines the percentage that graduate within four or five years with a Regular Diploma.** | The higher of the four- or five-year adjusted cohort graduation rate over the last two years. Adjustments are made for students entering and transferring out, and other cases. Thresholds for points (max. 5) are different between 4-year and 5-year graduation rates. |
| 5. Subgroup Graduation Rate | N/A - 15% - 25% | Same definition as the Graduation Rate, but includes the four subgroups. | Calculated similarly to the Graduation Rate. |

* Percent contribution to a school's overall rating for Elementary/Middle Schools, Consolidated Schools (K-12), and High Schools, respectively. Percentages will aggregate to 100% for all 5 performance measures for a specific type of school.

** Students receiving modified, extended, or adult high school diploma, or a GED are categorized as "Completers" that are included in the Report Card, and their numbers are included in the denominator for the Graduation Rate calculation (i.e., they lower the rate).

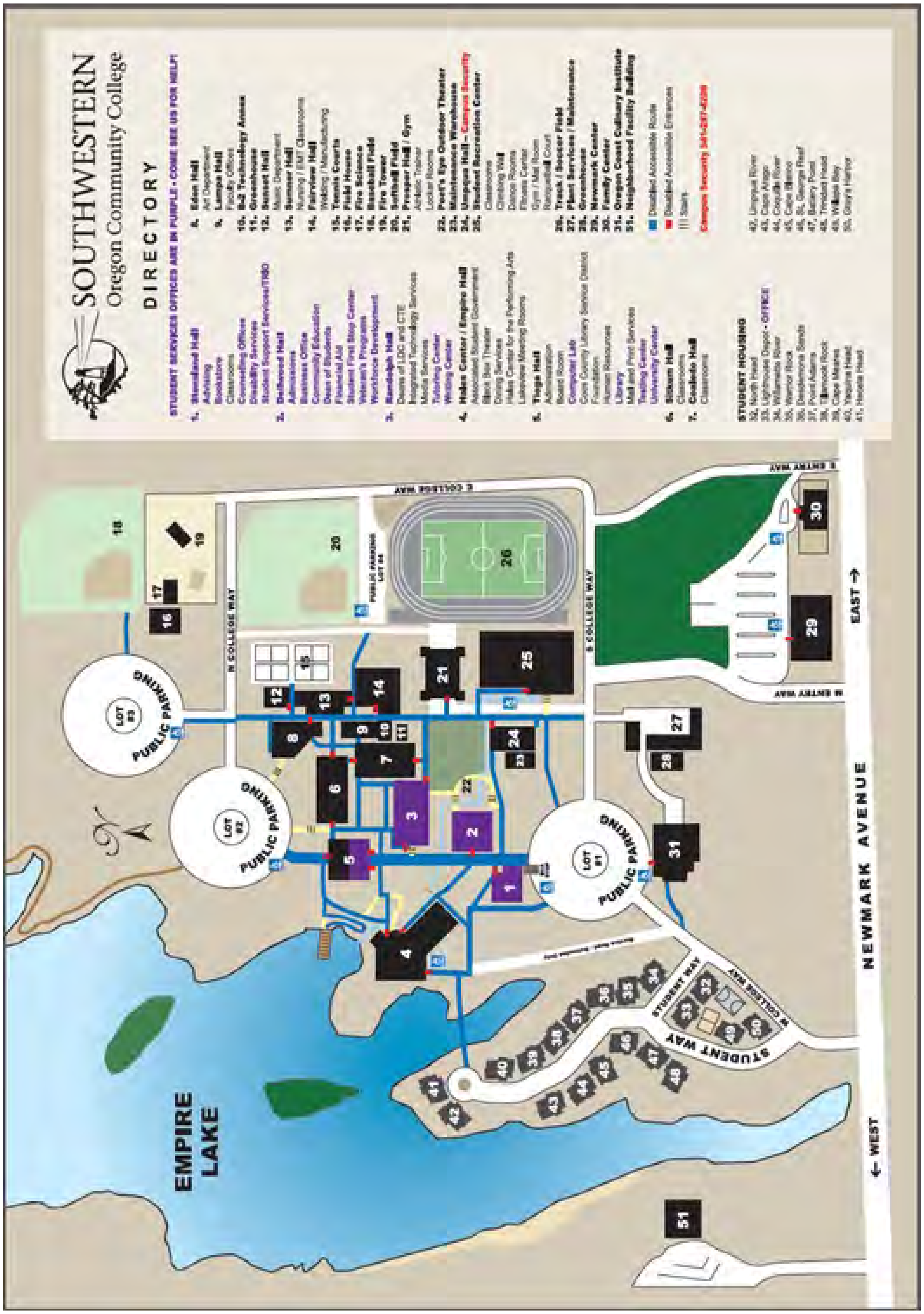
Source: ODE 2013b and ODE 2013c.

Appendix 3. Source: Southwestern Oregon Community College 2015

## Appendix 3: Southwestern Oregon Community College Certificates and Degrees (2015).

- Associate of Arts – Oregon Transfer Degree (AA/OT)
- Oregon Transfer Module (OTM)
- Associate of Science Degree (AS)
    - Childhood Education and Family Studies Emphasis
    - Criminal Justice Emphasis
    - Fire Science Emphasis
    - Forestry Emphasis
    - Marine Biology Emphasis
    - Natural Resources Emphasis
- Associate of General Studies Degree (AGS)
- Associate of Applied Science Degree (AAS) [Career Technical/Professional Technical]
    - Accounting
    - Administrative Office Professional
    - Baking & Pastry Arts
    - Business Management/Entrepreneurship
    - Childhood Education and Family Studies
    - CIS: Digital Design
    - CIS: Software Development
    - Computer Information Systems
    - Criminal Justice
    - Culinary Arts
    - Emergency Medical Technology (EMT) – Paramedic
    - Fire Science Technology
    - Medical Assistant
    - Nursing
    - Welding
- Associate of Science/Oregon Transfer Degree in Business (AS/OT-BUS)
- Associate of Science/Oregon Transfer Degree in Computer Science (AS/OT-CS)
- Career Pathways Certificate of Completion
- One-Year Certificate of Completion
    - Accounting Clerk
    - Baking and Pastry Arts
    - Bookkeeping Clerical
    - Childhood Education and Family Studies
    - Clerical
    - Computer Information Systems
    - Culinary Arts
    - Digital Design
    - Emergency Medical Technology (EMT)
    - Fire Science Technology: Level II
    - Forest Technology
    - Green Industrial Maintenance Technician
    - Medical Clerical
    - Para Educator/Educational Assistant
    - Pharmacy Technician
    - Phlebotomy Technician
    - Programming Technician
    - Rural Health Aide
    - Welding
- Less than One-Year Certificate of Completion
    - Personal Trainer/Aging Adult
    - Personal Trainer/Group Exercise Leader
    - Retail Management

Appendix 4. Map of Southwestern Oregon Community College main campus in Coos Bay



# **Chapter 8:** Physical Description of the Coos Estuary and Lower Coos Watershed

*Jenni Schmitt, Colleen Burch Johnson, Erik Larsen, John Bragg, Max Beeken- South Slough NERR*

***Geographic Features***: *The Coos estuary comprises a wide variety of intertidal mudflats, channels, and marshes; upland habitats are dominated by highly productive coniferous forests.*

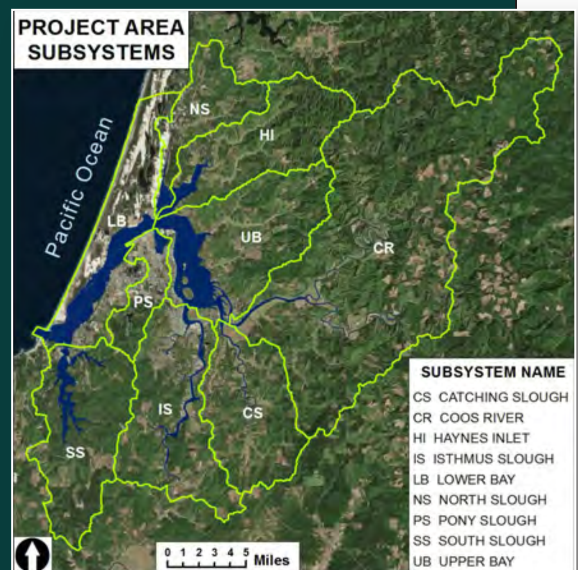
***Meteorology***: *The project area experiences wet winters and dry summers. There is no apparent trend in local climate variability.*

***Hydrology***: *Ocean tides and freshwater from rivers and streams determine the quality and distribution of estuarine and riparian habitats.*

***Geology***: *Tectonic activity causes the incremental uplift of project area lands which historically have given way to sudden land subsidence during infrequent earthquakes.*

***Land Cover/Land Use***: *Land cover and land use have been mapped frequently since 1900, but different methods, resolution, focus and classifications make direct comparisons challenging.*

***Human Infrastructure***: *76 miles of functioning dikes are protecting 17,300 acres of developed land in the project area; impervious surface area is increasing; road density exceeds thresholds for healthy watersheds.*




*The "project area" is defined by a network of nine environmental "subsystems," which collectively comprise the lower Coos watershed.*

## Chapter 8: Physical description of the Coos estuary and the Lower Coos Watershed

*This section includes the following data summaries:* ***Geographic Features****,* ***Meteorology****,* ***Hydrology****,* ***Geology****,* ***Land Use/Land Cover****, and* ***Human Infrastructure*** *— which describe physical properties of the Coos estuary and lower Coos watershed.*

Geographic Features: The Geographic Features data summary provides information about the Coos estuary's wetted surface area, shape, length, and major channels, as well as the extent of estuarine (tidal) influence. It additionally describes different estuarine regions, and the watershed size for the major slough subsystems and tributaries. Changes to the project area lands from pre-contact conditions are discussed as well.

Much of the information supporting the Geographic Features data summary came from agency reports (e.g., Rumrill 2006, CoosWA 2006), peer-reviewed publications (e.g., Hickey and Banas 2003), and academic theses (e.g., Hyde 2007). Data used to create shoreline maps and describe the size of the Coos estuary and its subsystems were provided by the Oregon Ocean Coastal Management Program (OCMP), a project led by the Oregon Department of Land Conservation and Development (DLCD 2011).

Information from the OCMP Coos estuary data was compiled from multiple shoreline data sources. The majority of those data were derived from the National Oceanic and Atmospheric Administration's (NOAA) Continually Updated Shoreline Product (CUSP). The CUSP shoreline was defined as the line of contact between land and water at approximately Mean High Water using Light Detection and Ranging (LiDAR) data or digital imagery interpretation.

Hydrology: The Hydrology data summary examines Coos estuary circulation by describing estuarine bathymetry (bottom contours), oceanic influences (including tides and coastal upwelling), and freshwater contributions to the estuary by local rivers and streams. In addition, the three-dimensional hydrodynamic model for the Coos estuary currently under development by a University of Oregon scientist (as of fall 2015) is described (Sutherland 2013).

Bathymetry information came from the United States Army Corps of Engineers (USACE 2014) hydrographic surveys, and surveys by Oregon State University scientists (Wood and Ruggiero 2014).

Information relating to ocean influences come from a variety of sources. The local sea level rise rate and tidal amplitude information were taken from NOAA's Tides and Currents Charleston Station (NOAA 2015). Flushing times were informed by graduate thesis work from the mid-1970's (Arneson 1976). Newly collected, unpublished data from the South Slough National Estuarine Research Reserve (SSNERR) were used to describe estuary currents (SSNERR 2015). Upwelling patterns for the Pacific Northwest came from the Northwest Fisheries Science Center website (NWFSC 2015).

Freshwater discharge data were compiled from existing reports (e.g., Cornu et al. 2012) and data from on-going  stream monitoring efforts (USGS 2015b). Spatial information describing stream size and type was based on Oregon Department of Forestry Geographic Information System (GIS) streams data (ODF n.d.).

Meteorology: Meteorological data for the project area came mainly from two sources:

1. SSNERR's System Wide Monitoring Program (SWMP) data.  SWMP is a long term monitoring program that collects a variety of water quality and meteorological data. In this data summary, meteorological data from 2007-2014 were used, which included air temperature, precipitation, wind speed and direction, and photosynethically active radiation (PAR)(SWMP 2015).

2. North Bend Municipal Airport (Airport) meteorological data provided online by the Western Regional Climate Center (WRCC n.d., MesoWest 2015). We used air temperature, precipitation, and wind speed and direction data from 1931-2014.

Since it is the largest available data set and represents the most complete record of long-term meteorological trends, we used the Airport data wherever possible. Additionally, because the Airport is closer to the geographic center of the project area, data from this monitoring station may be considered generally more representative of the project area as a whole. In cases where Airport data were not available (e.g., PAR), the SWMP data were used as alternatives.

In addition to the above-mentioned sources, the Meteorology data summary describes the Pacific Decadal Oscillation. This information is available through the Joint Institute for the Study of the Atmosphere and Ocean (JISAO 2015).  Wind speed and direction data were analyzed and the associated figures were generated using Openair, a statistical package developed by Carslaw and Ropkins (2012).

Geology: The Geology data summary describes the tectonic activity affecting the project area, along with its related history of infrequent earthquakes and tsunamis. Bedrock formations, superficial deposits, soils, and landslides are also discussed.

Spatial data used to support the Geology data summary came from multiple sources. The Oregon Department of Geology and Mineral Industries (DOGAMI) compiled geological data for Oregon from various state and federal agencies, student theses, and consultants as part of a six year project (DOGAMI 2009). This data set enabled us to characterized the faults and folds within and near the project area. The United States Geological Survey (USGS 2005b) provided spatial information characterizing the locations of those faults and folds in the U.S. believed to be sources of significant earthquakes (those of magnitude 6 or greater) during the past 1.6 million years (paleoseismic earthquakes). These USGS data also provided information on age, direction and rate of slippage, angle and direction of dip, visibility, and type (e.g., strike-slip, normal, reverse, thrust) of each paleoseismic fault.

Landslide spatial information came from DOGAMI (2014) efforts to compile previously mapped landslides, LiDAR-based mapping of landslide features, and aerial photography review. It also included information on landslide classification, depth of failure, movement type, and confidence of interpretation (i.e. that the features called landslides are actually landslides), along with known costs associated with damage and losses. This dataset was cropped to the project area to identify landslide-prone areas where historic landslides have occurred.

Distribution of lands at high or moderate debris flow risk was provided by Oregon Department of Forestry (ODF 2000a). This dataset was derived from USGS Digital Elevation Models (DEMs) of the project area landscape; DEMs are used to evaluate slope steepness, stream channel confinement, and shape of debris flow deposits (fan shape). Historical information on debris flows was also used to inform the USGS dataset.

USGS (2015a) is a compilation of earthquake metrics (e.g., magnitude, amplitude, hypocenter, etc.) measured by contributing seismic networks, such as the Pacific Northwest Seismograph Network, the Oregon State University Geophysics Group, and the University of Oregon Department of Geology.

Soil distribution information came from the National Cooperative Soil Survey (USDA 2000), which provides the most detailed spatial data available about soils in the project area. This information came from digitizing maps and revising digitized maps using remotely sensed information.

Other information for the Geology data summary was provided by primary literature and agency reports. For example, definitions of major soil types found in the project area were provided by Haagen (1989); information about tsunami history was provided by Kelsey et al. (2005).

Land Use/Land Cover: The topics discussed in the Land Use/Land Cover data summary include the distribution of land use and land cover (LULC) in the project area's nine subsystems and their changes over time. LULC types include: forests, scrub/shrub, grassland, agriculture, developed/urban, barren, water, and wetlands.

Two extensive, multi-year sources of recent LULC data were used for this summary: the National Land Cover Database (NLCD) and the Coastal Change Analysis Program (C-CAP).

The NLCD was developed by a group of U.S. federal agencies called the Multi-Resolution Land Characteristics Consortium (MRLC), and is based on Landsat satellite imagery and supplemental data sources (Homer et al. 2012). NLCD spatial data are available for the years 1992, 2001, 2006, and 2011. These data are national in scope and have 16 general land use and land cover classes, plus four vegetation types used for Alaska only. Only the classes relevant to the project area are included in the LULC data summary as outlined in its Table 1. The 1992, 2001, and 2006 editions of the NLCD data were retrofitted to enable comparisons with the 2011 dataset (Fry et al. 2009; Sohl, pers. comm, 2015). The 2011 NLCD data are based primarily on a decision-tree classification of Landsat data (Homer et al. 2012).

Areas near the U.S. coastline are also included in the C-CAP land cover data from NOAA (C-CAP 2014). Land cover change for Oregon is available for the years 1996, 2001, 2006 and 2010. NOAA is one of the member agencies for the MRLC, so C-CAP land cover data are similar to NLCD data. Both are based on remotely sensed imagery, at 30 meter resolution, and both try to update their data sets every five years. The primary differences between the C-CAP and NLCD classification schemes are:

1. C-CAP distinguishes unconsolidated shore materials from other "barren" lands; and

2. C-CAP includes several additional wetland classes that NLCD does not.

However, both classification schemes can be aggregated to nine LULC categories: agriculture, barren (bare land), developed/urban, forest, grassland, scrub/shrub, water, emergent wetlands, and woody wetlands.

Additional data sources, a 1970's USGS data set (USGS 2005a), Oregon Department of Forestry's (ODF) ground surveys between 1895 and 1898 (ODF 2000b), and a Potential Natural Vegetation map developed from 1938 data by Tobalske and Osborne-Gowey (2002), provide "snapshots" of past LULC mapping efforts. However, because these maps differ in source materials, methods, resolution, and classification schemes, they cannot be directly compared to the recent NLCD or C-CAP data.

Finally, two models designed to project land cover patterns into the future are briefly described in the data summary. Models described are: 1) Coastal Landscape Analysis and Modeling Study (Kline et al. 2003); and 2) a GIS-based, deterministic model created by ODF (2014).

<u>Human Infrastructure</u>: The Human Infrastructure data summary describes for the project area: 1) location and condition of, and management responsibility for levees; 2) location of tide gates; 3) location and percent cover of impervious surfaces; 4) location of stormwater outfalls; and 5) location and density of roads. Most data were derived from analyses of existing spatial data (e.g., OCMP 2011a), but several reports were used to augment these data (e.g., NOAA 2010).

Thresholds for maximum recommended densities for impervious surfaces and roads referenced in the data summary came from a variety of sources, including agency reports (e.g., USEPA 2014) and peer-reviewed literature (e.g., Forman and Alexander 1998).

Spatial data describing project area levees and tidegates came from an OCMP geospatial database that uses LiDAR data and aerial photography (OCMP 2011a, b, c). The original purpose of this dataset was to provide coastal managers with quantitative information about levees and tide gates in Oregon estuaries. Location and condition of levees were digitized from LiDAR products and verified by field ground truthing and "participatory mapping," where local experts in each estuarine system were asked to offer their best professional judgments.

Information about levee-protected lands was derived from tax-assessor maps, by identifying tax parcels immediately adjacent or abutting levees (OCMP 2011b).

Tide gate locations were identified from local inventories (e.g., ODOT tide gate locations, fish passage barriers, restoration projects), local expert knowledge, and on-the-ground investigations, then digitized with the benefit of LiDAR landscape contour and elevation data (OCMP 2011c).

The impervious surface data are products of the NLCD provided by MRLC, created for the years 2001, 2006, and 2011 (MRLC 2015). MRLC's Percent Developed Imperviousness maps were created by: 1) classifying images with a nominal spatial resolution of 1 meter into pervious or impervious surfaces and summed within 30-meter Landsat pixels to obtain a percentage; 2) using the reference data and Landsat spectral bands to calibrate density prediction models; and 3) spatially extrapolating the models for per-pixel imperviousness (NLCD 2001 metadata).

Stormwater outfall locations were provided by the Cities of North Bend and Coos Bay for outfalls within their city limits (City of North Bend 2005, City of Coos Bay n.d.).

Roads spatial data came from the Oregon Department of Transportation's statewide compilation of roads (ODOT 2014).

Climate Change Summary: The National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center created maps to show predicted sea level rise inundation extents ranging from 1-6 ft (above MHHW)(USDOC 2012). These maps inform coastal managers and scientists about related coastal flooding impacts. Scenarios were created using a modified bathtub model, which accounts for local/regional tidal variability and hydrologic connectivity. Data used to create the model came from DEMs and a tidal surface model (which was created with NOAA's VDatum in conjunction with spatial interpolation/extrapolation methods). Models do not take into account potential erosion scenarios.

**Data Gaps and Limitations**

Geographic Features: Some of the information presented in the Geographic Features data summary may be dated, because the best available information came from an Oregon Department of Fish and Wildlife report from 1979 (Roye 1979).

Hydrology: Our understanding of tidal hydrology in the Coos estuary is limited or dated information. Bathymetry data (bottom contours) are available for the main shipping channel in the Coos estuary but elsewhere the data are severely limited. The incomplete nature of bathymetry data affects our ability to more fully understand tidal flushing rates in the estuary because these rates are largely based on estuarine bathymetry. In addition, the tidal flushing rates reported in the data summary are referenced from a 1976 report (Arneson 1976) which will not reflect changes which have taken place in the estuary since then (e.g., changes in the size of the Coos estuary's commercial shipping channel).

Head of tide information came from a 1989 Oregon Department of State Land (ODSL) report, which was then digitized into a GIS shapefile using both on-screen and manual digitization methods in 2000 (ODSL 2000). The methods detailing how head of tide locations were determined in the 1989 report were not included in the original publication and the authors are since deceased. Heads of tide locations appear to include major tributaries only; minor tributaries were excluded. Many heads of tide locations for the project area include observation dates, but not all. Years of listed observations were in different years (either 1979 or 1984) and months (March-July). Observations were all made during high tides, but whether or not they were made during the highest high tide of the day was not mentioned (it's a logical to assume they were but this is not confirmed in the source material). Likewise, it is unknown if high river and stream flows were accounted for.

Meteorology: The Meteorology data summary makes use of two meteorological monitoring stations in the project area: 1) the North Bend Municipal Airport monitoring station (WRCC n.d., MesoWest 2015); and 2) SSNERR's meteorological monitoring station located in Charleston (SWMP 2015). Two additional stations are located in the project area (NOAA's Climate Reference Network station in upper South Slough and the meteorological monitoring station associated with the NOAA tide station in Charleston), but were not used because these data sets are not as complete as the Airport and SWMP data. Furthermore, the locations of the unused data are encompassed by the Airport and SWMP sets.

The analysis of project area meteorology data was limited by the resources available. The two stations we used oftentimes produced vast data sets (some data collected multiple times per hour for the past 10-20 years), comprehensive analysis of which was beyond the scope of this project. While we were able to use those data to characterize basic meteorological status and trends for the project area, we feel there would be significant benefit to making a special effort to secure funding to complete a more robust analysis of those large data sets.

The meteorological data are subject to quality assurance and quality control (QA/QC) concerns (e.g., equipment malfunction, instrument recording error, failure to deploy instrument, instrument calibration issues, etc.). Data that have been compromised by QA/QC concerns were dropped prior to analyses. In rare cases, the validity of wind speed data from the MesoWest (2015) dataset were called into question even in the absence of any QA/QC flags. Observations from these data meeting the following illogical or unlikely conditions were removed prior to analysis:

- Sustained wind speed exceeds the speed of wind gusts.
- Unlikely high sustained wind speed (e.g., 129 mph reported on July 12, 2005)
- Unreasonably large gap between sustained wind speed and speed of wind gusts (e.g., sustained winds of 6 mph and wind gusts of 92 mph reported on October 25, 2012)

It is important to note that the removal of questionable observations from these data sets does not obscure seasonal or long-term trends, because the number of compromised data points represents a very small percentage of all meteorological observations.

We also favored the use of the SWMP (2015) data for precipitation analyses since the MesoWest (2015) data included several thousand observations indicating the highly unlikely occurrence of storm events during which the amount of local precipitation received in a 24-hour period met or exceeded 60 inches (the approximate annual precipitation total for the project area).

SSNERR staff maintain the SWMP meteorological monitoring station. From 2007-2014 this station was located on the University of Oregon Institute of Marine Biology (OIMB) campus in Charleston near the northern end of the South Slough Subsystem. In December 2014, OIMB installed a new wind turbine in proximity to the SWMP monitoring station which raised concerns about the turbine's potential effects on the station's data. As a result SSNERR is relocating the SWMP meteorological monitoring station. Beginning in 2016, data collection will occur at a new location in Tom's Creek Marsh near the southern end of the South Slough Subsystem. Although this data summary reports only data occurring prior to 2016 (i.e., prior to the move), it should be noted that future comparisons of pre-2016 meteorological SWMP data to post-2016 data should be made with caution because of this change.

This data summary uses a technique called "time series decomposition" to examine the data for long-term air temperature and precipitation trends. Although this method shows that no trends are immediately apparent for air temperature or precipitation in the 80-year data set, it should be noted that this does rule out possible longer-term trends for the project area. For example, it's feasible that an overall warming trend in the project area may have occurred since the Industrial Revolution (early 18th century). However, since data are only available starting in the early 20th century, it could be the case that this warming trend is not detectable because the time horizon of the available data may be too small to detect any true long term trend.

Analyses of changes in the frequency and intensity of storm events requires access to very high resolution data over a very long time period. To understand the intensity of a storm, one must have access to complete and highly detailed meteorological records (e.g., precipitation received per hour). Although the SWMP (2015) dataset provides precipitation data at this level of detail, it includes only seven years of data (2007-2014), which is not enough time to facilitate meaningful analyses of change in storm frequency and intensity. Furthermore, the 80-year MicroWest (2015) data set only provides precipitation totals over 24-hour periods, subject to the QA/QC concerns mentioned above. At this point, the currently available meteorology data do not appear to lend themselves to support meaningful analyses of changes to storm frequency and intensity in the project area.

For the reasons listed above, we suggest that additional data collection and analysis is needed to fully understand meteorology trends in the project area.

<u>Geology</u>: Several caveats should be noted about the spatial data sets used in the Geology data summary.

First, it's likely that the DOGAMI (2014) landslide data are not comprehensive for the project area; not all landslides were identified in the data. This information is a compilation of several data sources which varied in scale and accuracy.

Second, debris flow spatial data provided by ODF (2000) should be used for general information, and not used to determine actual hazards at any given location. Hazard values were based on slope, basin area, and rock formation. On-the-ground verification was completed to check mapping accuracy. Horizontal accuracy at the 1:24,000 scale was about 45 ft.

Third, the accuracy of the fault and fold information from DOGAMI (2009) may be limited because it's a compilation from various data sources; accuracy varies according to the source data. However, it should be noted that in the process of creating this dataset, DOGAMI did check for discrepancies between sources and made adjustments as needed.

Finally, fault and fold data from USGS (2005) is intended to be used at 1:250,000 or smaller scales, which is smaller scale (i.e., bigger area) than the project area. The accuracy at their intended scale equates to 450 ft for fault/fold line placement.

<u>Land Use/Land Cover (LULC)</u>: Data accuracy varies by geographic region and specific LULC classes.  The data are most accurate when applied to regional or national analyses, rather than local evaluations. The accuracy of these

data for our study area is unknown and would require local information and additional analysis to determine.

Overall accuracy in the Pacific Northwest was determined to be 83% (standard error = 2%) for NLCD 1992 Anderson Level I classes, and 63% (standard error = 2%) for Level II (Wickham et al. 2004). Level I classes comprise broad categories; Level II classes comprise more specific categories. A comparison of NLCD 1992 with similar data in Rhode Island and Massachusetts revealed acceptable accuracy for developed land, agriculture, forest, and water, but consistently poor classifications for rangeland, wetlands, and barren lands (Hollister et al. 2004). In the 2001 NLCD data, the region encompassing coastal Oregon had an overall “user’s accuracy” of 79% at Level II, but varied from 20% for woody wetlands to 98% for high-intensity developed land (Wickham et al. 2010). The “user’s accuracy” measures the probability that the mapped classification corresponds to what is on the ground (Congalton 2005). Wickham et al. (2010) reported a substantial improvement in the national accuracy of forest and cropland classes from the 1992 data to the 2001 and 2006 data. On the other hand, the user accuracy for land cover change between 2001 and 2006 for the same region was below 50% for the classes agriculture gain, agriculture loss, water loss, and forest gain (Wickham et al. 2013). All NLCD data are considered “provisional” until a formal accuracy assessment is done and is not yet available for the 2011 NLCD.

In addition, unlike previous years’ NLCD classifications, the 2011 NLCD data for the Coos Bay area excludes the estuary itself- the water body. This important data gap confounds direct comparisons among years based on subsystem land cover percentages. To compensate for this discrepancy, percentages for NLCD 2011 data were calculated using the land areas without the estuary and also by approximating the estuary extent by inserting the 2006 NLCD data. Another land cover class affected by the depiction of the estuary is the “Barren” or “bare land” category because mudflats and other shoreline areas may or may not be visible in the satellite imagery. Apparently the images show low tide in some years and high tide in others, thus the water and Barren percentages fluctuate.

Because C-CAP and NLCD are based on the same source information, it’s assumed that overall accuracy for the shared land cover types are generally the same. In the C-CAP data, small areas classified as perennial ice or snow were assumed to be errors caused by bright reflective surfaces including, but not limited to, temporary frost, snow, or ice. Because the snow/ice errors were less than 0.1% of the study area, the data were retained “as is”.

Neither the NLCD nor the C-CAP data distinguish between natural forest and trees managed for timber production.

It is important to recognize several differences between the 1970’s data (USGS 2005a) and subsequent land cover maps. First, different methods, source materials, and classification schemes were used. Second, the 1970's maps were also substantially coarser (larger minimum mapping unit) than subsequent data, with an unknown accuracy rate. The 1970's data, and other historic data, are presented in the data summary to indicate general land cover trends and the evolution of LULC data over time.

The ODF (2000b) map depicting timber production and burned areas in the project area is also less detailed due to its small scale (1:500,000). It does not include all land cover categories, therefore cannot be used for direct comparisons with more recent classifications. Similar issues regarding spatial and categorical resolution also exist for the pre-settlement vegetation map (Tobalske and Osborne-Gowey 2002).

Human Infrastructure: The coarse-scale OCMP data, which were used to highlight lands in the project area excluded from tidal flooding (currently or historically) by levees (Figure 5 in the Human Infrastructure data summary), are derived solely from tax assessor data. No hydrology or elevation data were used to estimate tidally-excluded acreage. Therefore, some lands not meeting the simple mapping criteria would be excluded from the map (e.g., low lying parcels not adjacent to a levee, or uplands adjacent to levees).

OCMP (2011c) tide gate information is very useful but appears to not be a fully comprehensive inventory since it was largely based on existing information and without the benefit of additional systematic field surveys.

According to the metadata associated with the NLCD 2010 Percent Developed Imperviousness data, the accuracy of zone 2, which encompasses the study area, is 86.7%.

A study by Roy and Shuster (2009) found that field measurements of Total Impervious Area (TIA) were considerably higher than the NLCD values in a small suburban basin in Cincinnati, Ohio. Use of the NLCD-based data in this study may therefore under-estimate the actual percentages of impervious surfaces for the project area.  Roy and Shuster also recommend on-site assessments to accurately map Directly Connected Impervious Areas (DCIA): those impervious surfaces that drain storm water directly to specific waterways through storm drains.  Neither DCIAs nor semi-impervious areas (such as compacted soil) are described in this data summary because no reliable data are currently available. Although some coefficients have been developed for estimating DCIA as a function of land use in the Northeastern United States (USEPA 2014), these values have not been evaluated for use in the project area.

Storm drain outfall locations were only available for the cities of North Bend and Coos Bay. Spatial information for outfalls in the project area are thus under-representative.

ODOT (2014) spatial road data were compiled from numerous sources throughout the state, based on best available data from each road authority. We used data relevant to the project area. Data have been compiled and digitized differently by each jurisdiction and thus are subject to different levels of accuracy. ODOT does validate some of its data (e.g., flags milepoints that are not logical). They assume a 1:24,000 accuracy for the entire state. The data used in this summary are ODOT's public data and do not include roads whose locations were restricted for distribution.

**References**


Arneson, R. J. 1976. Seasonal Variations in Tidal Dynamics, Water Quality, and Sediments in the Coos Bay Estuary. Thesis (M.Oc.E.) – Oregon State University, Corvallis.

Carslaw, D. C. and K. Ropkins. 2012. Openair --- an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61.

City of Coos Bay. n.d. [Storm Sewer Outfalls Locations]. GIS shapefiles.

City of North Bend. 2005. Storm Drain Outfalls. GIS shapefiles.

Coastal Change Analysis Program (C-CAP). 2014. C-CAP FTP Download, GIS data files. Accessed 23 October 2014: http://coast.noaa.gov/ccapftp/

Congalton, R. G. 2005. Thematic and positional accuracy assessment of digital remotely sensed data. Proceedings of the Seventh Annual Forest Inventory and Analysis Symposium.

Coos Watershed Association (CoosWA). 2006. Coos Bay Lowland Assessment and Restoration Plan. Coos Watershed Association, Charleston, Oregon. 268pp.

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp. Accessed 21 March 2016: http://www.partnershipforcoastalwatersheds.org/watersheds/

Forman, R. T. and L. E.  Alexander.  1998. Roads and Their Major Ecological Effects. Annual review of ecology and systematics, 207-C2.

Fry, J., M. Coan, C. Homer, D. Meyer, and J. Wickham. 2009. Completion of the National Land Cover Database (NLCD) 1992–2001 land cover change retrofit product: U.S. Geological Survey Open-File Report 2008–1379, 18 p.

Haagen, J. T. 1989. Soil survey of Coos County, Oregon. National Cooperative Soil Survey, Washington, D.C. Accessed 30 June 2015: http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OR

Hickey, B. M. and N. S. Banas. 2003. Oceanography of the U.S. Pacific Northwest Coastal Ocean and Estuaries with Application to Coastal Ecology. Estuaries, 26(4): 1010-1031.

Hollister, J. W., M. L. Gonzalez, J. F. Paul, P. V. August, and J. L. Copeland. 2004. Assessing the accuracy of National Land Cover Dataset area estimates at multiple spatial Extents. Photogrammetric Engineering & Remote Sensing, Vol. 70, No4, pp. 405-414.

Homer, C. H., J. A. Fry, and C. A. Barnes. 2012. The National Land Cover Database, U.S. Geological Survey Fact Sheet 2012-3020, 4 p. Accessed November 25, 2014. http://pubs.usgs.gov/fs/2012/3020/fs2012-3020.pdf

Hyde, N. 2007. Towards National Estuarine Modeling and Characterization/Classification Systems: A Pilot Study for Coos Bay. Thesis (M.S.)—Oregon Health and Science University.

Joint Institute for the Study of the Atmosphere and Ocean (JISAO). 2015. PDO Index. [PDO database hosted by JISAO and the University of Washington]. Accessed 5 June 2015: http://research.jisao.washington.edu/pdo/PDO.latest

Kelsey, H. M., A. R. Nelson, E. Hemphill-Haley, and R. C. Witter, 2005. Tsunami History of an Oregon coastal lake reveals a 4600 yr record of great earthquakes on the Cascadia subduction zone. GAS Bulletin. 117(7-8):1009-1032.

Kline, J. D., D. L. Azuma, and A. Moses. 2003. Modeling the spatially dynamic distribution of humans in the Oregon (USA) Coast Range. Landscape Ecology: 347-361.

Multi-Resolution Land Characteristics Consortium (MRLC). 2015. National Land Cover Database (NLCD). Accessed 31 March 2015: http://www.mrlc.gov/index.php

National Land Cover Database (NLCD). 2001a. 1992-2001 Retrofit Land Cover Change Product. Accessed 31 March 2015:http://www.mrlc.gov/nlcdrlc_data.php

National Land Cover Database (NLCD). 2001b. NLCD 2001 Land Cover (2011 Edition). Accessed 31 March 2015: http://www.mrlc.gov/nlcd01_data.php

National Land Cover Database (NLCD). 2006. NLCD 2006 Land Cover (2011 Edition). Accessed 31 March 2015: http://www.mrlc.gov/nlcd06_data.php

National Land Cover Database (NLCD). 2011. NLCD 2011 Land Cover. Accessed 31 March 2015: http://www.mrlc.gov/nlcd11_data.php

National Oceanographic and Atmospheric Administration (NOAA). 2010. Coastal Services Center, Land Cover Data Sheet, Coos County, Oregon. Accessed 24 April 2015: www.coast.noaa.gov/ccapatlas

National Oceanographic and Atmospheric Administration (NOAA). 2015. Tides and Currents, [Mean Sea Level Trend for station 9432780 Charleston, Oregon]. Accessed 8 May 2015: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

Northwest Fisheries Science Center (NWFSC). 2015. Coastal Upwelling. Accessed 8 May 2015: http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/db-coastal-upwelling-index.cfm

Oregon Coastal Management Program (OCMP). 2011a. Estuarine Levees Inventory. GIS database. Accessed 5 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BB794DBD7-4775-4BCC-932A-EA7B35334E8F%7D

Oregon Coastal Management Program (OCMP). 2011b. Estuarine Levees Protected Lands. GIS database. Accessed 5 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BC448FFE2-E1DC-4CA7-8506-E64D83285A76%7D

Oregon Coastal Management Program (OCMP). 2011c. Tidegates in Oregon Estuaries. GIS database. Accessed 5 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7B654F9538-7971-494A-98ED-54928923E284%7D

Oregon Department of Forestry (ODF). 2000a. Locations Subject to Naturally Occurring Debris Flows in the Coos Watershed. Accessed 4 October 2013: http://www.coastalatlas.net/metadata/LocationsSubjecttoNaturallyOccurringDebrisFlowsintheCoosWatershed,ODF,2000.htm

Oregon Department of Forestry (ODF). 2000b. LULC_vegetation_1900_500k. GIS Downloadable data. Accessed 22 July 2014: http://www.odf.state.or.us/gis/data/LandUse_Cover/Veg_1900.zip

Oregon Department of Forestry (ODF). 2014. Forests, Farms and People: projecting future conversion of resource land to developed use. Oregon Department of Forestry Resources Planning Program.

Oregon Department of Forestry (ODF). n.d. GIS Data Export. Accessed 17 March 2016: http://www.oregon.gov/ODF/AboutODF/Pages/ExtractData.aspx

Oregon Department of Geology and Mineral Industries (DOGAMI). 2009. Oregon Geologic Data Compilation. Accessed 26 October 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BD9B42C23-07E9-496F-8188-7C06A6D0E891%7D

Oregon Department of Geology and Mineral Industries (DOGAMI). 2014. Statewide Landslide Information Database for Oregon (SLIDO). Accessed 27 May 2015: http://www.oregongeology.org/sub/slido/data.htm

Oregon Department of Land Conservation and Development (DLCD). 2011. Mean High Water Shoreline. GIS data files.

Oregon Department of State Lands (ODSL). 2000. Digitization of: DSL. 1989. Heads of Tide for Coastal Streams in Oregon.

Oregon Department of Transportation (ODOT). 2014. Oregon Transportation Network – 2014. GIS database, accessed 11 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7B2DADDE86-9546-4B88-A793-7D15F86C08AB%7D

Roy, A. H. and W. D. Shuster. Assessing impervious surface connectivity and applications for watershed management. Journal of the American Water Resources Association (JAWRA). 45(1): 198-209.

Roye, C. 1979. Natural Resources of the Coos Bay Estuary, 2:6. Estuary Inventory Report. Oregon Department of Fish and Wildlife, 506 SW Mill Street, PO Box 3503 Portland, Oregon 97208.

Rumrill, S. S. 2006. The Ecology of the South Slough Estuary: Site Profile of the South Slough National Estuarine Research Reserve. Salem, Oregon: NOAA, Oregon Department of State Lands Technical Report. 238pp.

South Slough National Estuarine Research Reserve (SSNERR). 2015. [ADCP data 2013-2015]. Unpublished data.

Sutherland, D. 2013. [Screenshots of initial surface-salinity hydrodynamic runs]. Unpublished data.

System-Wide Monitoring Program data (SWMP). 2015. SWMP: South Slough Meteorological Data (2007-2014). Accessed June, 2015 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Tobalske, C. and J. Osborne-Gowey. (2002) Oregon's Historic Vegetation (1938) - reclassified to functional type. Accessed 17 March 2016: http://databasin.org/datasets/baee765527ae48f0a6ae024f4100086a

University of Utah MesoWest (MesoWest). 2015. KOTH database. [Online meteorological database hosted for North Bend Municipal Airport]. Accessed 5 June 2015: http://mesowest.utah.edu/cgi-bin/droman/download_ndb.cgi?stn=KOTH&hour1=22&min1=56&timetype=LOCAL&unit=0&graph=0

United States Army Corps of Engineers (USACE). 2014. Hydrographic Surveys. Accessed 8 May 2015: http://www.nwp.usace.army.mil/Missions/Navigation/Surveys.aspx

United States Department of Agriculture (USDA). 2000. Soil Survey Geographic (SSURGO) Database for Coos County, Oregon. U.S. Department of Agriculture, Natural Resources Conservation Service, Fort Worth, Texas.

United States Department of Commerce (USDOC). 2012. NOAA Coastal Services Center Sea Level Rise Data: 1-6 ft Sea Level rise Inundation Extent. Accessed 19 June 2015: http://coast.noaa.gov/digitalcoast/tools/slr

United States Environmental Protection Agency (USEPA). 2014. Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for Massachusetts Small MS4 Permit. Accessed 26 March 2015: http://www.epa.gov/region1/npdes/stormwater/ma/MADCIA.pdf

US Geological Survey (USGS). 2005a. 1970's land use data refined with 2000 population data to indicate new residential development for the conterminous United States. GIS data. Accessed 15 April 2014: https://catalog.data.gov/dataset/1970s-land-use-data-refined-with-2000-population-data-to-indicate-new-residential-development-f

United States Geological Survey (USGS). 2005b. Fault Lines. Accessed 26 October 2013: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7B99AA3A13-0354-4579-A0D4-463C433D6952%7

United States Geological Survey (USGS). 2015a. Search Earthquake Archives. Accessed 5 June 2015: http://earthquake.usgs.gov/earthquakes/search/

United States Geological Survey (USGS). 2015b. The StreamStats program for Oregon. Accessed 20 May 2015: http://water.usgs.gov/osw/streamstats/oregon.html

Western Regional Climate Center (WRCC). n.d. North Bend RGNL AP, Oregon (356073). [Online meteorological database hosted by WRCC]. Accessed 5 June 2015: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?or6073

Wickham, J. D., S. V. Stehman, J. H. Smith, and L. Yang. 2004. Thematic accuracy of MRLC-NLCD land cover for the western United States: Remote Sensing of Environment. v. 91, no. 3-4, p. 452-468.

Wickham, J. D., S. V. Stehman, J. A. Fry, J. H. Smith, and C. G. Homer. 2010. Thematic accuracy of the NLCD 2001 land cover for the conterminous United States: Remote Sensing of Environment. v. 114, no. 6, p. 1286-1296.

Wickham, J. D., S. V. Stehman, L. Gass, J. Dewitz, J. A. Fry, and T. G. Wade. 2013. Accuracy of NLCD 2006 land cover and impervious surface: Remote Sensing of Environment. v. 130, p. 294-304.

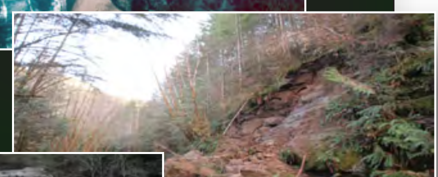
Wood, J. and P. Ruggiero. 2014. 2014 Estuarine Bathymetry Data Collection, Analysis, and Archiving at Coos Bay, OR. Oregon State University, Newport, Oregon.

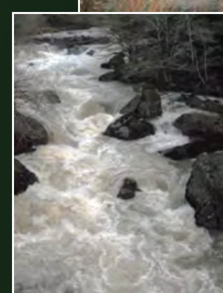
# How Local Effects of Climate Change Could Affect Physical Features in the Lower Coos Watershed

CLW DATA SOURCE

*There are several climate-related changes expected on the Oregon coast that could potentially affect the physical features of the Coos estuary:*

- *Sea level rise will likely alter land uses in shoreline areas.*
- *The structural integrity and function of tide gates, levees, and other waterway structures may be affected by sea level rise.*
- *Climate-related changes in river and stream hydrology may change key natural processes such as sediment transport and erosion that shape the existing landscape.*
- *Climate change may affect local weather conditions, including air temperature, precipitation, and high wind events.*





Top: Entrance to the Coos Estuary Photo: SSNERR

Middle: Eroding Hillside Photo: SSNERR

Right: Peak Flow below Coos River Subsystem's Gold and Silver Falls Photo: SSNERR

This climate change summary focuses on the effects of climate-related changes to physical features of the project area (i.e., land cover, hydrology, geology, meteorology, and water course structures). Although the anticipated changes to these physical features may result in ecosystem responses (e.g., shifting hydrology may affect the distribution of plants and foraging species such as deer and elk), these feedback effects are not discussed here. For a discussion of the effects of climate change on plant and animal communities in the project area, refer to the Table of Contents to find the applicable climate change summary.

Climate change may affect the physical features of the lower Coos watershed through sea level rise and changing weather patterns (meteorology). Even relatively minor changes in sea level and meteorology could alter local geophysical processes such as sediment transport in local waterways, as well as erosion and landslides hazards elsewhere. Anticipating the exact effects of these changes is difficult for a number of reasons, not the least of which is the fact that coastal processes are complex and will likely respond uniquely to climate-related change along different parts of the coast (Scavia et al. 2002). Despite this uncertainty, existing research offers some important clues as to how the physical aspects of the project area may change as the climate continues to evolve.

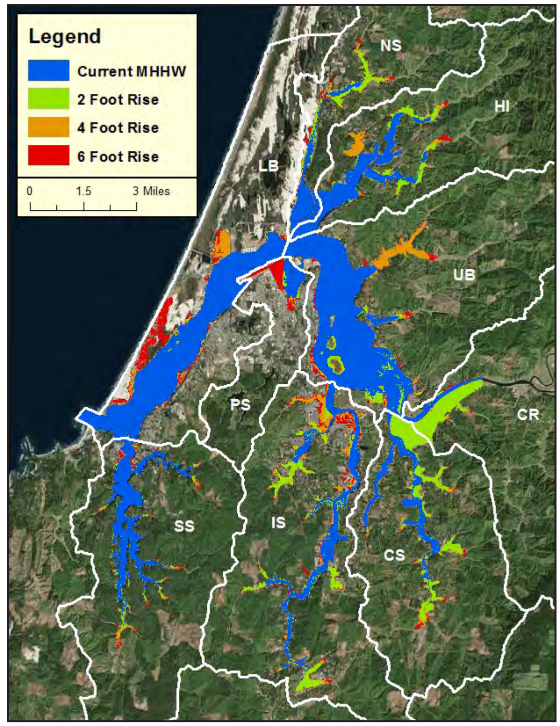



Figure 1. Sea level rise scenarios in the Project Area. Data: USDOC 2012. Subsystems: CR- Coos River; CS- Catching Slough; HI- Haynes Inlet; IS- Isthmus Slough; LB- Lower Bay; NS- North Slough; PS- Pony Slough; SS- South Slough; UB- Upper Bay

### Sea Level Rise

Sea level rise (SLR) has the potential to expand the amount of land within the project area that floods on both a regular basis (tidal flooding) and during storms. The project area and subsystem maps presented in Figures 1 through 6 illustrate flooding associated with four tide levels relative to Mean Higher High Water (MHHW): 1) current regular tidal flooding at MHHW level; 2) regular tidal flooding with MHHW level raised two feet by SLR; 3) regular tidal flooding with MHHW level raised four feet by SLR; and 4) regular tidal flooding with MHHW level raised six feet by SLR. MHHW is the average of all higher high tides during the current National Tidal Datum Epoch (1983-2001), and is about equal to the elevation of the highest part of a salt marsh, just below the tree line. Figure 1 includes the entire project area and Figures 2-6 show detailed views of project area subsystems. These maps show normal higher high tide flooding levels and do not illustrate possible tidal inundation during extreme high tide conditions (any above average higher high tide levels). It's important to note that storm-driven high tides will cause flooding problems for developed areas in the lower Coos watershed

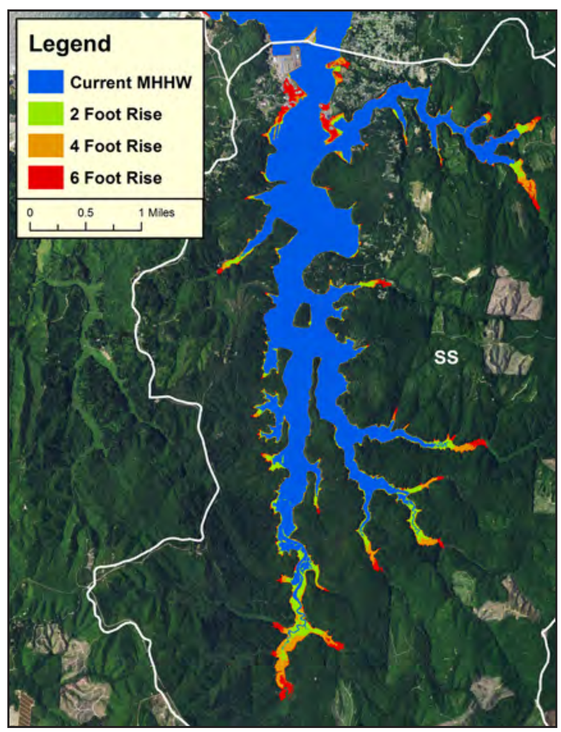


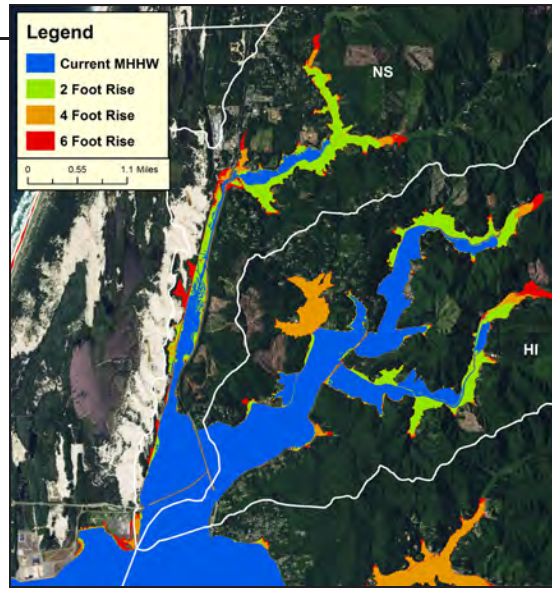

Figure 2. Sea level rise scenarios in the South Slough subsystem. Data: USDOC 2012.

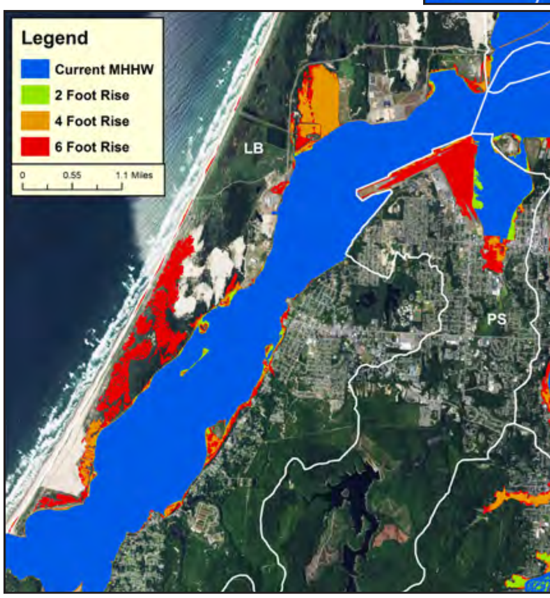
Top: Figure 3. Sea level rise scenarios in the North Slough and Haynes Inlet subsystems. Data: USDOC 2012.

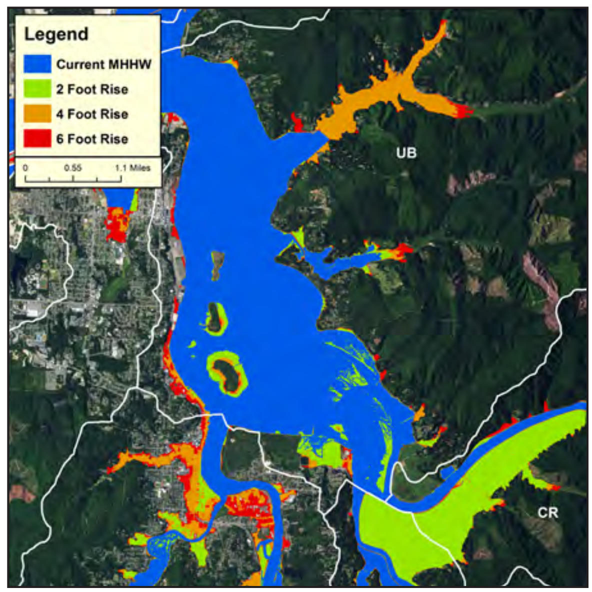
Below left: Figure 4. Sea level rise scenarios in the Lower Bay and Pony Slough subsystems. Data: USDOC 2012.

Below right: Figure 5. Sea level rise scenarios in the Upper Bay and lower Coos River subsystems. Data: USDOC 2012.

Bottom: Figure 6. Sea level rise scenarios in the Isthmus Slough and Catching Slough subsystems. Data: USDOC 2012.

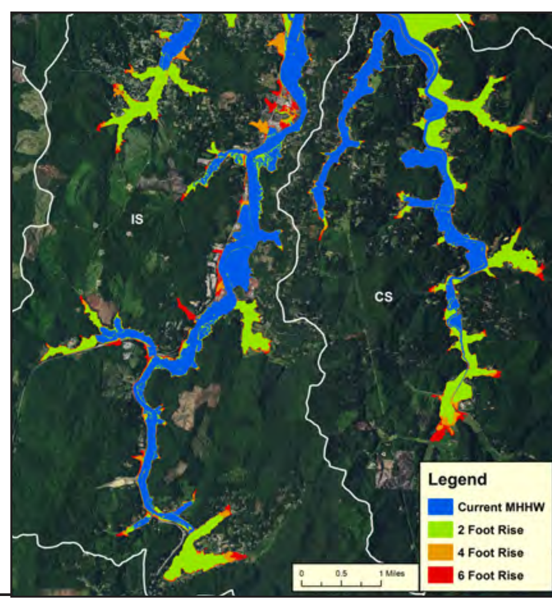



long before SLR causes current upland areas to flood during regular higher high tides. Storms frequently help create above average higher high tide flooding.

In the future SLR has the potential to "drown" tidal marshes and eelgrass beds important for supporting local fisheries. Those habitats remain at a constant elevation relative to tidal flooding through the incremental accumulation of sediments imported with each high tide. Scientists have not yet determined whether marshes, eelgrass beds, or even sand



and mud flats will be able to keep pace with sea level rise (see sidebar). Sedimentation accumulation rates may adjust with sea level rise resulting in very little change to the estuarine habitats. However, if SLR accelerates, it may out-pace sediment accumulation and cause significant change in the Coos estuary.

Accelerated SLR could result in substantial changes to current land use within the project area. Scavia et al. (2002) explain that coastal communities may adopt one of two basic strategies for dealing with SLR: hold the sea back or allow shorelines to move inland. Although this is a simplification of a complex trade-off between development and SLR, it highlights a fundamental climate change-related land use issue: SLR is likely to facilitate the conversion of existing terrestrial land uses (e.g., agriculture, development, forest) into aquatic systems (e.g., estuary, forested swamp, open water) in low-lying shore lands where tide waters are permitted to migrate inland (Rosenzweig et al. 2002). This conversion will likely not occur in areas where rising ocean levels are managed through shoreline defenses (e.g., levees, revetments, tide gates).

Although it's difficult to determine exactly how SLR might change future land use in the project area, existing land use may offer some clues. For example, some researchers suggest that it is unlikely the existing shoreline will be allowed to migrate inland near the existing high tide zone in areas where high value real estate already exists (Glick et al. 2007; Yamanaka et al. 2013).

*Sea Level Rise*

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, according to the National Research Council (NRC), predicted SLR rates for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary), are reported as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100 .*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

In addition to potentially affecting land use decisions, SLR could affect the hydrology of the Coos estuary. OCCRI (2010) explains that the Coos estuary is classified as a tidally-dominated drowned river mouth with tidal influence reaching far up the Coos River and other river and stream systems in the lower Coos watershed. Since the ocean's tidal influence plays such a major role in determining the hydrological characteristics of this system, future SLR can be expected to make that ocean influence even more significant than it already is, causing tidal influence to reach even farther up local rivers and streams into freshwater marshes and swamps. Researchers expect SLR to permanently convert many of the region's coastal freshwater wetlands to brackish and salt marshes, moving tidal freshwater habitats further upstream (again, where tide waters are permitted to migrate inland)(Glick et al. 2007; Scavia et al. 2002).

In some cases, SLR combined with other climate-related changes could cause feedback loops that may exacerbate the loss or conversion of wetland areas or otherwise change the existing physical features of the project area. For example, SLR coupled with expected increases in storm intensity may decrease dry land cover, a trend that could result in increased rates of erosion, especially if climate change results in heightened storm surges within the project area (OCCRI 2010; Ruggiero 2008).

SLR may also result in conditions that could challenge the integrity of existing waterway structures.  As much of 70-95% of the historical extent of tidally-influenced wetlands in the project area has been converted to terrestrial-based land uses (e.g., urban development, agriculture) by the historic construction of levees, tide gates, and other structures that control water flow (CoosWA 2006; Hofnagle et al. 1976). These structures were constructed to prevent tidal flooding of converted lands during high tide, and allow waterways behind dikes and tide gates to flow into the estuary during low tide. Rising sea levels, especially during storm tides, will put increasing pressure on these and other shoreline structures, thus requiring additional maintenance or mechanical improvements.

**Changing Watershed Hydrology**

Jones (2011) describes climate-related changes in stream flow as "one of the most significant consequences" of global climate change. In Oregon, watershed hydrology is likely to change as precipitation and temperature continue to evolve with climate change (OCCRI 2010). For example, in those parts of Oregon affected by snow pack, climate change experts predict streams will likely experience increased winter flow and decreased summer flow due to changes in temperature (IPCC 2007; OCCRI 2010). But since snow pack does not affect stream flows in the project area, and significant changes in Oregon coast precipitation are not expected (see below), experts remain unsure how much change in watershed hydrology to expect locally.

**Changing Meteorology**

Generally, it's hypothesized that climate change could alter local weather by affecting air temperature, precipitation, and wind (i.e., increasing storm frequency and intensity). Researchers emphasize the Pacific Ocean's influence on project area meteorology which will both enhance and obscure the effects of climate change on local weather. For example, Dalton et al. (2013) explain that climate variability in the Pacific Northwest is "dominated by the interaction between the atmosphere and ocean in the tropical Pacific Ocean responsible for El Niño and La Niña." They cite warmer than average temperatures and drier than average conditions that are typical of El Niño winters and springs as an example of the Ocean's influence on Pacific Northwest weather. Even though climate change signals may be made "noisy" by the influence of the Pacific Ocean, experts project that the following changes to weather may occur in the project area.

- Increasing air temperatures: Although data from the project area show no discernible warming trends since the early 20th century, this may be an anomaly worth investigating further. Mote (2003) suggests that the "vast majority" of temperature monitoring stations in Oregon, Washington, Idaho, and British Columbia have indicated that air temperature has increased since the 1920s. These conclusions have been corroborated by researchers and policy makers who found that the average increase in annual temperature has been about 0.6-1.7° C (1-3° F) in the Pacific Northwest over the past century (OSU 2005). While this warming trend may be explained by natural climatic variation in the first half of the 20th century, it appears that increased concentrations of atmospheric greenhouse gases may have contributed to the continuation of this trend in recent years (Water Resources Breakout Group 2004 as cited in OSU 2005). Air temperatures are expected to continue warming, with the average increase in annual temperature expected to reach approximately 2.3°C (4.1°F) by 2040 (Mote 2003).

- Precipitation: The effects that climate change will have on Pacific Northwest precipitation patterns is a matter of continued debate. On one hand, researchers suggest that precipitation regimes seem to be changing in the Pacific Northwest. For example, Dalton et al. (2013) explain that since the 1970s there have been larger than average year-to-year changes in precipitation, concluding that precipitation in the Pacific Northwest has become increasingly volatile over the past 40 years. Similarly, the United States Global Change Research Program indicates the Pacific Northwest has experienced a modest increase in precipitation since 1915, with annual precipitation totals about 10% higher than their early 20th century levels (USGCRP 2001 as cited in OSU 2005). But even though OCCRI (2010) and Mielbrecht et al. (2014) suggest possible climate change-related decreases in summer precipitation and more intense winter rain events for Oregon, researchers emphasize uncertainty by pointing out that precipitation has shown no clearly increasing or decreasing trend in the Pacific Northwest during the 20th century (Dalton et al. 2013)(see sidebar).

- Changes in Wind Patterns: The local effects of climate change may affect the frequency and intensity of extreme wind events on the southern Oregon coast. However, the exact effects of climate change on wind remain uncertain. Ruggeiro et al. (2013) explain that intense winter storms crossing the Northern Pacific ocean typically make landfall in the Pacific Northwest latitudes (i.e., between 42°- 48°N) and sometimes achieve hurricane force wind speeds. Some climate change experts report that these storms may have become stronger since the 1970s, as suggested by statistically significant increases in both wind speeds and average wave height on the Oregon coast (OCCRI 2010, Ruggeiro et al. 2013). Similarly, others have documented a clear increase in wind speed during "extra-tropical" storm events (storms occurring outside of the tropical latitudes) in the north Pacific Ocean since the 1940s (Graham and Diaz 2001; Favre and Gershunov 2006). Despite evidence to suggest that climate change may result in increased intensity and frequency of wind storms on the Oregon coast, some researchers conclude that the impact has been negligible on the Oregon coast, because storm surge records show no increase in surge levels since the late 1960s (Allan et al. 2011).

*Changes in Precipitation Timing, Frequency, and Intensity*

*In the future, precipitation in coastal Oregon is expected to remain a predominately wintertime phenomenon (i.e., most precipitation will continue to occur in winter), but the extent to which precipitation timing, frequency, and intensity on the Oregon coast may change remains uncertain. There is some evidence that high-intensity storms are becoming more frequent, and that the frequency of weak to moderate-strength storms is declining.*

*Sources: Sharp 2012, OCCRI 2010, OSU 2005*

**References**


Allan, J. C., P. D. Komar, and P. Ruggiero. 2011. "Storm Surge Magnitudes and Frequency on the Central Oregon Coast." In Solutions to Coastal Disasters 2011, 53-64, ASCE Conference Proceedings, Anchorage, AK. doi: 10.1061/41185(417)6.

Coos Watershed Association (CoosWA). 2006. *Coos Bay Lowland Assessment and Restoration Plan.* Coos Watershed Association, Charleston, Oregon, pp. 47, 70, 93. Accessed 07 April 2015 from http://www.cooswatershed.org/Publications/Coos%20Bay%20Lowland%20Assessment%20and%20Restoration%20Plan01-07.pdf

Dalton, M. M., P. W. Mote, and A. K. Snover (eds.). 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press.

Favre, A. and A. Gershunov. 2006. "Extra-Tropical Cyclonic/Anticyclonic Activity in NorthEastern Pacific and Air Temperature Extremes in Western North America." Climate Dynamics 26 (6): 617-629. doi: 10.1007/s00382-005-0101-9.

Graham, N. E. and H. F. Diaz. 2001. "Evidence for Intensification of North Pacific Winter Cyclones Since 1948." Bulletin of American Meteorological Society 82 (9): 1869-1893. doi: 10.1175/1520-0477(2001)0822.3.CO;2.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-level Rise and Coastal Habitat in the Pacific Northwest: An analysis for Pudget Sound, Southwester Washington, and Northwestern Oregon. National Widlife Federation. Accessed 15 January 2014. Available online http://www.nwf.org/pdf/Wildlife/PacificNWSeaLevelRise.pdf

Hofnagle, J., R. Ashley, B. Cherrick, M. Gant, R. Hall, C. Magwire, M. Martin, J. Schrag, L. Stuntz, K. Vanderzanden, and B. Van Ness. 1976. A comparative study of salt marshes in the Coos Bay Estuary. National Science Foundation Student Originated Project. Summer, 1976. University of Oregon, Oregon Institute of Marine Biology, Charleston, Oregon.

Intergovernmental Panel on Climate Change (IPCC). 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Jones, J. A. 2011. Hydrologic responses to climate change: considering geographic context and alternative hypothesis. *Hydrological Processes 25*(12), 1996-2000.

Mielbrecht, E., J Weber, C. Swenson, D. Patte, and S. Denney. 2014. Coquille Estuary Climate Change Vulnerability Assessment. EcoAdapt/US Fish and Wildlife Service report. 79 pp.

Mote, P. W. 2003. Trends in temperature and precipitation in the Pacific Northwest during the twentieth century.

NOAA Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Retrieved from: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Washington, DC: The National Academies Press. 201 pp.

Oregon Climate Change Research Institute (OCCRI). 2010. Oregon Climate Assessment Report, K. D. Dello and P. W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR http://occri.net/wp-content/uploads/2011/01/OCAR2010_v1.2.pdf

Oregon State University (OSU). 2005. Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest. Unpublished report no. 2004-3. Corvallis OR. Retrieved from: http://ir.library.oregonstate.edu/jspui/handle/1957/113

Rosenzweig, C., F. N. Tubiello, R. Goldberg, E. Mills and J. Bloomfield. 2002. Increased crop damage in the US from excess precipitation under climate change. *Global Environmental Change 12*: 197-202.

Ruggiero, P. 2008. Impacts of climate change on coastal erosion and flood probability in the US Pacific Northwest, Proceedings of Solutions to Coastal Disasters. Oregon state University.

Ruggiero, P., M. G. Kratzmann, E. A. Himmelstoss, D. Reid, J. Allan, and G. Kaminsky. 2013. National assessment of shoreline change—Historical shoreline change along the Pacific Northwest coast: U.S. Geological Survey Open-File Report 2012–1007, 62 p., http://dx.doi.org/10.3133/ofr20121007

Scavia, D., J. C. Field, D. F. Boesch, R. W. Buddemeier, V. Burkett, D. R. Cayan, and J. G. Titus. 2002. Climate change impacts on US coastal and marine ecosystems. *Estuaries, 25*(2), 149-164.

Sharp, D. 2012. Climate Change and the Lower Coquille Watershed. Unpublished report. Oregon Climate Change Research Institute/EcoAdapt. Retrieved from: http://ecoadapt.org/data/documents/CoquilleClimate_02nov2012_FINAL.pdf

United States Department of Commerce (USDOC). 2012. NOAA Coastal Services Center Sea Level Rise Data: 1-6 ft Sea Level rise Inundation Extent. Accessed 19 June 2015: http://coast.noaa.gov/digitalcoast/tools/slr

United States Global Change Research Program, National Assessment Synthesis Team (USGCRP). 2001. Potential Consequences of Climate Change Variability and Change for the Pacific Northwest. Chapter 9 in Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. Cambridge University Press, Cambridge, United Kingdom. 612 pp.

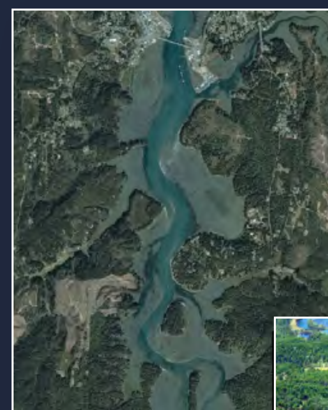
Water Resources Breakout Group. 2004. Summary of breakout group discussion at the June 14, 2004 Impacts of Climate Change on the Pacific Northwest Meeting, Oregon State University, Corvallis, Oregon. Available at http://inr.oregonstate.edu/policy/climate_breakout_water.pdf

Yamanaka, T., D. Raffaelli, and P. White. 2013. Non-linear interactions determine the impact of sea-level rise on estuarine benthic biodiversity and ecosystem processes. PLoS

# Geographic Features of the Coos Estuary and Lower Coos Watershed

*Summary:*

- *The Coos estuary is the second largest estuary in Oregon, and the sixth largest on the US west coast.*
- *Large expanses of intertidal sand and mud flats complement channels, eelgrass beds, vegetated marshes, and swamps to provide a diversity of estuarine habitats.*
- *After a century and a half of development about ten percent of the original tide lands remain.*



Steep forested hills of the South Slough (left), wetlands (below) and the expansive tide flats of the Coos River delta (below left) typify the variety of habitats found in the lower Coos watershed.


Figure 1. Coos estuary shoreline at Mean High Water (MHW). Data source: DLCD 2011

This data summary consists of three sections in which the geographic features of the Coos estuary and lower Coos watershed are briefly described. In the Current Features section, geographic features as they exist today are described. In the Historic Changes to the Coos Estuary section, several key differences between current geographic features and historic conditions are described. And in the Many Uses of the Coos Estuary section we discuss some of the estuary-dependant activities taking place in the project area.

***Tidal Datums***

*Tidal datums commonly used in this summary are described below:*

***Mean Sea Level (MSL)*** *is based on hourly average water level at the local tide station in Charleston, OR.*

***Mean High Water (MHW)*** *is average height of all high tides.*

***Mean Lower Low Water (MLLW)*** *is the average of the lower of the two low tides each tidal cycle.*

*Tidal datums are based on a 19-year period of water level averaging (called the National Tidal Datum Epoch) which is established by NOAA's National Ocean Service. The current epoch is based on tide level averages between 1983 and 2001.*

*Source: NGS 2015*

**Current Features**

Coos Estuary

At latitude 43° 21' N, longitude 124° 20' W, the Coos estuary is the largest estuary completely within Oregon (second largest in Oregon after the Columbia River estuary), and the sixth largest on the US west coast (Rumrill 2006)(Table 1).

The surface area of the Coos estuary at Mean High Water (MHW) is approximately 50 $km^2$ (19 $mi^2$)(Figure 1), or approximately 34 $km^2$ (13 $mi^2$) at Mean Sea Level (MSL)(Hyde 2007). The average depth of the Coos estuary is 4 m (13 ft) and average volume is 0.14 $km^3$ (0.03 $mi^3$)(Hickey and Banas 2003). The estuarine drainage area (the part of the Coos watershed which empties into the estuary) is 1,500 $km^2$ (580 $mi^2$)(NOAA 1985).

The Coos estuary is composed of two tidal areas: the intertidal area, which is subject to daily tidal fluctuations, and the subtidal area, which is always flooded (i.e. deep channels). The intertidal comprises 47% of the MHW area (23.5 $km^2$ / 6 $mi^2$)(Percy et al. 1974 in Hickey and Banas 2003). Extensive filling and diking in the Coos estuary and its tributary sloughs for agricultural, industrial and urban development have reduced the intertidal area to about 10% of its pre-settlement extent (Roye 1979). It should be noted that these figures are over 30 years old and may have changed.

The Coos estuary's commercial shipping channel is routinely dredged by the US Army Corps of Engineers (USACE) to an average depth of 11.5 m (38 ft)(MLLW) and width of 300 m (984 ft)(Hyde 2007). USACE maintains

| Ranking of Major U.S. West Coast Estuaries* | | |
|---|---|---|
| | Estuarine Surface Area** | |
| | km$^2$ | mi$^2$ |
| Puget Sound, WA | 17,985 | 6,944 |
| San Francisco Bay, CA | 1,171 | 452 |
| Willapa Bay, WA | 238 | 92 |
| Grays Harbor, WA | 150 | 58 |
| Humboldt Bay, CA | 49 | 19 |
| Coos Bay, OR | 34 | 13 |

*The Columbia River estuary, with an area of 554 km$^2$ (214 mi$^2$), is generally not included in comparison with outer coast estuaries.

** Described in NOAA 1985 as mid-tide elevation. Using that source, Hickey and Banas (2003) report values as MSL.

**Table 1.** Sizes of the largest coastal estuaries on the west coast. Data source: NOAA 1985

a shallower, narrower channel to the Charleston marina at the mouth of South Slough, and to the shipyard just south of the Charleston bridge.

Discounting the dramatic change rendered by the shipping channel, the Coos estuary exhibits the typical features of a drowned river valley estuary type. It features a V-shaped cross section, a relatively shallow and gently sloping estuary bottom, and a fairly uniform increase in depth from the upper, river-dominated part of the estuary toward the mouth. For more detailed bathymetry information, see the Hydrology data summary in this chapter.

Two massive rock boulder jetties guard both sides of the Coos estuary mouth to help maintain a deep channel and ensure safe ship and boat passage across the bar to the ocean. An inner rock jetty helps protect the Charleston marina from winter storm surges and powerful waves that can pass through the mouth of the estuary. Two turning basins and an anchorage basin for commercial shipping traffic are located in the upper portion of the Coos estuary.

From the entrance, the lower bay runs nine miles northeast then swings to the south after the McCullough Bridge in North Bend and widens into the tide-flat dominated upper bay. The Coos River enters the upper bay near the confluence with Catching Slough, about 27.35 km (17 mi) from the mouth of the estuary (Roye 1979). Coos River empties through two channels. The north, unmarked Cooston Channel flows up the east side of the estuary and empties abreast of the city of North Bend. The Marshfield Channel, marked by lighted range markers and buoys, crosses the flats to the city of Coos Bay shoreline then turns north along the western side of the estuary.

Estuarine Regions

In the Oregon Estuary Plan Book, Cortright et al. (1987) describe four distinct regions in the Coos estuary – Marine, Bay, Slough and Riverine – each based on distinct physical features and bottom types, salinity gradients, habitats, and dominant species. There are no distinct boundaries between the regions, but each has distinctive features.

The highly energetic Marine region extends from the Coos estuary mouth up to about river mile (RM) 2.5. Although the estuary entrance is protected by jetties, powerful waves nevertheless propagate through the mouth during winter storms. Water quality and salinity are similar to the open ocean in this region, but it is moderated by rain-fed river and stream flow during winter months.

The Bay region, divided into the Lower Bay and the Upper Bay, is characterized by broad, mostly unvegetated (except for intertidal eelgrass beds) tidal flats exposed at low tide and flooded by brackish water during higher tides. Tidal flats range from sandy to muddy throughout the bay, depending on currents and circulation. Sand may be either terrestrial (erosional) or carried into the lower bay from nearby ocean sources (Aagard et al. 1971, in Roye 1979).

The Lower Bay region begins above RM 2.5 and extends to about the railroad bridge at RM 9. Water salinity in this region is slightly fresher than in the ocean, whose influence gradually diminishes throughout this zone as the distance from the ocean increases.

The Upper Bay begins at the railroad bridge (RM 9) and extends to the southeastern corner of Bull Island at RM 17 (Figure 2c). Although the shoreline has been drastically altered over the past 150 years, the upper bay still includes extensive tidal flats, many acres of which are used for commercial oyster cultivation. The shipping channel runs along the western shore of the upper bay to access the shipping terminals located along the developed shorelines of the cities of North Bend and Coos Bay.

The Coos estuary includes multiple Slough regions. A half-dozen major sloughs and at least as many lesser sloughs feed the estuary. Most of the intertidal areas associated with the sloughs have been developed for various land uses through historic wetland filling, diking and draining activities. Eleven of the sloughs are described in more detail in 'Slough Subsystems' below.

About 30 tributaries enter the Coos estuary from the lower portions of the Coos watershed's 605 $mi^2$ drainage area, most entering by way of various sloughs. Several form riverine estuarine subsystems above the sloughs.

The Coos estuary includes multiple Riverine regions, the Lower Coos River being the main one. It forms at the confluence of the Millicoma River and the South Fork Coos River. From the mouth of the estuary, the head of tide is located approximately 51.5 km (32 mi) up the South Fork Coos River and 54.72 km (34 mi) up the Millicoma River (Wilsey and Ham Inc. 1974 in Roye 1979). See the Hydrology summary in this chapter for more information about heads of tide.

Slough Subsystems

The following major slough subsystems are described in more detail: South Slough, Pony Slough, North Slough, Haynes Inlet (detailing Palouse and Larson Sloughs within), Isthmus Slough, and Catching Slough (Figure 2a-c). The much smaller Kentuck and Willanch Sloughs and Echo Creek in the upper bay are also described. The Coos Watershed Association (CoosWA), having completed habitat assessments in many of these sloughs to identify opportunities for habitat restoration, provided the foundation for much of the information in this section.

| Estuarine Surface Area (MHW) | | |
|---|---|---|
| **Subsystem** | **km$^2$** | **mile$^2$** |
| Catching Slough | 0.70 | 0.27 |
| Coos River | 2.50 | 0.97 |
| Haynes Inlet | 3.16 | 1.22 |
| Isthmus Slough | 3.39 | 1.31 |
| Lower Bay | 15.75 | 6.08 |
| North Slough | 1.92 | 0.74 |
| Pony Slough | 1.15 | 0.45 |
| South Slough | 5.46 | 2.11 |
| Upper Bay | 16.01 | 6.18 |
| **All Coos Estuary** | **50.04** | **19.32** |

Table 2. Wetted estuarine surface area at Mean High Water (MHW) for the Coos estuary and each major subsystem. Derived from: DLCD 2011

South Slough: Oriented north/south near the mouth of the Coos estuary, the South Slough estuary surface area is approximately 5.46 km$^2$ (2.11 mi$^2$) at MHW, making it Coos estuary's largest slough (Table 2).

Over 225 km (140 mi) of freshwater streams flow into the estuary from the 7,935 ha (19,600 ac) South Slough watershed. Winchester Creek is the largest of the creeks, and it forms the head of South Slough's western Winchester Arm. The eastern Sengstacken Arm is fed by Elliot, Talbot, John B. and other smaller creeks. Joe Ney Creek, the northernmost arm of South Slough, forms a tributary slough (Rumrill 2006).

Pony Slough: Pony Slough is the most heavily developed slough. Commercial development began around the slough in 1917. Pony Slough was once a triangular embayment, but now it is a narrow channel about a mile long with a wide tide flat on both sides of its mouth. It currently has a wetted surface area of 1.15 km$^2$ (0.45 mi$^2$)(Table 2).

North Slough: The northernmost sub-basin of the Coos estuary, oriented northeast to southwest, has an estuary surface area of 1.92 km$^2$ (0.74 mi$^2$) at MHW (Table 2).

According to CoosWA (2006), North Slough watershed drains an approximately 2,995 ha (7,401 ac) watershed and includes 83.7 km (52 mi) of streams. The main stem of North Slough is approximately 2.41 km (1.5 mi) long from the tide gate at U.S. Highway 101 to the Bear Creek-North Slough Creek confluence. The main channels of Bear Creek and North Slough Creek are approximately 6.92 km and 7.40 km (4.6 mi and 4.3 mi) long, respectively. Elevation in the basin ranges up to 292.61 m (960 ft) above sea level (CoosWA 2006).

Haynes Inlet: Haynes Inlet extends about two and a half miles northeast from its confluence with the Coos estuary, just east of North Slough. The estuary surface area of Haynes Inlet at MHW is 3.16 km$^2$ (1.22 mi$^2$)(Table 2). It drains a 2,881 ha (7,120 ac) watershed, which includes two major salmon producing tributaries, Larson and Palouse creeks.

CoosWA's (2006) Larson and Palouse creek assessments describe those system as once supporting substantial tidal marsh area. Today the creeks are both restricted by major tide gates, one of which (Larson) was upgraded in 2001 to a fish-friendly style tide gate. The drainage area of Larson watershed is approx-

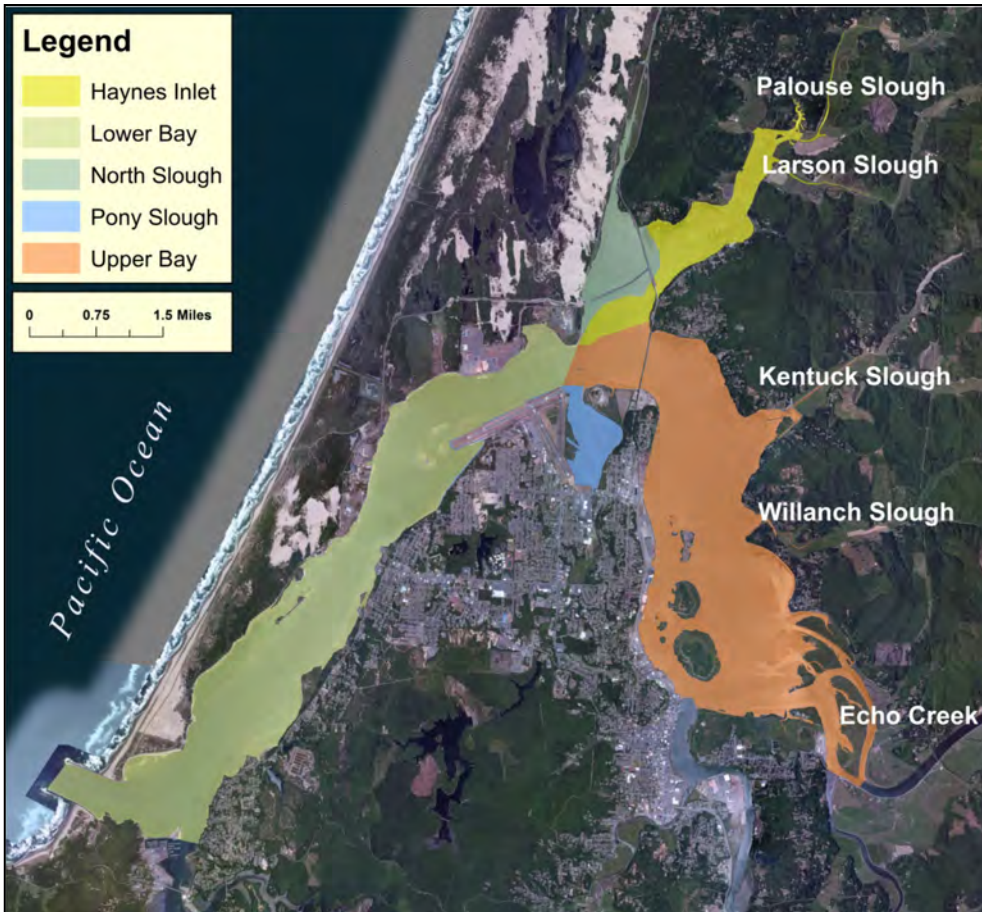



Figure 2a.
Northern portion of the Coos estuary shoreline at Mean High Water (MHW) using 2011 vector shoreline data. Major subsystems are designated by color. Data source: DLCD 2011

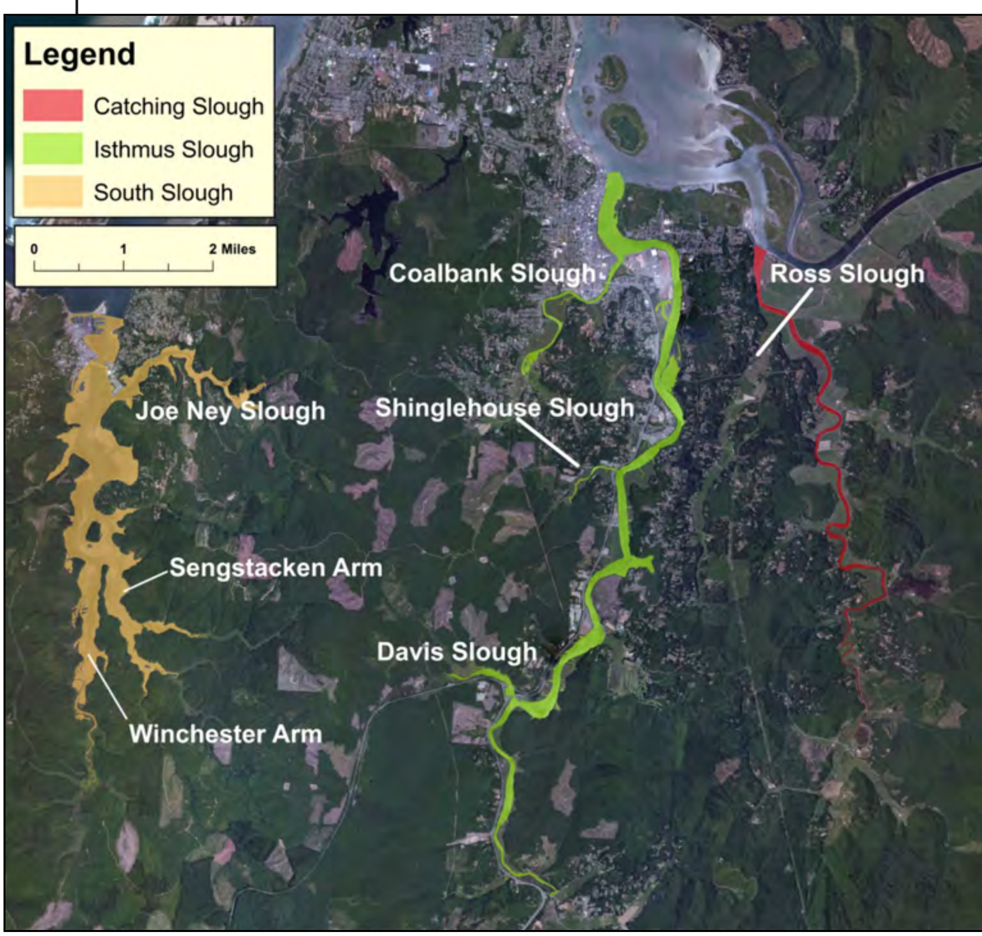



Figure 2b.
Southern portion of the Coos estuary shoreline at Mean High Water (MHW) using 2011 vector shoreline data. Major subsystems are designated by color. Data source: DLCD 2011


Figure 2c. Eastern portion of the Coos estuary shoreline (i.e., the Coos River subsystem) at Mean High Water (MHW) using 2011 vector shoreline data. Data source: DLCD 2011

imately 2,810.18 ha (6,944 ac) and includes approximately 75.96 km (47.2 mi) of streams. From the tide gate near the mouth, the Larson main stem is approximately 12.87 km (8.0 mi) long. The elevation in the basin ranges up to 421.54 m (1,383 ft) above sea level.

The Palouse watershed is approximately 2,814 ha (6,954 ac). There are approximately 78.05 km (8.5 mi) of streams within the Palouse watershed including very small intermittent headwater streams. From the tide gate at the mouth, the Palouse main stem is approximately 14.65 km (9.1 mi) long. The elevation in the basin ranges up to 463.30 m (1,520 ft) above sea level.

<u>Isthmus Slough</u>: The shoreline of Isthmus Slough, the second largest slough subsystem in the Coos estuary, is well developed. It includes the southern-most portion of the Coos estuary's commercial shipping channel. Coalbank Slough, Shinglehouse Slough, and Davis Slough are all tributary to Isthmus Slough which has a wetted surface area of 3.39 $km^2$ (1.31 $mi^2$) at MHW (Table 2). Isthmus Slough watershed covers 8,682 ha (21,456 ac), which is 5.4% of the entire Coos watershed (CoosWA 2011).

<u>Catching Slough:</u> Catching Slough enters the Coos estuary at the mouth of the Coos River. It is fed by several small streams, the largest of which is Ross Slough. Catching Slough is about 16.9 $km^2$ (10.5 $mi^2$) long and drains a 1,012 ha (2,500 ac) watershed (CoosWA 2008). It is the smallest of the major sloughs with an estuary surface area of 0.7 km (0.27 mi) at MHW (Table 2).

<u>Kentuck Slough:</u> The Kentuck sub-basin is oriented east to west, and is made up of two major tributaries, Kentuck and Mettman Creeks. These streams converge in the lowlands to form Kentuck Slough, which drains into the Coos estuary through a major tide gate (not yet fish-friendly). The drainage area of the watershed is approximately 4304.64 ha

(10,637 ac). There are approximately 95.40 km (59.28 mi) of streams within the drainage basin. From the tide gate at East Bay Drive, Kentuck main stem is approximately 13 km (8.1 mi) long, and Mettman Creek main stem is 5.47 km (3.4 mi) long. The elevation in the basin ranges up to 406.60 m (1,334 ft) above sea level.

Willanch Slough: The Willanch sub-basin is located south of Kentuck Slough and is also oriented east to west. It drains into the Coos estuary through a now fish-friendly tide gate. Willanch Creek's main tributary is Johnson Creek which converges from the south approximately 5.63 km (3.5 mi) upstream from the mouth. The drainage area of Willanch sub-basin is approximately 2,172.76 ha (5,369 ac). The total length of streams within the Willanch sub-basin is approximately 54.40 km (33.8 mi). The Willanch main stem is approximately 9.65 km (6 mi) in length. The elevation in the basin extends up to 368.5 m (1,209 ft) above sea level.

Echo Creek: The Echo sub-basin is the smallest slough system, found in the southeastern portion of the bay. It consists of four streams that empty directly into the Coos estuary's Cooston Channel, which runs along the eastern side of the upper Coos estuary's mud flats (Upper Bay region). The Echo Creek sub-basin is bordered on the south by the South Fork Coos River, which converges with the bay at the southern tip of the sub-basin. The drainage area is approximately 479.14 ha (1184 ac). The sub-basin has approximately 17.1 km (10.6 mi) of streams, with Echo Creek main stem approximately 7.23 km (4.49 mi) in length. The elevation in the basin ranges up to 275.23 m (903 ft) above sea level.

**Historic Changes to the Coos Estuary**

According to Oberrecht (2001), when the first Euro-American immigrants began to settle in 1853, the Coos estuary's main channel was about 3 m (10 ft) deep and 61 m (200 ft) wide at the mouth. The channel deepened up the estuary in the Lower Bay region to about 3.5 m (11.5 ft). In the Upper Bay region, above North Bend, the main channel gradually decreased in width and depth until at Marshfield (current day Coos Bay) the channel was about 15 m (50 ft) wide by about 1.8 m (6 ft) deep, with numerous shoals.

In the mid-twentieth century the lower Coos River changed its course through the upper bay (Aagard et al. 1971, in Roye 1979). Formerly, the main channel of the Coos River flowed through the Cooston channel east of Bull Island. At the northern end of Bull Island the channel split into the west-flowing Marshfield Channel and the East Channel, which continued north along the eastern shoreline. Over time the effects of logging (e.g., splash-damming and log-rafting) and dredging widened the channel south of Bull Island, so that the main flow of the Lower Coos River and Catching Slough is now along the western shore of the estuary along the Coos Bay and North Bend waterfronts (Aagard et al. 1971, in Roye 1979). The tendency for channel migration remains, since changes in hydrographic conditions may have unpredicted effects on channels and shorelines.

Tidal marsh filling historically occurred along the Coos estuary's western shore (much of Coos Bay's business district is built atop filled marshes), south of the Marshfield Channel at Eastside, and on several tide flats, where dredged materials now form several forested spoil islands. In the decades before federal and state laws began to regulate the alteration and filling of wetlands, extensive wetland fills occurred when dredge spoils from the maintenance and deepening of commercial shipping channels and harbor areas were used to create develop-able land on the shores of the Coos estuary (Roye 1979).

**Many Uses of the Coos Estuary**

<u>Bay and Riverine Regions</u>
Socioeconomically, the Coos estuary is important for being the second-busiest maritime commerce center in Oregon, according to the Oregon International Port of Coos Bay (OIPCB 2014). The western portion of the Upper Bay, adjacent to the cities of Coos Bay and North Bend, contains deep draft shipping terminals where the main shipping channel hugs the west side of the Coos estuary.

Environmentally (and indirectly socioeconomically), the Coos estuary is important for a number of reasons. The Riverine regions provide important habitat for commercially, recreationally, and ecologically important fish. Adult Coho salmon, Chinook salmon, and Steelhead trout populate the Coos estuary in the spring and fall en route to spawning streams. The Coos system is a major freshwater rearing area for Chinook, especially during their first year. The Lower Bay region of the estuary is also used by starry flounder and staghorn sculpin. Prickly sculpin and shiner perch occur in the upper portions (Rumrill 2006).

The marshes of the Coos River delta islands constitute major tracts of salt and brackish marshes. The entire eastern side of the Upper Bay—from Jordan Point to Bull Island, and west to the shipping channel—is a vast complex of flats, marshes, and eelgrass beds, providing valuable habitat and a rich source of organic material for the entire estuary. The tidal flats of the Upper Bay are feeding and rearing habitats for many fish species. Extensive brackish marshes can also be found on the spoil islands east of the main shipping channel in the Upper Bay.

<u>Slough Subsystems</u>
<u>South Slough</u>: South Slough was selected in 1974 as the site of the nation's first National Estuarine Research Reserve; as such, it conducts research and education programs focused on helping coastal communities effectively manage estuarine resources. South Slough contains about 1,000 acres of estuarine habitat including salt marshes, mudflats, and beds of eelgrass within its meandering, shallow channels, as well as about 5,000 acres of upland and riparian habitat. These areas all provide research, education and recreational opportunities for Reserve staff, visiting scientists and educators, and visitors.

The unincorporated town of Charleston is situated at the mouth of South Slough and includes stores, restaurants, a motel, a marina, fishing processing plants, and a shipyard. The University of Oregon's Institute of Marine Biology (OIMB) is located in Charleston and conducts research and educational programs for University students and visiting researchers.

North Slough: The North Slough has a 673 ha (1,664 ac) salt marsh below its tide gate. It has undergone several changes over the years, including the development of Highway 101 and historic dredging. It also provides key nursery habitats in the estuary for several important aquatic speices (e.g. salmon, trout) (CoosWA 2006).

Pony Slough: Pony Slough attracts many bird species, probably due to its sheltered location (Roye 1979). The most urban slough subsystem, Pony Slough is completely surrounded by the Southwest Oregon Regional Airport, Coast Guard air station, Pony Village Mall, and North Bend residential development.

Haynes Inlet: The tidal marshes associated with Palouse and Larson creek floodplains have been converted to agricultural uses through diking and construction of a system of tide gates (Roye 1979). In 2001, CoosWA facilitated the replacement of the main Larson Slough tide gate with an upgraded "fish-friendly" tide gate which allows fish to more easily pass between Larson Creek and Haynes Inlet (CoosWA 2006).

Isthmus Slough: Historically, many of the marshes in lsthmus Slough were eliminated by diking, filling, and log storage. In Coalbank Slough alone, marshes occupied 241.6 ha (597 ac) in 1892, but by 1979 only 23 ha (57 ac) remained (Hoffnagle and Olson 1974, in Roye 1979). On the western bank of the lower Isthmus Slough, multiple boat terminals and a marina can be accessed off the main shipping channel. A recreational boat launch can be found on the eastern shore.

Catching Slough: In the late 1800s, Catching Slough was an area of vast tidal marshes. Strong tidal flushing was responsible for maintaining main channel depths of 5.5-6.0 m (18 to 20 ft) at its confluence with the Marshfield Channel. By the 1940s diking of Catching Slough for agricultural purposes had decreased tidal transport and velocity through Marshfield Channel (Aagard et al. 1971, in Roye 1979).

Kentuck Slough: Today, Kentuck Slough features tidal marshes at its mouth outside the main tide gate. During the early part of the twentieth century the lower end of Kentuck Slough was straightened and confined to a rectangular box channel and the tide gate constructed near its confluence with the main part of the estuary. In 2006, CoosWA facilitated the replacement of the tide gate with a newer one designed to provide better passage for migrating fish (CoosWA 2006). Historically, the former tidal marshes on the south side of the channel were converted agricultural and then recreational uses (golf course). Plans are currently under way to restore tidal flooding and marsh habitat at the golf course site as part of the compensatory mitigation required to replace the wetlands lost to planned development projects at Jordan Cove on the other side of the Coos estuary.

Willanch Slough and Echo Creek: Extensive salt marshes are found along the eastern side of the upper bay at the mouth of Willanch Inlet, although most of the marsh area has been lost through diking and reduced tidal inundation from the placement of a tide gate in 1947. Improved fish passage across the tide gate occurred in 2010 when it was replaced with a more fish friendly side-hinged version. Salt marsh habitat is abundant on the Coos River delta islands adjacent to Echo Creek and on the northeastern portion of the Eastside peninsula.

**References**


Aagard, K., H. R. Sanborn, and R. W. Sternberg. 1971. A fluvial and hydrographic survey of Coos Bay, Oregon. Submitted to Weyerhauser Co., North Bend. 16 pp.

Coos Watershed Association (CoosWA). 2006. *Coos Bay Lowland Assessment and Restoration Plan.* Coos Watershed Association, Charleston, Oregon. 268pp.

Coos Watershed Association (CoosWA). 2008. *Catching Slough, Daniel's Creek and Heads of Tide Sub-basin Assessment and Restoration Opportunities.* Coos Watershed Association, Charleston, Oregon. 144 pp.

Coos Watershed Association (CoosWA). 2011. *Isthmus and Coalbank Slough Sub-basin Assessment and Restoration Opportunities.* Coos Watershed Association, Charleston, Oregon. 99 pp.

Cortright, R., J. Weber, and R. Bailey. 1987. The Oregon Estuary Plan Book. Oregon Department of Land Conservation and Development, Salem, Oregon.

Hickey, B. M. and N. S. Banas. 2003. Oceanography of the U.S. Pacific Northwest Coastal Ocean and Estuaries with Application to Coastal Ecology. *Estuaries*, 26(4): 1010-1031.

Hoffnagle, J. and R. Olson. 1974. The salt marshes of the Coos Bay Estuary. Port Coos Bay Comm. and University of Oregon Institute of Marine Biology, Charleston. 86 pp.

Hyde, N. 2007. Towards National Estuarine Modeling and Characterization/Classification Systems: A Pilot Study for Coos Bay. Thesis (M.S.)—Oregon Health and Science University.

National Geodetic Survey (NGS). 2015. Vertical Datums. Accessed 12 June 2015: http://www.ngs.noaa.gov/datums/vertical/

National Oceanic and Atmospheric Administration (NOAA). 1985. National Estuarine Inventory Data Atlas. Vol. 1, Physical and hydrologic characteristics. Rockville, Md.

Oberrecht, K. 2001. Pioneer Settlement on Coos Bay. Estuary Feature Series No. 43. South Slough National Estuarine Research Reserve, Charleston, Ore., 97420. Accessed 3 June 2015: http://www.oregon.gov/dsl/SSNERR/docs/EFS/EFS43pionsettle.pdf

Oregon Department of Land Conservation and Development (DLCD). 2011. Mean High Water Shoreline. GIS data files.
Oregon International Port of Coos Bay. Accessed 17 April 2015: www.portofcoosbay.com/inside.htm

Oregon International Port of Coos Bay (OIPCB). 2014. Maritime Commerce. Accessed September 22, 2015. http://portofcoosbay.com/maritime.htm

Percy, K. L., D. A. Bella, C. Sutterlin, and P. C. Klingeman. 1974. Descriptions and information sources for Oregon estuaries. Sea Grant College Program, Oregon State University. Corvallis, Oregon.

Roye, C. 1979. Natural Resources of the Coos Bay Estuary, 2:6. Estuary Inventory Report. Oregon Department of Fish and Wildlife, 506 SW Mill Street, PO Box 3503 Portland, Oregon 97208.

Rumrill, S. S. 2006. *The Ecology of the South Slough Estuary: Site Profile of the South Slough National Estuarine Research Reserve.* Salem, Oregon: NOAA, Oregon Department of State Lands Technical Report. 238pp.

Wilsey and Ham Inc. 1974. Estuarine resources of the Oregon Coast. A natural resource inventory report to the Oregon Coastal Conservation and Development Commission. 233 pp.

# Lower Coos Watershed Meteorology

CLW DATA SOURCE

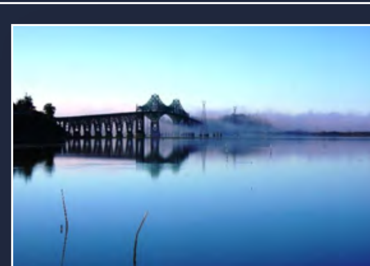


Photo: High Tide Cafe

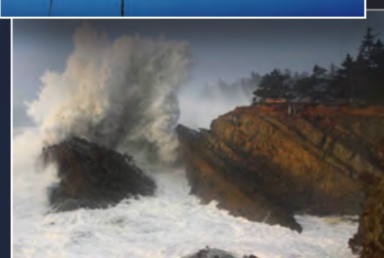


Photo: Steven Michael


*Summary:*

- *The lower Coos watershed is characterized by seasonal weather patterns, including comparatively warm, dry summers and cool, wet winters.*
- *Summer is characterized by consistently high winds from the north. Winter winds originate from the south and, while they are lighter on average, gusts from winter storms bring the highest wind speeds year-round.*
- *While no underlying long term meteorological trends in the project area are apparent, additional analyses are needed.*


**Evaluation**

Continued data collection and further analysis is needed to fully understand long term trends.

**DATA GAP**

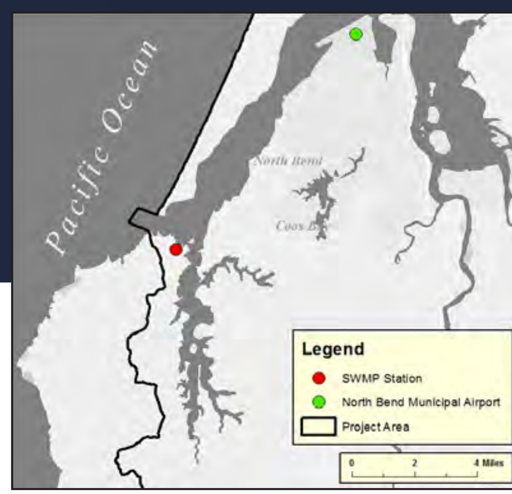



Figure 1. Location of meteorological (weather) stations in the project area.

**What's happening?**

This data summary discusses the meteorological characteristics of the lower Coos watershed by describing the following: air temperature, precipitation, wind, and Photosynthetically Active Radiation (PAR). Data came from several meteorological (weather) stations in the project area (Figure 1), but for a number of reasons (see Chapter Summary), emphasis is given to weather data collected at the North Bend Municipal Airport. We analyzed available data to describe both recurring seasonal patterns in the project area, and any underlying long term trends occurring independently of seasonal weather patterns. See Table 1 for questions addressed.

| Type of Trend | Variable | Example Question |
|---|---|---|
| Seasonal Pattern | Air Temperature | How much warmer are summertime temperatures compared to winter temperatures? |
| Long Term Trend | Air Temperature | Have summer temperatures become warmer on average over the years? |
| Seasonal Pattern | Precipitation | How much rain falls in January? |
| Long Term Trend | Precipitation | Has rainfall become more variable over time? |

Table 1. This data summary describes seasonal variation in local meteorology and looks for underlying long term trends in the data. Examples of research questions pertaining to these two topical approaches have been provided for clarification.

Air Temperature

The median annual temperature in the project area is approximately 50.9° F (10.5° C), based on data from the weather station at the mouth of South Slough (Figure 1) (SWMP 2015). Air temperature data display a clear seasonal pattern with summertime temperatures above the annual median and wintertime temperatures generally below the median (Figure 2). Mean monthly low temperatures range from 40 - 53° F (approximately 4.4 – 11.6° C), while mean monthly highs range from 53 - 67° F (11.7 - 19.6° C), based on data from the North Bend weather station (Figure 1)(WRCC n.d.)(Figure 3).

Precipitation

Mean monthly precipitation in the project area varies from 0.5 to 11.5 inches (14 to 289 mm)(WRCC n.d)(Figure 3). Not surprisingly to those who live in the Pacific Northwest, precipitation displays a clear seasonal pattern: much more precipitation occurs in winter months than summer months. Also unsurprisingly, the magnitude of precipitation events show strong seasonal patterns. The probability of occurrence for both large (more than 1 inch in 24 hours) and small (0.01 – 0.25 inches in 24 hours) precipitation events decreases during the summer months (WRCC n.d)(Figure 4).

Wind Speed

Wind speed in the project area is summarized by Table 2 and Figure 5. Wind speed data come from MesoWest (2015). The lower Coos watershed experiences sustained winds of up to 50 mph year-round, with an average annual wind speed of approximately 12 mph. Wind gusts exceed 65 mph, with an annual average of about 26 mph.

The average speed of sustained winds varies seasonally, with both the highest average and maximum sustained wind speeds occurring in the summer months (i.e., June, July, and August). The average speed of wind gusts (i.e., monthly mean) also appears to be highest during summer, but it should be noted that both the variance (i.e., standard deviation) and maximum speed of wind gusts is higher in the winter. This trend suggests that summer is characterized by both high sustained winds and consistently strong gusts while wintertime winds, which are lighter on average, are subject to more variation in the form of intermittent storm events associated with anomalously strong wind gusts.

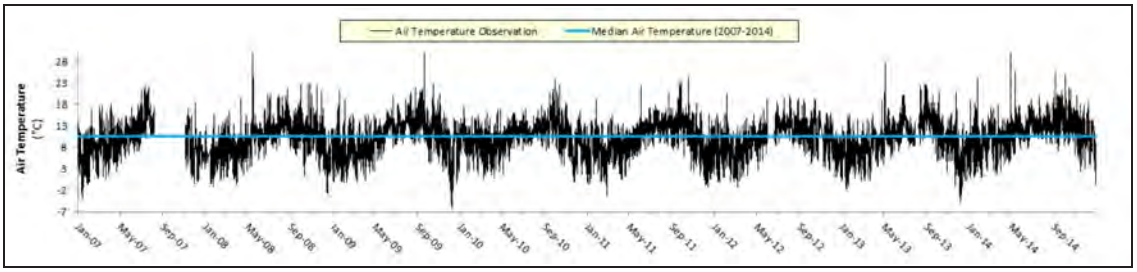
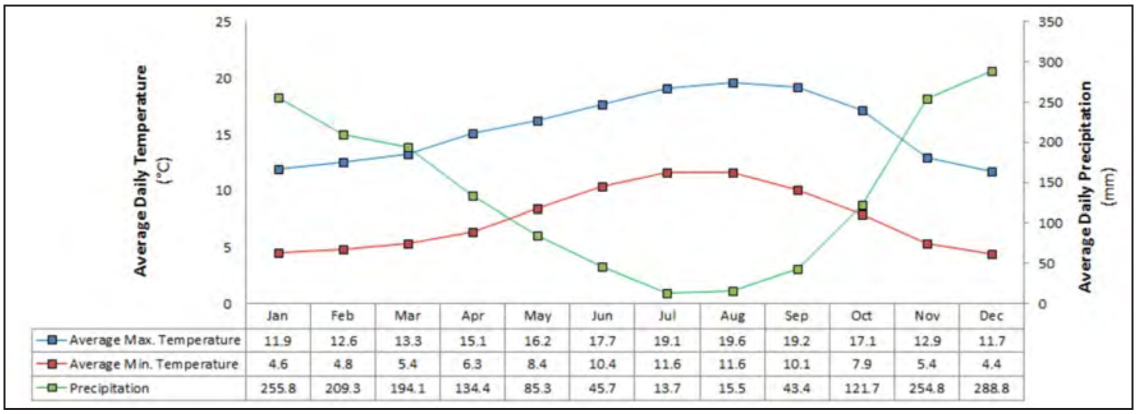



Figure 2. Air temperature observations (black) from the South Slough weather station (2007-2014). Central tendency (blue) as represented by seven-year median daily air temperature is 10.5° C (50.9° F). Labels occur quarterly along the time axis (i.e., the x axis). Air temperature data display a clear seasonal signature with warmer temperatures occurring in the summer months and cooler temperatures in the winter. Data: SWMP 2015




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Max. Temperature | 11.9 | 12.6 | 13.3 | 15.1 | 16.2 | 17.7 | 19.1 | 19.6 | 19.2 | 17.1 | 12.9 | 11.7 |
| Average Min. Temperature | 4.6 | 4.8 | 5.4 | 6.3 | 8.4 | 10.4 | 11.6 | 11.6 | 10.1 | 7.9 | 5.4 | 4.4 |
| Precipitation | 255.8 | 209.3 | 194.1 | 134.4 | 85.3 | 45.7 | 13.7 | 15.5 | 43.4 | 121.7 | 254.8 | 288.8 |

Figure 3. Average daily temperature from the North Bend weather station (1981-2010). Mean daily low temperature (blue) is plotted against mean daily high temperature (red) and mean daily precipitation (green). Periods of warm temperatures occur during the summer months, when average daily precipitation is low. Winter is characterized by cooler temperatures and increased precipitation. Data: WRCC n.d.

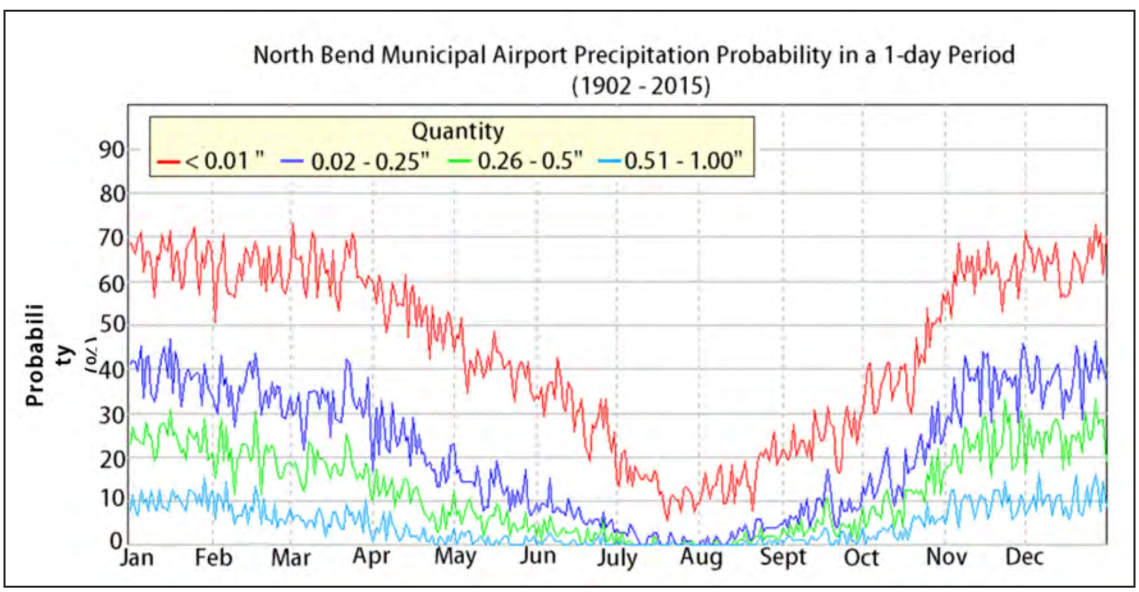



Figure 4. Probability of indicated precipitation quantity in a 1-day period. Data: WRCC n.d.

| | Sustainted Winds | | | | Wind Gusts | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Mean | Max | Std. Dev. | N | Mean | Max | Std. Dev. |
| January | 30,631 | 10.3 | 48 | 5.6 | 5,008 | 25.8 | 65.6 | 7.2 |
| February | 25,437 | 10.1 | 49 | 5.3 | 3,687 | 24.7 | 55.2 | 6.7 |
| March | 30,673 | 11.2 | 41 | 5.8 | 6,076 | 24.4 | 55.2 | 6.2 |
| April | 30,029 | 11.3 | 42 | 6.0 | 5,645 | 23.9 | 48.3 | 5.4 |
| May | 31,565 | 12.0 | 41 | 6.7 | 6,637 | 24.9 | 51.8 | 5.9 |
| June | 26,792 | 12.8 | 48 | 7.5 | 6,495 | 26.6 | 47.2 | 6.3 |
| July | 28,211 | 14.5 | 50 | 8.5 | 8,520 | 28.5 | 49.5 | 6.4 |
| August | 26,626 | 12.9 | 44 | 7.7 | 6,121 | 27.1 | 50.6 | 5.8 |
| September | 21,619 | 11.2 | 40 | 6.9 | 3,296 | 26.7 | 48.3 | 5.9 |
| October | 28,183 | 9.8 | 42 | 5.3 | 3,208 | 23.5 | 55.2 | 5.8 |
| Novemver | 26,972 | 10.4 | 44 | 5.6 | 4,435 | 25.9 | 58.7 | 7.3 |
| December | 29,997 | 10.9 | 49 | 6.0 | 5,335 | 26.8 | 65.6 | 7.6 |
| **All Months** | **336,735** | **11.4** | **50** | **6.6** | **64,463** | **25.9** | **65.6** | **6.6** |

Table 2. Wind speed at the North Bend weather station (1997-2015). All speeds are reported in miles per hour.
Data: MesoWest 2015

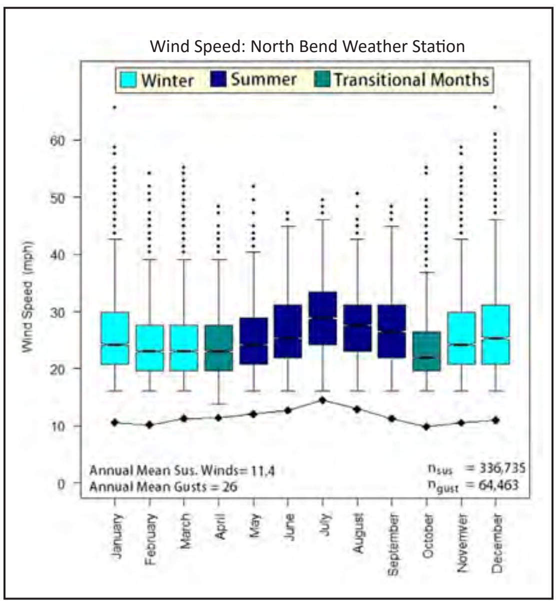



Figure 5. Wind at the North Bend weather station (1997-2015). Wind gusts (box and whisker plots) plotted next to monthly mean sustained wind speed (black line). Average monthly wind speed is generally higher in the summer months (dark blue) than the winter months (light blue). However, wind gusts are more variable in winter, and extreme values are higher in winter months than in summer months. Data: MesoWest 2015

Wind Direction

Figure 6 summarizes the distribution of wind direction data at the North Bend weather station (MesoWest 2015). Winds in the project area originate from the north, south, and the west, but rarely come from easterly directions (i.e., between approximately 30° and 130°). High winds (i.e., sustained winds 35-50 mph) generally come from the north, with high southerly winds occurring less frequently. Generally, winter months are characterized by south winds of approximately 10-11 mph on average, with high wind events occurring from the southwest associated with winter storms. By contrast, the mean monthly wind speed increases to approximately 12-15 mph in the summer months, when the prevailing wind direction switches to the north. April and October appear to be “transitional months” that display some characteristics of both winter and summer winds.

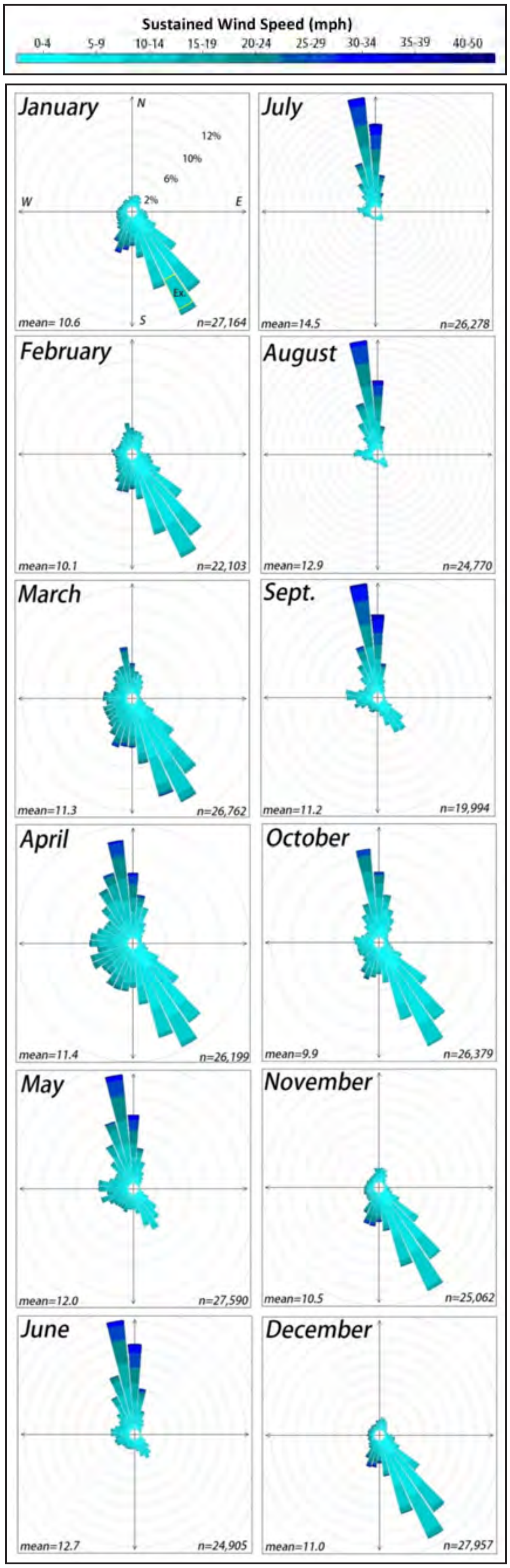



Figure 6. Speed and direction of sustained winds at the North Bend weather station (1997-2015). Wind direction is indicated by the underlying compass rose, with each spoke representing 10° (i.e., 9 spokes between cardinal directions). Wind speed is indicated by color, with darker colors representing higher wind speeds. Concentric rings around the center of the compass rose indicate the percentage of data coming from each wind speed category. Each ring represents 2% of all observations (see January for labels). Data: MesoWest 2015 using data package created by Carslaw and Ropkins 2012.

Refer to the segment labeled “Ex.” (outlined in yellow, in January) for the following example: winds coming from 150° S at 10-14 mph represent about 4% of all January winds, because the length of this segment spans approximately 2 concentric rings.

Photosynthetically Active Radiation (PAR)

PAR measures solar radiation available to plants for photosynthesis (see sidebar below). PAR data from the North Bend weather station suggest that average daily PAR varies seasonally, with the highest daily mean occurring, not surprisingly, during summer months (Figure 7). PAR also appears to vary on a daily basis depending on the seasonal changes such as the length of the "photoperiod" (i.e., daylight hours) as well as other factors (e.g., cloud cover)(Figure 8).

***Photosynthetically Active Radiation***

*Photosynthetically Active Radiation (PAR) measures the amount of light in the 400-700 nanometer wavelength range. Light in this wavelength range is readily available for plants to use in photosynthesis, the process that allows them to convert sunlight to energy for growth. PAR is commonly reported in units of millimoles per square meter (mmol $m^2$).*

*PAR values vary depending on several factors determining light availability (e.g., season, latitude, time of day, cloud cover). High PAR levels promote plant growth.*

*The continued monitoring of PAR ensures that local land managers have the information they need to track long term changes in climate-related light levels that may affect agricultural, habitat conservation or restoration operations.*

*Source: Fondriest Staff 2010*

Long Term Meteorological Trends

In order to analyze the data for underlying long term trends, this data summary makes use of "time series decomposition" where the data are robust enough. This statistical technique highlights trends by controlling for both seasonal variation and statistical "noise" in the data (see sidebar below). Decomposition of both air temperature and precipitation series yield no immediately apparent trend (Figures 9 and 10). Similar analyses were not

***Seasonal Time Series***

*There are three components to seasonal time series data: 1) seasonality (a recurring pattern influenced by seasonal factors); 2) trends (overall increasing or decreasing pattern); and 3) statistical "noise" (variations in the data that cannot be identified as either seasonality or trends).*

*Seasonal time series relationships can be complicated and may require the use of special analytical techniques to adequately describe. For example, seasonality data and statistical noise can obscure an underlying trend. Statisticians are able to examine time series data for underlying trends by "decomposing" the series into its component parts and controlling for both seasonal effects and statistical noise.*

*This data summary highlights the underlying trend of meteorological time series data by simultaneously "smoothing" statistical noise and "seasonally adjusting" a series. This technique isolates the trend component of a time series and allows for a clearer presentation of any underlying pattern not dependent on seasonal variation.*

*Source: Hyndman and Athanasopoulos 2014*

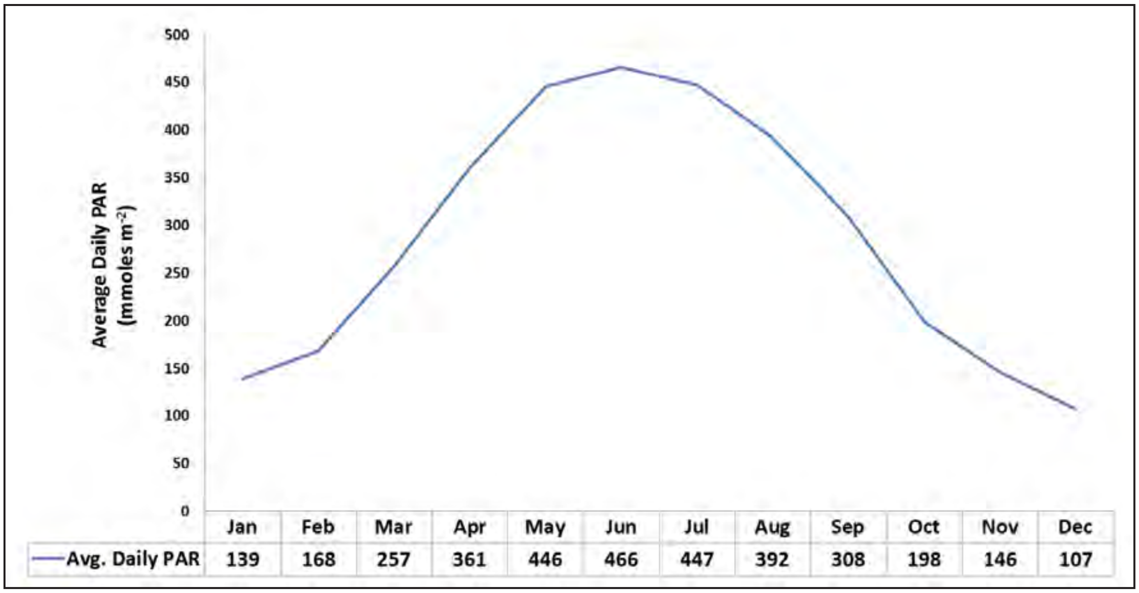



Figure 7. Seasonal signature of PAR based on seven year average (2007-2014) shows that mean daily PAR increases during the summer months and decreases during the winter months. Data: SWMP 2015

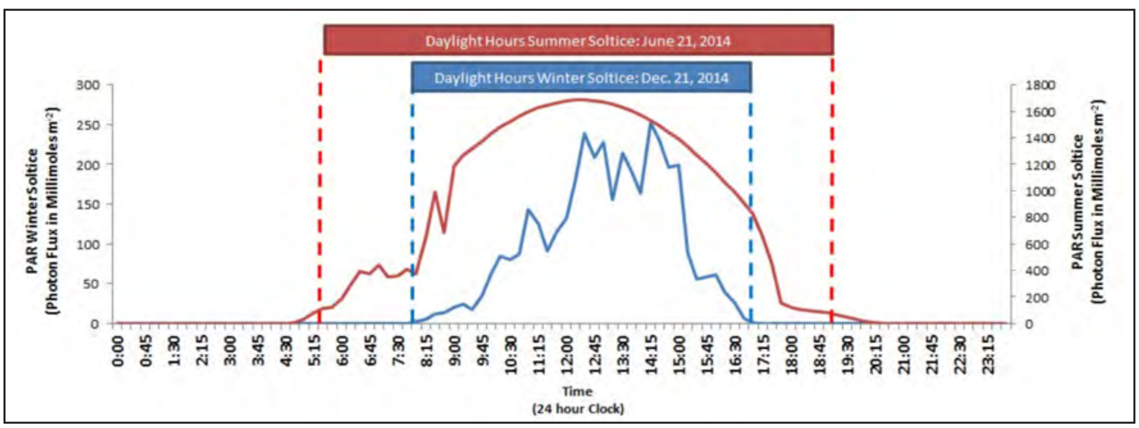



Figure 8. PAR over the course of a single day shows a daily pattern of peak solar radiation during the afternoon. Radiation occurs during daylight hours between sunrise and sunset (dashed lines). Radiation is strongest during the summer months. PAR Data: SWMP 2015; Daylight Hours Data: TimeandDate.com 2015

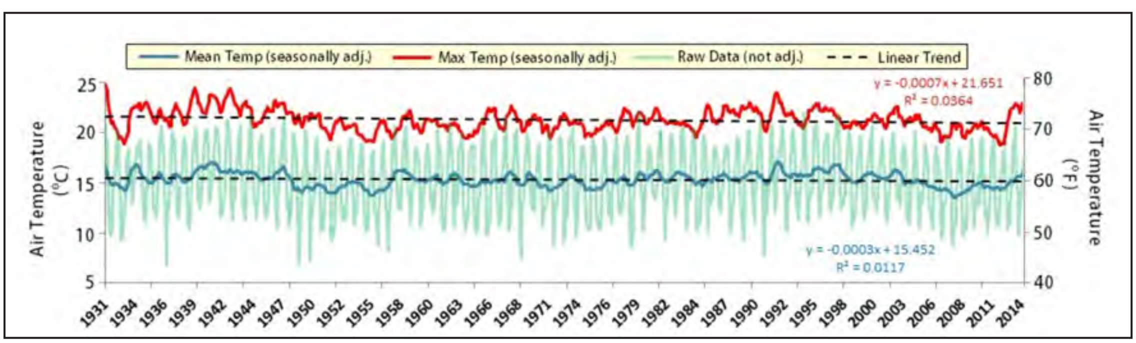



Figure 9. Seasonally adjusted long term air temperature trends (1931-2014) for both maximum daily temperature (red) and mean daily temperature (blue). Raw data (green) have been controlled for both seasonal effects and statistical noise. Linear regression of seasonally adjusted trend on year suggests that temperature change over time is not statistically different from zero (i.e., no change) when controlled from seasonal variations. Data: WRCC n.d.

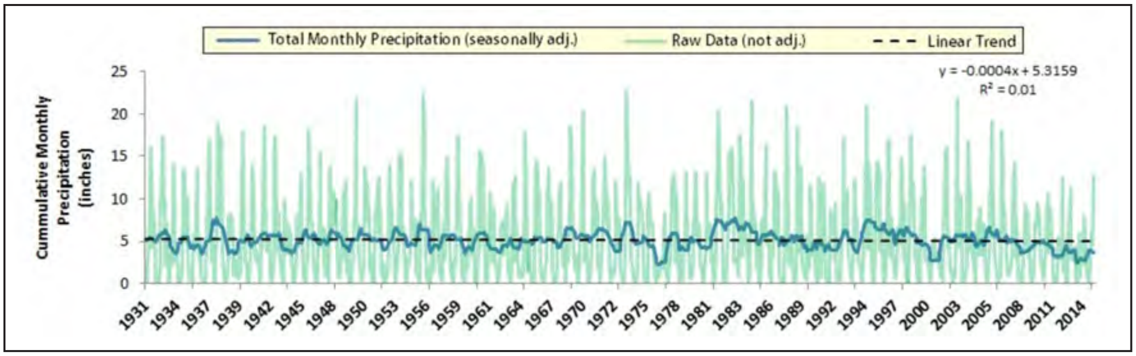



Figure 10. Seasonally adjusted long term precipitation trend (1931-2014) for total monthly precipitation (blue). Raw data (green) have been controlled for both seasonal effects and statistical noise. Linear regression of seasonally adjusted trend on year suggests that precipitation change over time is not statistically different from zero (i.e., no change) when controlled from seasonal variations. Data: WRCC n.d.

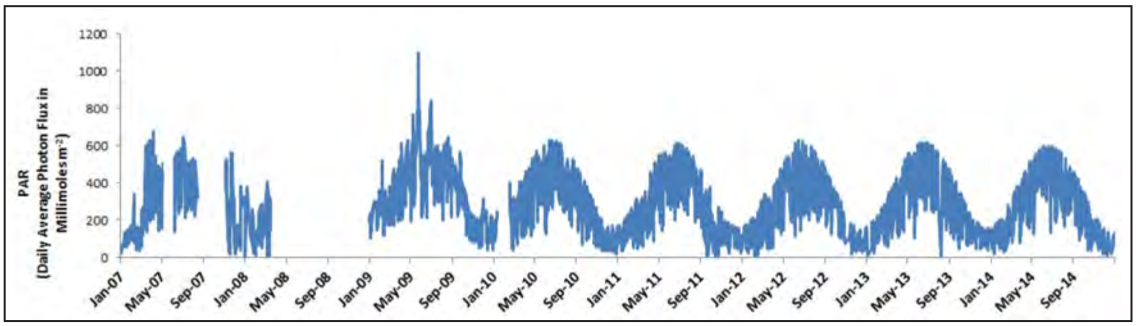



Figure 11. Visual inspection of PAR time series at the South Slough weather station (2007-2014) suggests that, although PAR is clearly seasonal, no noticeable increasing or decreasing trend over time exists. Data: SWMP 2015

conducted for wind or PAR, because the size of these data sets (18 years for wind and 7 years for PAR) is not conducive to analysis of long term trends. However, visual inspection of the available PAR data suggest that, although PAR is highly seasonal, there does not appear to be any significant change in PAR over time (Figure 11).

It's important to note the information presented in this data summary is subject to data limitations. More analysis is needed to determine how meteorological patterns may or may not have changed in the project area over time. For a discussion of data limitations, see the Chapter 8 summary.

Storm Events and Climatic Variability

Due to the data limitations mentioned above, it is difficult to determine whether the intensity of storms in the project area has changed over time. Similarly, it is also difficult to assess overall trends in climatic variability (i.e., magnitude of changes in temperature, precipitation, etc.). Decomposition analysis shows no apparent trend in the variance of either air temperature or precipitation over time, when controlling for seasonal effects and statistical noise (Figures 12 and 13). However, more detailed data and additional analyses are needed to fully understand how extreme weather events and climatic variability in the project area may have changed over time.

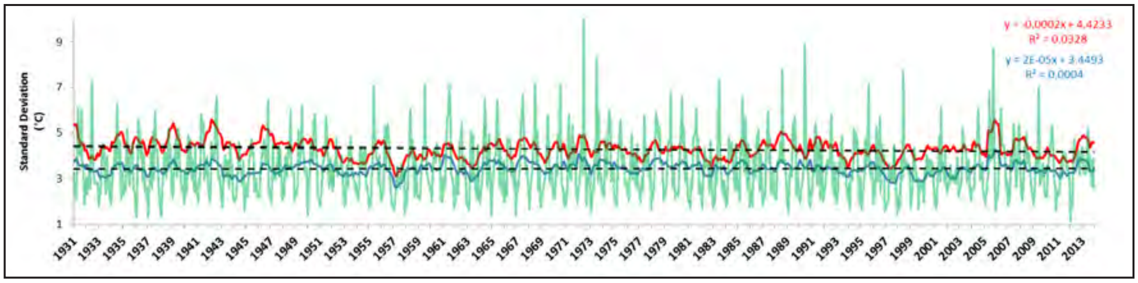



Figure 12. Variance of raw air temperature data (green) plotted against seasonally adjusted trend for variance of both mean daily temperature (blue) and maximum daily temperature (red). Data show no clear trend in variance and linear regression (black) since 1931, which suggests that the change in variance over time is not statistically different from zero (i.e., variance remains unchanged over time). Data: WRCC n.d.

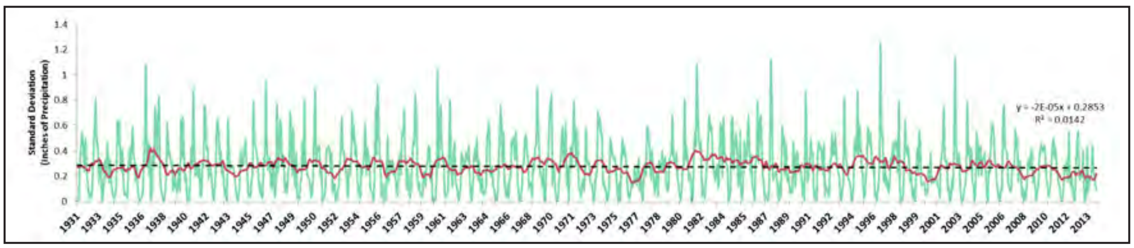



Figure 13. Variance of total monthly precipitation (green) plotted against seasonally adjusted trend (red). Data show no clear trend in variance of monthly precipitation and linear regression (black) since 1931, which suggests that the change in variance over time is not statistically different from zero (i.e., variance remains unchanged over time). Data: WRCC n.d.

**Why is it happening?**

The world's oceans play a critical role in determining climate conditions of coastal environments by absorbing and distributing solar radiation, fueling the hydrological cycle, and generating storms (Boesch et al. 2000). Rumrill (2008) explains that two ocean environmental factors influence climate over the Pacific Northwest, the Oregon coast and Coos Bay: Large-scale variability in atmospheric pressure over the northern Pacific Ocean (Pacific Decadal Oscillation- PDO), and cyclical patterns in nearshore ocean currents. The relationship between PDO and meteorological patterns in the project area (data from the North Bend weather station), suggest that a weak but positive correlation between these two factors exists (Figure 14).

The cool, southerly California Current system is the predominant oceanographic feature that influences climate between Cape Mendocino, California, and the mouth of the Columbia River, which includes the project area. The California Current is about 500-750 mi (800-1,200 km) wide and generally flows south at a rate of about 2.5-5 mi (4-8 km) per day. In summers, a narrow, deep current (the California Undercurrent) flows northward at depths below 650 ft (200 m)(Halpern et al. 1978 as cited in Rumrill 2008). It is relatively fast and flows at a rate of 4-10 mi (6-16 km) per day (Rumrill 2008; Mysak 1977; Collins et al. 2000). From late August to October the nearshore component of the California Current weakens, although flows remain in a southerly direction farther offshore (Briggs 1974 as cited in Rumrill 2008). From Novem-

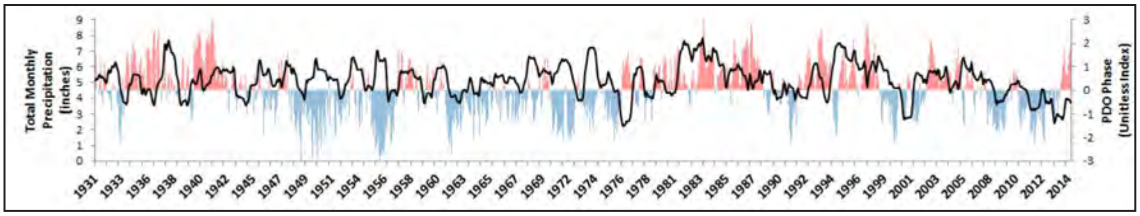



Figure 14. Seasonally adjusted total monthly precipitation (black) plotted against the Pacific Decadal Oscillation (PDO). PDO is measured by a "unitless" index that is negative during cool phases of the PDO (blue) and positive during warm phases (red). Linear regression analysis shows a positive and statistically significant relationship between PDO and seasonally adjusted precipitation ($p = 0.05$), meaning that precipitation is likely to increase slightly during the warm phase of the PDO and decrease slightly during the cool phase. Alternative statistical measures also show a weak but positive correlation between the two variables (Pearson's $r = 0.09$). $R^2=0.007$. One interpretation of this correlation is that although ocean conditions appear to influence precipitation, they are not perfect predictors of precipitation, because other variables (e.g., dew point as determined by air temperature) are also likely to contribute. Precipitation Data: WRCC n.d.; PDO Data: JISAO 2015

ber through February the swift Davidson Current flows northward at a rate of about 5.5-12.5 mi (9-20 km) per day, at all depths, across the continental margin between the California Current and the shoreline.

The Coos estuary is exposed to the full force of Pacific Ocean storms when winter winds begin to blow in November. These produce large swells and push rain and moisture inland, generating enormous waves that can cause significant erosion as well as sediment movement and deposition. During the transition to spring (April-May) the offshore winds become northwesterly and generally remain so through the summer and early fall.

Northwesterly winds trigger the spring-summer upwelling pattern, which can modify coastal climate and biological productivity. When strong northwesterly winds persist for several days, surface waters near the coast are pushed west by the rotation of the Earth, away from shore. The offshore flow causes cold, nutrient-rich water from the deep ocean to well up near the shore. Although the most active upwelling is restricted to a narrow band approximately 5-15 mi (8-24 km) from shore, upwelling greatly influences currents across the entire continental shelf. Upwelling also modifies the summer climate, causing coastal fog that can persist onshore for days or weeks when "upwelled" cold ocean waters meet warm, moist air.

Upwelling contributes to high levels of biotic productivity throughout the region. Indeed, the rates and volumes of upwelling observed between Cape Mendocino and the mouth of the Columbia River are greater than anywhere else along the west coast of North America. While upwelling tends to be strongest between Cape Mendocino and Cape Blanco, evidence of upwelling is demonstrated by the patchy distribution of temperate faunal communities as far south as the northern coast of Baja California (Rumrill 2008).

## References

Boesch, D.F., J.C. Field, and D. Scavia, (Eds.) 2000. The Potential Consequences of Climate Variability and Change on Coastal Areas and Marine Resources: Report of the Coastal Areas and Marine Resources Sector Team, U.S. National Assessment of the Potential Consequences of Climate Variability and Change, U.S. Global Change Research Program. NOAA Coastal Ocean Program Decision Analysis Series No. # 21. NOAA Coastal Ocean Program, Silver Spring, MD. 163 pp.

Briggs, J.C. 1974. Marine Zoogeography. New York: McGrawHill. 475 p.

Carslaw, D. C. and K. Ropkins. 2012. openair --- an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-28, 52-61.

Collins, C. A., N. Garfield, T. A. Rago, F. W. Rischmiller, and E. Carter. 2000. Mean structure of the inshore countercurrent and California undercurrent off Point Sur, California. Dee-Sea Research II 47: 765-782.

Frondriest Staff. 2010. What is Photosynthetically Active Radiation? [Publication from Environmental Monitor, online journal]. Accessed 19 June 23, 2015 from http://www.fondriest.com/news/photosyntheticradiation.htm

Halpern, D., R.L. Smith, and D.K. Reed. 1978. On the California undercurrent ver the continental shelf off Oregon. Journal of Geophysical Research 83: 1366-1372.

Hyndman, R. J. and G. Athanasopoulos. 2014. Forecasting: principles and practice. Accessed 22 June 2015 from https://www.otexts.org/fpp

Joint Institute for the Study of the Atmosphere and Ocean (JISAO). 2015. PDO Index. [PDO database hosted by JISAO and the University of Washington]. Accessed 5 June 2015 from http://research.jisao.washington.edu/pdo/PDO.latest

Mysak, L.A. 1977. On the stability of the California Undercurrent off Vancouver Island. Journal of Physical Oceanography 7: 904-917.

Rumrill, S. 2008. Ecology of the South Slough Estuary—Site profile of the South Slough National Estuarine Research Reserve.

System-Wide Monitoring Program data (SWMP). 2015. SWMP: South Slough Meteorological Data (2007-2014). Accessed June, 2015 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

TimeandDate.com. 2015. Coos Bay, U.S.A.-Sunrise, sunset, and daylength time. Accessed 17 June 2015 from http://www.timeanddate.com/sun/usa/coos-bay

University of Utah MesoWest (MesoWest). 2015. KOTH database. [Online meteorological database hosted for North Bend Municipal Airport]. Accessed 5 June 2015 from http://mesowest.utah.edu/cgi-bin/droman/download_ndb.cgi?stn=KOTH&hour1=22&min1=56&timetype=LOCAL&unit=0&graph=0

Western Regional Climate Center (WRCC). n.d. North Bend RGNL AP, Oregon (356073). [Online meteorological database hosted by WRCC]. Accessed 5 June 2015 from http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?or6073

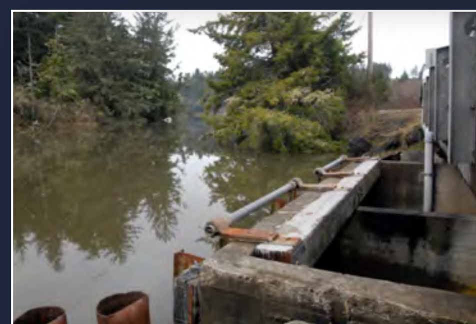
# Hydrology of the Lower Coos Watershed

CLW DATA SOURCE


*Summary:*

- *The South Fork Coos and Millicoma Rivers provide the largest source of fresh water to the Coos estuary.*
- *Coastal upwelling and tidal exchange help drive estuarine productivity. Their benefits can be greatly affected by cyclical oceanic/ climate variations (e.g., El Niño, Pacific Decadal Oscillation).*
- *A hydrodynamic (circulation) model will soon enable scientists and coastal managers to investigate the affects of planned or anticipated future changes on the Coos estuary.*


Storm-driven waves break at the entrance to the Coos estuary.



Tide gate regulates tidal flooding at Willanch Slough.

**Evaluation**

Once the UO's circulation model is completed, our community's understanding of the Coos estuary hydrology will be greatly enhanced.

**Evaluation**

Water discharge gauges on Coos estuary's principle rivers and streams help our community track changes in local hydrology.

**Evaluation**

Bathymetry data, especially in shallow portions of the estuary, are limited.

! DATA GAP

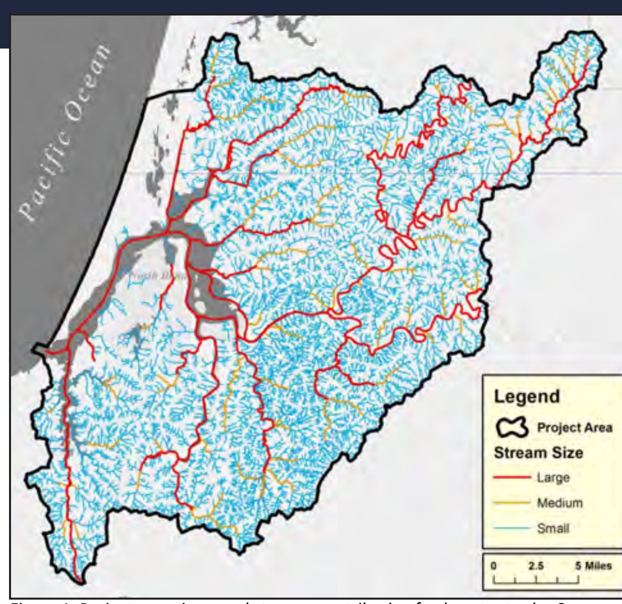



Figure 1. Project area rivers and streams contributing fresh water to the Coos estuary, sorted by size. Large stream flows average ≥10 cfs/year; Medium stream flows average 2-10 cfs/year; Small stream flows average ≤2 cfs/year. Data: ODF n.d., OAR 2015. Subsystems: CR- Coos River, CS- Catching Slough, HI-Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay

**What's happening?**

This data summary describes the information that allows scientists, resource managers, landowners, developers, and other stakeholders to understand the behavior of water in the lower Coos watershed. It also describes the monitoring and modeling which provide users with hydrology-related data, including river and stream discharge, tide information (timing, tide heights, current velocity and direction), and water temperature and salinity patterns (daily/seasonal) in the Coos estuary.

Water Movement in the Coos Estuary

The Coos estuary is the project area's dominant hydrological feature; it is the water body into which all the hydrological elements associated with the lower Coos watershed (e.g., ocean, rivers, streams, groundwater) are either directly or indirectly connected (Figure 1).

Water movement in the Coos estuary is controlled primarily by ocean and fluvial (river) forces, but is also greatly influenced by the estuary's bottom contours (bathymetry), wind direction and speed, and climate-related processes, such as coastal upwelling, El Niño, and Pacific Decadal Oscillation. Each of these controlling factors affects: 1) how well-mixed water salinity and temperatures are between the estuary's surface and deeper waters (vertical mixing); 2) how stratified the estuary is (how often denser waters (high salinity and low temperature) are separated in the estuary's water column from lighter waters (low salinity and high temperature)); 3) what the residence time for estuarine waters is (how long water resides in the estuary or how rapidly it gets flushed out); and 4) how swiftly and in what directions the estuary's tidal and fluvial currents flow.

The timing and duration of these physical conditions largely determine which estuarine plant and animal communities become established in and near the estuary. The status of these estuarine plant and animal communities can greatly influence our local community's commercial and recreational activities.

The Coos estuary changes remarkably with the seasons. For example, the Coos estuary is considered to be vertically well-mixed in the summer and partially mixed in the fall. In the winter the estuary is considered highly stratified; bottom waters, especially in the lower estuary, largely consist of a tidally-driven "salt wedge" separated from fresher surface waters (O'Neill and Sutherland 2015).

A newly developed computer-based hydrodynamic model is helping us understand Coos estuary's water movement patterns. Ultimately, this system could be used to help predict the environmental effects and commercial costs associated with development or conservation proposals associated with the Coos estuary, as well as helping plan for catastrophic coastal hazards such as earthquakes and tsunamis. Dr. David Sutherland, Assistant Professor of Geological Sciences at the University of Oregon, has nearly completed this project as of summer 2015. It is a three-dimensional model of the Coos estuary

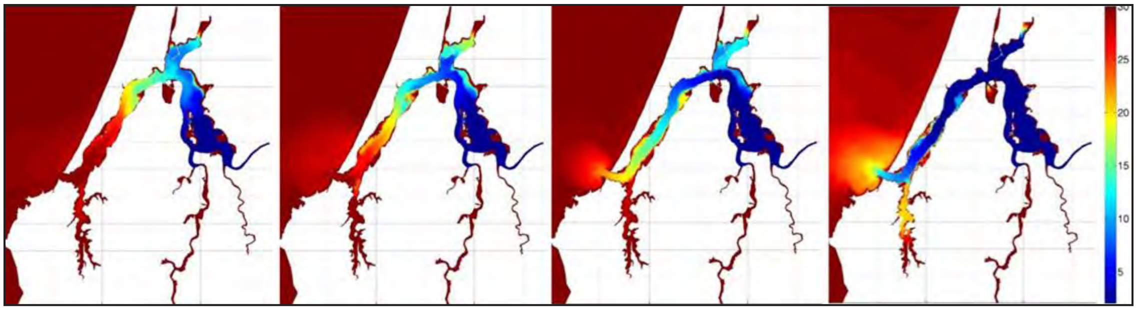


Figure 2. Computer screenshots of the prototype of the Coos estuary hydrodynamic model showing water surface salinity before, during and after a freshwater discharge event. Salinity color legend is shown at right. Sutherland 2013.

(Figure 2), and consists of a high resolution Coos estuary-shaped three-dimensional digital grid into which Dr. Sutherland loads river discharge, surface and bottom water temperature, salinity, tidal current velocity and direction from data loggers deployed in the estuary and local rivers and streams. Modeling software processes these very large data sets so that eventually, the model will be a closely accurate representation of the estuary's year-round behavior, including water circulation and associated attributes (temperature, salinity).

When the model is complete, it could be used to inform local stakeholders' decision making associated with issues local community members have expressed interest in such as: the likely affects of sea level rise on coastal developments; the extent and speed at which spilled oil spreads under different weather and tide conditions; seasonal or long term water quality variations in nearshore ocean and lower estuary waters where hypoxic (low dissolved oxygen) areas persist; Dungeness crab larvae dispersal patterns; the potential effects on commercial oyster cultivation associated with relocating the secondary wastewater treatment plant outfalls elsewhere in the Coos estuary (Sutherland n.d., C. Cornu pers. comm. 2015).

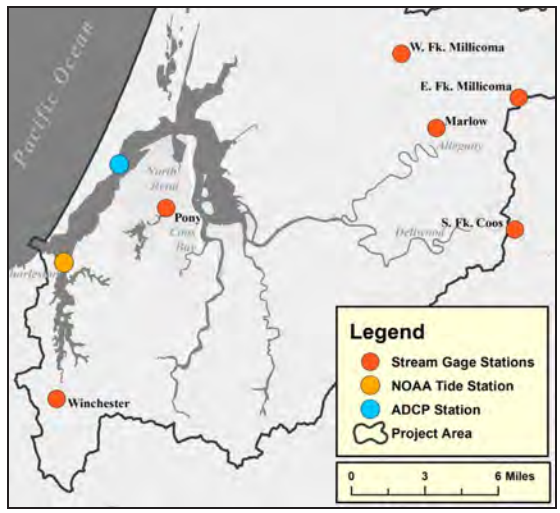



Figure 3. Station locations for the South Slough National Estuarine Research Reserve acoustic Doppler current profiler (ADCP) station, NOAA Charleston Tide Station, and stream gaging stations maintained by Coos Watershed Association.

In 2013-14, South Slough National Estuarine Research Reserve (SSNERR) staff deployed and maintained numerous instruments to help Sutherland validate his Coos estuary hydrodynamic model. They set up water level, temperature, and salinity instruments for one year at various locations in lower and mid-Coos estuar y. They also deployed as an acoustic Doppler current profiler (ADCP) for one year in the lower estuary to collect local

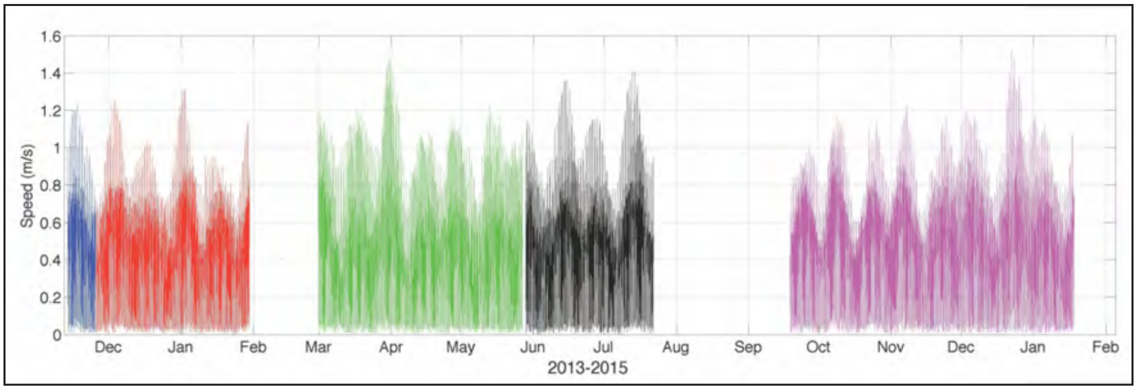



Figure 4. Depth-averaged speed of estuarine water over time. Different colors represent individual deployments of the acoustic Doppler current profiler (ADCP). Figure: Sutherland 2015; Data source: SSNERR 2015.

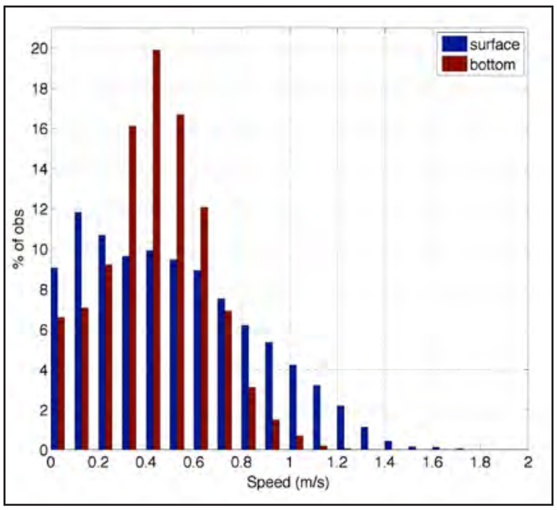



Figure 5. Surface (2 m depth) vs. bottom (8 m depth) speeds as measured by the acoustic Doppler current profiler (ADCP). Figure: Sutherland 2015; Data source: SSNERR 2015.

water current velocity and direction data (Figure 3)(SSNERR 2015). Sutherland has incorporated these usable data into the model. River discharge data, managed by the Coos Watershed Association (CoosWA), were also used to validate the model and are discussed in more detail below.

The ADCP water current velocity data clearly show the cyclical nature of water currents in the Coos estuary (Figure 4). Differences in water surface velocity (at a depth of about 2 m) compared to bottom velocity (at about 8 m) are also apparent (Figure 5). While both surface and bottom currents moved at about the same average velocity (0.5 m/s and 0.45 m/s respectively), data show surface waters moved more often at greater velocities than bottom waters (D. Sutherland pers. comm. 2015). The highest observed surface water velocity was 1.8 m/s, while the highest observed bottom velocity was 1.2 m/s. Velocities in the Coos estuary are strongly linked to rising and falling tides. Therefore, patterns are more closely linked with the lunar cycle than with seasonal changes. Other non-tidal forcings that do have a seasonal component, such as river discharge, also affect velocity; however, these currents are much slower than tidal currents (averaging 0.1 m/s)(D. Sutherland pers. comm. 2015).

*Coos Estuary Bathymetry*

Water movement in the Coos estuary is greatly affected its bottom contours, or bathymetry. Available Coos estuary bathymetry data

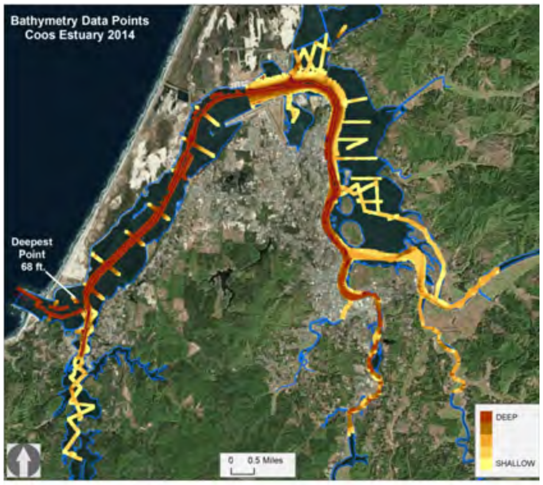



Figure 6. Known bathymetry of the Coos estuary. The estuary boundary is outlined in blue. Data came from regular U.S. Army Corps of Engineer hydrographic surveys, and bathymetry surveying conducted by Oregon State University in 2014. Data Source: USACE 2014; Wood and Ruggiero 2014

come from the United States Army Corps of Engineers (USACE) and Oregon State University (OSU).

USACE surveys indicate that the estuary's average depth is nearly -8.5m (-28 ft) relative to North American Vertical Datum of 1988 (NAVD88); the deepest part of the estuary measures -20.7m (-68 ft) NAVD88 near the mouth of the Coos estuary (Figure 6). It should be noted that because the USACE surveys are designed to characterize the bathymetry of Coos Bay's commercial shipping channel, they focus their efforts on the deeper parts of the estuary (although their surveys extend slightly into shallower regions around the estuary's northern bend). Therefore, USACE's depth averages are likely greater than the actual average depth of the Coos estuary (USACE 2014).

Very little information is available for the shallow portions of the estuary that extend laterally beyond the regularly dredged shipping channel. The information we do have has been provided by OSU scientists, who completed 35 transects across the estuary in 2014 using their Coastal Profiling System. This system pairs high speed personal watercraft with echo sounder and Global Positioning System (GPS) instruments, allowing them to survey shallow parts of the estuary that larger survey vessels are unable to navigate (Figure 7). Their deepest point was similar to USACE's in both location and depth: -20.5 m (-67 ft) NAVD88 near the mouth of the estuary. The shallowest points were -0.9 m NAVD88. The average depth of all their survey points (both channel and shallow data) was -3.9 m (-12.8 ft) NAVD88.

*Tidal Influences*

Tides affect Coos estuary hydrology as far into the project area as Allegany on the Millicoma River, and near Dellwood on the South Fork Coos River. In the northeast portion of the Coos estuary, most major "heads of tide" (the


Figure 7. Oregon State University's Coastal Profiling System set-up, which allows access to shallow sections of the estuary. Source: Wood and Ruggiero 2014

transition zone between tidal and non-tidal waters) end at tide gates (Figure 8)(DSL 2014). The exact location of heads of tide can vary. Wind-driven storm surges and heavy precipitation (high river stage) can affect the upper reaches of the tide's influence.

The Coos estuary is subject to mixed semi-diurnal tides (i.e., two unequal low and two unequal high tides per day). The maximum observed tide at NOAA's Charleston station, near the mouth of the Coos estuary, was in January 1983 at 3.408 m (11.7 ft) above mean lower low water (MLLW)(Figure 3) (NOAA 2015b). For comparison, the average of all higher high tides is 2.323 m (7.62 ft) relative to MLLW. The minimum observed tide of -0.941 m (-3.01 ft) relative to MLLW occurred in May 2003. The mean tide range at the Charleston station (i.e., difference in height between mean high water and mean low water) is 1.7 m (5.7 ft). The mean diurnal tide range (i.e., difference in height between mean higher high water [MHHW] and MLLW) is 2.3 m (7.6 ft)(NOAA 2015b). Tide range decreases the greater the distance from the mouth of the estuary. In the upper Coos estuary, mean diurnal tide range is approximately 10 cm smaller (2.2 m) than the mean diurnal tide range at Charleston (Rumrill 2008).

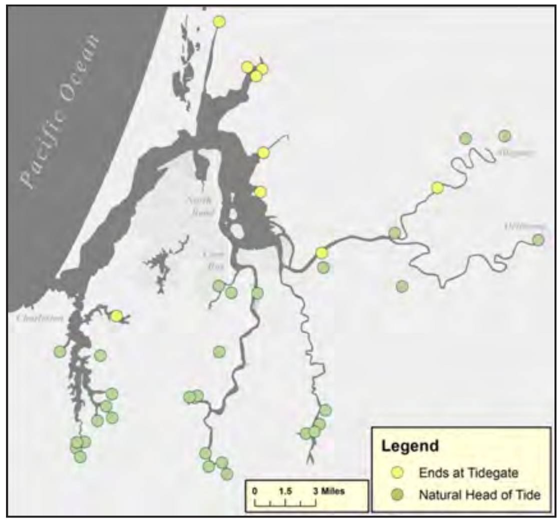



Figure 8. Approximate major head of tide locations for the Coos estuary. It should be noted that these approximate locations were identified using distinctively qualitative methods: e.g., "best professional judgment" observations from single site visits or recollections of local landowners. Data: DSL 2014.

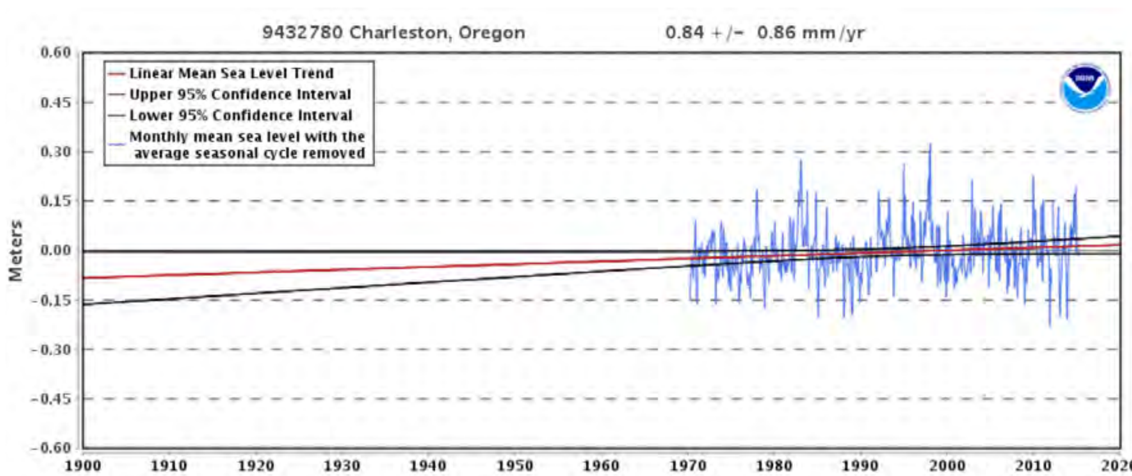



Figure 9. Monthly mean sea level trend at NOAA's Charleston, OR tide station from 1970 to 2014. Seasonal fluctuations due to coastal water temperatures, salinities, winds, atmospheric pressures and ocean currents are removed. Source: NOAA 2015

As mentioned previously with respect to heads of tide, tidal range varies depending on oceanographic conditions. Strong southerly winds can cause lower than expected tides, while strong summer winds can cause higher than predicted tides (Rumrill 2008). Changes in sea level also affect tidal range. Mean tidal height (i.e., sea level), as measured at NOAA's Charleston station, (located at the mouth of the South Slough near the ocean) has risen since 1970 at an average rate of 0.84 mm/yr (0.03 inches/yr)(Figure 9)(NOAA 2015b). This rate is equivalent to a 0.27 ft (3.3 inches) increase in 100 years. The rate of sea level rise is expected to accelerate due to climate-related changes, including thermal expansion caused by the warming of the oceans and melting of land ice (e.g., glaciers, continental ice sheets)(OCCRI 2010).

Both sea level and tidal action also greatly influence the residence time of water in the Coos estuary. Residence time is an indicator of an estuary's status. Short residence times indicate well-flushed estuaries which tend to be more resilient to circumstances affecting water quality (e.g., point and non-point source pollution including excessive nutrient inputs) than those less well-flushed estuaries. Arneson (1976) calculated flushing times for the Coos estuary and, unsurprisingly, found that residence times in different parts of the estuary was highly dependent on: 1) distance from the mouth; 2) river discharge; and 3) tidal range. For example, it took approximately 6 days for water to flush from the Coos estuary at river mile 7.6 (near North Bend) during high river flow and relatively high tidal range, while this same task took 19 days during low flow/tidal range. On average, 31% of the water (at MHW) drains from the Coos estuary during the ebb tide, highlighting the tide's dominant role in flushing the Coos estuary (NOAA 1985 as cited in Hicky and Banas 2003). This tidal prism (volume of water that leaves an estuary during ebb tide) is considered large. It is markedly different from estuarine systems on the East Coast, but smaller than many other Pacific Northwest estuaries. For example, Narrangansett Bay, a large estuary in Rhode Island, has a tidal prism of 10%, while similarly sized Willipa Bay (WA) has a tital prism volume of 50% (NOAA 1985 as cited in Hicky and Banas 2003).

Coastal Upwelling

An important spring and summertime phenomenon, coastal upwelling occurs when strong north winds push surface ocean waters offshore, allowing colder, nutrient-rich bottom waters to rise to the surface (Figure 10). The timing and duration of upwelling events has been linked to Dungeness crab production and abundance of returning adult salmon (NWFSC 2015).

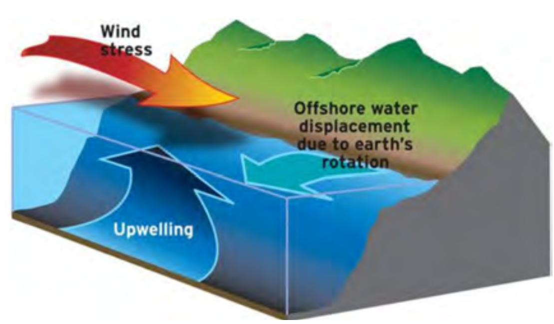



Figure 10. Depiction of coastal upwelling forces along Oregon's coast. Source: NWFSC 2015.

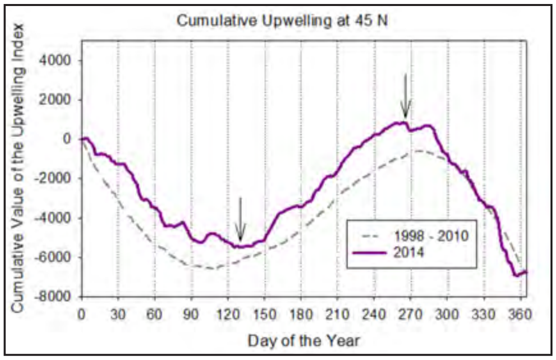



Figure 11. Cumulative upwelling plot for the Pacific Northwest (45°N) in 2014. Upwelling events occur between the days designated by the two arrows (spring transition: early May; fall transition: mid-October). Cumulative upwelling plots add the amount of upwelling ($m^3$/s per 100 m coastline) on day 1 (January 1st) to that of day 2, and so on. Thus, days with upwelling move the curve up while days with downwelling move the curve down. Source: NWFSC 2015.

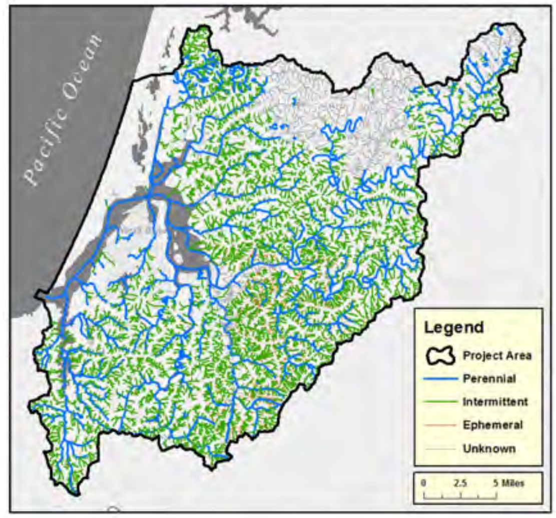



Figure 12. Location of stream types in the project area. Data: ODF n.d.

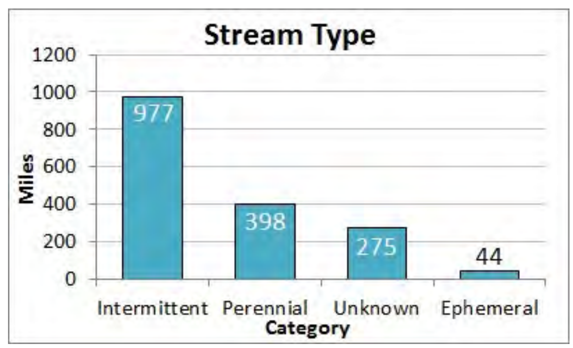



Figure 13. Miles of streams in the project area categorized by duration; intermittent streams hold water in the wet season, perennial streams flow year round, and ephemeral streams only hold water immediately following rain events. Data: ODF n.d.

NOAA's Northwest Fisheries Science Center (NWFSC 2015) provides the most up-to-date information on upwelling patterns along the Pacific Northwest coast and calculates upwelling indices using data that measure the strength and direction of surface wind stress. Their most recent cumulative upwelling index quantifies the late start date (spring transition) and early end date (fall transition) for 2014 upwelling events. Generally, the earlier the start date for the spring transition, the higher the primary productivity will be that year (allowing for higher oceanic salmon survival). The average date of spring transition is April 13th (103rd day of the year). Despite the later than average spring transition, total upwelling for 2014 was normal (6,326 $m^3$/s per 100 m coastline) when compared to the 40-year average (6,163 $m^3$/s per 100 m coastline)(Figure 11). No data are available describing the status and trends of Coos estuary or south coast Oregon upwelling.

Downwelling is the reverse process, in which strong south winds push warm, nutrient-poor surface waters closer to shore. It results in poor primary production and occurs during the winter season.

<u>Freshwater Input</u>

There are approximately 1,700 miles of rivers and streams in the project area (Figure 1) (ODF n.d.). Nearly 1,000 miles are intermittent streams (streams that only flow part of the year), providing highly seasonal sources

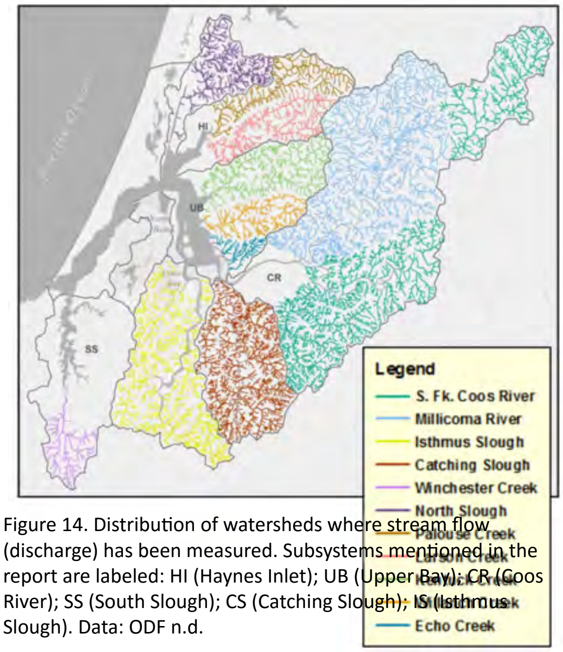



Figure 14. Distribution of watersheds where stream flow (discharge) has been measured. Subsystems mentioned in the report are labeled: HI (Haynes Inlet); UB (Upper Bay); CR (Coos River); SS (South Slough); CS (Catching Slough); IS (Isthmus Slough). Data: ODF n.d.

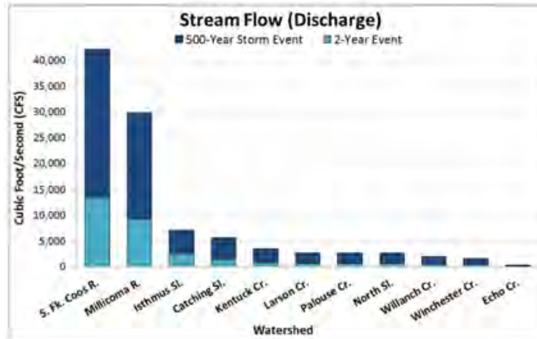



Figure 15. Estimated annual peak stream flows for bank full (i.e., two year) and 500-year storm events for several tributaries to the Coos estuary. Data source: CoosWA 2006, 2008, 2011; USGS 2015.

of freshwater to the estuary (Figures 12 and 13). Approximately 400 miles are perennial rivers and streams (flowing year-round). Nearly all seasonal variations in river and stream flow come from rainfall; snowmelt plays almost no role in project area hydrology (Hickey and Banas 2003).

Historical estimates of total freshwater flow at the mouth of the Coos estuary have been made using extrapolations of the Millicoma River streamflow data collected by the United States Geological Survey (USGS)(1955-1981). Using these data, Percy and colleagues (1974) reported that on average about 2.2 million acre-feet of freshwater are discharged annually (Percy et al. 1974).

CoosWA currently collects stream discharge data from gauging stations on six lower Coos watershed rivers and streams (Figure 3). These data helped the CoosWA assess 10 Coos estuary tributaries in support of their watershed restoration programs (CoosWA 2006, 2008, 2011). Tributaries assessed were: North Slough, Palouse and Larson Sloughs (in the Haynes Inlet subsystem); Kentuck and Willanch Sloughs, and Echo Creek (in the Upper Bay subsystem); Millicoma and South Fork Coos Rivers (in the Coos River subsystem); and Catching and Isthmus Sloughs (Catching Slough and Isthmus Slough subsystems)(Figure 14). Stream discharge data for Winchester Creek in the South Slough subsystem are also included (USGS 2015).

These data confirm the South Fork Coos and Millicoma Rivers as the principle freshwater contributors to the Coos estuary. South Fork Coos and Millicoma River discharge estimates for a two-year storm event are 13,500 and 9,330 cubic feet per second (cfs) respectively (Figure 15). During a 500-yr storm, estimated river discharge reaches 42,200 and 29,800 cfs respectively. Echo Creek, the smallest tributary to the Coos estuary assessed releases 69 cfs of water during a two-year storm event and 310 cfs of water during a 500-year event.

**Background**

Bathymetry

Bathymetry data are required for many commercial and recreational activities associated with navigating, understanding and managing estuaries. These activities include developing navigation charts, hazards mapping, classifying habitats and estuary use zones, and hydrodynamic modeling. In addition, bathymetry data collected from both the nearshore ocean and the estuary help scientists model the effects of potential tsunamis and sea level rise.

As mentioned, UO's hydrodynamic model for the Coos estuary, a tool which will ultimately be useful in many of the applications described above, is validated using field data (e.g., stream discharge, water temperature and salinity, wind speed and direction, water current speed and direction). For an accurate working model to be created, those data need to be used with precise, complete bathymetry data set that very closely characterize Coos estuary's bottom contours.

Tidal Influences

Pacific ocean tides directly and indirectly affect human communities living around the Coos estuary. Local communities have long built and maintained sea walls, tide gates, jetties and other shoreline structures designed to withstand the largest expected tidal surges. Ships plan port arrivals and departures, and navigate through estuaries and coastal waters, based on their knowledge of tides and currents. Tides influence the design of habitat restoration projects. Fishermen know that various commercial and recreational fish species concentrate, migrate through, or spawn in different parts of the estuary depending on many factors, including the timing and magnitude of tidal fluctuations associated with those habitats (NOAA 2014). High tides during storms can exacerbate the erosion of beaches and sand dunes, or re-position the stream outlets blocked by drifting sands. Tidally-driven estuarine flushing rates are important for understanding how long pollutants will remain in the estuary (Arneson 1976).

Tidal exchange plays an important role in distributing macronutrients throughout the estuary; these nutrients maintain estuarine productivity and influence the structure and well-being of marine and estuarine communities, especially during upwelling events. In a study of Washington and Oregon's outer coast estuaries, Hickey and Banas (2003) examined various factors that influence estuarine productivity, including nutrient sources (i.e., whether riverine or marine), currents and upwelling patterns, the difference in area and bathymetry of the continental shelf off Oregon and Washington, and estuarine tidal regimes. They found that cold, nutrient rich water upwelling from off the continental shelf and carried into the estuaries by tides is the principal source of nutrients for estuaries of the Pacific Northwest coast. This is in stark contrast to the large, eastern seaboard estuaries such as Chesapeake or Delaware Bays, where large rivers deliver the bulk of nutrients to the estuaries. By comparison, even the largest outer coast estuaries in the Pacific

Northwest (e.g., Coos estuary, Grey's Harbor, Willapa Bay) are small enough to be thought of as extensions of the coastal ocean.

Coastal Upwelling

NOAA's NWFSC (2015) provides the following information on coastal upwelling along the Pacific Northwest coast, which is one of the world's major upwelling coasts:

The Coos estuary is greatly influenced by coastal upwelling. The strength of upwelling is moderated by recurring variations in hemispheric ocean and climate conditions such as the Pacific Decadal Oscillation (PDO). PDO conditions shift between cool and warm phases every 20-30 years. Strong upwelling tends to occur during the cool phases, while during warm phases upwelling is less intense. Since NOAA's Pacific Fisheries Environmental Laboratory began collecting data in 1947, the strongest Pacific coast upwelling events were recorded in 1965-67 (the corresponding cool phase lasted from 1947 to 1976). The last significant warm phase occurred from 1976-1997; in 13 of those years, upwelling was unusually weak.

Normally, upwelling brings nutrient-rich water to the surface, and that, in turn, fuels the productivity that supports life in the upper layers of the ocean. For example, Gunsolus (1978) and Nickelson (1986) first showed a predictable relationship between upwelling and the survival of Coho salmon (*Oncorhynchus kisutch*).

However, other hemispheric ocean and climate processes, such as El Niño, can adversely affect upwelling. During El Niño events, unusually warm water appears off the coast of South America, affecting regional ocean and climate conditions. Scientists initially thought El Niño to be a local effect. Now with its cool-water counterpart, La Niña, El Niño is a recognized part of a large, global climate system known as the El Niño-Southern Oscillation (southern oscillation refers to a shifting of surface air pressure between the western and eastern parts of the Pacific Ocean). A strong El Niño may affect weather and climate around the Pacific ocean, including the occasional appearance of unusually warm water off the Oregon coast at times when upwelling is occurring (NOAA 2015a). During the strong 1998 El Niño, upwelling was relatively robust, yet plankton production was weak, which greatly affected Pacific coast biological communities. This phenomenon occurred because the deep, cold nutrient-rich waters that typically rise to the ocean surface were replaced during the El Niño event by warmer, nutrient-poor water (NOAA 2005).

Freshwater Input

Freshwater inputs to the Coos estuary are affected by watershed conditions. When land is modified (e.g., timber harvests, agricultural practices, road construction, development) watershed hydrology can be affected to varying degrees depending on land modification scale and methods, watershed geology, soil types, vegetation cover, topography, and runoff rates (CoosWA 2006). Contemporary land modification/management practices are designed to minimize negative impacts to watershed hydrology and other important natural processes.

Among the concerns of land owners and resource managers alike are storm-related increases in peak stream and river flows exacerbated by poor land management practices. The primary factor determining peak stream flow is the ability of watershed soils to absorb rainfall, which in turn depends on the management of vegetative cover, land uses, the characteristics of the soil (CoosWA 2006) and the amount and duration of rainfall. Increases in runoff can result in loss of property, vegetation and wildlife habitat, flooding, erosion and landslides (CoosWA 2006, DOGAMI 2008).

Additional information about landslides can be found in this chapter's Geology Data Summary.

**References**

Arneson, R. J. 1976. Seasonal Variations in Tidal Dynamics, Water Quality, and Sediments in the Coos Bay Estuary. Thesis (M.Oc.E.) – Oregon State University, Corvallis.

Coos Watershed Association (CoosWA). 2006. Coos Bay Lowland Assessment and Restoration Plan. Coos Watershed Association, Charleston, Oregon, pp. 47, 70, 93.

Coos Watershed Association (CoosWA). 2008. Catching Slough, Daniel's Creek and Heads of Tide Sub-basin Assessment and Restoration Opportunities. Coos Watershed Association, Charleston, Oregon. 144 pp.

Coos Watershed Association (CoosWA). 2011. Isthmus and Coalbank Slough Sub-basin Assessment and Restoration Opportunities. Coos Watershed Association, Charleston, Oregon. 99 pp.

Gunsolus, R. T. 1978. The status of Oregon Coho and recommendations for managing the production, harvest, and escapement of wild and hatchery reared stocks. Oreg. Dep. Fish Wildl. Fish Div. Proc. Rep., Portland, OR. 59p.

Hickey, B. M. and N. S. Banas. 2003. Oceanography of the U.S. Pacific Northwest Coastal Ocean and Estuaries with Application to Coastal Ecology. Estuaries, 26(4): 1010-1031.

National Oceanic and Atmospheric Administration (NOAA). 1985. National Estuarine Inventory Data Atlas. Strategic Assessment Branch, Ocean Assessments Division, Office of Oceanography and Marine Assessment, National Ocean Service, Rockville, Maryland.

National Oceanic and Atmospheric Administration (NOAA). 2005. Climate Prediction Center. Accessed 11 May, 2015: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/enso_schem.shtml

National Oceanographic and Atmospheric Administration (NOAA). 2014. National Ocean Service: Why do we study tides? Accessed 11 May, 2015: http://oceanservice.noaa.gov/facts/tidestudy.html

National Oceanic and Atmospheric Administration (NOAA). 2015a. El Niño Portal. Accessed 11 May, 2015: http://www.elnino.noaa.gov

National Oceanographic and Atmospheric Administration (NOAA). 2015b. Tides and Currents, [Mean Sea Level Trend for station 9432780 Charleston, Oregon], accessed 8 May 2015: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

Nickelson, T. E. 1986. Influences of upwelling, ocean temperature, and smolt abundance on marine survival of Coho salmon (*Oncorhynchus kisutch*) in the Oregon Productio Area.

Can. J. Fish. Aquat. Sci. 43: 527-535.

Northwest Fisheries Science Center (NWFSC). 2015. Coastal Upwelling, viewed 8 May 2015: http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/db-coastal-upwelling-index.cfm

O'Neill, M. and D. Sutherland. 2015. "Hydrographic and Dissolved Oxygen Variability in a Seasonal Pacific Northwest Estuary." Manuscript submitted for publication. Accessed 8 June 2015: http://pages.uoregon.edu/dsuth/student_pics/molly/MollyONeill_CoosBay_new.pdf

Oregon Administrative Rules (OAR). 2015. Department of Forestry: OAR 629-635. Accessed 30 June 2015: http://arcweb.sos.state.or.us/pages/rules/oars_600/oar_629/629_635.html

Oregon Climate Change Research Institute (OCCRI). 2010. Oregon Climate Assessment Report. K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Oregon Department of Forestry (ODF). n.d. GIS Data Export, accessed 11 May 2015: http://www.oregon.gov/odf/Pages/gis/GISDataExport.aspx

Oregon Department of Geology and Mineral Industries (DOGAMI). 2008. Landslide Hazards in Oregon. Accessed online 11 May 2015: http://www.oregongeology.org/sub/publications/landslide-factsheet.pdf

Oregon Department of State Lands (DSL). 2014. Digitized revision of: DSL. 1989. Heads of Tide for Coastal Streams in Oregon.

Percy, K. L., D. A. Bella, C. Sutterlin, and P. C. Klingeman. 1974. Descriptions and information sources for Oregon estuaries. Sea Grant College Program, Oregon State University, Corvallis, Oregon.

Rumrill, S. 2006. Ecology of the South Slough Estuary: Site profile of the South Slough National Estuarine Research Reserve. South Slough National Estuarine Research Reserve 259 pp.

South Slough National Estuarine Research Reserve (SSNERR). 2015. [ADCP data 2013-2015]. Unpublished data.

Sutherland, D. 2013. [Screenshots of initial surface-salinity hydrodynamic runs]. Unpublished data.

Sutherland, D. 2015. [Plots of ADCP data]. Unpublished data.

Sutherland, D. (n.d.) Coastal and Estuarine Physical Oceanography. Accessed 11 May 2015: http://pages.uoregon.edu/dsuth/

United States Army Corps of Engineers (USACE). 2014. Hydrographic Surveys, accessed 8 May 2015: http://www.nwp.usace.army.mil/Missions/Navigation/Surveys.aspx

United States Geological Survey (USGS). 2015. The StreamStats program for Oregon. Accessed 20 May, 2015: http://water.usgs.gov/osw/streamstats/oregon.html

Wood, J. and P. Ruggiero. 2014. 2014 Estuarine Bathymetry Data Collection, Analysis, and Archiving at Coos Bay, OR. Oregon State University, Newport, Oregon.

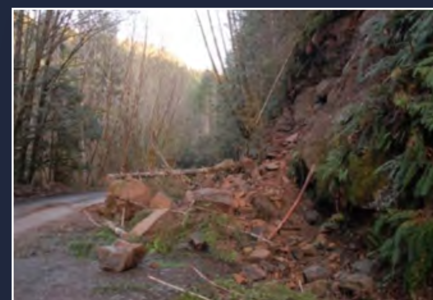
# Geology of the Coos Estuary and Lower Coos Watershed

CLW DATA SOURCE

*Summary:*


- *Tectonic interactions between the Pacific, Gorda, Juan de Fuca, and North American plates, and the Juan de Fuca and Gorda oceanic ridges are the source of incremental , long-term coastal uplift and infrequent earthquakes when coastal lands suddenly subside.*

- *Tectonic processes, along with long-term cyclical changes in climate and related glacial spread and retreat, have created the bedrock and soil formations found in the project area.*

Landslide along the Smith River in the Oregon coast range.

Local geologic formations are revealed at Coos Head.

**What's happening?**

This summary describes local geology (e.g., soil and bedrock types), in the context of larger geological processes (e.g., plate tectonics) in four sections:

1. Plate Tectonics – which examines interactions between continental plates, faults, and folds, as well as earthquakes and tsunamis affecting the project area;
2. Geologic Formations – which describes the project area's geologic formations, superficial deposits, and geologic age;
3. Soils – which provides information on soil types within the project area; and
4. Landslides – which describes areas within the project area most at risk for landslides and debris flows.

These four sections are followed by a Background section which provides more in-depth information for each of the sections in this data summary.

## Plate Tectonics

Plate Movement: The underlying geology of the Coos estuary and surrounding watershed results from the tectonic interactions between the Pacific, Gorda, Juan de Fuca, and North American (i.e., North American continent) tectonic plates, and oceanic spreading from two ridges (Juan de Fuca and Gorda) (Figure 1)(see also Geology Terminology sidebar). Large-scale plate movements (e.g., slip of the Juan de Fuca plate along the Blanco Transform Fault, and subduction of the Juan de Fuca plate beneath the North American plate) have been coupled with localized sea floor spreading along two ridges: the Gorda Ridge at a rate of 2.3-5.5 cm (0.9-2.2 in) per year, and the Juan de Fuca Ridge at a rate of 4.0 cm (1.6 in) per year (Komar 1997; Clague 1997). Along the Oregon coast, pressure from these tectonic movements of the earth's crust have resulted in the folded and warped outer continental shelf margin and cycles of long-term, incremental uplift of the coastal lands followed by rapid subsidence events (i.e., earthquakes)(Rumrill 2006).

Stratigraphic (i.e., study of rock layers) investigations of rock outcroppings by Nelson et al. (1996, 1998) and analysis of the composition and age of buried microfossils indicate that the South Slough tidal basin has undergone catastrophic subsidence of 0.50-1.0 m (1.64-3.28 ft) at least three times over the past 4,000 years, and possibly as many as nine times.

### *Geology Terminology*

*Tectonic Plate – The rigid outermost shell of the planet (crust and upper mantle), is broken into major (e.g., continental plates) and minor tectonic "plates".*

*Ocean Ridge – Underwater mountain range formed by rising magma in a zone on the ocean floor where two tectonic plates are moving apart.*

*Subduction Zone – An area where two tectonic plates converge causing one plate to slide beneath the other.*

*Cascadia Subduction Zone – The area where the Juan de Fuca Plate slides beneath the North American Plate.*

*Faults – Fractures in the earth's crust caused by compression, tensional, or shearing forces, often associated with the boundaries between tectonic plates.*

*Slip or Strike-slip Fault – Vertical fractures in the earth's crust where the blocks of land have mostly moved horizontally.*

*Paleoseismic Faults – Faults that were the source of significant earthquakes (magnitude 6.0 or greater) in the past 1.6 million years*

*Sources: USGS 2014a; DOGAMI 2009; PNSN n.d.*

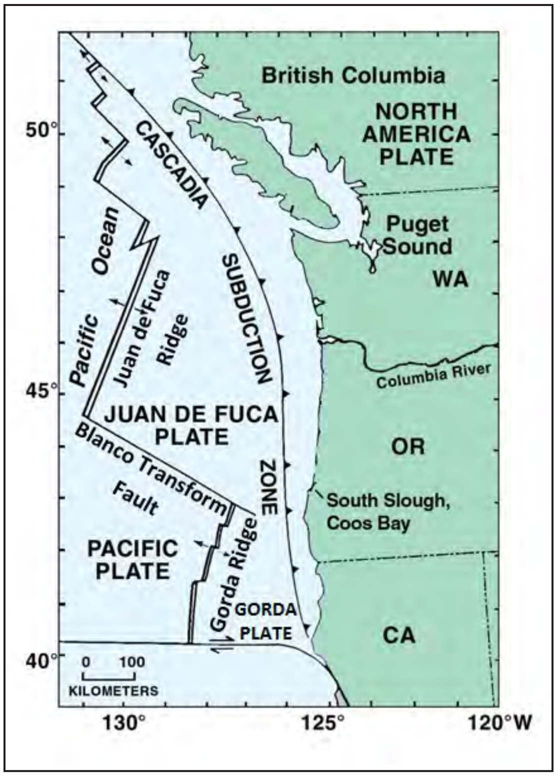



Figure 1: Tectonic components (ridges and plates) in the Pacific Northwest. Arrows on ridges indicate direction of spread. Cascadia Subduction Zone is where the Juan de Fuca Plate is pushed under the North American Plate. Amended from Rumrill 2006

<u>Faults and Folds</u>: The chief geological feature of the Coos estuary is the South Slough Syncline, which is an asymmetric fold with steep sandstone and shale on its western side and gently sloping marine terraces on its eastern side, all of which are offset by several minor cross faults (Rumrill 2006; McInelly and Kelsey 1990)(Figure 2). According to Rumrill (2006), “South Slough marks the point where the Cascadia fold and thrust belt comes onshore; north of Coos Bay most compressional structures occur offshore on the continental shelf and slope”.

Paleoseismic faults in the project area – or faults that were the source of significant earthquakes (magnitude 6.0 or greater) in the past 1.6 million years – were found almost exclusively in the South Slough subsystem (Figure 2). Similarly, nearly all non-paleoseismic faults and folds in the project area are found

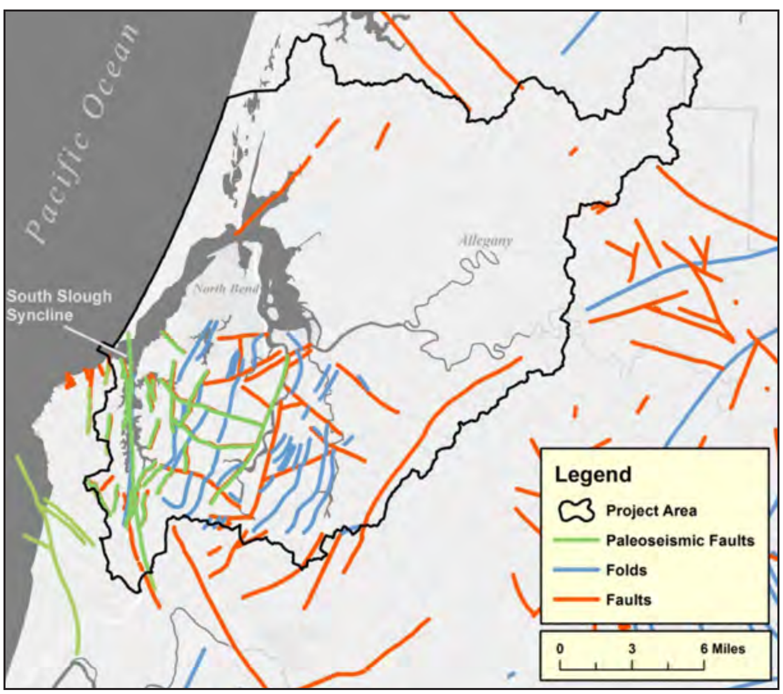



Figure 2: Faults and folds occurring within project boundaries. Paleoseismic faults are highlighted, designating faults that were the source of significant earthquake (6.0 or greater) in the past 1.6 million years. Data: USGS 2005; DOGAMI 2009.

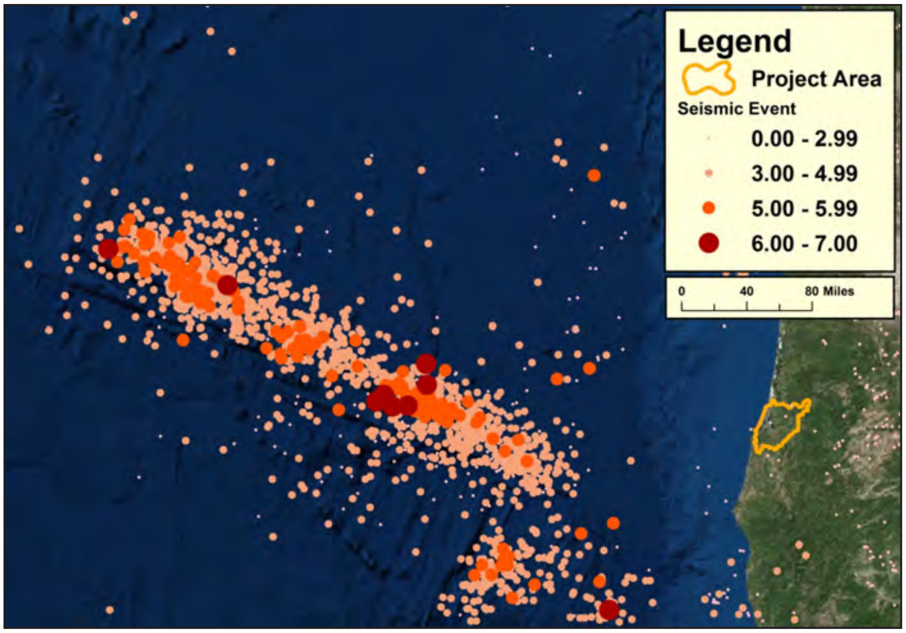



Figure 3: Seismic events between 1969 and 2015.
Data USGS 2015

| Year | Month | Magnitude | Depth | Latitude | Longitude |
|---|---|---|---|---|---|
| 1991 | July | 6.9 | 11 | 42.182 | -125.641 |
| 1985 | March | 6.5 | 10 | 43.51 | -127.561 |
| 2008 | January | 6.3 | 13 | 43.785 | -127.264 |
| 2003 | January | 6.3 | 10 | 44.284 | -129.024 |
| 1994 | October | 6.3 | 20 | 43.515 | -127.427 |
| 2000 | June | 6.2 | 10 | 44.513 | -130.081 |
| 1981 | November | 6.2 | 10 | 43.542 | -127.706 |
| 2000 | January | 6.1 | 10 | 43.649 | -127.257 |
| 2012 | April | 6.0 | 8 | 43.584 | -127.638 |

Table 1: Seismic events (between 1969 and 2015) with magnitudes 6.0 or higher. Depth is kilometers below the earth's surface. Data USGS 2015

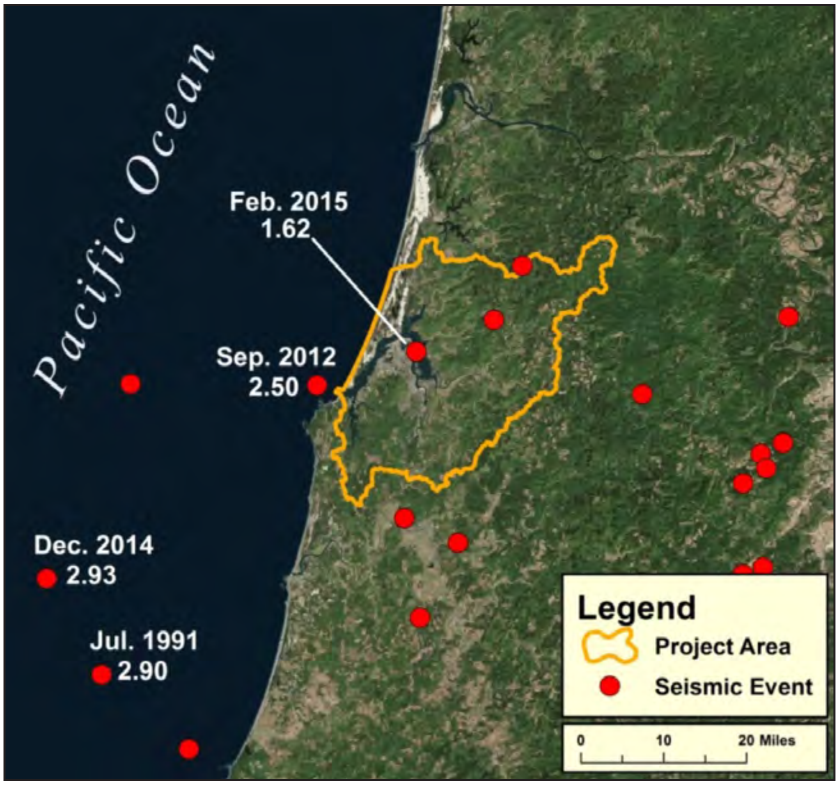



Figure 4: Seismic events (occurring between 1969 and 2015) closest in proximity to the project area. Dates and strength of the highest magnitude events are labeled. Data USGS 2015

in its southern portions (i.e., South, Isthmus and Catching Slough subsystems).

Earthquakes and Tsunamis: Of the over 2,100 earthquakes measured off the Oregon coast since 1965, only nine have been a magnitude 6.0 or higher (Figure 3). The strongest of these (magnitude 6.9) occurred in July 1991 (Table 1). The average magnitude of all earthquakes during that time period was 3.5 and the average depth was 10.7 km (6.6 mi) below the earth's surface. Many earthquakes were concentrated around the Blanco Transform Fault. In contrast, only a few earthquake events were located in close proximity to the project area and those were much smaller in magnitude during the same time period (Figure 4). The largest of these closer proximity earthquakes (2.5 magnitude) occurred just off Cape Arago in September 2012.

Stratigraphic investigations conducted over the past few decades have provided evidence that much of the Pacific Northwest coast has experienced significant (magnitude greater than 8) Cascadia megathrust earthquakes and accompanying tsunamis repeatedly over the past 5,500-6,500 years. These earthquakes occurred every 500-600 years on average (varying from a few hundred years to almost 1,000 years)(Kelsey et al. 2002; Witter et al. 2003). For example, soil cores provide evidence for historically reoccurring rapid coastal subsidence events. Cores taken from current-day tidal marshes in the project area show ancient marsh soils (full of organic materials such as march plant roots) abruptly buried by fine intertidal mud when the coastal land mass rapidly subsided during historic earthquakes. Often these abrupt transitions in the soil  cores include a coarse sandy layer full of woody debris deposited during earthquake-generated tsunamis.

The most recent Cascadia megathrust earthquake (magnitude 9) and tsunami on the Oregon coast (including the Coos estuary) occurred on January 29, 1700, caused by a sudden slip of the Juan de Fuca plate beneath the North America plate along the 1,000 km (621 mi) long Cascadia subduction zone (Satake et al. 1996; Rumrill 2006). This caused the land mass to subside an estimated 0.6 m (2.0 ft) (Leonard et al. 2004). Estimates of subsidence from future mega-thrust earthquakes in Coos Bay range from 0-1.5 m (0-4.9 ft) (Leonard et al. 2004) while maximum subsidence, modeled for this area, could be as high as 2 m (7 ft)(Witter et al. 2011). According to Rumrill (2006), "the probability of a future earthquake and coastal subsidence event is conservatively estimated at 10-20% within the next 50 years (or 20-40% within the next 100 years)".

Lately, seismic activity along the subduction zone appears to have fallen off, leaving the zone "eerily quiet" (Banse 2014). Quoted in several northwest media outlets in December, 2014, Doug Toomey, a geophysics professor at the University of Oregon, said, "all of Cascadia is quiet. It's extraordinarily quiet when you compare it to other subduction zones globally" (Banse 2014). In 2011, Toomey and other scientists began the Cascadia Initiative, a four-year study in which seismometers were deployed at 160 sites along the entire Cascadia subduction zone to help determine what that silence means. If they find the boundary between the two plates is fully locked, pressure will continue to build until another serious earthquake occurs. "If it is completely locked, it means [the Cascadia subduction zone] is increasingly storing energy and that has to be released at some point." (Toomey, on Banse 2014).

**Geologic Formations and Deposits**

Tyee and Coaledo formations make up the vast majority of the underlying bedrock in the project area (71% combined)(Figure 5). Both formations are sandstones with minor siltstone embedded within (Beaulieu and Hughes 1975)(see definitions in sidebars and in Table 2). Landforms surrounding most of the South Slough shoreline and eastern portions of the lower bay are composed primarily of marine terrace deposits (Figure 5). The remainder of the lower bay is made up of eolian deposits (wind-generated deposits: in this case, dune sand) and beach deposits, while alluvial deposits (river-formed) are found under and along each major tributary to the Coos estuary. Man-made fill deposits can be found under most of the project area's low-lying urban centers.

The Coos Bay Coal Field (oriented north to south and roughly 30 mi long by 12 mi wide, overlaps the Coaledo formation), lies under North Bend, Coos Bay, Isthmus Slough and Catching Slough (and their tributaries), and the Lower Coos River, and extends down to the Coquille River (DOGAMI n.d.)(Figure 5). From the late nineteenth century through the mid-twentieth century extensive coal mining and geologic testing occurred in the Coos

### *Geologic Formation*

*A geological formation is a rock unit that is distinctive enough in appearance that a geologic mapper can tell it apart from the surrounding rock layers. It must also be thick enough and extensive enough to plot on a map.*

*Source: Wilkerson 2001*

### *Geologic Deposits*

*Geologic deposits (superficial) are recent (quaternary: 2.6 million years old or less) unconsolidated sediments, soil or rocks added to a landform, generally named according to their origin (e.g., beach deposit, landslide deposit). Older deposits are referred to as bedrock.*

*Source: Wikipedia 2015b*

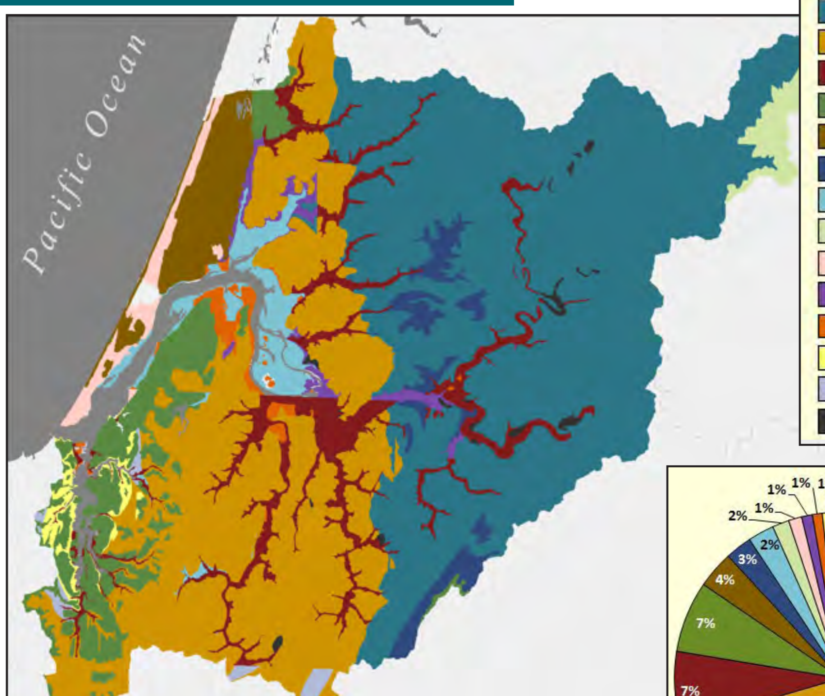
### *Sandstone*

*Sandstone (sometimes known as arenite) is a medium-grained sedimentary rock composed primarily of minerals or rock grains cemented together.*

### *Siltstone*

*Siltstone is sedimentary rock made up of cemented together silt particles, similar to shale, but does not demonstrate fissility (breaking along planes into sheets).*

*Source: USGS 2014b*



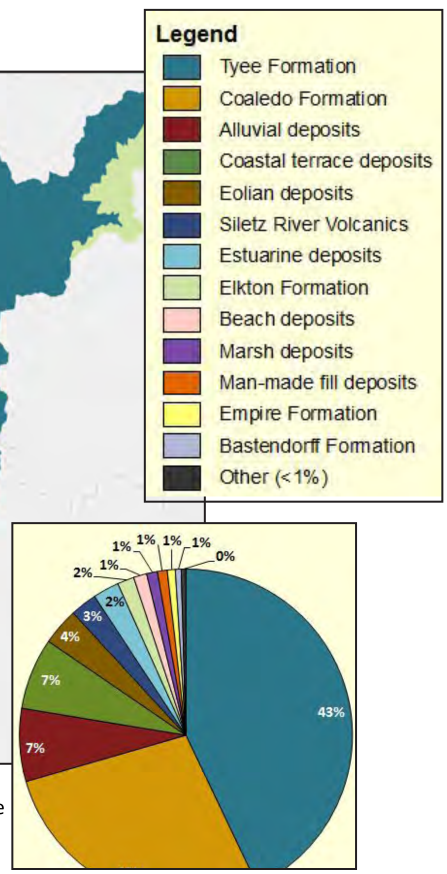




Figure 5. Spatial distribution of geological formations and deposits within the project area. Inset pie chart shows percentage of each formation/deposit in the project area. The category "Other (<1%)" includes terrace and landslide deposits. The Coos Bay Coal Field overlaps the Coaledo formation within the project area, but the coal field is not shown in its entirety. Data: DOGAMI 2009

| Geologic Unit | Bedrock Description | Age | Structure |
|---|---|---|---|
| **Alluvial deposits** | Silt, sand, and gravel filling channels of present day streams/rivers. | Quaternary | |
| **Bastendorff Formation** | 3,000 ft of shale and siltstone with thin (50') sandstone | Late Eocene | Major synclines |
| **Beach deposits** | Fine-grained sand | Holocene-present | |
| **Coaledo Formation** | Coarse to fine-grained cross-bedded, deltaic sandstone and minor siltstone | Late Eocene | Moderately to tightly folded with steep dips |
| **Coastal terrace deposits** | Compact, horizontally bedded, deeply weathered silt, sand and clay | Quaternary | |
| **Elkton Formation** | Thousands of feet of clayey siltstone with minor beds of | Mid-Eocene | Gently folded and |
| **Empire Formation** | Thick sandstone beds with very minor quantities of siltstone | Pliocene | Gently dipping folds |
| **Eolian deposits** | Fine-grained sand | variable | |
| **Estuarine deposits** | Horizontally bedded sand, silt, and clay, rich in organic material | Holocene-present | |
| **Landslide deposits*** | Unstratified mixture of bedrock fragments | Holocene | |
| **Man-made fill deposits** | Dredge spoils, sand, silt, clay, woodchips | <100 years | |
| **Marsh deposits** | Horizontally bedded sand, silt, and clay, rich in organic material | Holocene-present | |
| **Siletz River volcanics*** | Basaltic pillow lava flows composed of basaltic siltstone, sandstone, tuff and conglomerate. Originated from oceanic crust. | Eocene | |
| **Terrace deposits** | Sand, silt, clay gravel, cross-bedded | Quaternary | |
| **Tyee Formation** | Thousands of feet of thick-bedded sandstone and minor rhythmically bedded siltsone | Mid-Eocene | Gently folded |

Table 2: Descriptions of geological formations and deposits in the project area. Source: Beaulieu and Hughes 1975; except those marked with an asterisk* sourced from USGS 2014b

Bay Coal Field. Nearly 2.5 million tons of coal were extracted from this coal field between 1882 and 1918 (Duncan 1953; DOGAMI n.d.). Mining ceased in the 1920's primarily due to competition from California fuel oils and higher grade coal from Utah and Wyoming (Duncan 1953; DOGAMI n.d.). Although coal mining no longer occurs in the project area, in the mid-2000s, portions of the coal field were explored to determine its potential for natural gas production using hydraulic fracturing techniques.

### Geologic Age of the Project Area

The project area is composed of bedrock formed in the Cenozoic era (65 million years ago-present), most of which was created during its Eocene epoch (Figure 6; Table 3).

According to Rumrill (2006), sandstone, siltstone, and shale were deposited deep in the Pacific ocean and in shallow coastal waters over the past 50 million years, from the Eocene epoch through the Quaternary period. During the marine regression in the middle to late Eocene epoch (38-45 million years ago), sea level dropped, which allowed Coos Bay to emerge as a distinct, wave-dominated (as opposed to river-dominated) deltaic coastal basin.

Beginning in the middle Eocene epoch (about 40-48 million years ago), sediments that largely form the present-day bedrock were laid down during repeating marine transgressions (period of high sea level) and regressions (period of low sea level)(Rumrill 2006). These fluctuations were caused primarily by

***Geological Time Scale***

*Span of time since the Earth's creation, divided by major geological events, strata composition, or radiometric dating. Eon is the largest division, followed by Era, Period, Epoch and finally Age.*

*Source: Wikipedia 2015a*

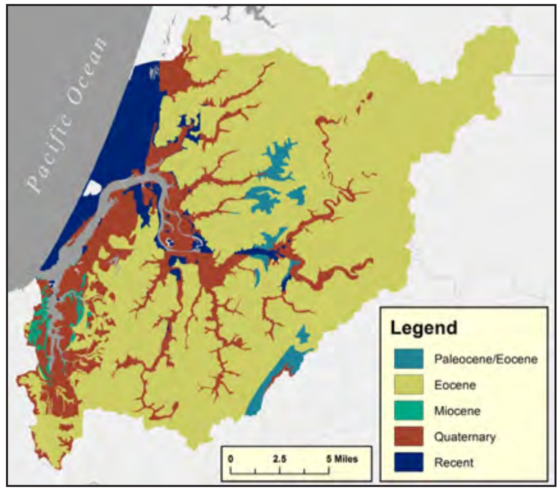



Figure 6: Spatial distribution the project area's geologic time scale. Legend ordered from oldest to most recent. Data: DOGAMI 2009

cyclical changes in climate that led to advances and retreat of continental glaciers, and subsequent rise and fall of sea level. These periods of major seal level fluctuations caused the continental shoreline to migrate back and forth tens of kilometers between the sea level extremes.

For example, beds of siltstone, mudstone, and sandstone formed in the middle Coaledo Formation beds (see "Formations" above) were laid down in deeper coastal waters during a marine transgression, while upper Coaledo beds (siltstone, mudstone, coal, and conglomerate) were deposited in shallow water during a subsequent regression (Rumrill 2006).

According to Rumrill (2006), absence of sediments for nearly 30 million years, dating from the Oligocene and early Miocene (8-36 million years ago), indicates a significant period of non-deposition, probably related to a combination of the onset of "tectonic plate deformation along the Cascadia subduction zone", glacial advance, and periods of low sea level. Rumrill (2006) discusses another gap of about four million years long occurring 6-2 million years ago, separating older formations

| Era | Period | Epoch | Geologic Age (million years ago) |
|---|---|---|---|
| Cenozoic | Quaternary | Holocene | 0.01-present |
| | | Pleistocene | 2.6-0.01 |
| | Neogene | Pliocene | 5.3 - 2.6 |
| | | Miocene | 23.0-5.3 |
| | Paleogene | Oligocene | 33.9-23.0 |
| | | Eocene | 56.0 -33.9 |
| | | Paleocene | 65.0-56.0 |

Table 3: Definition of geological ages in the Cenozoic era.

such as the Miocene epoch's Empire formation from more recent Pleistocene marine terraces and Holocene estuarine and sand deposits.

**Soils**

This section discusses soil types found in the project area. Definitions of soil types discussed in this section can be found in Table 4.

Estuarine Soils

Sediments in the estuarine tidal channel vary from coarse-grained sand to fine-grained sand, silt and clay (Rumrill 2006). See "Sediment Composition" summary in "Chapter 10: Sediment" for more detail on estuary sediments.

Tide flat sediments are primarily open sand flats and mudflats, which are composed of Udorthents, a combination of sand, silt, mud or organic materials, largely devoid of emergent vegetation (Haagen 1989). Mudflats typically occur in regions of the estuary that experience low tidal energy while sand flats occur in areas of high tidal energy (Rumrill 2006).

In the South Slough estuary, sand flats frequently occur on the inside of major bends in the tidal channel. These sand flats frequently have sand ripples or waves, the patterns of which are directly related to water velocity (Rumrill 2006).

According to Rumrill (2006) tidal beaches within South Slough are generally steep (9-15% slope) and sediments increase in mean grain size with depth, and decrease in mean grain size along the estuarine gradient (i.e., sediment is more fine further away from the mouth of the estuary). Most beach sediments are well-sorted. The decrease in mean sediment grain size along the estuarine gradient (from the high-energy estuary mouth to the low-energy upper estuary) is most likely a result of the gradual decrease in velocity of tidal currents, which in turn reduces their capacity to carry larger sediment particles (Arkett 1980, in Rumrill 2006).

Tidal Wetland Soils

Soils in the tidal wetlands of the Coos estuary are predominately Fluvaquents-Histosols, which, typical of permanently or frequently saturated soils, are particularly rich in organic matter (Haagen 1989).

Rumrill (2006) described surface soils within South Slough riparian areas, forested wetlands, and emergent freshwater marshes as typically sandy loams, also rich in organic matter.

***Soil Complex***

*Soil complex is defined as two or more soils which are so integrated that they cannot be separated at the map scale.*

***Soil Association***

*Soil association is defined as two or more soils that are intricately mixed but could still be separated at the map scale (although it's not practical to do so).*

*Source: Haagen 1989*

Table 4: Most common soil types, soil complexes, and soil associations found in the project area.

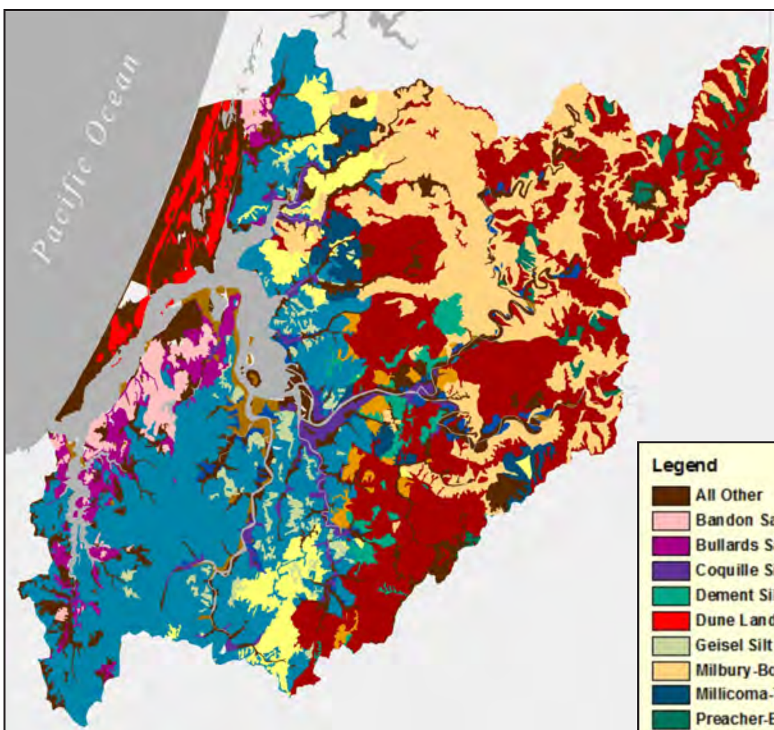
| Soils | Abridged Definition (Haagan 1989) |
|---|---|
| **Bandon Sandy Loam** | Deep, well drained soils, with a thick (1") covering of organic litter, found on dissected marine terraces. Top 5" is dark gray/brown sandy loam, followed by 25" dark red/brown sandy loam subsoil, 13" pale brown cemented sandy material and a substratum of yellow/brown loam. |
| **Bullards-Bandon-Blacklock** | Loamy and sandy soils derived from marine sediment and found on marine terraces. |
| Bullards (58%) | See Bullards Sandy Loam above |
| Bandon (20%) | See Bandon Sandy Loam above |
| Blacklock (18%) | Poorly drained, nearly level (0-3%) soils on depression areas of marine terraces. Black fine sandy loam surface (9") soil, with upper subsoil (2") black mucky loam, and lower subsoil (37") with a yellow/brown cemented sand. Base substratum is light olive/red or brown sand. |
| **Bullards Sandy Loam** | Deep, well drained soils, with a thick (3") covering of organic litter, found on dissected marine terraces. Surface soil (7") is dark gray/brown sandy loam, with 34" dark red/brown gravelly sandy loam subsoil beneath, under which is yellow/brown sand. |
| **Coquille-Nestucca-Langlois** | Poorly drained, silty and clayey soils found on flood plains; formed from alluvial processes. |
| Coquille (22%) | See Coquille Silt Loam below. |
| Nestucca (19%) | Poorly drained soils found in depressions with mottled dark brown silt loam on the surface (14"). Subsoil is mottled dark gray/brown silty clay loam (26"). Substratum is mottled olive brown silty clay. |
| Langlois (14%) | Very poorly drained soils found in depressions and old tide flats. A thick (5") dark gray/brown peat layer sits atop surface soils. Surface soils are mottled dark gray/brown silty clay loam (10") and dark gray/brown silty clay upper subsoil (20") with dark gray clay lower subsoil (60"). |
| Other minor soils (45%) | Combination of minor elements. |
| **Coquille Silt Loam** | Deep, poor draining soils, found primarily on flood plains (formed from alluvium). Thick (14") surface layer is dark gray/brown silt loam with gray/olive silty clay loam subsoil. Substratum is dark gray silty clay loam. |
| **Dement Silt Loam** | Deep, well drained soils derived from silt or sandstone, frequently found on ridgetops. Surface is dark gray/brown silt loam (7"), followed by red/brown silty clay loam subsoil (38"). Under this is found weathered sedimentary rock. |
| **Dune Land** | Shifting fine and medium grained sand, extremely permeable. |
| **Dune Land-Waldport-Heceta** | Sandy soils found on sand dunes and deflation plains. |
| Dune Land (30%) | See Dune Land above |
| Waldport (29%) | Found on stabilized sand dunes (leeward side of deflation plains). Surface 4" is dark gray/brown fine sand with dark yellow/brown fine sand beneath. |
| Heceta (18%) | Deep poorly drained soils found in deflation plains and depressions between dunes. Surface layer (4") is dark gray/brown fine sand with mottled gray/brown sand beneath. |
| Other minor soils (23%) | Combination of minor elements. |
| **Fluvaquents-Histosols Complex** | Level (slope ≤ 1%) tidelands of bays, inlets and estuaries |
| Fluvaquents (50%) | Covered by mean high water. Layers of mineral and organic material in varying thicknesses. Surface layer is generally sandy, silty or clayey depending on tidal currents. |
| Histosols (40%) | Covered by mean higher high water. Thick (16") organic layer over alternating layers of mineral and organic matter. |
| **Geisel Silt Loam** | Deep, well drained soil found on side slopes, derived from sedimentary rock. Surface layer is dark red/brown silt loam (4" thick). Upper subsoil (26") is dark red/brown silt loam and silty clay loam, while lower subsoil (24") is dark red/brown silty clay. Weathered siltstone forms base rock. |
| **Milbury-Bohannon-Umpcoos Association** | Moderately deep and shallow, gravelly loamy soils, derived from sedimentary rock |
| Milbury (40%) | Derived from sandstone, moderately deep well drained soil with very gravelly black sand loam on surface (10") and dark gray brown very cobbly loam subsoil (26"). These sit atop consolidated sandstone. |
| Bohannon (27%) | Moderately deep, well drained soil derived from arkosic sandstone. Surface (11") is very dark brown loam and gravelly loam; subsoil is dark yellow/brown gravelly loam (20"). Base substratum is weathered fractured sandstone. |
| Umpcoos (22%) | Shallow, well drained soils derived from sandstone, found on rock outcrops and ridgelines. Surface (3") is dark gray/brown very gravelly sand loam. Subsoil is brown very gravelly sandy loam (13"). Hard sandstone is underneath. |
| Other soils (11%) | Combination of minor elements. |
| **Millicoma-Templeton Complex** | Found on ridgetops and side slopes |
| Millicoma (55%) | Deep well drained, derived from sandstone. Surface layer is very dark/gray brown gravelly loam (18") with very gravelly dark brown loam subsoil (17"). Underneath that is partially weathered sandstone. |
| Templeton (25%) | Deep well drained, derived from sandstone. Surface layer is very dark brown silt loam (16") with red/brown/yellow silty clay loam subsoil (26"). Weathered fractured siltstone is under that. |
| Salander and other soils (20%) | Salander - see Salander Silt Loam below; small areas of clay loam or soils with ≤ 35% rock fragment. |
| **Preacher-Blachly Association** | Found on broad ridgetops and benches. |
| Preacher (50%) | Found in concave areas, deep, well drained soil derived from arkosic sandstone. Surface is organic litter (4") with dark gray/brown loam (14"). Subsoil is dark yellow/brown clay loam (34"). Base substratum is yellow brown clay loam. |
| Blachly (35%) | Deep, well drained soil, derived from basalt or sedimentary rock. Surface is red/gray or dark red/brown silty clay loam (7"). Upper subsoil (45") is dark red or yellow/red silty clay; lower subsoil (8") is yellow/red silty clay loam. |
| Bohannon, Digger (15%) | See Bohannon in Milbury-Bohannon-Umpcoos above. |
| **Preacher-Bohannon Loams** | Deep gravelly and loamy soils found on broad ridgetops, benches and steep side slopes. |
| Preacher (50%) | See Preacher in Preacher-Blachly Association above. |
| Bohannon (30%) | See Bohannon in Milbury-Bohannon-Umpcoos above. |
| Milbury, Digger, Blachly (20%) | Milbury - see Milbury-Bohannon-Umpcoos above. Blachly - see Preacher-Blachly Association above. Digger soil is moderately deep well drained derived from sedimentary rock. Organic layer (1") thick on top has dark brown gravelly loam (6") underneath. Upper subsoil (3") is dark yellow/brown gravelly loam; bottom 18" is brown very gravelly and cobbly loam. Base rock is brown extremely cobbly loam (4") with weathered, fractured sandstone beneath. |
| **Rinearson Silt Loam** | Deep, well drained soil, found on ridgetops and side slopes, derived from sedimentary rock. Surface soils are dark red/brown silt loam (6"). Upper subsoil (12") is dark/red brown silt loam; lower subsoil (24") is red/brown silty clay loam. Base substratum is weathered sandstone. |
| **Salander Silt Loam** | Deep, well drained soil, found on side slopes, derived from sedimentary rock. Surface layer (26") and top layer of subsoil (14") is dark red/brown silt loam. Lower subsoil (25") is dark red/brown silty clay loam. |
| **Templeton Silt Loam** | Deep, well drained soil, found on ridgetops and benches, derived from sedimentary rock. Surface layer is very dark brown silt loam (16") with red/brown/yellowish red silty clay loam subsoil (26"). Soft weathered fractured siltstone makes up the base substratum. |
| **Udorthents** | Level (slope ≤ 1%) flood plains, marshes, and tidal flats on major water bodies (including filled and leveled areas). Soils are a mixture of sand, silt or clay materials; dredge spoils also consist of dune sand and wood chips. |
| **Wintley Silt Loam** | Deep well drained souls found on high terraces, derived from alluvial processes. Surface is topped with 1" undecomposed organics, followed by 4" dark brown silt loam. Upper subsoil (12") is dark brown silty clay loam; lower subsoil (31") is brown silty clay and silty clay loam. Base substratum is dark yellow/brown very gravelly loam. |

## Dune Soils

The Coos Bay Dune Sheet is a mass of sand that extends, unbroken but for the mouths of rivers and streams, from Haceta Head to Cape Arago, making it the largest dune sheet in North America and the only 'oblique-ridge dune' in the world (Cooper 1958; Crook 1979). Dune lands in Coos County are generally made up of DuneLand-Waldport-Heceta soil types. Extensive portions of the dunes have been stabilized by plantings of the invasive European beachgrass (*Ammophila arenaria*), which began in 1910 (for more information on this, see "Vegetation" summary in "Chapter 18: Non-Native/Invasive Spp.").

## Upland and Lowland Soils

Fifteen principle soil types are found in the lower Coos basin (Figure 7). Of those, three predominate and are found in distinctly different areas of the landscape. Most common are Preacher-Bohannon loams (24% of total soil cover), found in a patchy, north-south oriented band of uplands east of the bay, along the western slopes and foothills of Blue Ridge, and in the Millicoma highlands. Templeton silt loam (23% of soil cover) extends from the uplands of the South Slough basin east through the drainages of Isthmus and Catching Sloughs, across the highlands of Pony Creek Reservoir, along the eastern slopes of Coos Bay and across the uplands between North



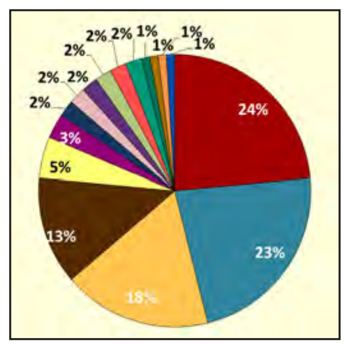





Figure 7: Distribution of different soil types in the project area. Inset pie chart shows percentage of each soil type that makes up the project area. Soil types for both figures were grouped by series (e.g., Bandon Sandy loam 0-7% slopes and Bandon Sandy Loam 7-12% slopes were grouped as Bandon Sandy Loam). Data: USDA 2000

Slough and Haynes Inlet. The Milbury-Bohannon-Umpcoos association (18% of cover) is interspersed with the Preacher-Bohannon series in the upper watershed.

Except where otherwise noted, the following soil descriptions for several major sub-basins, are taken from an assessment of Coos estuary tributary basins conducted by the Coos Watershed Association (CoosWA 2006).

<u>North Slough</u>
North Slough differs in its soils from other sub-basins in that it is dominated by the very soft, highly erosive sandstones of Dune Land-Waldport-Heceta and Bullards-Bandon-Blacklock soils.

<u>Palouse and Larson Sloughs</u>
Three general soil types dominate the Palouse and Larson Slough sub-basin: Dune land-Waldport-Heceta, which is common to dune areas, Templeton and Salander loams, common to the lowland area, and Milbury-Bohannon-Umpcoos, found in the uplands.

<u>Kentuck Slough</u>
Soils in the Kentuck Slough sub-basin consist of Templeton and Salander loams in the lowlands, and Preacher-Bohannon loams in the uplands. The headwaters of Kentuck Creek are on the Milbury-Bohannon-Umpcoos soil type.

<u>Willanch Slough</u>
General soil types in the Willanch Slough sub-basin are Templeton and Salander loams (lowlands) and Preacher-Bohannon loams, (uplands).

<u>Echo Creek</u>
The Echo Creek sub-basin hosts three general soil types: the Coquille-Nestucca-Langlois soil, found in level areas, areas along the bay, and Coos River; Templeton and Salander loams (lowlands), and the Preacher-Bohannon loams (uplands).

<u>Lower Millicoma and South Fork Coos Rivers</u>
According to CoosWA (2008), Preacher-Bohannon loams are the most prevalent soils in Lower Millicoma and South Fork Coos River sub-basin. Other soils include Milbury-Bohannon-Umpcoos on steep slopes and poorly draining, clay Coquille-Nestucca-Langlois soils along floodplains.

<u>South Slough</u>
Haagen (1989) shows the primary soils in this sub-basin as Templeton loams, with some Bullards-Bandon-Blacklock group.

**Landslides**

According to Wang et al. (2002), Oregon economic losses due to landslides exceed $10 million/year. In years with heavy storm events, losses can exceed $100 million. These losses are expected to increase as the state's human population increases, expanding current land uses.

Landslides occur frequently in the Coos region, as they do throughout much of the central Coast Range. The Oregon Department of Geology and Mineral Industries (DOGAMI) has compiled an inventory of historic landslide locations, which helps identify areas potentially prone to future land failures (Figure 8).

Oregon Department of Forestry (ODF) developed debris flow (a type of landslide – see Background below) hazard maps, based on slopes derived from USGS digital elevation models. Slopes >40% and an area greater than 150,000 $ft^2$ were considered moderately hazardous. Tyee Formation slopes >65% over an area of 100,000 $ft^2$ or >60% for more than ⅓ the total basin area were considered a high risk for debris flows. Other formations were considered a high risk if they had a slope >70% and an area exceeding 150,000 $ft^2$ or ¼ total basin area. Extreme hazard values were assigned to locations where debris flows have occurred frequently over the past 35 years.

Areas of high and moderate debris flow risk have been mapped for the project area using these data (Figure 9). The hills east of the main Coos estuary are at considerably higher risk for debris flow occurrences than lands closer to the ocean. In fact, the Coos River subsystem has the highest percentage of both high (9.5%) and moderate (18%) lands at risk for debris flow events (Figure 10). When taken as a whole, 33% and 12% of the entire project area is at moderate and high risk, respectively, for debris flows.

**Background**

Plate Tectonics

Rumrill (2006) describes the Coos estuary as being formed by the interactions of "several coastal geomorphic processes in the recent geologic past" (thousands to tens of thousands of years ago), including "slow coastal uplift and sudden subsidence" (driven by tectonic movement of offshore crustal plates); "regional transgression and regression of the sea as a result of ice-age glacial advance and retreat"; and "fluvial erosion of a major riverine drainage system caused by differential coastal uplift".

Folds and faults

Long-term seismic shifting of the North America and Juan de Fuca plates contributed to east-west compression that formed the South Slough syncline and other folds throughout the southern Oregon coastal region. Folding and faulting cause different areas of the coast to rise at different rates, significantly altering the topography of the Coos drainage basin (Kelsey et al. 2002). For example, before the creation of the current coastal terraces (which were created by folding and faulting processes), the Coquille River drained into the Pacific Ocean through Isthmus and South Sloughs (Baldwin 1945; Nyborg 1993 as cited in Rumrill 2006). Evidence of this can be seen along several outcrops in the South Slough where Pleistocene alluvial floodplain materials (including aquatic invertebrate fossil assemblages) are identical to those found at the mouth of the Coquille River (Nyborg 1993 as cited in Rumrill 2006).

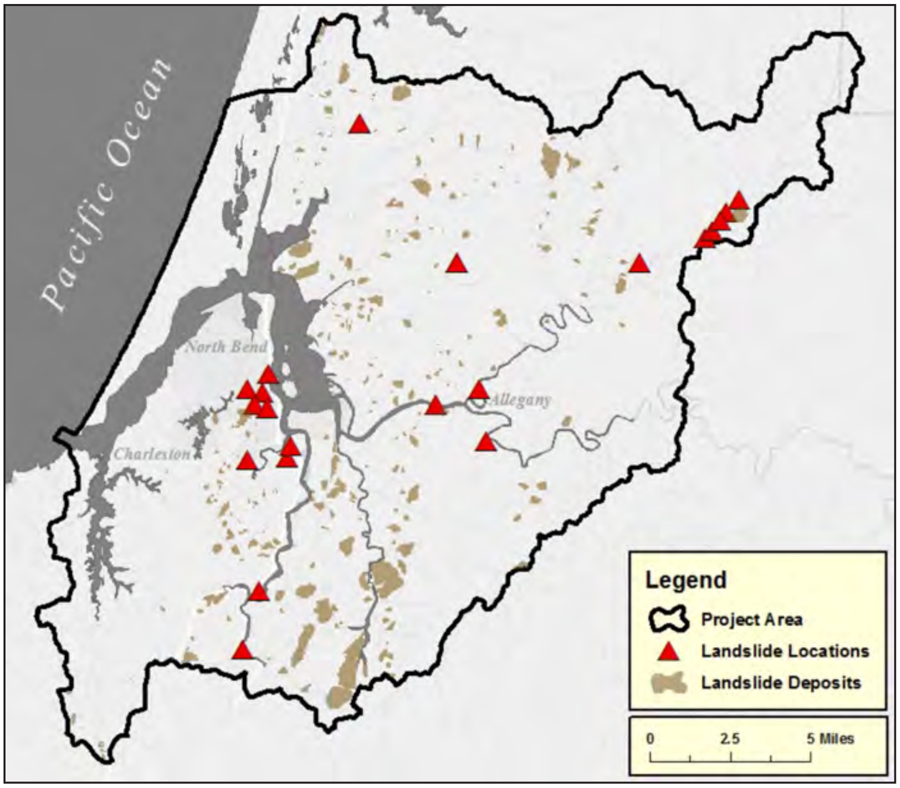



Figure 8: Inventory of historic landslides (1849-2013), identifying landslide-prone areas, which may be susceptible to future landslides. Landslide deposits include debris flow fans and talus extent. Data: DOGAMI 2014

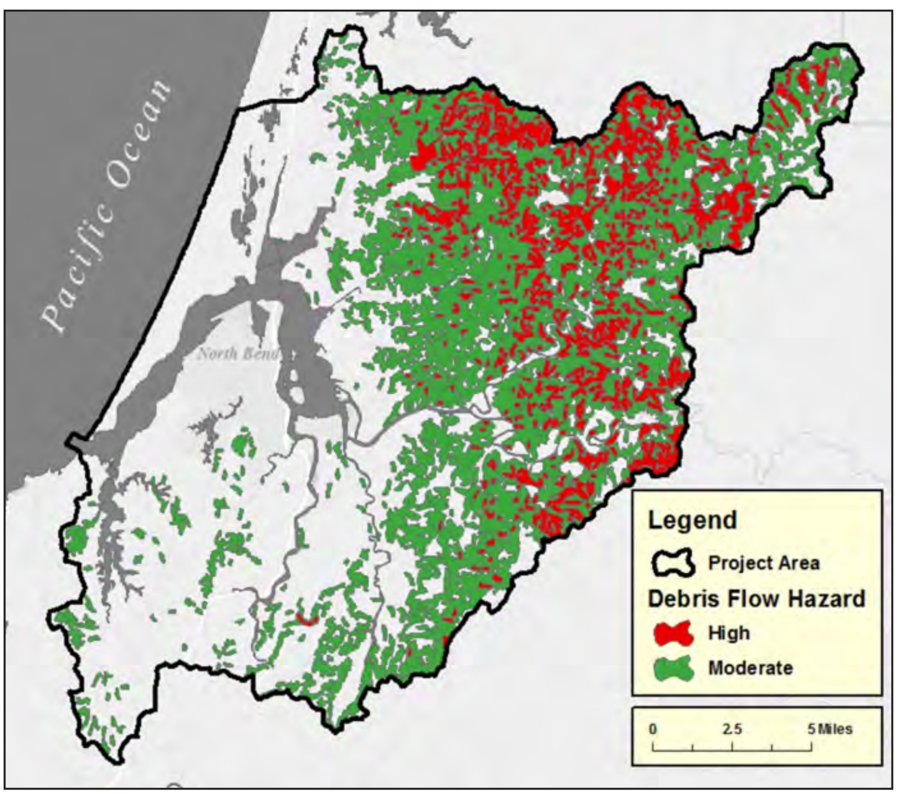



Figure 9: Distribution of lands that are highly or moderately at risk of debris flows in the project area. Data: ODF 2000.

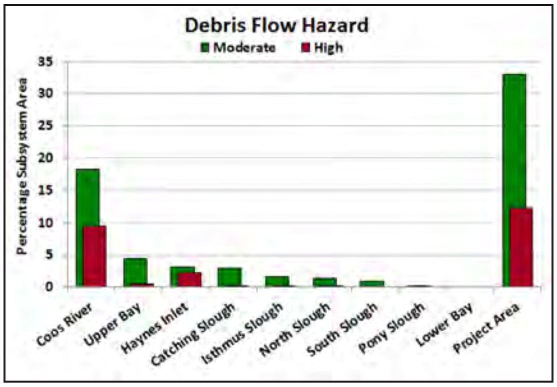



Figure 10: Percentage of each subsystem and entire project area that is at high and moderate risk for debris flow. Data: ODF 2000.

Other evidence of subduction processes were described by Witter et al. (2003), who found that stepped marine terraces occurring in the hills surrounding the Coos estuary are a result of ocean-derived sediments scraped off the Juan de Fuca plate as it slid down under the North American Plate.

Earthquakes

Pressure that accumulates in the earth as a result of forces and movements of plates is released episodically during earthquakes. Three types of earthquakes affect coastal Oregon: Cascadia megathrust, deep intraplate, and crustal earthquakes (see sidebar). The most frequently occurring of these are crustal earthquakes, which occur along active fault lines (Rumrill 2006). Seismic studies conducted near the Coos estuary's Jordan Cove indicate fewer deep intraplate earthquakes occur in the Coos Bay area compared with areas to the north and south (GRI 2013). The largest earthquakes in our area tend to occur along the Cascadia Subduction Zone boundary and can cause sudden coastal subsidence of from 0.5-2 m (1.64-6.56 ft)(Darienzo and Peterson 1990 as cited in Rumrill 2006).

According to NOAA's Pacific Northwest Seismic Network (PNSN n.d.), the Cascadia Subduction Zone is locked by friction at depths shallower than 30 km (16.6 mi). Strain continues to build slowly as the tectonic forces act (including expansion at the Juan de Fuca Ridge). Eventually, when the frictional strength is exceeded, the plates will slip past each other, causing a megathrust earthquake. The fault's frictional properties change with depth, such that immediately below the locked part is a strip (called the transition zone) that slides slowly and slips a few centimeters every year or so. These small slips relieve the stress on the plate boundary in one location, but add to the stress on the fault elsewhere. Below the transition zone geodetic evidence suggests that the faults slide continuously and silently past one another.

Tsunamis

Tsunamis are triggered when the elevation of the coastal margin suddenly changes, displacing a large volume of water. Tsunami waves propagate rapidly through the open ocean and can reverberate throughout the entire Pacific Ocean basin in the 24-hour period following a sufficiently strong earthquake. In the Pacific Ocean, tsunamis move at speeds of ~435 mph, losing little energy as they travel (Petroff n.d.).

Geologists examined sediments deposited in the Coquille River estuary (Witter et al. 2003) and those of coastal lakes (Kelsey et al. 2005)

***Local Earthquake Types***

*<u>Cascadia Megathrust</u> – The most powerful recorded earthquakes in the area (magnitude 8-9 or higher), Cascadia megrathrust earthquakes are caused the by sudden release of built-up energy when the Juan de Fuca Plate (locked against the North American Plate) is suddenly released and the plates slip past each other.*

*<u>Deep Intraplate</u> – Deep intraplate earthquakes occur when the Juan de Fuca plate cracks as it is bent deep underneath the North American Plate (at depths from 30-70 km [19-43 mi]). Deep intraplate earthquakes occur about every 30 years at magnitudes as high as 7.5. Because they usually occur under the Cascade and Coastal ranges, these earthquakes can be the most damaging to population centers.*

*<u>Crustal</u> – Crustal earthquakes occur on shallow faults (to 35 km [22 mi] deep) in the North American Plate and are relatively common off the southern Oregon coast (maximum magnitudes <7).*

*<u>Earthquake Magnitude</u> (i.e., strength), originally based on the Richter Scale but now based on the moment magnitude scale (MMS), quantifies the energy released by an earthquake.*

*Sources: PNSN n.d.; DOGAMI 1996*

for evidence of periodic tsunamis, and to improve their understanding of the impact of movements and interactions of crustal plates of the Cascadia Subduction Zone on the landforms and elevation of the southern Oregon coast, including the Coos estuary. Witter and colleagues traced 12 cycles of uplift and subsidence in the record of low-lying forests and tidal wetlands over the last 6,700 years while Kelsey and colleagues found a record of repeated local tsunamis in the sediments of Bradley Lake in Curry County.

**Soils**

<u>Tidal Areas</u>

According to Rumrill (2006), tide flats in the Coos estuary likely formed during the past 1,000-2,000 years as estuarine sediment eroded from marine terraces, filling in the Coos estuary tidal basin and creating the tide flats we see today.

Other sources of tide flat sediments are terrestrial runoff, oceanic deposition, and biotic material (Rumrill 2006). For example, much of the mud, silt, and clay within the estuarine tidal basin enters South Slough from Coos Bay and the nearshore Pacific Ocean during flood tides (Wilson 2003 in Rumrill 2006).

Sand flats are created largely from land sources, including erosion of nearby cliffs, then transported by high velocity tidal currents (Rumrill 2006).

Tide flats are often highly channelized with shallow drainage channels, which facilitate a continued cycle of erosion and deposition as sediments are re-suspended, transported, and deposited with every tidal cycle (Rumrill 2006).

Tidal Wetlands

Tidal wetland soils can inform us about sea level rise rates. For example, Rumrill (2006) explains that “Prevalence of peat layers in the upper 1.0-1.5 m (3.28-4.92 ft) of sediment cores taken from brackish marshes in many parts of the Coos estuary suggests a reduction in the rate of sea-level rise or an increase in the rate of sedimentation over the past 1,000-1,500 years”.

**Landslides**

Landslides are typically triggered by heavy rain. Less commonly they are caused by earthquakes, road construction, rapidly melting snow, or a combination of these and other events (DOGAMI 2008).

A particularly damaging landslide is known as a debris flow. A debris flow (synonymous with mudslide, mudflow, or rapidly moving landslide) is a fast moving (exceeding 30 mph) mixture of water, rock, soil, and vegetation. Debris flows begin as small landslides, and then, upon entering a steep sloping stream channel, gain momentum and more debris, until they finally end as massive deposits at the outlet of the channel (DOGAMI 2008; ODF 2012).

Debris flows can travel long distances, sometimes scour the channel down to bedrock, and frequently cause major structural damage to houses and roads. They are extremely hazardous, especially in populated areas (Robison et al. 1999; ODF 2012). It should be noted, however, that debris flows also deliver large wood to streams where they add complex structure that provide high quality fish habitat (ODF 2012).

In 1996, two very large storms severely affected western Oregon, one of which was a 100-year rain event that set an all-time one-day precipitation record at North Bend (6.67 inches in 24 hrs)(Robison et al. 1999). Both storms triggered large numbers of landslides in western Oregon, prompting ODF to take a closer look at activities, such as forest-road building and logging, that were thought to play a role in landslides. This report (Robison et al. 1999) examined eight locations affected by these two storms and found that lands with the highest hazards for landslides were found on slopes >70-80% steepness (depending on surface geology and landform). For example, Tyee Core formations are very susceptible to debris flows generally due to steep slopes, shallow low-cohesion soils, with an impermeable layer beneath. Lands with moderate hazard were found on slopes 50-70%. In addition, concave shaped landforms with large drainage areas were most frequently associated with landslides.

Robison et al. (1999) determined that forest cover and time since last timber harvest also influenced landslide occurrence, with lands 0-10 years post-harvest being most susceptible to landslides. However, forest stand age did not appear to affect the size of landslides.

Further, road-associated landslides were found to be four times larger (volume of earth moved) than landslides not occurring near roads. Landslides associated with abandoned logging roads ("legacy" roads) were smaller in size than those associated with active logging roads. Roads where drainage water was diverted (e.g., culvert or other relief structure), had higher landslide occurrences if the water exited on fill slopes. Roads carved out of slopes often deposit excavated fill on the downslope edge of the road, further influencing landslide hazards.

Rain-induced landslides are also thought to be more frequent during La Niña years, when the Pacific Northwest experiences increased storminess, increased precipitation and more days with measurable precipitation (UO 2012; NOAA 2002).

**References**

Arkett, S. A. 1980. Vertical and horizontal distributions of major meiofauna taxa on selected beaches in the South Slough estuary, Charleston, Oregon, U.S.A. Master's thesis, University of the Pacific. 67 pp.

Baldwin, E. M. 1945. Some revisions of the Late Cenozoic stratigraphy of the southern Oregon Coast. *Journal of Geology* 52: 35-46.

Banse, T. 2014. Offshore Fault Where The 'Big One' Originates Eerily Quiet. KPLU. Seattle, Washington. Radio broadcast transcript Accessed 2 June 2015: http://www.kplu.org/post/study-offshore-fault-where-big-one-originates-eerily-quiet

Beaulieu, J. D., and P. W. Hughes. 1975. Environmental geology of western Coos and Douglas Counties, Oregon. Portland: State of Oregon, Dept. of Geology and Mineral Industries.

Clague, J. J. 1997. Evidence for large earthquakes at the Cascadia subduction zone. *Reviews of Geophysics*, 35(4), 439-460.

Cooper, W. S. 1958. Coastal Sand Dunes of Oregon and Washington. Geological Society of America, New York.

Coos Watershed Association (CoosWA). 2006. *Coos Bay Lowland Assessment and Restoration Plan.* Coos Watershed Association, Charleston, Oregon. 268p.

Coos Watershed Association (CoosWA). 2008. *Catching Slough, Daniel's Creek and Heads of Tide Sub-basin Assessment and Restoration Opportunities.* Coos Watershed Association, Charleston, Oregon, 160p.

Crook, C. S. 1979. A system of classifying and identifying Oregon's coastal beaches and dunes. Oregon Coastal Zone Management Association, Inc., Newport, OR.

Darienzo, M. E. and C. D. Peterson. 1990. Episodic tectonic subsidence of late Holocene salt marshes, northern Oregon central Cascadia margin. Tectonics 9: 1-12.

Duncan, D. 1953. Geology and Coal Deposits in Part of the Coos Bay Coal Field, Oregon: A contribution to economic geology. Geological Survey Bulletin 982-B. Department of Interior, U.S. Geological Survey, Washington D.C.

Haagen, J. T. 1989. Soil survey of Coos County, Oregon. National Cooperative Soil Survey, Washington, D.C. Accessed 30 June 2015: http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=OR

Kelsey, H. M., R. C. Witter, and E. Hemphill-Haley. 2002. "Plate-boundary earthquakes and tsunamis of the past 5500 yr, Sixes River estuary, southern Oregon". *Geological Society of America Bulletin*, 114(3), 298-314.

Kelsey, H. M., A. R. Nelson, E. Hemphill-Haley, and R. C. Witter, 2005. Tsunami History of an Oregon coastal lake reveals a 4600 yr record of great earthquakes on the Cascadia subduction zone. *GAS Bulletin*. 117(7-8):1009-1032.

Komar, P. D. 1997. *The Pacific Northwest coast: living with the shores of Oregon and Washington.* Duke University Press.

Leonard, L. J., R. D. Hyndman, and S. Mazzotti. 2004. "Coseismic subsidence in the 1700 great Cascadia earthquake: Coastal estimates versus elastic dislocation models." *Geological Society of America Bulletin* 116(5/6): 655-670.

McInelly, G. W., and H. M. Kelsey. 1990. "Late Quaternary tectonic deformation in the Cape Arago-Bandon region of coastal Oregon as deduced from wave-cut platforms." *Journal of Geophysical Research* 95(B5): 6699-6713.

National Oceanic and Atmospheric Administration (NOAA). 2002. Monitoring Intraseasonal Oscillations. Accessed 2 July 2015: http://www.cpc.ncep.noaa.gov/products/intraseasonal/intraseasonal_faq.html

Nelson, A. R., A. E. Jennings, and K. Kashima. 1996. An earthquake history derived from stratigraphic and microfossil evidence of relative sea-level change at Coos Bay, southern coastal Oregon. *Geological Society of America Bulletin* 108(2): 141-154.

Nelson, A. R., Y. Ota, M. Umitsu, K. Kashima, and Y. Matsushima. 1998. "Seismic or hydrodynamic control of rapid late-Holocene sea-level rises in southern coastal Oregon, USA?." *The Holocene* 8(3): 287-299.

Oregon Department of Forestry (ODF). 2000. Locations Subject to Naturally Occurring Debris Flows in the Coos Watershed. Accessed 4 October 2013: http://www.coastalatlas.net/metadata/LocationsSubjecttoNaturallyOccurringDebrisFlowsintheCoosWatershed,ODF,2000.htm

Oregon Department of Forestry (ODF). 2012. Forest Facts: Landslides and Debris Flows. Accessed 27 May 2015: http://www.oregon.gov/ODF/Documents/AboutODF/Landslides-DebrisFlowsFactsheet.pdf

Oregon Department of Geology and Mineral Industries (DOGAMI). 1996. Earthquake Hazard Maps for Oregon. I.P. Madin and M.A. Mabey (eds). Accessed 26 June 2015: http://www.oregongeology.org/pubs/gms/GMS-100.pdf

Oregon Department of Geology and Mineral Industries (DOGAMI). 2008. Landslide Hazards in Oregon. Accessed 11 May 2015: http://www.oregongeology.org/sub/publications/landslide-factsheet.pdf

Oregon Department of Geology and Mineral Industries (DOGAMI). 2009. Oregon Geologic Data Compilation. Accessed 26 October 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BD9B42C23-07E9-496F-8188-7C06A6D0E891%7D

Oregon Department of Geology and Mineral Industries (DOGAMI). 2014. Statewide Landslide Information Database for Oregon (SLIDO). Accessed 27 May 2015: http://www.oregongeology.org/sub/slido/data.htm

Oregon Department of Geology and Mineral Industries (DOGAMI). n.d. Oregon Historical Mining Information: Mining Records – Coos County: The Coos Bay Coal Field Report. 21pp. Accessed 29 July 2015: http://www.oregongeology.org/sub/milo/archive/Mining-Districts/CoosCounty/CoosbayCoalField/CoosbayCoalField/CoosbayCoalFieldReport.pdf

Nyborg, T. 1993. Investigation into the geology and paleontology of the South Slough National Estuarine Reserve, Coos County, Oregon. OIMB Student Report, Charleston, OR. 52 pp.

Pacific Northwest Seismic Network (PNSN). n.d. Earthquake Sources of the PNW. Accessed 26 June 2015: http://pnsn.org/outreach/earthquakesources

Petroff, C. n.d. Tsunami! How do tsunamis differ from other waves? Accessed 26 June 2015: http://faculty.washington.edu/cpetroff/wordpress/?page_id=321

Robison, G., K. Mills, J. Paul, L. Dent, and A. Skaugset, 1999. Storm Impacts and Landslides of 1996: Final Report. Oregon Department of Forestry. Forest Practices Technical Report No. 4. 157 pp.

Rumrill, S. 2006. Ecology of the South Slough Estuary: Site profile of the South Slough National Estuarine Research Reserve. South Slough National Estuarine Research Reserve 259 pp.

Satake, K., K. Shimazaki, Y. Tsuji, and K. Ueda. 1996. Time and size of a giant earthquake in Cascadia inferred from Japanese tsunami records of January 1700. *Nature*, 379(6562), 246-249.

Geotechnical Resources Inc. (GRI). 2013. Site-Specific Seismic Hazard Study for the Proposed Jordan Cove LNG Facility, Coos County, Oregon. Beaverton, OR.

University of Oregon (UO). 2012. State of Oregon: Natural Hazards Mitigation Plan. Oregon Partnership for Disaster Resilience. Accessed 2 July 2015: http://www.oregon.gov/LCD/HAZ/Pages/2012nhmp_sections.aspx

U. S. Department of Agriculture (USDA). 2000. Soil Survey Geographic (SSURGO) Database for Coos County, Oregon. U.S. Department of Agriculture, Natural Resources Conservation Service, Fort Worth, Texas.

U.S. Geological Survey (USGS). 2005. Fault Lines. Accessed 26 October 2013: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7B99AA3A13-0354-4579-A0D4-463C433D6952%7

U.S. Geological Survey (USGS). 2014a. Visual Glossary. Accessed 23 June 2015: http://geomaps.wr.usgs.gov/parks/deform/gfaults.html

U.S. Geological Survey (USGS). 2014b. Geologic Units in Coos County, Oregon. Accessed 9 July 2015: http://mrdata.usgs.gov/geology/state/fips-unit.php?code=f41011

U.S. Geological Survey (USGS). 2015. Search Earthquake Archives. Accessed 5 June 2015: http://earthquake.usgs.gov/earthquakes/search/

Wang, Y., R. D. Summers, and R. J. Hofmeister. 2002. Landslide loss estimation pilot project in Oregon. Department of Geology and Mineral Industries, 94p. Accessed 2 July 2015: https://services.oregon.gov/LCD/docs/rulemaking/012308/item_1_Kehoe_att_b.pdf

Wikipedia. 2015a. Geologic Time Scale. Accessed 17 November 2015: https://en.wikipedia.org/wiki/Geologic_time_scale

Wikipedia. 2015b. Superficial Deposits. Accessed 17 November 2015: https://en.wikipedia.org/wiki/Superficial_deposits

Wilkerson, C. 2001. What is a formation? Utah Geological Survey web page accessed Oct 2015: http://geology.utah.gov/map-pub/survey-notes/glad-you-asked/what-is-a-formation/

Wilson, C. 2003. Erosion and transport of fine sediments from watersheds tributary to NERR estuaries. Ph.D. thesis, Case-Western University. 156 pp.

Witter, R. C., H. M. Kelsey and E. Hemphill-Haley. 2003. Great Cascadia earthquakes and tsunamis of the past 6700 years, Coquille River estuary, southern coastal Oregon. DOI: 10.1130/B25189.1 Geological Society of America Bulletin 2003;115, no. 10;1289-1306.

Witter, R. C., Y. Zhang, K. Wang, G. R. Priest, C. Goldfinger, L. Stimely, J. T. English, and P. A. Ferro. 2011. Simulating Tsunami Inundation at Bandon, Coos County, Oregon, Using Hypothetical Cascadia and Alaska Earthquake Scenarios, DOGAMI Special Paper 43.

# Land Use/Land Cover in the Lower Coos Watershed

*Summary:*

- *Between 1996 to 2010, land use/land cover changed in over 20% of the project area.*
- *Forest cover declined and shrub/scrub cover increased, reflecting the dominant role forestry activities play in project area land cover dynamics.*
- *Increases in developed land came mostly from conversions of forest and grassland cover classes.*
- *Agricultural lands comprise roughly 2% of the project area; agricultural land cover has remained relatively stable since the 1990's.*

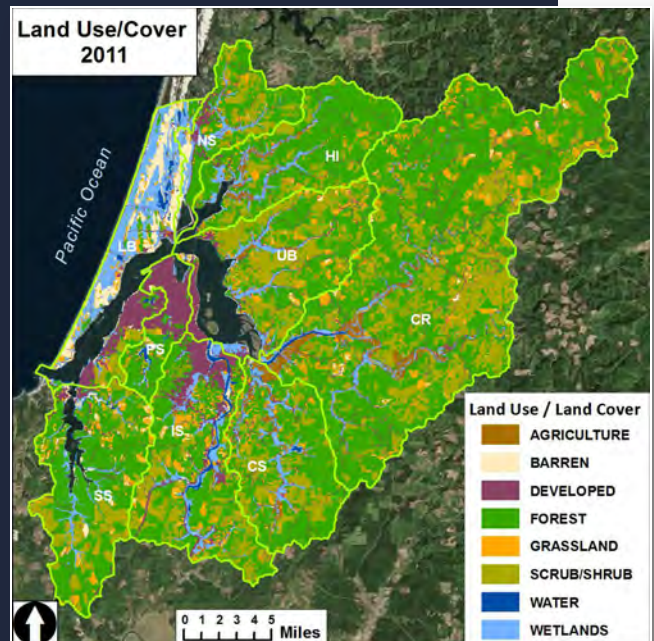
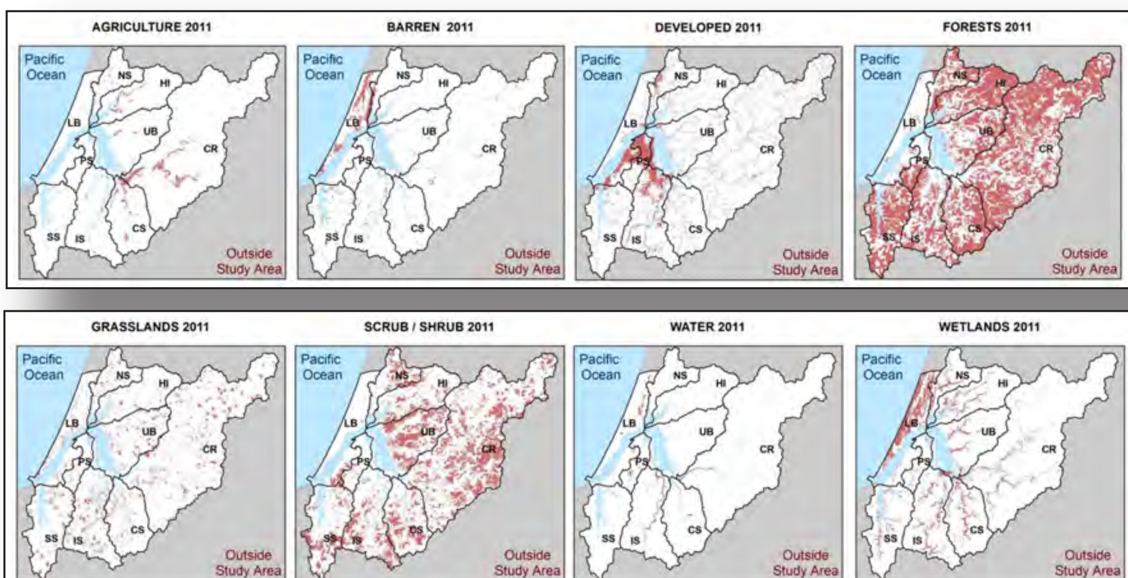



Figure 1. Land use patterns within the project area's nine subsystems. Data Source: NLCD 2011. Subsystems: CR- Coos River; CS- Catching Slough; HI- Haynes Inlet; IS- Isthmus Slough; LB- Lower Bay; NS- North Slough; PS- Pony Slough; SS- South Slough; UB- Upper Bay




2011 distribution of each designated Land Use and Land Cover type in the project area. Red shaded areas indicate land use and cover type distribution. 2011 is the most recent land use and cover data available.

**What's Happening**

The character, extent, and status of the project area's land uses and land cover significantly affect its environmental and socio-economic well-being.  Oregon, and by extension, Coos County, through its long history of comprehensive land use planning, has tracked the status and trends of local land uses for a variety of purposes, including assessing local taxes, facilitating responsible development, and guiding sensible natural resource management.

This data summary describes current land use and land cover status (first section) and trends (second section) in the project area between 1996 and 2010 based on available data. Although some land uses are commonly associated with land cover types such as forest, agriculture, or industrial, some human activities (e.g., recreation) are not directly related to a land cover. The terms land use and land cover are frequently referred to as LULC in this data summary (see sidebar).

The topics discussed below include current and recent historic LULC patterns in the project area's nine subsystems (Figure 1).

Table 1 lists the LULC classes used in this data summary and the equivalent LULC classes used by its major data sources (US Geological Survey, Coastal Change Analysis Program, National Land Cover Database).

Table 2 summarizes the characteristics of the datasets used in this summary. Forest, Scrub/Shrub, and Wetlands are included here as LULC  classes, but readers should consult Chapter 12: Vegetation for information about project area vegetation communities. Similarly, impervious surfaces, roads, tide gates, and levees are examined in detail in separate data summaries within the current chapter (Chapter 8: Physical Description).

***Land Use and Land Cover (LULC)***

*The terms "land use" and "land cover" are frequently used interchangeably because they are closely related.*

***Land use** focuses on human activities and often has management or zoning connotations whereas **land cover** describes the natural or constructed materials on the land surface. The distinction can be important because land use and land cover data were frequently developed separately, for particular purposes, and with different methods and resolutions, thereby leaving gaps and inconsistencies for users.*

*Although many human activities are associated with a particular **land cover** (e.g., agriculture), some activities are not exclusively associated with a specific land cover type. For example, hunting is a common recreational **land use** but where it occurs could be in forest, range, or agriculture land cover classes (Anderson et al. 1976).*

| This LULC Summary | USGS (1970) | NLCD (1992-2001 - Retrofit) | NLCD (2001; 2006; 2011) | C-Cap (1996-2010) |
|---|---|---|---|---|
| Agriculture | Cropland/Pasture; Other Agricultural Land | Orchards/Vineyards; Pasture/Hay; Row Crops; Small Grains; Fallow | Pasture/Hay; Cultivated Crops | Pasture/Hay; Cultivated Crops |
| Aquatic Bed | | | | Estuarine or Palustrine Aquatic Bed |
| Barren | Beaches; Sandy Areas (not beaches);Quarry/Strip Mine/Gravel Pit; Transitional Areas | Bare Rock/Sand; Quarry/Strip Mine/Gravel Pit; Transitional Areas | Barren Land (Rock/Sand/Clay) | Barren Land |
| Forest | Deciduous; Evergreen; Mixed Forest | Deciduous; Evergreen; Mixed Forest | Deciduous; Evergreen; Mixed Forest | Deciduous; Evergreen; Mixed Forest |
| Scrub/Shrub | Rangeland = Herbaceous, Shrub and Brush, or Mixed | Shrubland | Shrub/Scrub | Shrub/Scrub |
| Grasslands | | Grasslands/Herbaceous | Grasslands/Herbaceous | Grasslands/Herbaceous |
| Unclassified | | | | Background; Unclassified |
| Unconsolidated Shore | | | | Unconsolidated Shore |
| Developed | New Residential; Residential; Commercial; Industrial; Transportation/ Communications/Utilities; Mixed Urban or Built-up Land; Other Urban or Built-up Land | Developed Open Space (i.e. recreational grasses); Low/Medium/High Intensity Residential; Commercial/ Industrial/ Roads | Developed Open Space (i.e. parks, golf courses, large-lot housing areas with mostly lawn grasses and impervious surfaces < 20% total area); Developed Low, Medium or High Intensity | Developed Open Space (i.e. mostly managed grasses with < 20% constructed surfaces); Developed Low, Medium or High Intensity |
| Water | Streams and Canals; Lakes; Reservoirs; Bays and | Open Water; Ice/Snow* | Open Water; Perennial Ice/Snow* | Open Water; Perennial Ice/Snow* |
| Wetlands | Forest or Nonforested Wetlands | Woody Wetlands; Emergent Herbaceous Wetlands | Woody Wetlands; Emergent Herbaceous Wetlands | Palustrine Forested Wetlands, Scrub/Shrub Wetlands or Emergent Wetlands; EstuarineForested Wetlands, Scrub/Shrub Wetlands or Emergent Wetlands |

Table 1. General land use and land cover types in project area and classes as referenced by data sources. Data Sources: USGS 2005; NLCD 2001a, 2001b, 2006, 2011, C-Cap 2014.
* Note: The Ice/Snow class is likely an error but since its total area is so insignificant, all classes were retained "as is".

LULC Status in the Project Area

Table 3 and Figures 2a-2c provide an overview of the areal distribution and percentages of the LULC categories for the project area and each of its subsystems based on 2010 Coastal Change Analysis Program data (C-CAP 2014), and 2011 National Land Cover Database data (NLCD 2011) . Detailed descriptions of the LULC categories in this section are presented in the following order: Forest, Scrub/Shrub, and Grassland (land cover); Urban/Developed, Agriculture (land use); and Barren, Wetlands, Water (natural features).

Forest

The C-CAP and NLCD datasets classify an area as Forest when more than 20% of the total area is covered by trees greater than 5 m (16 ft) tall. Both C-CAP and NLCD data sources are in close agreement on Forest coverage in the project area. About 50% (C-CAP: 49.9%; NLCD: 50.1%) of land cover types are classified as Forest (Table 3 and Figures 2a, 2b, 2c, 3). Forest coverage is further classified as Deciduous (C-CAP: 1.6%; NLCD: 1.2%), Evergreen (C-CAP: 30.6%; NLCD: 31.3%), and Mixed (both evergreen and deciduous) (C-CAP: 17.6%; NLCD: 18.3%). Neither data set distinguishes between natural forest and trees managed for timber production.

The two data sources are also in close agreement on subsystem Forest coverage (Table 3, Figure 2a). At least 50% of Coos River, Catching Slough, Haynes Inlet, and South

| DATASET | PROVIDER | SCALE/ RESOLUTION | FOCUS | YEAR(S) | SOURCE METHODS | NOTES | CITATION |
|---|---|---|---|---|---|---|---|
| 1996-2010 C-CAP | NOAA Coastal Change Analysis Program | 30 X 30 m | Land Cover Classification / Change | 1996, 2010 | Satellite Imagery; supervised/unsupervised classification | C-CAP Classification; contains more wetland, aquatic bed, & shoreline classes than USGS or NLCD | C-Cap 2014 |
| 2011 NLCD | Multi-Resolution Land Characteristics Consortium (MRLC) | 30 X 30 m | Land Cover Classification / Change | 2011; 2014 version | Satellite Imagery; supervised/unsupervised classification | NLCD classification Coos Estuary Not Classified | NLCD 2011 |
| 2006 NLCD | Multi-Resolution Land Characteristics Consortium (MRLC) | 30 X 30 m | Land Cover Classification / Change | 2006; 2011 edition | Satellite Imagery; supervised/unsupervised classification | NLCD classification | NLCD 2006 |
| 2001 NLCD | Multi-Resolution Land Characteristics Consortium (MRLC) | 30 X 30 m | Land Cover Classification | 2001; 2011 edition | Satellite Imagery; supervised/unsupervised classification | NLCD classification | NLCD 2001b |
| 1992 NLCD | Multi-Resolution Land Characteristics Consortium (MRLC) | 30 X 30 m | Land Cover Classification | 1992 | Satellite Imagery; supervised/unsupervised classification | Retrofit to 2001 Classification | NLCD 2001a |
| 1970's USGS | USGS refined with 2000 U.S. Census | 1:100,000 - 1:250,000 | Historic Land Cover Updated residential | 1970-1985 | Aerial photography; manual interpretation | Anderson Classification (USGS); "range" includes shrub/scrub & grassland | USGS 2005 |
| 1900's | ODF based on USGS 21st annual report, part V | 1:500,000 | Timber harvest and burned areas | 1895-1896 1897-1898 | Ground Surveys | Classes related to timber, cuts, and stocking; barren; burnt; timberless; water; woodland | ODF 2000 |
| POTENTIAL NATURAL VEGETATION | Conservation Biology Institute | Varies - overall ~ 1:100,000 | Küchler's Potential Natural Vegetation modified by Brendan Rogers | 1938 | Merged multiple data sources (H.J. Andrews Experimental Forest, Soil Survey, GLO, BLM); reclassified to functional type | No classes for development or agriculture | Tobalske and Osborne-Gowey 2002 |

Table 2. General characteristics of major data sources used in this data summary.

**PERCENT OF SUBSYSTEM OR PROJECT AREA**

| LAND USE AND LAND COVER CLASSES — SUBSYSTEM | COOS RIVER | | CATCHING SLOUGH | | HAYNES INLET | | ISTHMUS SLOUGH | | LOWER BAY | | NORTH SLOUGH | | PONY SLOUGH | | SOUTH SLOUGH | | UPPER BAY | | PROJECT AREA | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATA SOURCE | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD | C-CAP | NLCD |
| **Agriculture: All Cultivated/Pasture/Hay** | 2.76 | 2.51 | 4.75 | 4.43 | 3.07 | 2.92 | 0.56 | 0.59 | 0.00 | 0.00 | 0.74 | 0.66 | 1.13 | 0.00 | 0.12 | 0.08 | 0.88 | 0.94 | 1.84 | 1.77 |
| Agriculture: Cultivated | 0.03 | 0.03 | 0.30 | 0.20 | 0.48 | 0.41 | 0.03 | 0.08 | 0.00 | 0.00 | 0.22 | 0.20 | 0.00 | 0.00 | 0.03 | 0.02 | 0.03 | 0 | 0.10 | 0.08 |
| Agriculture: Pasture/Hay | 2.72 | 2.48 | 4.45 | 4.24 | 2.60 | 2.51 | 0.53 | 0.50 | 0.00 | 0.00 | 0.52 | 0.47 | 0.00 | 0.00 | 0.10 | 0.06 | 0.85 | 0.94 | 1.74 | 1.69 |
| **Barren** | 0.55 | 0.50 | 0.03 | 0.29 | 0.07 | 0.23 | 0.83 | 1.36 | 17.99 | 23.20 | 4.48 | 5.27 | 1.13 | 1.61 | 1.87 | 2.95 | 0.69 | 1.12 | 2.34 | 2.72 |
| **Developed: All Developed Lands/Open Space** | 0.20 | 4.18 | 0.63 | 4.52 | 0.69 | 4.25 | 10.73 | 14.89 | 12.11 | 17.23 | 5.27 | 9.23 | 42.77 | 47.19 | 1.71 | 5.06 | 4.30 | 9.56 | 4.45 | 8.38 |
| Developed: High Intensity | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 1.52 | 1.65 | 0.87 | 1.46 | 0.42 | 0.46 | 3.97 | 5.18 | 0.10 | 0.15 | 0.81 | 1.05 | 0.47 | 0.57 |
| Developed: Intermediate (Medium) Intensity | 0.03 | 0.04 | 0.03 | 0.04 | 0.03 | 0.04 | 1.72 | 2.12 | 2.54 | 4.02 | 0.66 | 0.93 | 11.70 | 14.48 | 0.13 | 0.17 | 0.68 | 1.01 | 0.86 | 1.10 |
| Developed: Low Intensity | 0.17 | 0.16 | 0.53 | 0.41 | 0.41 | 0.26 | 4.81 | 4.42 | 6.64 | 8.25 | 3.32 | 3.24 | 19.75 | 19.09 | 1.19 | 1.19 | 1.96 | 2.16 | 2.26 | 2.21 |
| Developed: Open Space | 0.00 | 3.98 | 0.08 | 4.07 | 0.22 | 3.95 | 2.69 | 6.69 | 2.05 | 3.50 | 0.88 | 4.59 | 7.35 | 8.43 | 0.29 | 3.55 | 0.84 | 5.34 | 0.86 | 4.50 |
| **Estuarine Aquatic Bed** | 0.01 | N/A | 0.00 | N/A | 0.11 | N/A | 0.00 | N/A | 3.01 | N/A | 0.19 | N/A | 0.43 | N/A | 1.05 | N/A | 0.91 | N/A | 0.50 | N/A |
| **Forest: All Deciduous/Evergreen/Mixed** | 60.89 | 58.34 | 55.10 | 54.27 | 64.95 | 66.46 | 46.06 | 44.67 | 7.28 | 8.74 | 47.41 | 48.27 | 36.44 | 37.49 | 58.59 | 59.97 | 33.03 | 38.86 | 49.87 | 50.83 |
| Forest: Deciduous | 2.21 | 1.64 | 2.23 | 1.60 | 2.33 | 1.90 | 1.85 | 1.39 | 0.11 | 0.11 | 0.84 | 0.58 | 0.53 | 0.28 | 0.22 | 0.08 | 1.36 | 1.24 | 1.60 | 1.24 |
| Forest: Evergreen | 36.05 | 34.71 | 24.50 | 23.34 | 36.71 | 37.41 | 28.13 | 27.23 | 6.36 | 7.67 | 33.42 | 34.08 | 25.35 | 26.12 | 48.23 | 50.28 | 19.41 | 22.76 | 30.63 | 31.27 |
| Forest: Mixed | 22.63 | 21.98 | 28.37 | 29.33 | 25.91 | 27.16 | 16.07 | 16.06 | 0.81 | 0.96 | 13.14 | 13.61 | 10.56 | 11.09 | 10.14 | 9.62 | 12.26 | 14.86 | 17.64 | 18.32 |
| **Grassland** | 6.23 | 5.37 | 6.98 | 5.36 | 3.52 | 2.81 | 9.59 | 7.87 | 6.30 | 6.66 | 6.45 | 4.91 | 4.20 | 3.30 | 6.71 | 6.03 | 6.97 | 7.34 | 6.52 | 5.70 |
| **Scrub/Shrub** | 26.46 | 26.51 | 22.99 | 22.73 | 16.16 | 16.63 | 20.61 | 20.31 | 4.86 | 6.04 | 20.48 | 21.17 | 4.29 | 4.35 | 18.94 | 20.15 | 28.67 | 35.75 | 21.46 | 22.59 |
| **Unconsolidated Shore** | 0.05 | N/A | 0.31 | N/A | 3.11 | N/A | 0.73 | N/A | 4.55 | N/A | 3.56 | N/A | 3.63 | N/A | 3.56 | N/A | 9.72 | N/A | 2.49 | N/A |
| **Water: All Open/Snow-Ice** | 0.34 | 0.33 | 0.55 | 0.54 | 1.21 | 0.14 | 2.52 | 2.46 | 17.11 | 3.31 | 0.77 | 0.14 | 3.05 | 2.63 | 1.74 | 0.46 | 6.37 | 0.25 | 3.02 | 0.85 |
| Water: Open | 0.34 | 0.33 | 0.55 | 0.54 | 1.21 | 0.14 | 2.45 | 2.41 | 17.11 | 3.31 | 0.77 | 0.14 | 3.05 | 2.63 | 1.74 | 0.46 | 6.36 | 0.25 | 3.01 | 0.84 |
| Water: Perennial Snow/Ice* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 |
| **Wetland: All Emergent (Estuarine/Palustrine)** | 1.48 | 1.44 | 6.21 | 6.04 | 4.05 | 3.89 | 6.21 | 6.21 | 14.21 | 18.14 | 6.03 | 5.91 | 2.89 | 2.32 | 2.14 | 1.76 | 6.58 | 4.70 | 4.59 | 4.36 |
| Wetland: Emergent Estuarine | 0.01 | N/A | 0.00 | N/A | 0.31 | N/A | 0.08 | N/A | 0.34 | N/A | 0.89 | N/A | 1.64 | N/A | 0.48 | N/A | 3.60 | N/A | 0.61 | N/A |
| Wetland: Emergent Palustrine | 1.48 | N/A | 6.21 | N/A | 3.75 | N/A | 6.13 | N/A | 13.87 | N/A | 5.14 | N/A | 1.26 | N/A | 1.66 | N/A | 2.98 | N/A | 3.98 | N/A |
| **Wetland: All Woody (Forested/Scrub-Shrub)** | 1.03 | 0.83 | 2.44 | 1.80 | 3.03 | 2.67 | 2.15 | 1.65 | 12.60 | 16.69 | 4.64 | 4.44 | 1.15 | 1.12 | 3.57 | 3.53 | 1.89 | 1.48 | 2.94 | 2.79 |
| Wetland: Forested Palustrine | 0.60 | N/A | 1.13 | N/A | 1.44 | N/A | 1.25 | N/A | 4.86 | N/A | 2.38 | N/A | 0.94 | N/A | 2.66 | N/A | 0.42 | N/A | 1.42 | N/A |
| Wetland: Scrub/Shrub Estuarine | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A | 0.00 | N/A |
| Wetland: Scrub/Shrub Palustrine | 0.42 | N/A | 1.31 | N/A | 1.59 | N/A | 0.90 | N/A | 7.74 | N/A | 2.26 | N/A | 0.21 | N/A | 0.91 | N/A | 1.47 | N/A | 1.52 | N/A |

* Likely error: No perennial snow or ice in the project area.

Table 3. Percent coverage of land classes in the project area and in each project area subsystem. Data Source: C-CAP 2014; NLCD 2011

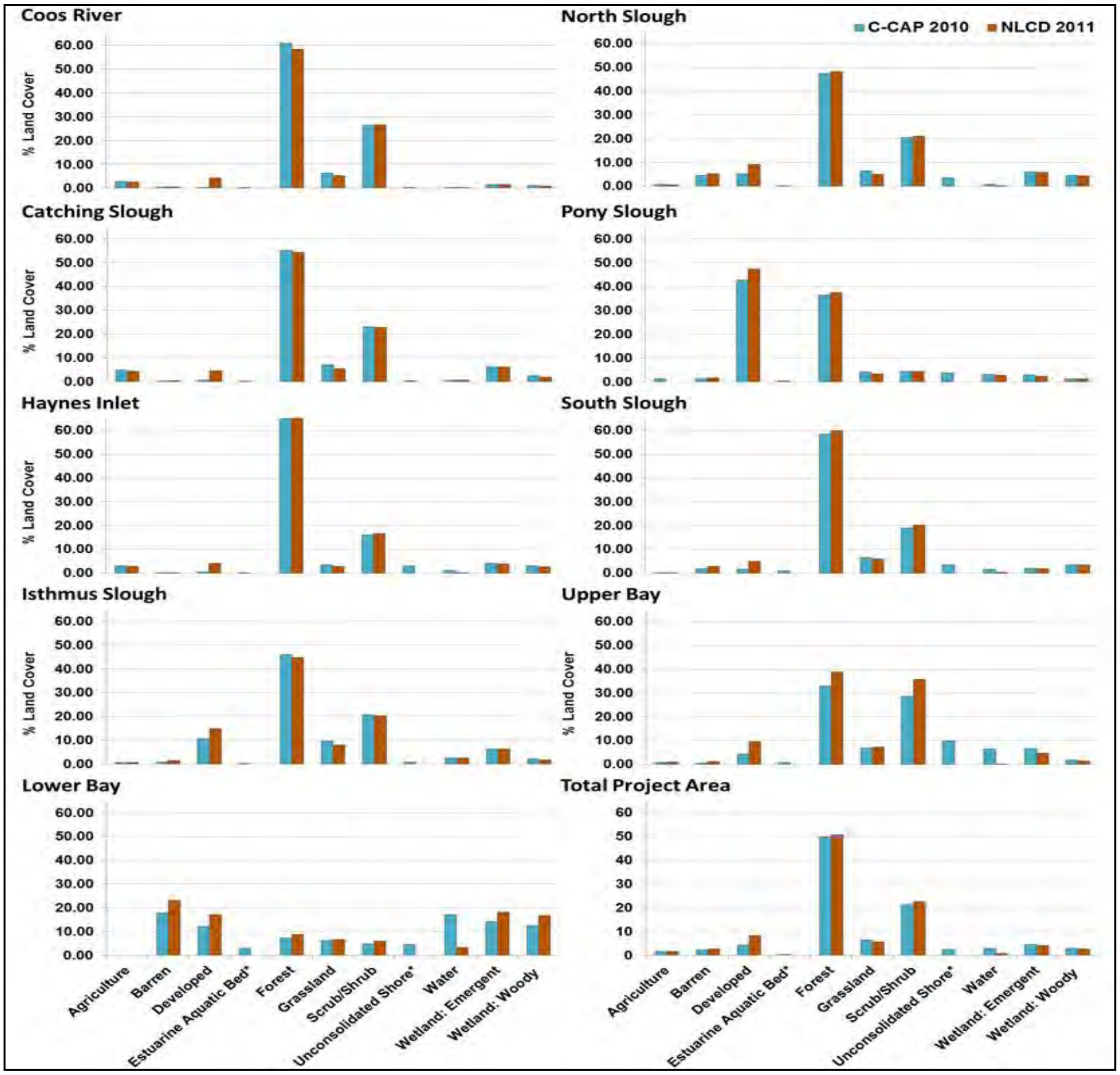



Figure 2a. Comparison of 2010 C-CAP and 2011 NLCD Land Cover for Subsystems and Project Area. Data Source: C-CAP 2014; NLCD 2011

Slough subsystems are classified as Forest. Isthmus Slough, North Slough, Pony Slough, and Upper Bay are 30-50% Forest. The Lower Bay is less than 10% Forest. Evergreen forests are more abundant than mixed forests in all subsystems except Catching Slough, which has slightly more mixed forests than evergreen. Deciduous forests occupy less than 2.5 percent of the area of each subsystem.

Scrub/Shrub

Scrub/Shrub areas are dominated by shrubs less than 5 meters tall and typically more than 20% of total vegetation. When forests are harvested using clear-cut methods, the re-growth of true shrubs or young trees is classified by C-CAP and NLCD as Scrub/Shrub, although very recent clear-cuts may also be classified as grasslands. Scrub/Shrub is the next most abundant land cover type for the

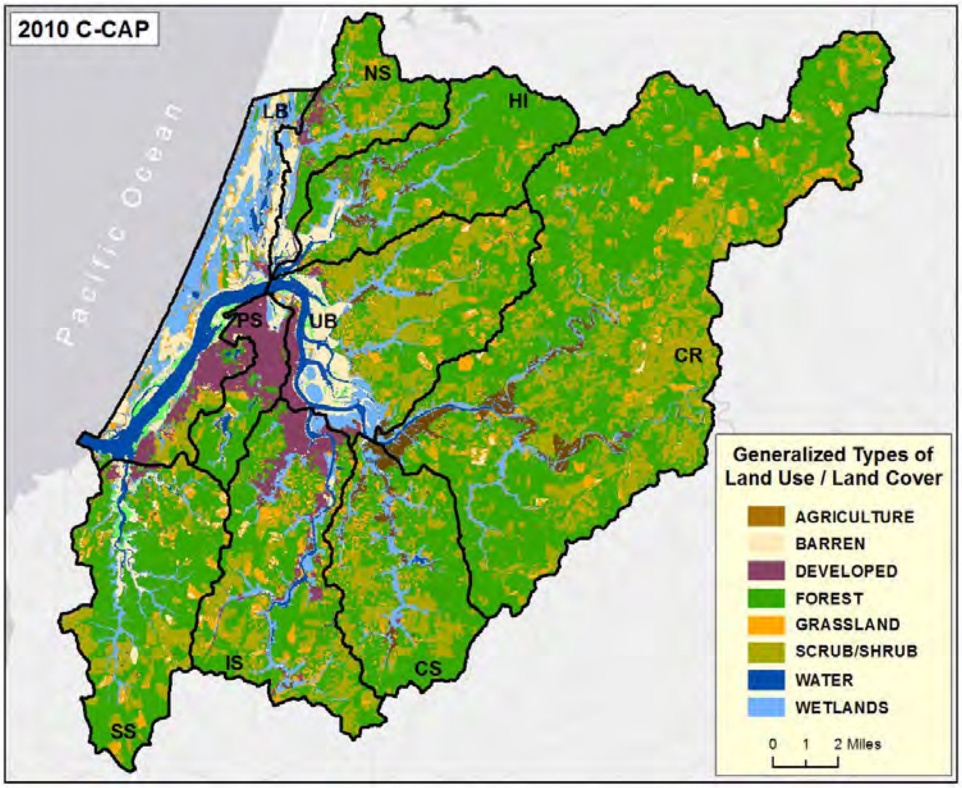



Figure 2b. Coastal Change Analysis Program (C-CAP) 2010 land use and cover. Data Source: C-CAP 2014

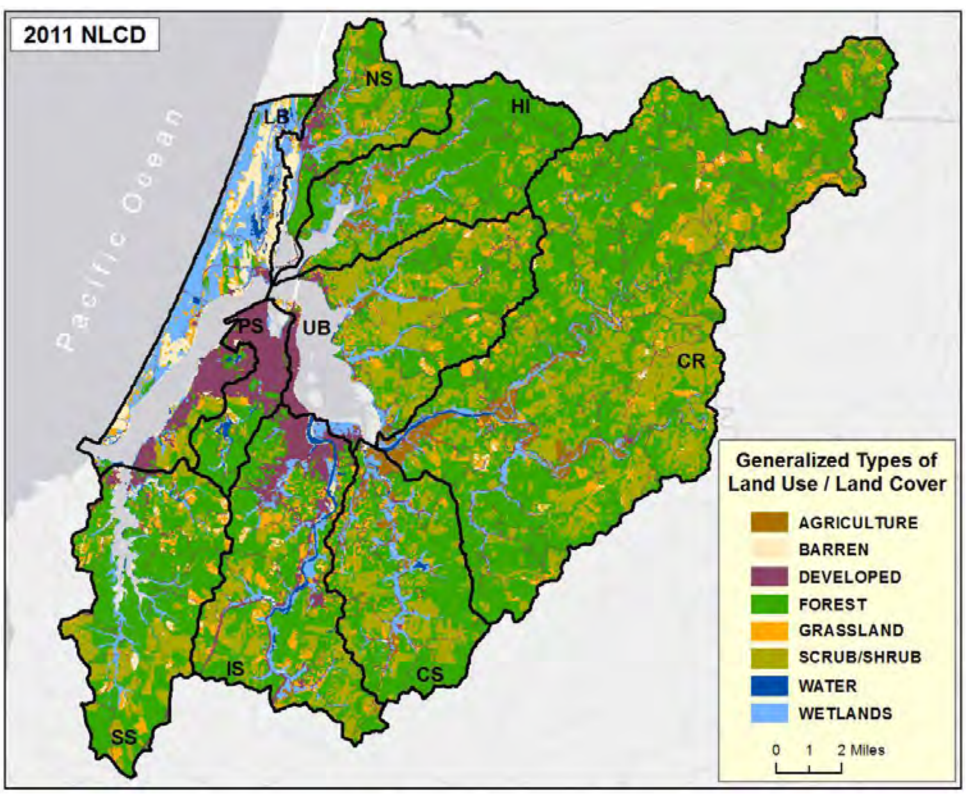
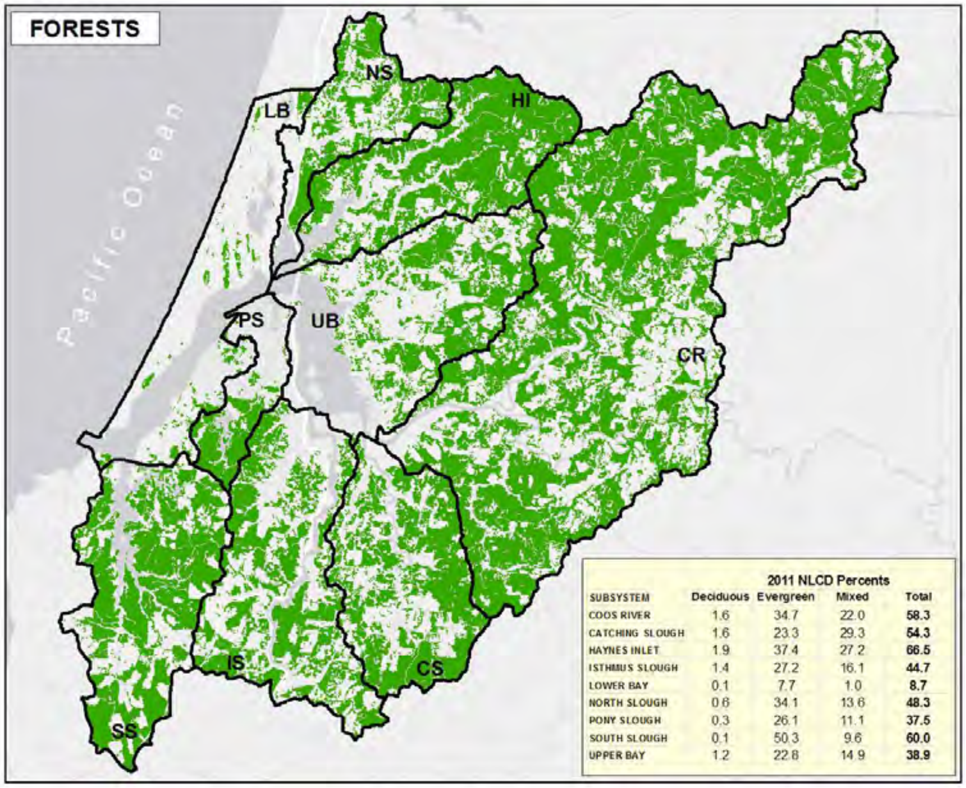
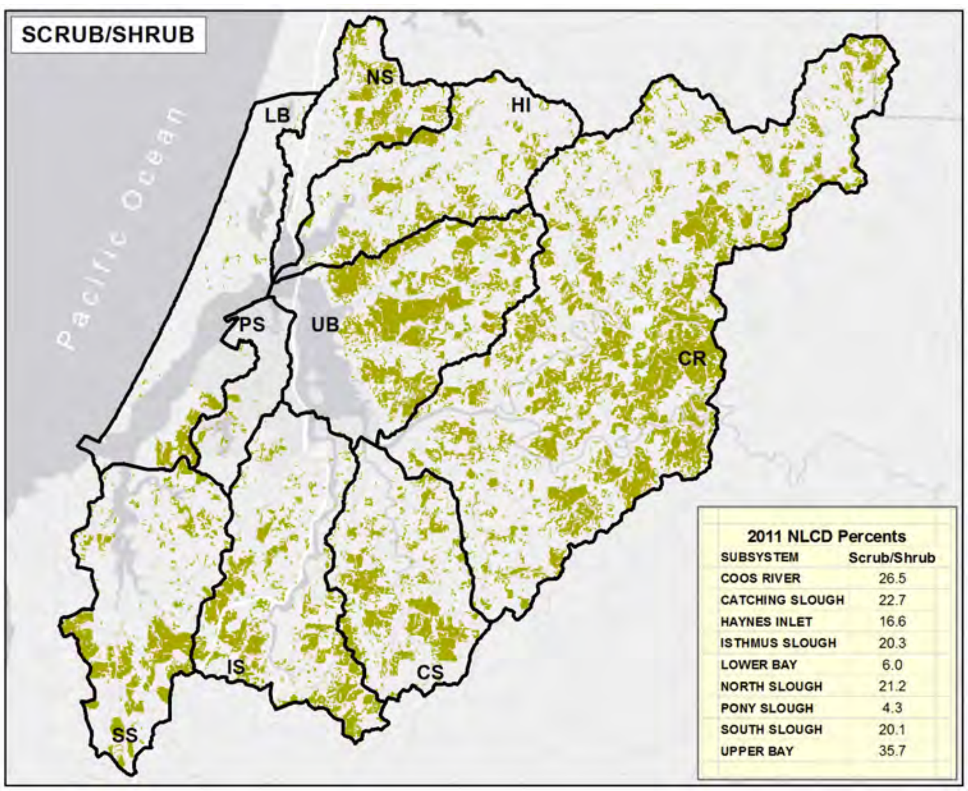



Figure 2c. National Land Cover Dataset (NLCD) 2011 land use and cover. Note the waters of the Coos Estuary were not included in NLCD's 2011 data. Data Source: NLCD 2011




| SUBSYSTEM | Deciduous | Evergreen | Mixed | Total |
|---|---|---|---|---|
| | 2011 NLCD Percents | | | |
| COOS RIVER | 1.6 | 34.7 | 22.0 | **58.3** |
| CATCHING SLOUGH | 1.6 | 23.3 | 29.3 | **54.3** |
| HAYNES INLET | 1.9 | 37.4 | 27.2 | **66.5** |
| ISTHMUS SLOUGH | 1.4 | 27.2 | 16.1 | **44.7** |
| LOWER BAY | 0.1 | 7.7 | 1.0 | **8.7** |
| NORTH SLOUGH | 0.6 | 34.1 | 13.6 | **48.3** |
| PONY SLOUGH | 0.3 | 26.1 | 11.1 | **37.5** |
| SOUTH SLOUGH | 0.1 | 50.3 | 9.6 | **60.0** |
| UPPER BAY | 1.2 | 22.8 | 14.9 | **38.9** |

Figure 3. Distribution of Forest land in project area subsystems. Data Source: NLCD 2011




| 2011 NLCD Percents | |
|---|---|
| SUBSYSTEM | Scrub/Shrub |
| COOS RIVER | 26.5 |
| CATCHING SLOUGH | 22.7 |
| HAYNES INLET | 16.6 |
| ISTHMUS SLOUGH | 20.3 |
| LOWER BAY | 6.0 |
| NORTH SLOUGH | 21.2 |
| PONY SLOUGH | 4.3 |
| SOUTH SLOUGH | 20.1 |
| UPPER BAY | 35.7 |

Figure 4. Distribution of Shrub/Scrub/Grass land in study area subsystems. Data Source: NLCD 2011

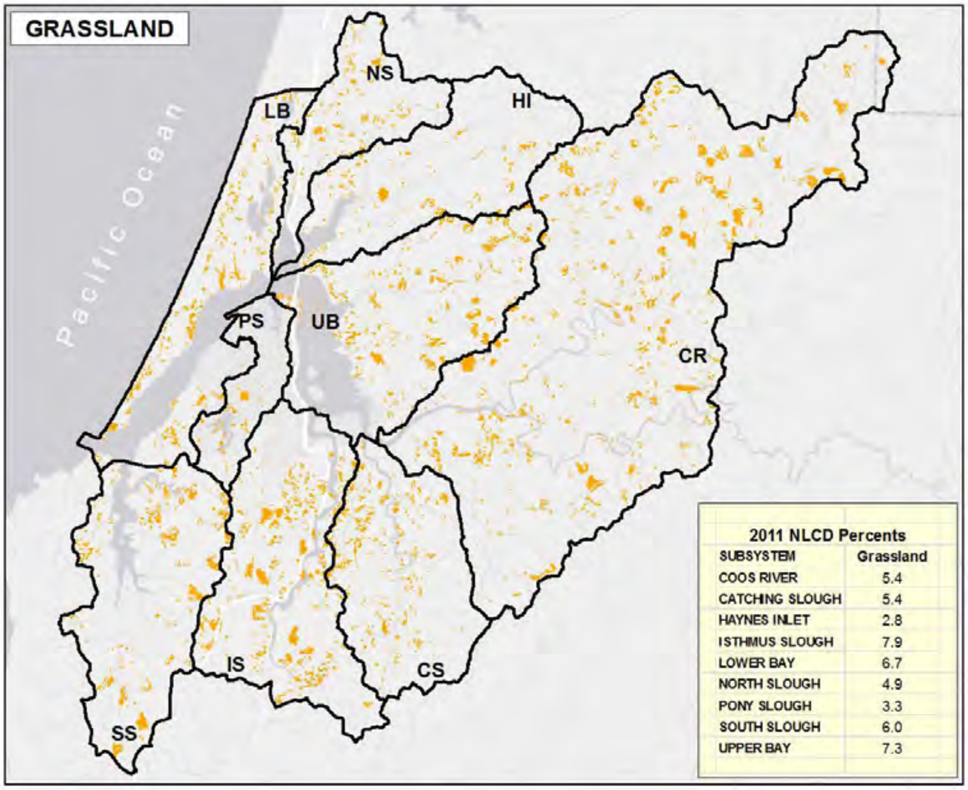



Figure 5. Distribution of Grassland in project area subsystems. Data Source: NLCD 2011

project area (roughly 22-23%) in both the C-CAP and NLCD data (Table 3, Figures 2a, 4). Scrub-Shrub percentages range between 15-35% for all subsystems, except for Lower Bay and Pony Slough, which range between 4-6% Scrub/Shrub.

Grassland

Grasslands are predominately composed of herbaceous (non-woody) or graminoid (grass, sedge, rush) vegetation that is not tilled or intensively managed, but may be used for grazing (NLCD). Although grasslands are often locally associated with recently clear-cut forests and scrub/shrub vegetation, coastal dunes and other grassy environments are also represented. Note the coastal and inland distribution of grasslands and scrub/shrub in Figure 5. The percent Grassland data is consistent between C-CAP and NLCD data sources for the project area (6-7%) and among the subsystems (approximately 3-10%)(Table 3, Figures 2a and 5).

Developed

Both data sources define four subclasses of Developed land, based on the percentage of constructed or impervious surfaces: High Intensity (80-100%); Medium Intensity (50-79%); Low Intensity (21-49%) and Developed Open Space (< 20%). The total percentage of land uses classified as Developed in the project area is relatively low (C-CAP: 4.45%; NLCD: 8.38%)(Table 3, Figures 2a and 6). The difference between the two data sources (NLCD's total Developed percentage is almost

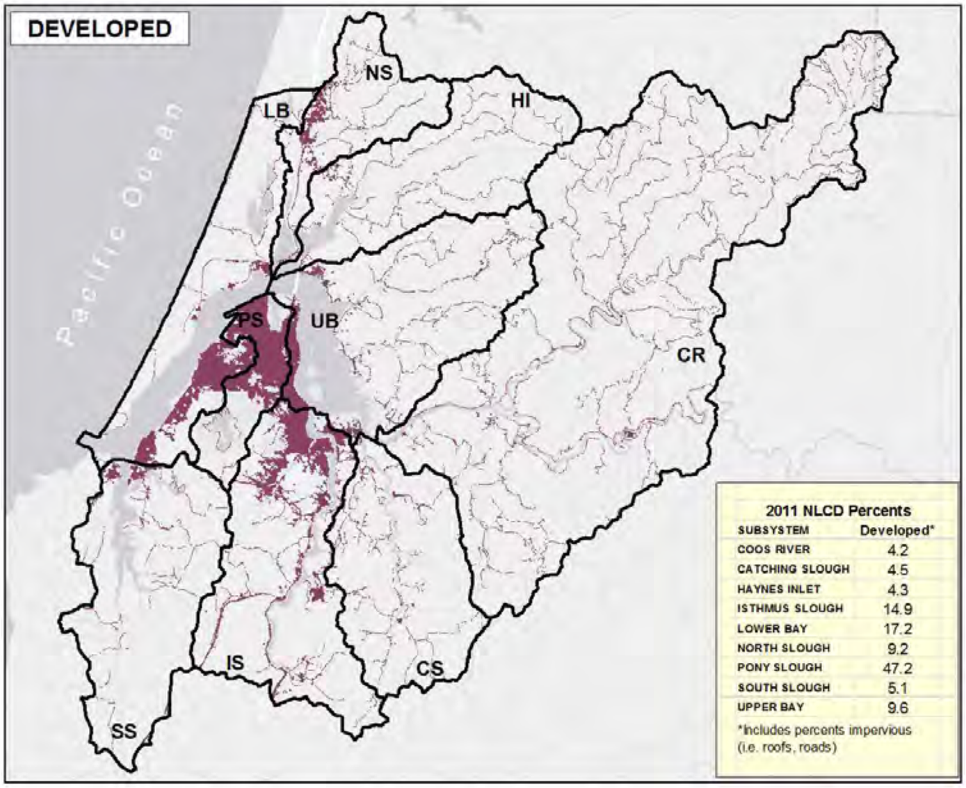



Figure 6. Distribution of Developed land in project area subsystems. Data Source: NLCD 2011

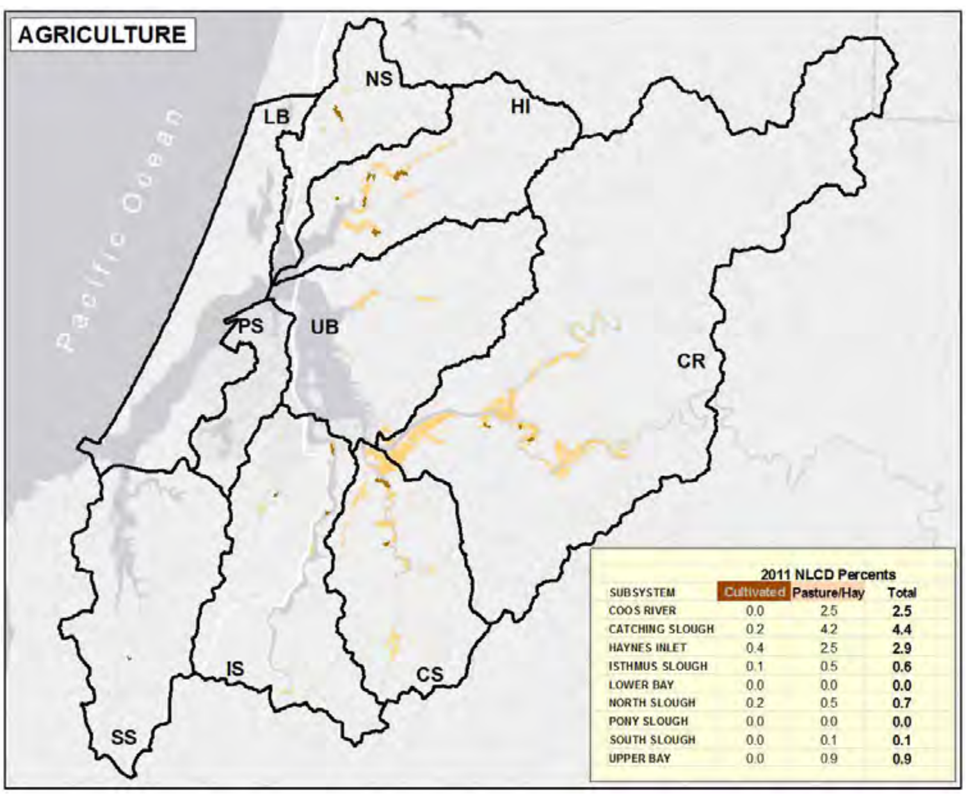
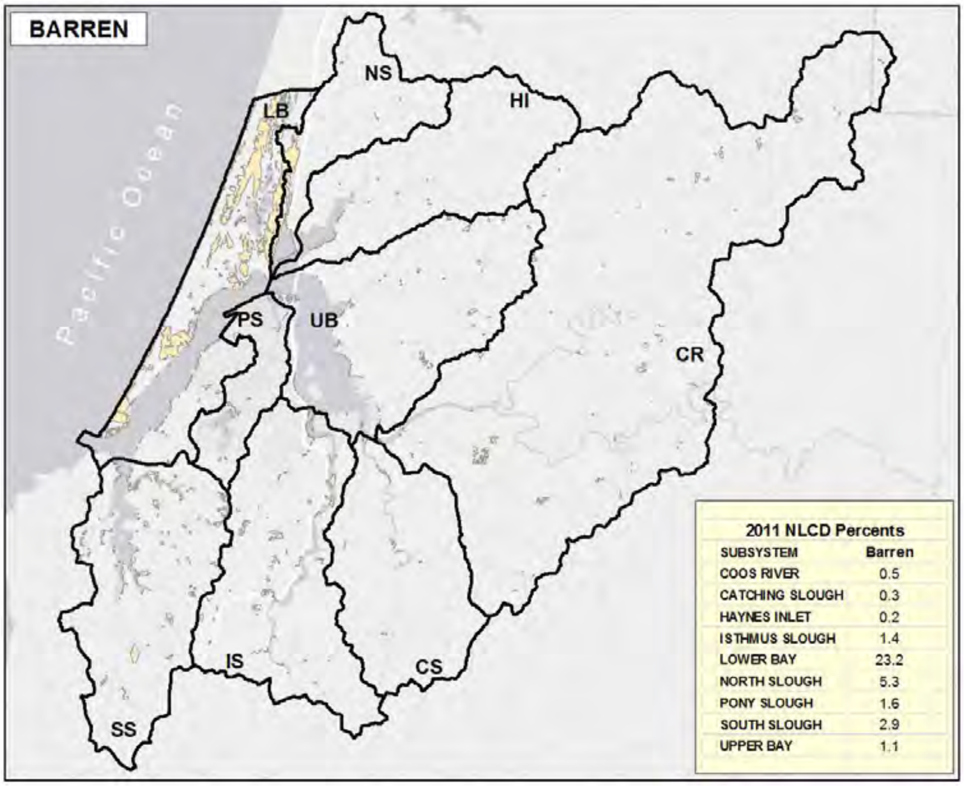
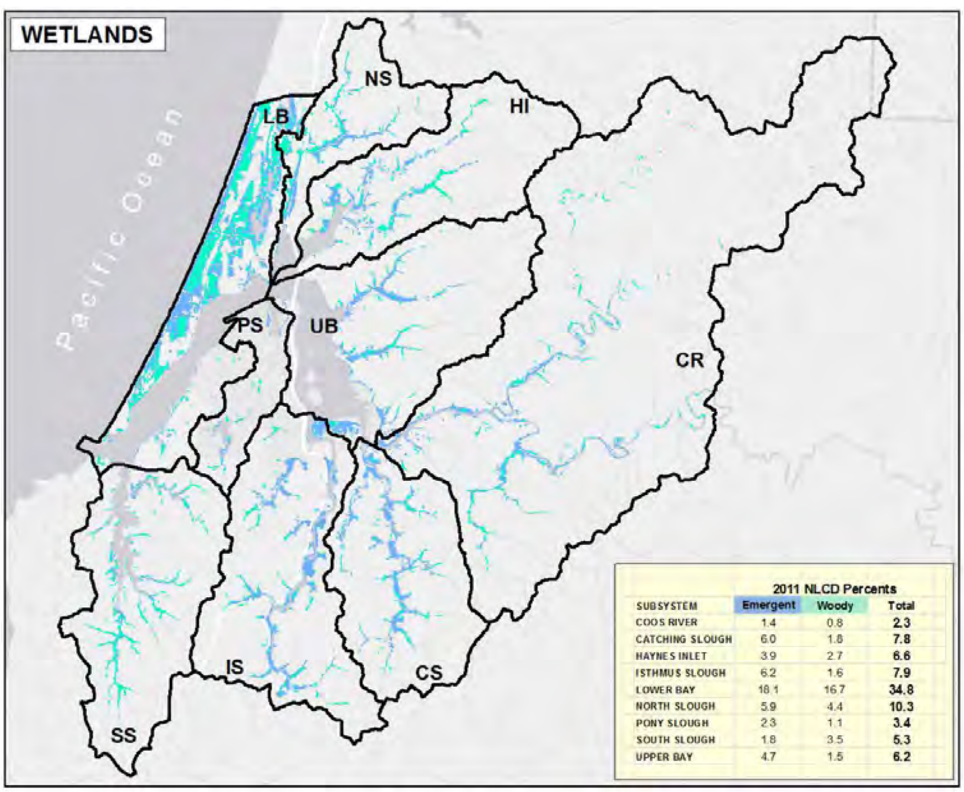



Figure 7. Distribution of Agricultural land in project area subsystems. Data Source: NLCD 2011




| 2011 NLCD Percents | |
|---|---|
| SUBSYSTEM | Barren |
| COOS RIVER | 0.5 |
| CATCHING SLOUGH | 0.3 |
| HAYNES INLET | 0.2 |
| ISTHMUS SLOUGH | 1.4 |
| LOWER BAY | 23.2 |
| NORTH SLOUGH | 5.3 |
| PONY SLOUGH | 1.6 |
| SOUTH SLOUGH | 2.9 |
| UPPER BAY | 1.1 |

Figure 8. Distribution of Bare Land in project area subsystems. Data Source: NLCD 2011




| | 2011 NLCD Percents | | |
|---|---|---|---|
| SUBSYSTEM | Emergent | Woody | Total |
| COOS RIVER | 1.4 | 0.8 | 2.3 |
| CATCHING SLOUGH | 6.0 | 1.8 | 7.8 |
| HAYNES INLET | 3.9 | 2.7 | 6.6 |
| ISTHMUS SLOUGH | 6.2 | 1.6 | 7.9 |
| LOWER BAY | 18.1 | 16.7 | 34.8 |
| NORTH SLOUGH | 5.9 | 4.4 | 10.3 |
| PONY SLOUGH | 2.3 | 1.1 | 3.4 |
| SOUTH SLOUGH | 1.8 | 3.5 | 5.3 |
| UPPER BAY | 4.7 | 1.5 | 6.2 |

Figure 9. Distribution of Wetlands in project area subsystems. Data Source: NLCD 2011

twice C-CAP's) reflects the large difference in their Developed Open Space category (C-CAP: 0.86%; NLCD: 4.50%), which appears to come from their distinctly different classification of that subclass. NLCD Developed Open Space data include large-lot housing units and uses percent imperviousness (roads, roof-tops) in its Developed Open Space classification, while C-CAP does not (Homer et al. 2004) .

Of the other three Developed subclasses, the greatest percentage in the project area is Low Intensity development (C-CAP: 2.26%; NLCD: 2.21%).

In project area subsystems, Pony Slough is the only subsystem with more than 40% developed land, Isthmus Slough and Lower Bay are about 10-20% developed, and the remaining subsystems are less than 10% developed. The NLCD data are consistently higher than the C-CAP data for all subsystems.

### Agriculture

Areas with more than 20% of the vegetation managed for crops, hay, livestock pasture or actively tilled are classified Agriculture by C-CAP and NLCD. Both sources are in close agreement on the total percentage of land uses classified as Agriculture in the project area (C-CAP: 1.84%; NLCD: 1.77%)(Table 3, Figures 2a and 7). Of the two land use subclasses comprising Agriculture, Pasture/hay is the largest component (C-CAP: 1.74%; NLCD: 1.69%). The other Agriculture subclass is Cultivated (C-CAP: 0.10%; NLCD: 0.08%). Agriculture comprises about 2.5 – 4.6% in Coos River, Catching Slough, and Haynes Inlet subsystems, roughly 0.5 – 1% in Isthmus Slough, North Slough, and Upper Bay, but near 0% in Lower Bay, South Slough, and Pony Slough (Figure 7).

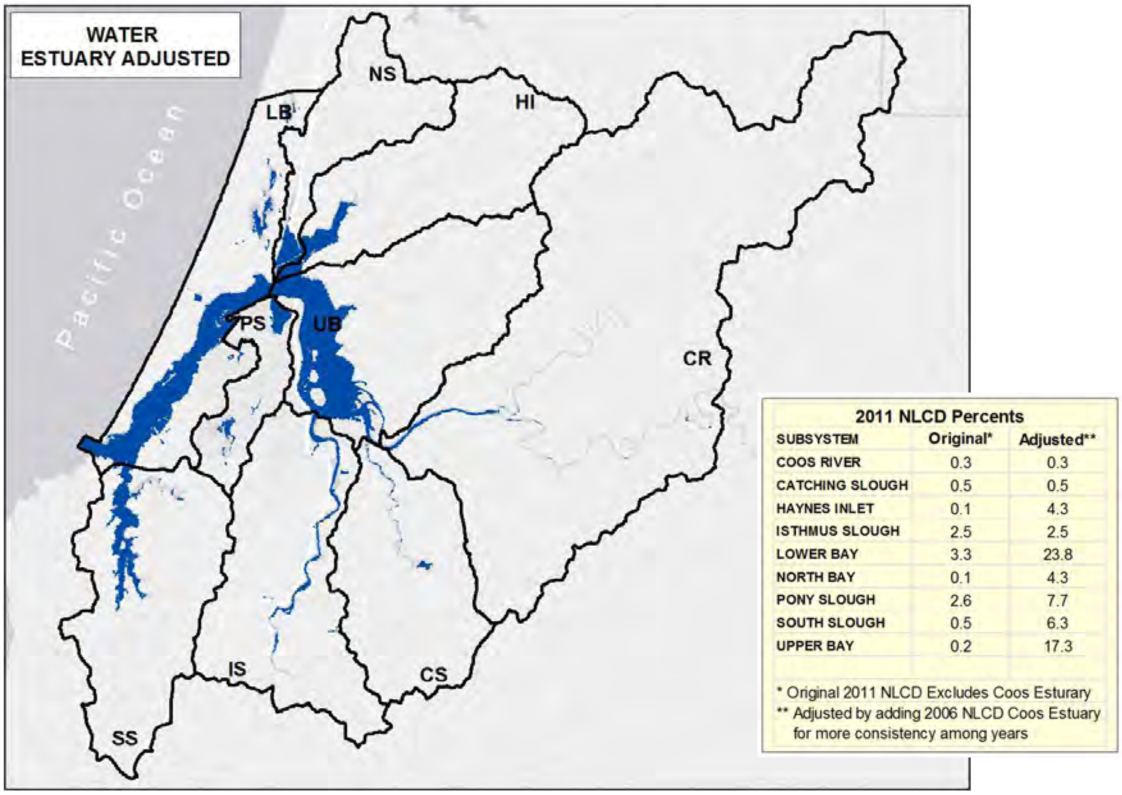
### Barren

The Barren LULC classification consists of exposed rock, sand, or clay including local areas of exposed bedrock, sand dunes, landslides, open mines, or gravel pits. Note that C-CAP also uses an "unconsolidated shore" category that includes silt, sand, and gravel subject to inundation, which is not used in NLCD classifications (Table 3). Both data sources are in close agreement on the total percentage of areas classified as Barren (C-CAP: 2.34%; NLCD: 2.72%)(Table 3, Figures 2a and 8). Barren land occupies about 21% in the Lower Bay subsystem (sand dunes); 2-5% in South and North Sloughs, respectively; and 0-1.5% in Coos River, Catching Slough, Haynes Inlet, Isthmus Slough, Pony Slough, and Upper Bay.

### Wetlands

Wetland classifications differ in the NLCD and C-CAP data. C-CAP distinguishes between Palustrine Wetlands (tidal and non-tidal areas with ocean-derived salinity below 0.5%) and Estuarine Wetlands (tidal areas with ≥ 0.5% salinity). Each C-CAP category is further divided into Forested, Scrub/Shrub, Emergent classes. In contrast to C-CAP's six wetland classes, NLCD distinguished only two: Woody and Emergent Herbaceous (Table 3).

Emergent Wetlands comprise 4-5% of the project area and Woody Wetlands are about




**2011 NLCD Percents**

| SUBSYSTEM | Original* | Adjusted** |
|---|---|---|
| COOS RIVER | 0.3 | 0.3 |
| CATCHING SLOUGH | 0.5 | 0.5 |
| HAYNES INLET | 0.1 | 4.3 |
| ISTHMUS SLOUGH | 2.5 | 2.5 |
| LOWER BAY | 3.3 | 23.8 |
| NORTH BAY | 0.1 | 4.3 |
| PONY SLOUGH | 2.6 | 7.7 |
| SOUTH SLOUGH | 0.5 | 6.3 |
| UPPER BAY | 0.2 | 17.3 |

* Original 2011 NLCD Excludes Coos Esturary
** Adjusted by adding 2006 NLCD Coos Estuary for more consistency among years

Figure 10. Water distribution in the project area- combining 2006 and 2011 NLCD data. Data Source: NLCD 2006; 2011.

3% in both data sets (Table 3, Figures 2a and 9). Emergent Wetlands (salt, brackish and freshwater marshes) cover about 1-3% of the Coos River, South Slough, and Pony Slough subsystems, and about 4%-6% in Haynes Inlet, Catching Slough, Isthmus Slough, North Slough, and Upper Bay subsystems. The Lower Bay subsystem is about 14-18% Emergent Wetlands.

Woody Wetlands (forested and shrubby freshwater wetlands) are between 1%- 4.5% of the area in every subsystem, except the Lower Bay which is about 13-17% Woody Wetlands. The Lower Bay is the most diverse of the subsystems due to significant proportions of lands classified as Woody Wetlands, Emergent Wetlands, Water, and Barren.

Water

Open water is classified by both C-CAP and NLCD as areas with less than 25% vegetation or soil. Perennial Ice/Snow is classified as Water in the NLCD but as Barren in C-CAP. For this data summary, the NLCD standard was used and the locally irrelevant percentage of "Ice/Snow" was considered Water.
To estimate and map the percentage of the project area classified as Water we used an adjusted version of the NLCD data that partially compensates for differences between data sources (e.g., the Coos Estuary was classified as Water in C-CAP, but not in NLCD 2011 (Table 3, Figures 2b, 2c)). The adjusted data and resulting map are shown in Figure 10.
The total percentage of Water in the project

area is estimated by C-CAP at 3.02% (Table 3) and by NLCD (adjusted) at 5.84% (Figure 10).

Trends: Project Area LULC Change Between 1996 and 2010

In this section, LULC changes are examined in a relatively short-term, recent interval based on the 1996-2010 C-CAP data. Following an overview of LULC trends in the project area and subsystems are descriptions of changes to Forest, Scrub/Shrub, Grasslands, Developed, Agriculture, Barren, Wetlands, and Water.

An analysis of C-CAP data from 1996 and 2010 showed that 21.6% of the project area underwent a land cover change (68 of 315 total $mi^2$) during that 14 year span (Figure 11 and Table 4)(for Coos County, the C-CAP atlas reported land cover changes for 21.3% of its area, thus land use change in the project area appears similar to the county as a whole).

When examined individually, the greatest areal and percentage of change occurred in the Coos River subsystem, at 31 $mi^2$ (28%), followed by Upper Bay, Isthmus Slough, South Slough and Catching Slough, each with more than 5 $mi^2$ of land use change (approx. 20-25% change). LULC changed roughly 1-3 $mi^2$ (8-16%) in the North Slough, Haynes Inlet, Lower Bay, and Pony Slough subsystems. The spatial distribution and percent change (relative to the total project area) of these LULC changes are provided in Figures 12 and 13 and Table 5, all of which is described in more detail in the following narrative organized by changed LULC classes.

LULC Change 1996-2010: Forest

The percent of land classified by C-CAP as Forest in the project area dropped by 11.5% between 1996 and 2010. The most common change for all Forest types was from Forest to Scrub/Shrub throughout the project area (see more in the Scrub/Shrub section below). Approximately 11% of the forests in the Coos River subsystem became Scrub/Shrub between 1996 and 2010, followed by 7.7% in South Slough, 6%-7% for Catching Slough, Isthmus Slough, North Slough and Upper Bay, 3.9% for Haynes Inlet, and 0.6% in Lower Bay (Figure 14).

LULC Change 1996-2010: Scrub/Shrub

Locally, the upland Scrub/Shrub LULC class represents transitional vegetation communities following natural disturbance events (e.g., slope failure, fire) or human activities such as timber harvest operations. In the project area, Scrub/Shrub lands increased by 36 $mi^2$; from 10% total coverage in 1996 to over 21% in 2010 (Figures 12 and 13, Table 5). As mentioned above, the greatest shift in vegetation cover in the project area was the conversion of Forest to the Scrub/Shrub LULC class (Figure 15). Over 18 $mi^2$ of forested lands were converted to Scrub/Shrub during the 14 year study period. For additional detail on changes in Scrub/Shrub vegetation see Grassland section below and the Terrestrial Vegetation data summary in Chapter 12: Vegetation.

LULC Change 1996-2010: Grasslands

Between 1996 and 2010 it appears that timber harvests and likely natural disturbances

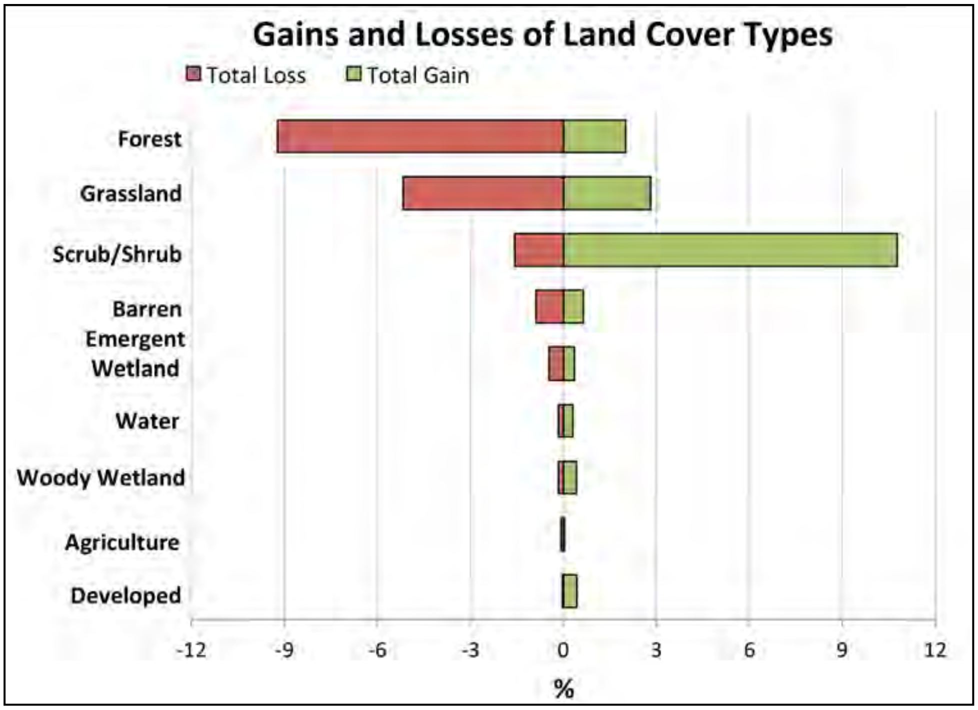



Figure 11. Percent change of LULC classes in the project area between 1996 and 2010. Data Source : C-CAP 2014

| SUBSYSTEM | TOTAL AREA ACRES | TOTAL AREA SQ. MI. | CHANGED CLASS 1996-2010 ACRES | CHANGED CLASS 1996-2010 SQ. MI. | PERCENT CHANGE |
|---|---|---|---|---|---|
| CR | 71433.7 | 111.6 | 20114.0 | 31.4 | 28.2 |
| UB | 22815.0 | 35.6 | 5604.5 | 8.7 | 24.6 |
| SS | 19628.9 | 30.7 | 4325.4 | 6.7 | 22.0 |
| IS | 21591.1 | 33.7 | 4502.2 | 7.0 | 20.9 |
| CS | 16836.3 | 26.3 | 3300.4 | 5.1 | 19.6 |
| NS | 9494.7 | 14.8 | 1528.0 | 2.4 | 16.1 |
| PS | 5518.2 | 8.6 | 692.5 | 1.1 | 12.5 |
| HI | 16891.6 | 26.4 | 2117.4 | 3.3 | 12.5 |
| LB | 17285.6 | 27.0 | 1407.7 | 2.2 | 8.1 |
| PROJECT | 201495.0 | 314.8 | 43592.2 | 68.0 | 21.6 |

Table 4. Percent LULC change in project area subsystems between 1996 and 2010. Data Source: C-CAP 2014

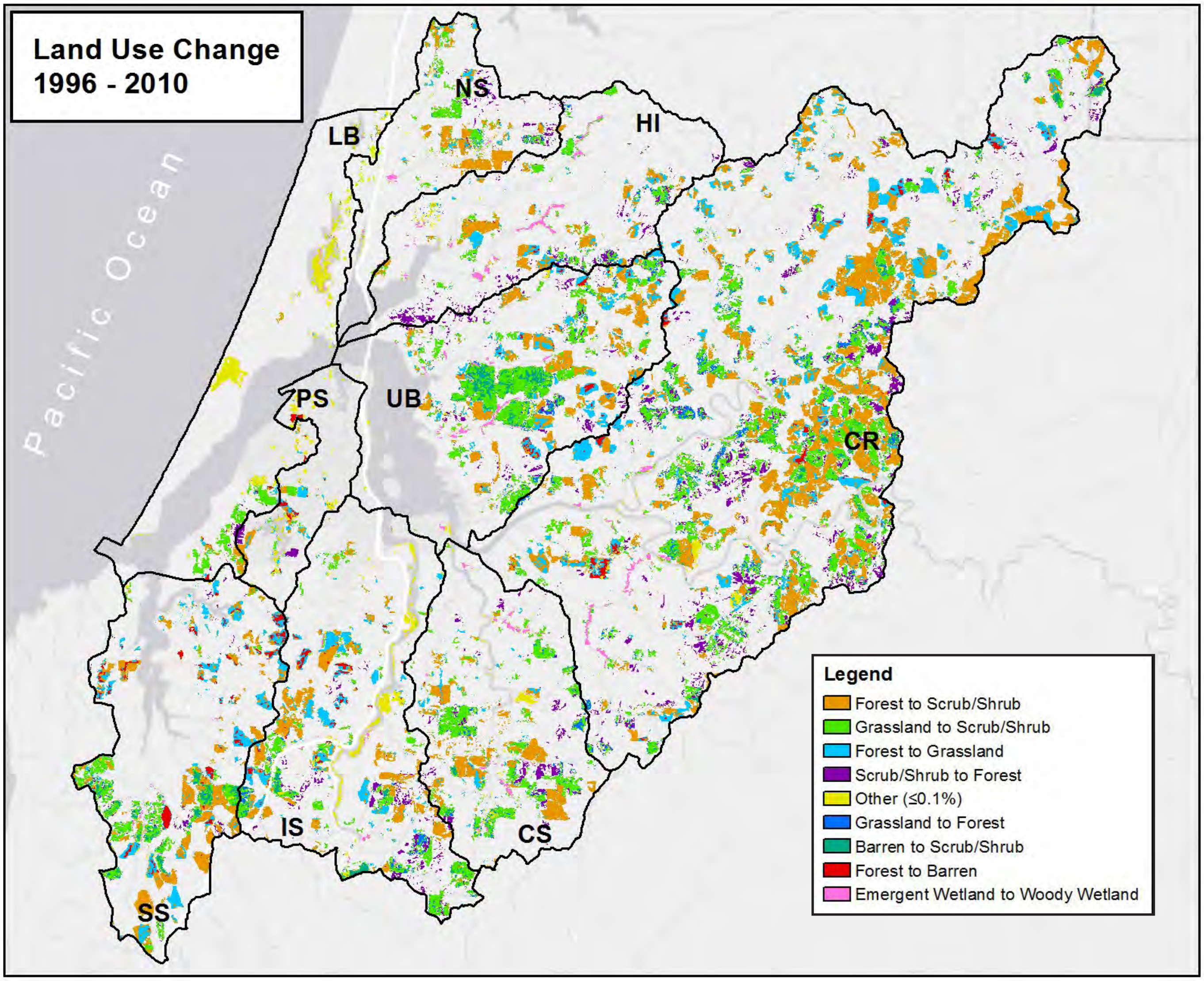



Figure 12. Distribution of the eight largest LULC class changes in the project area between 1996 and 2010. All other changes are indicated in the "Other" category. Within the project area, gray areas not colored were unchanged. Data Source: C-CAP 2014

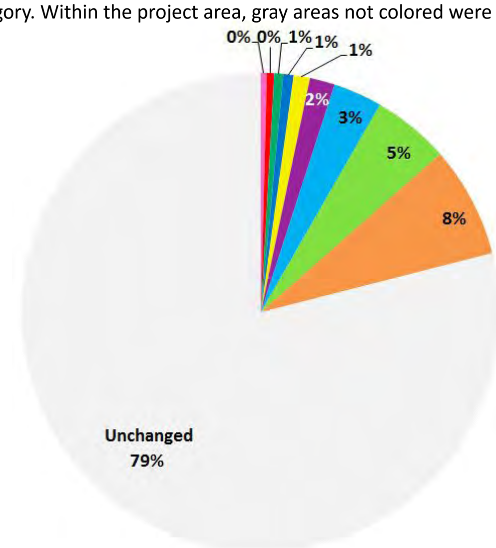



Figure 13. Percent relative to the total project area of the eight largest LULC class changes between 1996 and 2010 in the project area. Use legend in Figure 12 to identify LULC class changes. Data Source: C-CAP 2014

| LULC Class Changes | Area (Acres) | Area ($m^2$) | Percent of Project Area |
|---|---|---|---|
| Forest to Scrub/Shrub | 15,170 | 61,389,482 | 7.5 |
| Grassland to Scrub/Shrub | 10,499 | 42,487,841 | 5.2 |
| Forest to Grassland | 6,578 | 26,621,180 | 3.3 |
| Scrub/Shrub to Forest | 3,399 | 13,755,984 | 1.7 |
| Grassland to Forest | 1,465 | 5,927,563 | 0.7 |
| Barren to Scrub/Shrub | 1,186 | 4,797,761 | 0.6 |
| Forest to Barren | 1,048 | 4,241,066 | 0.5 |
| Emergent Wetland to Woody Wetland | 725 | 2,932,494 | 0.4 |
| Scrub/Shrub to Grassland | 291 | 1,176,253 | 0.1 |
| Barren to Water | 280 | 1,132,616 | 0.1 |
| Water to Emergent Wetland | 214 | 866,933 | 0.1 |
| Forest to Developed | 208 | 842,056 | 0.1 |
| Barren to Forest | 147 | 594,790 | 0.1 |
| Grassland to Developed | 146 | 592,472 | 0.1 |
| Woody Wetland to Emergent Wetland | 141 | 572,424 | 0.1 |
| Barren to Grassland | 123 | 496,934 | 0.1 |
| Agriculture to Emergent Wetland | 90 | 363,207 | 0.04 |
| Forest to Agriculture | 74 | 299,213 | 0.04 |
| Barren to Emergent Wetland | 67 | 271,491 | 0.03 |
| Emergent Wetland to Water | 55 | 221,412 | 0.03 |
| Grassland to Water | 54 | 217,684 | 0.03 |
| Scrub/Shrub to Barren | 40 | 162,583 | 0.02 |
| Grassland to Barren | 36 | 146,147 | 0.02 |
| Agriculture to Developed | 36 | 145,501 | 0.02 |
| Developed to Barren | 31 | 125,015 | 0.02 |
| Emergent Wetland to Barren | 30 | 121,785 | 0.01 |
| Emergent Wetland to Developed | 24 | 96,260 | 0.01 |
| Barren to Developed | 23 | 92,093 | 0.01 |
| Grassland to Emergent Wetland | 21 | 85,645 | 0.01 |
| Grassland to Woody Wetland | 21 | 85,296 | 0.01 |
| Water to Barren | 20 | 82,613 | 0.01 |
| Emergent Wetland to Scrub/Shrub | 20 | 82,421 | 0.01 |
| Barren to Woody Wetland | 19 | 78,672 | 0.01 |
| Woody Wetland to Barren | 18 | 74,298 | 0.01 |
| Forest to Water | 14 | 58,426 | 0.01 |
| Scrub/Shrub to Developed | 13 | 54,167 | 0.01 |
| Agriculture to Water | 13 | 51,212 | 0.01 |
| Forest to Woody Wetland | 12 | 49,849 | 0.01 |
| Woody Wetland to Developed | 11 | 44,350 | 0.01 |

| LULC Class Changes (continued) | Area (Acres) | Area ($m^2$) | Percent of Project Area |
|---|---|---|---|
| Agriculture to Barren | 10 | 39,876 | 0.005 |
| Woody Wetland to Scrub/Shrub | 10 | 39,315 | 0.005 |
| Forest to Emergent Wetland | 9 | 36,749 | 0.005 |
| Barren to Agriculture | 9 | 35,025 | 0.004 |
| Emergent Wetland to Grassland | 8 | 33,849 | 0.004 |
| Agriculture to Scrub/Shrub | 8 | 31,243 | 0.004 |
| Emergent Wetland to Agriculture | 7 | 30,033 | 0.004 |
| Woody Wetland to Grassland | 6 | 26,113 | 0.003 |
| Woody Wetland to Forest | 6 | 24,245 | 0.003 |
| Water to Grassland | 5 | 19,252 | 0.002 |
| Woody Wetland to Water | 5 | 18,905 | 0.002 |
| Scrub/Shrub to Water | 5 | 18,746 | 0.002 |
| Developed to Scrub/Shrub | 5 | 18,470 | 0.002 |
| Grassland to Agriculture | 4 | 17,836 | 0.002 |
| Aquatic to Bed to Barren | 4 | 15,197 | 0.002 |
| Scrub/Shrub to Woody Wetland | 3 | 13,332 | 0.002 |
| Scrub/Shrub to Agriculture | 3 | 12,757 | 0.002 |
| Woody Wetland to Agriculture | 3 | 12,450 | 0.002 |
| Developed to Grassland | 3 | 11,894 | 0.001 |
| Emergent Wetland to Forest | 3 | 10,946 | 0.001 |
| Agriculture to Woody Wetland | 3 | 10,759 | 0.001 |
| Developed to Forest | 2 | 9,656 | 0.001 |
| Scrub/Shrub to Emergent Wetland | 2 | 7,156 | 0.001 |
| Water to Forest | 2 | 7,107 | 0.001 |
| Agriculture to Grassland | 1 | 5,341 | 0.001 |
| Water to Scrub/Shrub | 1 | 5,067 | 0.001 |
| Developed to Emergent Wetland | 1 | 4,179 | 0.001 |
| Water to Developed | 1 | 4,049 | 0.0005 |
| Water to Woody Wetland | 1 | 3,759 | 0.0005 |
| Aquatic to Bed to Emergent Wetland | 1 | 3,216 | 0.0004 |
| Aquatic to Bed to Water | 1 | 3,096 | 0.0004 |
| Developed to Water | 1 | 2,971 | 0.0004 |
| Agriculture to Forest | 1 | 2,271 | 0.0003 |
| Water to Agriculture | 1 | 2,033 | 0.0002 |
| Barren to Aquatic to Bed | 0.5 | 1,865 | 0.0002 |
| Developed to Woody Wetland | 0.3 | 1,261 | 0.0002 |
| Water to Aquatic to Bed | 0.1 | 268 | 0.00003 |
| Aquatic to Bed to Woody Wetland | 0.01 | 28 | 0.00003 |

Table 5. Area and percent relative to the total project area of all LULC class changes between 1996 and 2010 in the project area. Data Source: C-CAP 2014

created new areas of Grassland (as classified by C-CAP). Grassland gains ranged from +0.4% to 5.1% in Lower Bay and South Slough subsystems respectively (Figures 12, 13, 16, Table 5).

Percent Grassland losses also occurred between 1996 and 2010 in project area subsystems- mainly conversions to Scrub/Shrub LULC- as follows: Upper Bay- 7.9%; Catching Slough- 6.7%; Coos River- 6.3%; South Slough- 4.5%; Isthmus Slough- 4.4%; North Slough- 4.2%; Haynes Inlet- 2.5%; Lower Bay- 2%; and Pony Slough- 1% subsystems. Grasslands (recent timber harvest areas) appear to C-CAP as Scrub/Shrub areas when vegetation cover in those recent timber harvest areas begin to mature into young forests full of tree seedlings and shrubs.

LULC Change 1996-2010: Developed

Developed land change analysis focused on three transition types: 1) non-Developed LULC classes re-classified to Developed classes; 2) changes from one Developed class to another Developed class; and 3) Developed classes re-classified to non-Developed classes. Each transition type is discussed separately below.

*1. Non-Developed Classes Reclassified to Developed Classes*

The non-Developed classes most frequently re-classified to Developed classes in the project area between 1996 and 2010 were Forests and Grasslands. Fewer Agriculture, Wetlands, and Scrub/Shrub areas were also reclassified to Developed classes (Figure 17a). The Pony Slough subsystem experienced about 121 acres (2.2% of its total area) converted from a non-Developed class to a Developed category (Figures 17b, 17c). About half the change was attributed to transitions to Low Intensity Developed, followed by Medium then High Intensity Developed. Nearly half the gains in Developed lands came from Forest conversions. In the Lower Bay subsystem, 118 acres (0.7%) were converted- in descending order of acreage- to Low, Medium, High Intensity Developed, and Developed Open Space. These were most often converted from Grassland (0.25%) or Forest (0.22%) classes. About 86 acres (0.4%) of the Isthmus Slough subsystem changed to Developed Open Space or Low Intensity Developed. Conversion primarily from Forest (0.19%) followed by Agriculture (0.11%). All the other subsystems experienced less than 40 acres (< 0.3%) change from non-Developed to Developed classes.

*2. Change from One Developed Class to Another Developed Class*

For changes between developed classes, the subsystems fell into two groups: a) very minor changes (essentially unchanged); and b) modest changes (roughly 5-15 acres). Very minor changes were detected in the Coos River, Catching Slough, Haynes Inlet, North Slough and South Slough subsystems. Modest changes were detected in the Upper Bay, Lower Bay, Pony Slough, and Isthmus Slough subsystems. Many of the changes are characterized by normal urban growth- transitions from lower intensity Developed classes to

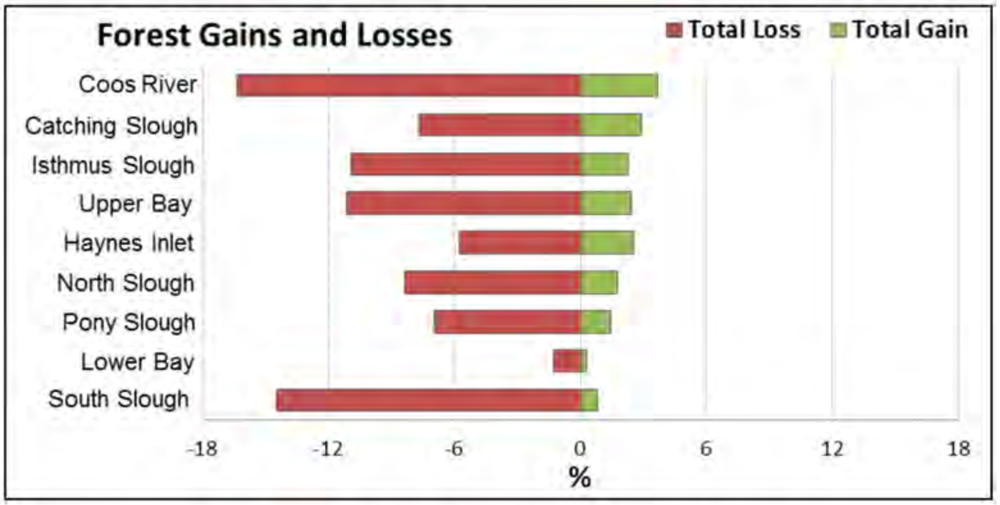



Figure 14. Forest gains and losses 1996-2010. Most losses were conversions to Scrub/Shrub. Data: C-CAP 2014

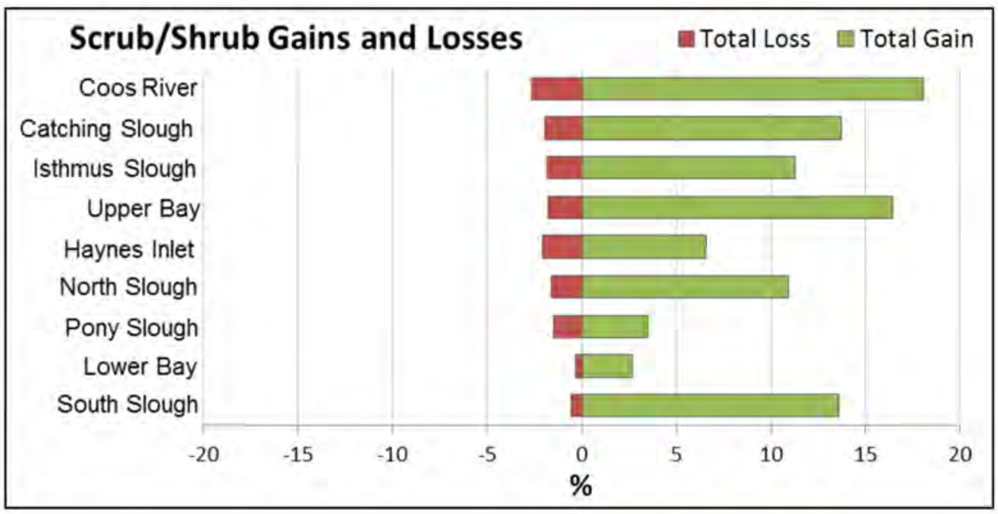



Figure 15. Scrub/shrub gains and losses 1996-2010. Gains were primarily conversions to Forest or Grassland. Data Source: C-CAP 2014

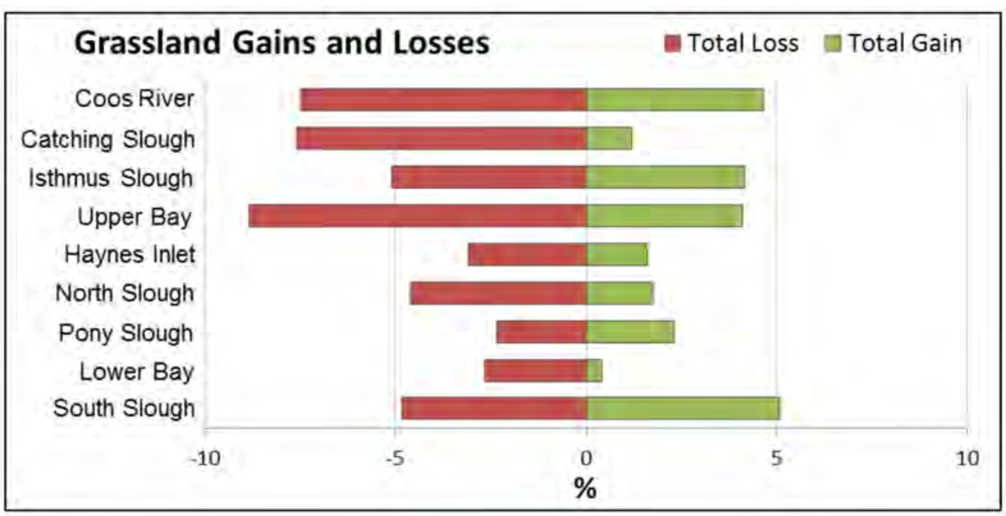
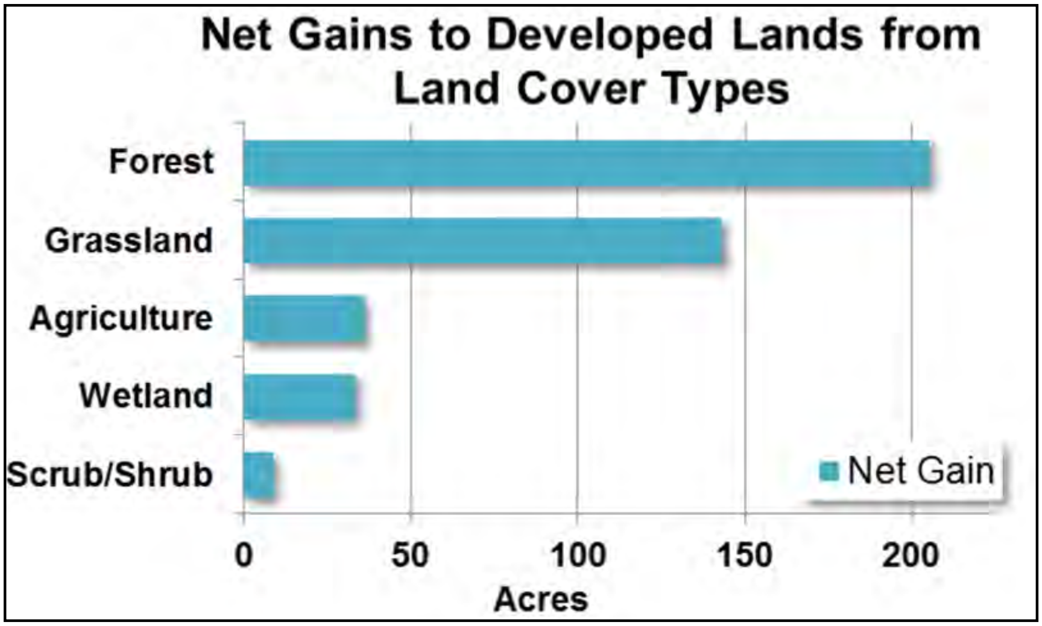
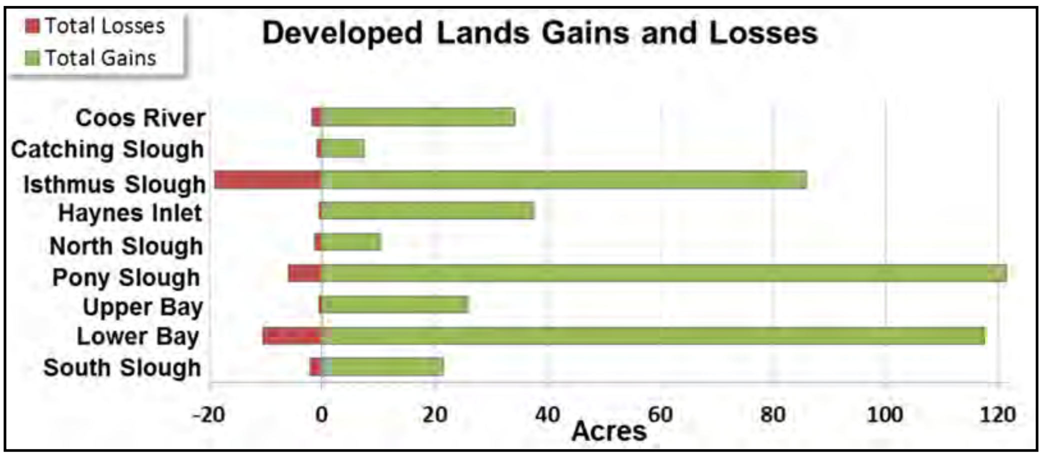
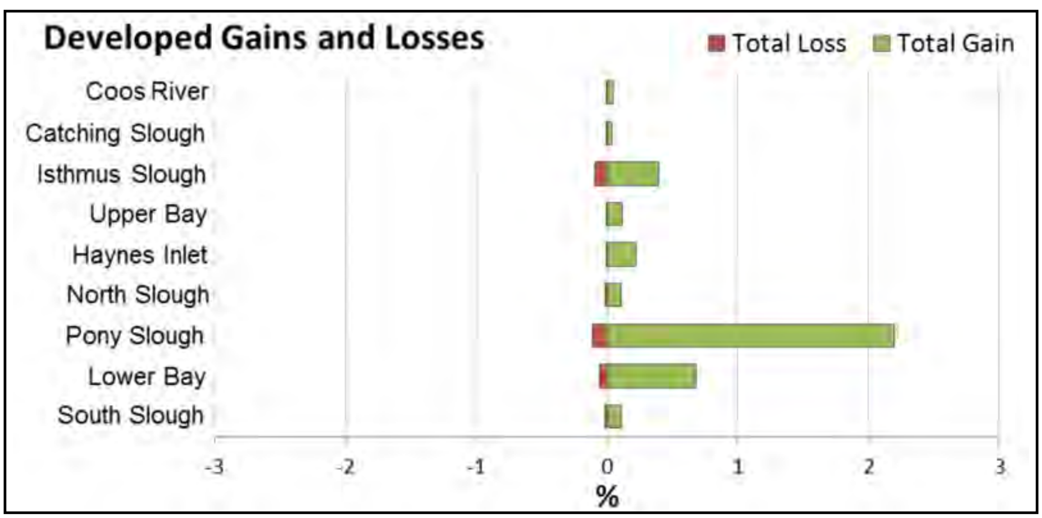



Figure 16. Grassland gains and losses 1996-2010. Data Source: Gains most often came from Forest, and losses from Scrub/Shrub conversions. Data Source: C-CAP 2014




Figures 17a (top), 17b (middle), 17c (bottom). Top development gains between 1996 and 2010 by land cover (17a), gains and losses to subsystems by acres (17b), and gains and losses to subsystems by percent (17c). Data Source: C-CAP 2014 higher intensity Developed classes. But the reverse also occurred when higher intensity Developed classes were reclassified to lower intensity classes for reasons that are less clear, though possibly explained by mapping and/or classification errors.

*3. Developed Classes Reclassified to Non-Developed Classes*

Changes from higher intensity Developed classes to Non-Developed classes are unlikely to be real changes because development tends to be permanent (NOAA 2010). All areas that appear to change from Developed to Forest are very small (<0.33 acres) and are most likely mapping errors. However, some areas need to be investigated further including Isthmus Slough which has the largest area (19 acres) reclassified from Developed to Non-Developed classes (mostly Barren) (Figures 17b and 17c). Similarly, significant changes in the Lower Bay (10.5 acres) and Pony Slough (6 acres) subsystems bear further investigation. In all cases Barren is the most common class into which Developed classes changed (Figures 12 and 13, Table 5). All other subsystems include less than three acres changed from Developed lands to Non-Developed classes.

LULC Change 1996-2010: Agriculture

Lands classified by C-CAP as Agriculture experienced a net loss of 59 acres in the project Area (0.3% of total area). The greatest loss was detected in the Isthmus Slough subsystem (Figure 18). However, interpreting specific changes to and from Agriculture may be confounded by classification errors. The net loss of areas classed Agriculture from 1996-2010 can mostly be attributed to conversions to Wetland (92 acres) and Developed (36 acres) classes. In some instances, herbaceous wetlands converted historically to agricultural uses may later have been intentionally (through restoration actions) inadvertently allowed to revert once again to wetlands. In addition, lands classed Agricultural can, under specific circumstances, be converted to residential land uses.

LULC Change 1996-2010: Barren

In the project area, lands classed by C-CAP as Barren changed minimally between 1996 and 2010. For example, the largest net percentage change from Barren land to other LULC classes was 1.3% in the Upper Bay subsystem followed by the Lower Bay subsystem (1%) (Figure 19). The Pony Slough subsystem experienced a 1% net gain in Barren lands. The net gains and losses for lands classified as Barren were less than 1% for all other subsystems.

LULC Change 1996-2010: Wetlands

The percentage of gains and losses in lands classified by C-CAP as Emergent Wetlands were generally very small, and varied across the subsystems (Figure 20a). The changes detected were so small that they may be classified as “noise” rather than actual changes in Emergent Wetland area. Detected “changes” included net gains in the Lower Bay (1%), Isthmus Slough (0.4%), and Pony Slough (0.2%)

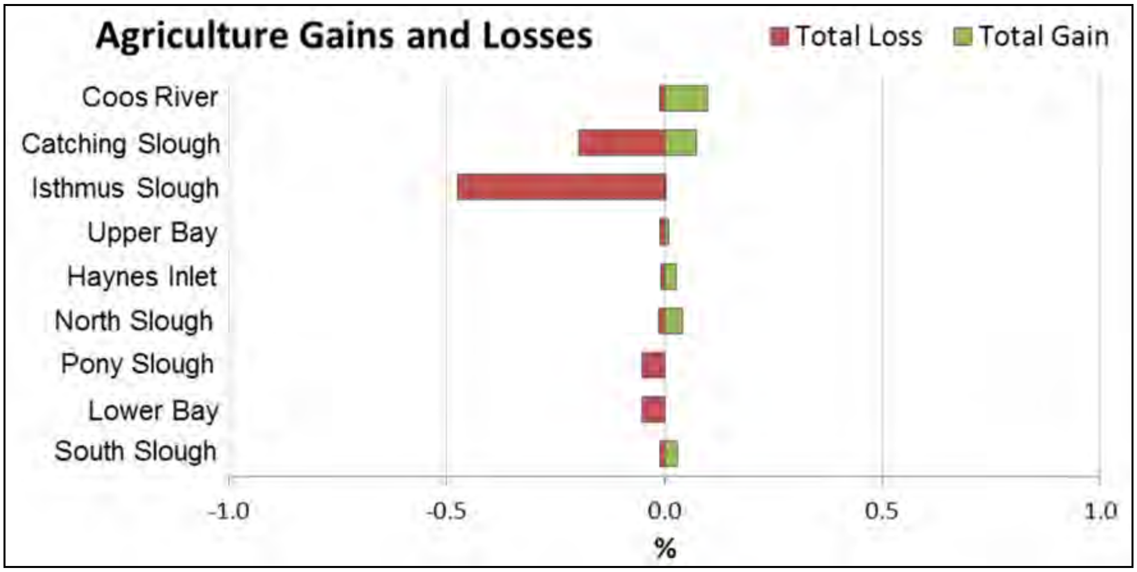



Figure 18. Agriculture Gains and Losses 1996-2010 by subsystem. Data Source: C-CAP 2014

subsystems; and net losses in Haynes Inlet (-1%), Catching Slough (-0.7%), Upper Bay (-0.5%), and smaller losses in the remaining subsystems. Most of the changes appeared to be attributable to transitions from the Emergent Wetland class to the Woody Wetland class (Figure 20b). However, without additional information, it is impossible to reliably determine if these apparent changes are real or simply artifacts of the mapping process (i.e. classification errors, or improvements in classification technology over time).

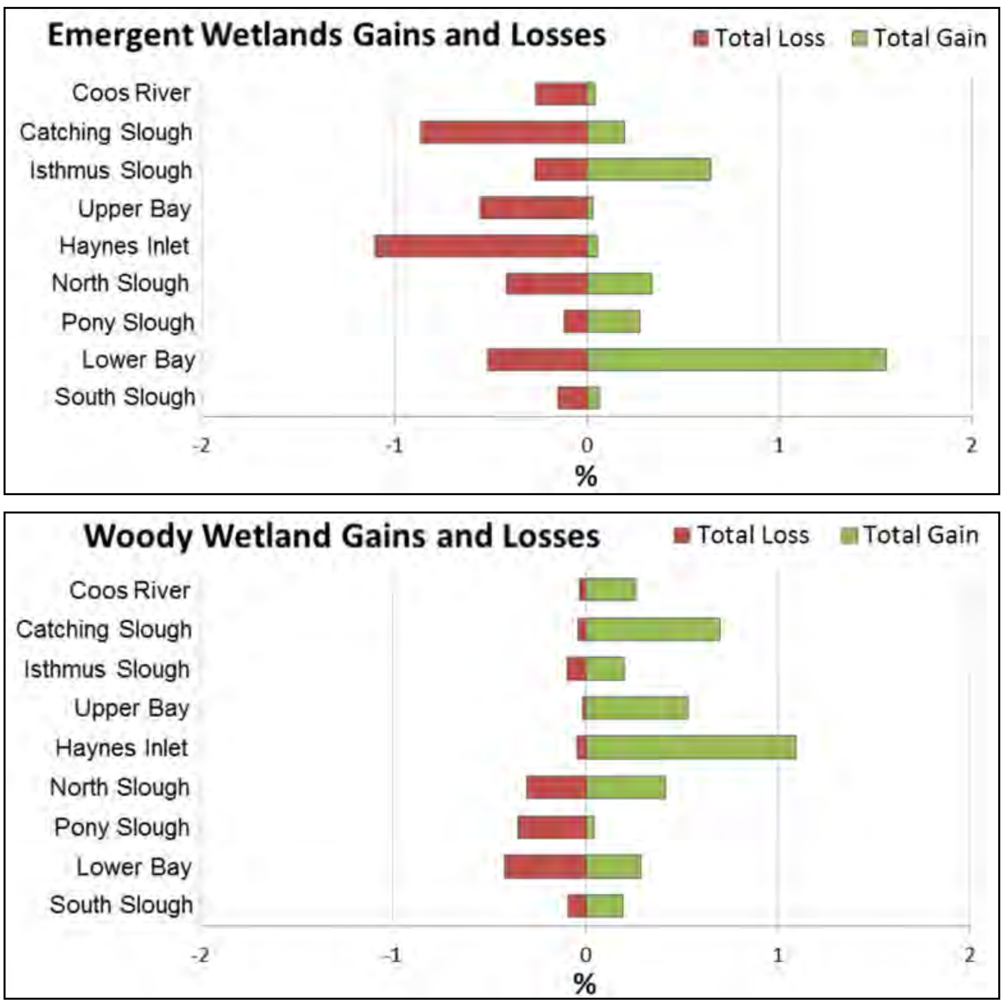
LULC Change 1996-2010: Water

Although our change analysis detected 426 acres of the project area reclassified to Water and 244 acres reclassified from Water to other LULC classes, these changes represent very small percentages of the total area and may be spurious. Given the dynamics of the tides and the length of the Coos estuary's shoreline, it's not surprising that the apparent gains and losses from the Water class appear mostly in the Barren and Wetland classes. Only the Pony Slough subsystem appeared to experience an apparent change approaching even 1% (Figure 21). Again, different map characteristics and classification techniques between 1996 and 2010, are feasible explanations for the small shifts between Water and other LULC classes.

**Background**

Land use and land cover information links the socio-economic and environmental characteristics of an area by describing 1) how and where a community's socioeconomic activities are physically reflected on the local landscape and 2) the location and extent of the natural resources most valued by the community. LULC status and trends information is critical to helping communities plan for the future by providing a foundation for discussing how land and associated natural resourc-


Figure 19. Barren land percent gains and losses by subsystem between 1996 and 2010. Data: C-CAP 2014




Figures 20a (top) and 20b (bottom). Emergent Wetland and Woody Wetland Gains and Losses 1996-2010. Data: C-CAP 2014 es will be used, conserved or restored in the foreseeable future. In this section we explain historic LULC trends and briefly discuss two models that planners use to describe future LULC scenarios.

Historic Status of Forest Lands

Historic LULC data are available for the project area (data sources listed in Table 2); however, since content, formats, and LULC classes were inconsistent between data sources, the effort needed to normalize and effectively analyze the data was deemed beyond the scope of this project. Since some of the historic data for the Forest class was relatively consistent across data sets, we present those findings below, with additional information about historic forest fires. This section is not intended to exhaustively describe the history of lands classed as Forest in the project area.

An Oregon Department of Forestry map entitled "Forest Land and Vegetative Land cover for the State of Oregon, circa 1900" allows comparison of current forest distribution with conditions over a century ago (ODF 2000). Although the map scale is coarse (1:500,000), it provides a useful historical perspective on the distribution of the forests and associated land use practices.

According to this map, the Catching Slough subsystem contained about 71% Forest and 29% Woodland while the Isthmus Slough subsystem contained about 57% Forest and 9% Woodland. Forest and/or Woodland comprised roughly 30% to 40% of the Coos River, Pony Slough, and South Slough subsystems, but were less than 10% of the North Slough (7%), Upper Bay (3%), Lower Bay (1%) and Haynes Inlet (0%) subsystems. Coos River was the only subsystem with a significant proportion (11%) of cut timber that was not being restocked in 1900. See Table 6 below

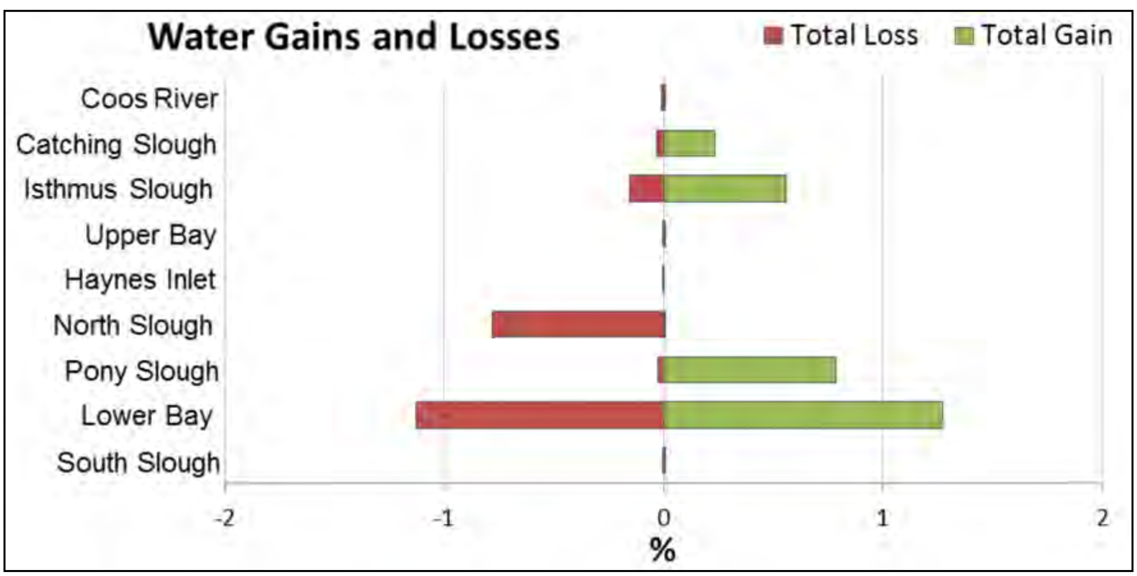



Figure 21. Water gains and losses by subsystem between 1996 and 2010. Data Source: C-CAP 2014

for Forest coverage in the project area from "pre-settlement" times (1880's) to 2011.

In 1900, Catching Slough was the only subsystem without burned areas (Table 6). According to Zybach (2003), the classification of burnt areas on Oregon Department of Forestry's 1900 map was intended to represent "nearly or complete" timber destruction and areas only partially destroyed by fires were not included. According to the map, the burnt class covered 65% of the Haynes Inlet subsystem. Burned areas were also extensive in the Upper Bay (60%), North Slough (56%), and South Slough (46%) subsystems, and present to a lesser degree in the Coos River (24%), Pony Slough (22%), Lower Bay (21%), and Isthmus Slough (19%) subsystems (Table 6).

For interested readers, Zybach (2003) also notes that two large fires were represented in the General Land Office surveys of the late 1890's upon which the 1900 map was based. The Millicoma fire (circa 1765) was likely caused by indigenous people but settlers probably caused the Coos fire of 1868. Both are classified as "catastrophic fires", covering more than 100,000 acres of contiguous forest land during a single event. Use of fires to change local wildlife habitat and provide foods for indigenous peoples is well known. However, fires were also important for the development of dense, even-aged stands of second-growth Douglas fir that promoted the timber industry in later years (Zybach 2003). Historic forests from "pre-settlement" times are shown on the map, "Oregon's Historic Vegetation (1938) – reclassified to functional type" (Tobalske and Osborn-Gowey 2002). It is a moderate-scale map (roughly 1:100,000) created by merging data from several sources and approximates the potential natural vegetation of that period.

Based on this map, in its natural state, the Coos River subsystem was 92% Forest, remaining relatively unchanged through the 1970's (95% forest)(Table 6). The percent

**Comparison of Percent Forests: Pre-settlement to 2011**

| Subsystem | Pre-Settlement | 1900 | 1900 Burnt | 1900 Forest + Burnt | 1970's | 1992 Retrofit | 2001 | 2006 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| CR | 92.2 | 36.9 | 24.3 | 61.1 | 94.5 | 65.5 | 66.0 | 60.4 | 58.3 |
| CS | 77.7 | 70.8 | 0.0 | 70.8 | 80.5 | 57.3 | 56.9 | 54.7 | 54.3 |
| HI | 84.7 | 0.0 | 65.2 | 65.2 | 86.3 | 67.2 | 66.3 | 65.2 | 66.5 |
| IS | 74.2 | 56.9 | 18.7 | 75.5 | 70.4 | 51.4 | 50.9 | 48.0 | 44.7 |
| LB | 53.1 | 0.8 | 21.0 | 21.7 | 23.6 | 8.7 | 7.3 | 7.2 | 8.7 |
| NS | 74.6 | 6.5 | 56.0 | 62.5 | 74.4 | 52.8 | 51.9 | 47.1 | 48.3 |
| PS | 79.7 | 32.7 | 22.2 | 54.9 | 47.8 | 39.3 | 38.8 | 35.7 | 37.5 |
| SS | 98.2 | 31.4 | 46.4 | 77.8 | 89.7 | 65.3 | 64.3 | 61.1 | 60.0 |
| UB | 80.5 | 3.3 | 59.7 | 63.0 | 66.8 | 39.6 | 39.4 | 34.0 | 38.9 |

Table 6. Changes in historic Forest cover. Subsystems: CR- Coos River; CS- Catching Slough; HI- Haynes Inlet; IS- Isthmus Slough; LB- Lower Bay; NS- North Slough; PS- Pony Slough; SS- South Slough; UB- Upper Bay. Data Sources: Tobalske and Osborne-Gowey (2002), ODF 2000, USGS 2005, NLCD 1992, 2001, 2006, 2011.

of Forest cover in the Coos River subsystem declined quickly between the 1970's and the 1990's, then more slowly in subsequent years, to about 58% in 2011. This same pattern of stability in Forest cover until the 1970's followed by rapid change is reflected in many other project area subsystems: Catching Slough, Haynes Inlet, Isthmus Slough, North Slough, and South Slough. For the Lower Bay, Pony Slough, and Upper Bay subsystems, a higher degree of change in Forest cover occurred between pre-settlement and 1970's time periods (e.g., the estimated percentages of pre-settlement forest areas were 14-32% larger than forest percentages in 1970's for these subsystems). It should be noted that these differences may well be actual changes but could also be attributable to mapping inaccuracies.

Future LULC Planning Scenarios

A brief discussion of two models that seek to portray future changes in land cover is provided for interested readers. Both models assume human population growth and conversions of natural landscapes to residential or other urban purposes are among several socio-economic and environmental factors expected to influence the distribution of land cover types and the rate of change in the future. It should be noted that the models are designed for relatively large areas (i.e. county, ecoregion), larger than the size of the project area. Each model simulates conditions for multiple time frames, but for convenience, only a single year (2050) is presented here to illustrate each model.

The Coastal Landscape Analysis and Modeling Study (CLAMS) developed an empirical model of building density (structure counts) for the Oregon Coast Range Mountains. The goal of the model was "to place current and future forest policies in an appropriate socioeconomic context by accounting for the future distribution of humans throughout the study region" (Kline et al. 2003). Although discrete categories of Forest and Developed lands were historically used to identify the presence or absence of humans, this model reflected a continuum of human habitation on Forest land. Photo-point observations of building density on non-federal lands from 1974, 1982, and 1994 were used to characterize the dispersed conversion of forests to low-density development (Kline et al. 2003). In addition, information on slope, elevation, land use zoning, and "gravity indices", which describe the spatial diffusion of human populations, were used to develop an empirical model.

Future building densities are computed by combining the CLAMS model with projected changes to the gravity indices and building densities. As an example of the model output for our project area see Figure 22, which was created by applying the projected gravity indices and building densities to a 1995 map as the base year and extended to 2050.

Another model, created by the Oregon Department of Forestry, illustrates the amount of Forest, Agriculture, or Range (Grassland and Scrub/Shrub LULC classes combined) lands that could become low-density residential or urban land to accommodate an additional 2.5 - 3.0 million people in Oregon by 2065 (ODF 2014, n.d.). This model allows users to change variables and assumptions to create alternative growth scenarios and examine the potential outcomes of land management decisions. The model identifies where growth would likely occur in each county based on 12 spatial data layers including recent land use, population, expected population increases in five-year intervals (using projections from the U.S. Bureau of Census and Portland State University Center for Population Research), slope, land ownership, management intentions, urban growth boundaries, and proximity to roads or currently developed areas. It projects the 2009 land use classes from "Forests, Farms, and People – Land Use Change on Non-Federal Land in Oregon 1974 – 2009" to the year 2065. The model provides three scenarios for increasing developed land: 1) "Grow-up" or "in-fill" where population density is increased only in areas already developed or within an urban growth boundary; 2) "Grow-out" conversion of forest, range, or agricultural land anywhere; and 3) "Protect Agriculture and Forest", which limits resource land conversions and approximates current land use regulations. Figures 23a and 23b display

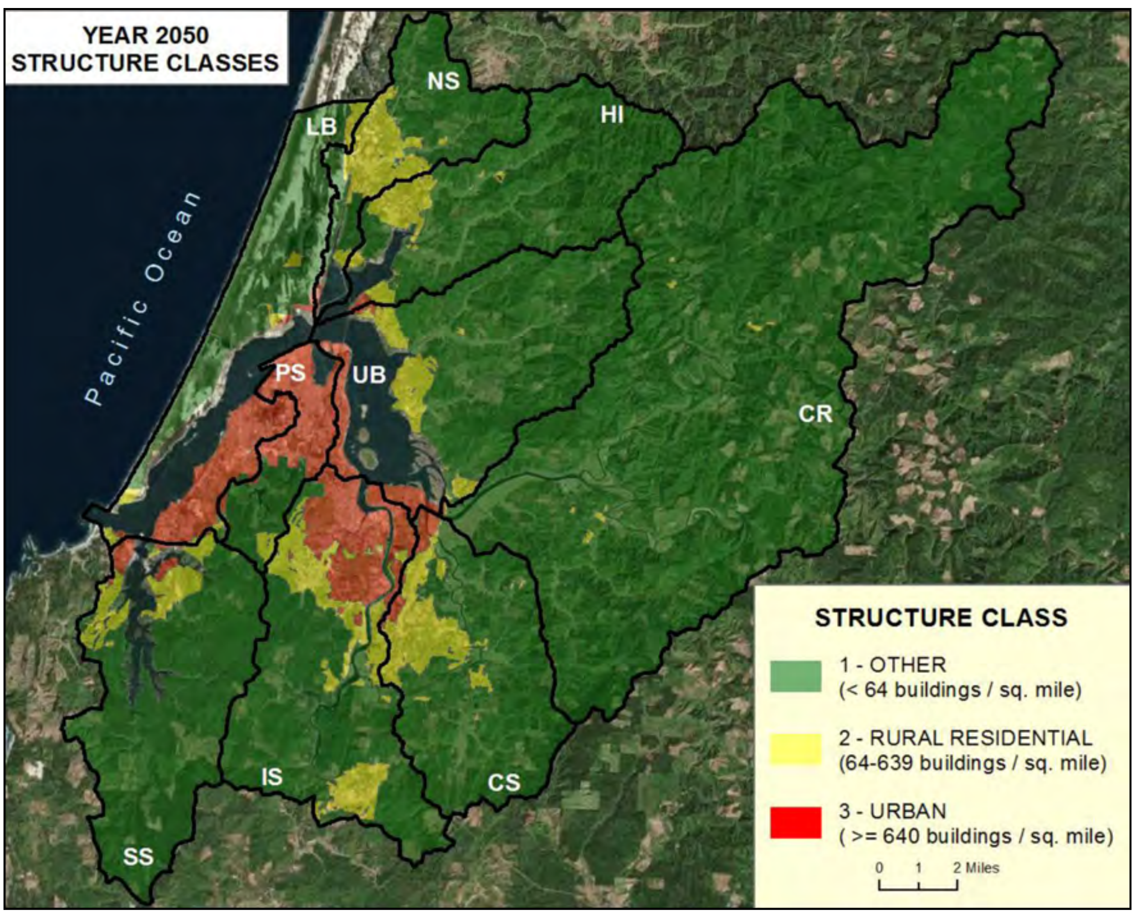
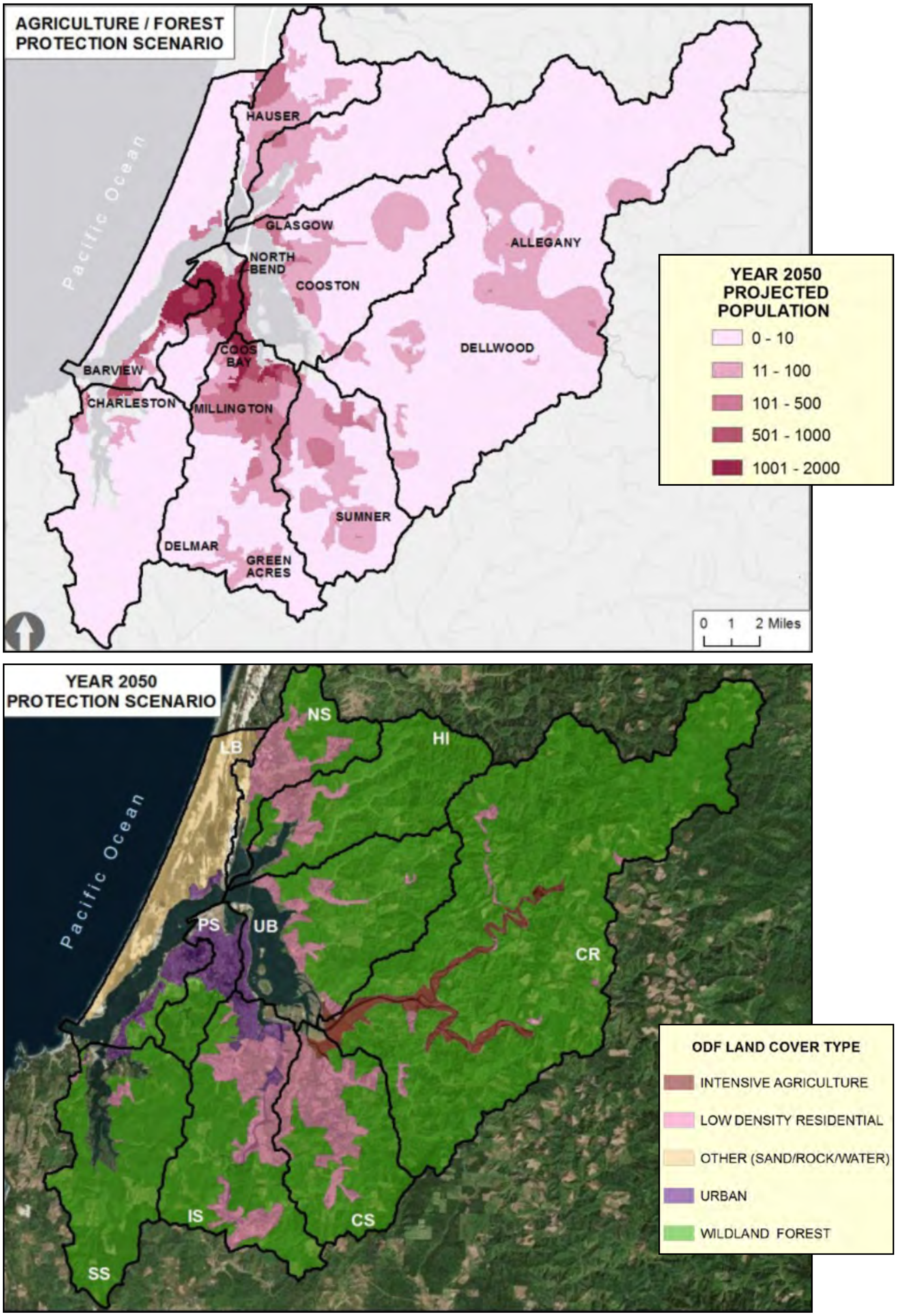



Figure 22. Projected distribution of Structure Density in year 2050. Data Source: CLAMS 2001




Figures 23a (top) and 23b (bottom). Projected distribution of population (23a) and land cover types (23b) in year 2050 according to the "Protect Agriculture and Forest" scenario. Data Source: ODF n.d.

the projected population and development areas according to the “Protect Agriculture and Forest” scenario for the year 2050 in the project area.

**References**

Anderson, J.R., Hardy, E.E., Roach, J.T., and Witmer, R.E. 1976. A land use and land cover classification system for use with remote sensor data: U.S. Geological Survey Professional Paper 964, 28 p. Accessed 17 March 2016: http://www.pbcgis.com/data_basics/anderson.pdf

Coastal Change Analysis Program (C-CAP). 2014. C-CAP FTP Download, GIS data files. Accessed 23 October 2014: http://coast.noaa.gov/ccapftp/

Coastal Landscape Analysis and Modeling Study (CLAMS). 2001. Land Development Change. GIS Data. Accessed 7 November 2014: http://www.fsl.orst.edu/clams/data_index.html

Homer, C., Huang, C., Yang L., Wylie, B., and Coan, M. 2004. Development of a 2001 National Land Cover Database for the United States. *Photogrammetric Engineering and Remote Sensing*, 70 (70): 829-840.

Kline, J.D., Azuma, D.L., and Moses, A. 2003. Modeling the spatially dynamic distribution of humans in the Oregon (USA) Coast Range. *Landscape Ecology*, 18:347-361.

National Land Cover Database (NLCD). 2001a. 1992-2001 Retrofit Land Cover Change Product. Accessed 31 March 2015:http://www.mrlc.gov/nlcdrlc_data.php

National Land Cover Database (NLCD). 2001b. NLCD 2001 Land Cover (2011 Edition). Accessed 31 March 2015: http://www.mrlc.gov/nlcd01_data.php

National Land Cover Database (NLCD). 2006. NLCD 2006 Land Cover (2011 Edition). Accessed 31 March 2015: http://www.mrlc.gov/nlcd06_data.php

National Land Cover Database (NLCD). 2011. NLCD 2011 Land Cover. Accessed 31 March 2015: http://www.mrlc.gov/nlcd11_data.php

National Oceanic and Atmospheric Administration (NOAA). 2010. C-Cap Land Cover Atlas. Accessed 24 April 2015: www.coast.noaa.gov/ccapatlas

Oregon Department of Forestry (ODF). 2000. LULC_vegetation_1900_500k. GIS Downloadable data. Accessed 22 July 2014: http://www.odf.state.or.us/gis/data/LandUse_Cover/Veg_1900.zip

Oregon Department of Forestry (ODF). 2014. Forests, Farms and People: projecting future conversion of resource land to developed use. Oregon Department of Forestry Resources Planning Program.

Oregon Department of Forestry (ODF). n.d. [Model Outputs for Future Development, GIS data]. Available upon request from ODF GIS Program.

Tobalske, C. and Osborne-Gowey, J. 2002. Oregon’s Historic Vegetation (1938) – reclassified to functional type. Accessed 26 November 2014: http://databasin.org/datasets/baee765527ae48f0a6ae024f4100086a

US Geological Survey (USGS). 2005. 1970’s land use data refined with 2000 population data to indicate new residential development for the conterminous United States. GIS data. Accessed 15 April 2014: https://catalog.data.gov/dataset/1970s-land-use-data-refined-with-2000-population-data-to-indicate-new-residential-development-f

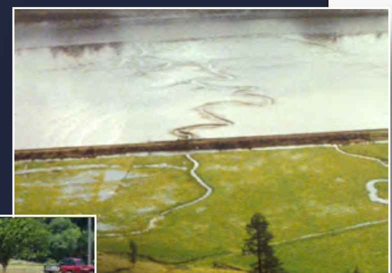
US Natural Resource Conservation Service (NRCS). 2006. Coos – 17100304 8-Digit Hydrologic Unit Profile. Department of Agriculture (USDA) publication. 12 pp. Accessed 1 July 2015: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_040519.pdf

Zybach, R. 2003. The Great Fires: Indian burning and catastrophic Forest fire patterns of the Oregon Coast Range. 1491-1951. PhD thesis. Oregon State University, Corvallis. Accessed 11 February 2015: http://ir.library.oregonstate.edu/xmlui/handle/1957/20240

# Human Infrastructure in the Lower Coos Watershed

*Summary:*

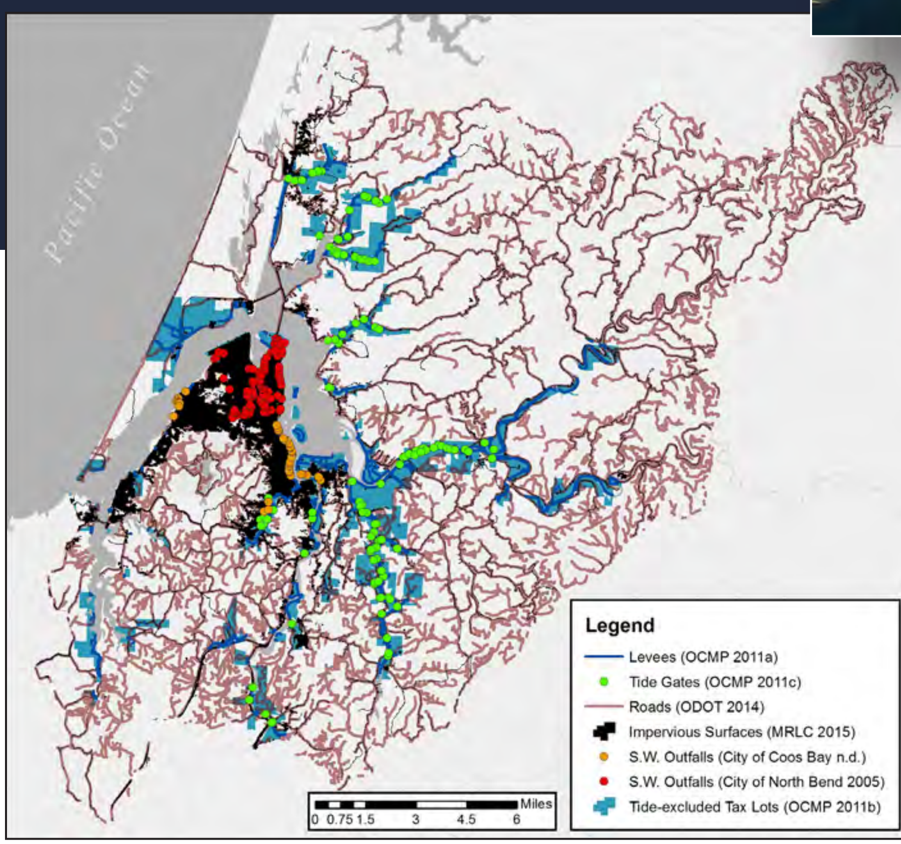
- *There are 76 miles of intact, functioning levees and 17 miles of breached levees in the project area; 138 tide-gated culverts pass through these levees.*
- *Total impervious surface area has steadily increased in the project area since 2001. The subsystem with the greatest impervious surface percentage is Pony Slough.*
- *Road densities in all subsystems far exceed commonly accepted criteria for healthy watersheds.*



Haynes Inlet levee

Kentuck Slough levee and tide gate

Impervious surfaces in the Pony Slough Subsystem




Location of major human infrastructure in the project area including levees, tide gates, roads, impervious surfaces, and stormwater outfalls, and their associated data sources. Also shown are tax lots where levees and tide gates either currently exclude, or historically excluded tidal flooding.

**What's happening?**

In the following data summary we provide the most current information describing the following types of human infrastructure in the project area: levees and tide gates, impervious surfaces, roads, and those lands (mapped as tax lots) where levees and tide gates either currently exclude, or historically excluded tidal flooding.

<u>Levees and Tide Gates</u>

As a sea level rise strategic planning tool, the Oregon Coastal Management Program (OCMP 2011a-c) created a geospatial database for coastal managers that allows anyone to map the locations of levees and tide gates in Oregon estuaries. The database was created using existing aerial photography and LiDAR land contour and elevation data. With this tool, coastal managers can identify flood-protected lands threatened by excessive storm tides and target levees in need of repair, or those that willing landowners can breach or remove to re-establish valuable tidal wetlands.

For the purposes of this assessment, these OCMP levee data were divided into four main categories to determine the condition of project area levees: 1) functioning levees; 2) breached levees; 3) historically present but removed levees; and 4) side-cast dredge material that functions like a levee (Figure 1). Using these categories, we found over 76 miles of functioning levees in the project area, and over 17 miles of breached levees which no longer function as intended (Figure 2).

***Levee –*** *An elevated embankment that provides protection to land behind it from flooding by rivers or tidally influenced channels. Levees can be natural or artificial and made from a variety of materials, although they are most commonly earthen structures. The term "dike" is commonly used interchangeably with "levee".*

***Sidecast –*** *The practice of piling soil on the side of the bank while dredging or excavating a drainage ditch.*

***Tide gate –*** *A culvert or opening placed into a levee with a hinged flap on the downstream end that allows freshwater to flow into the estuary, but prevents brackish water from flooding land behind the levee.*

We analyzed each of the OCMP levee data categories by levee land owner (Figures 3 and 4). Over 50 miles (or over 65%) of levees are managed by private entities in the project area (this includes residential and commercial land owners). Local government land owners manage the next highest number of levees (nearly 28 miles). Private land owners manage the most levee types.

Private land owners manage the most levees in each category. Of all levees managed by local government land owners, 91% are functioning levees. This is also the highest percent of functioning levees in a single land owner group. State government, by contrast,

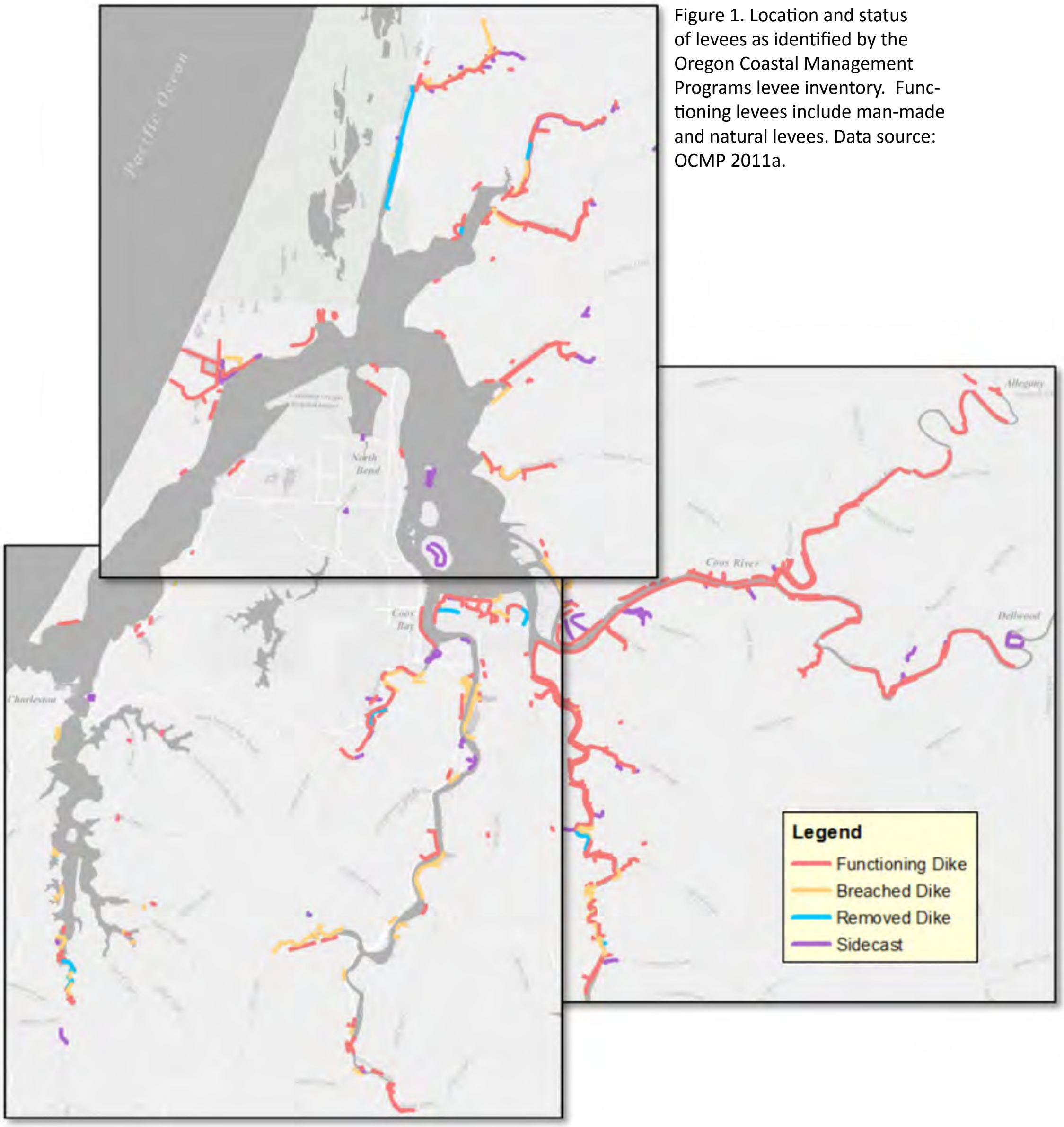



Figure 1. Location and status of levees as identified by the Oregon Coastal Management Programs levee inventory. Functioning levees include man-made and natural levees. Data source: OCMP 2011a.

manage the greatest percentage of breached levees (26%) as a percentage of all state-managed levees in the project area. The greatest number of miles of levee removed (over four miles) has occurred on private lands; this is the highest percent of removed levees by a single owner group (8%). Drainage districts managed more sidecast-type levees as a percentage of their holdings than any other managing entity.

OCMP (2011b) provides coarse-scale spatial data which can be used to highlight lands in the project area excluded from tidal flooding by levees (currently or historically)(Figure 5). Based on tax assessor parcels, these data include any lands clearly being protected by a levee or immediately adjacent to a levee. Because not all the land in these adjacent parcels is/was protected by the levee, these data are an overestimation of the levee-influ-

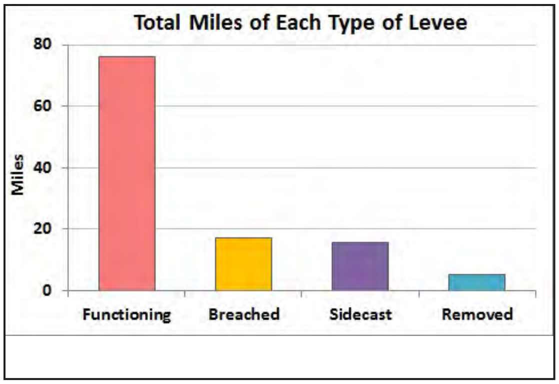



Figure 2. Total miles of levee as identified by the Oregon Coastal Management Programs levee inventory. Functioning levees include manmade and natural levees. Data source: OCMP 2011a.

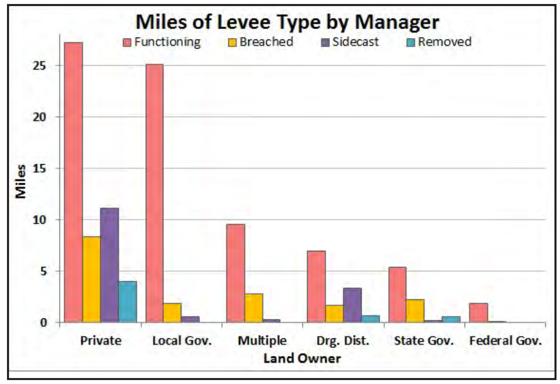



Figure 3. Total miles of each category of levee by land manager. Private managers include residential and commercial owners. "Drg. Dist" stands for drainage district. Data source: OCMP 2011a.

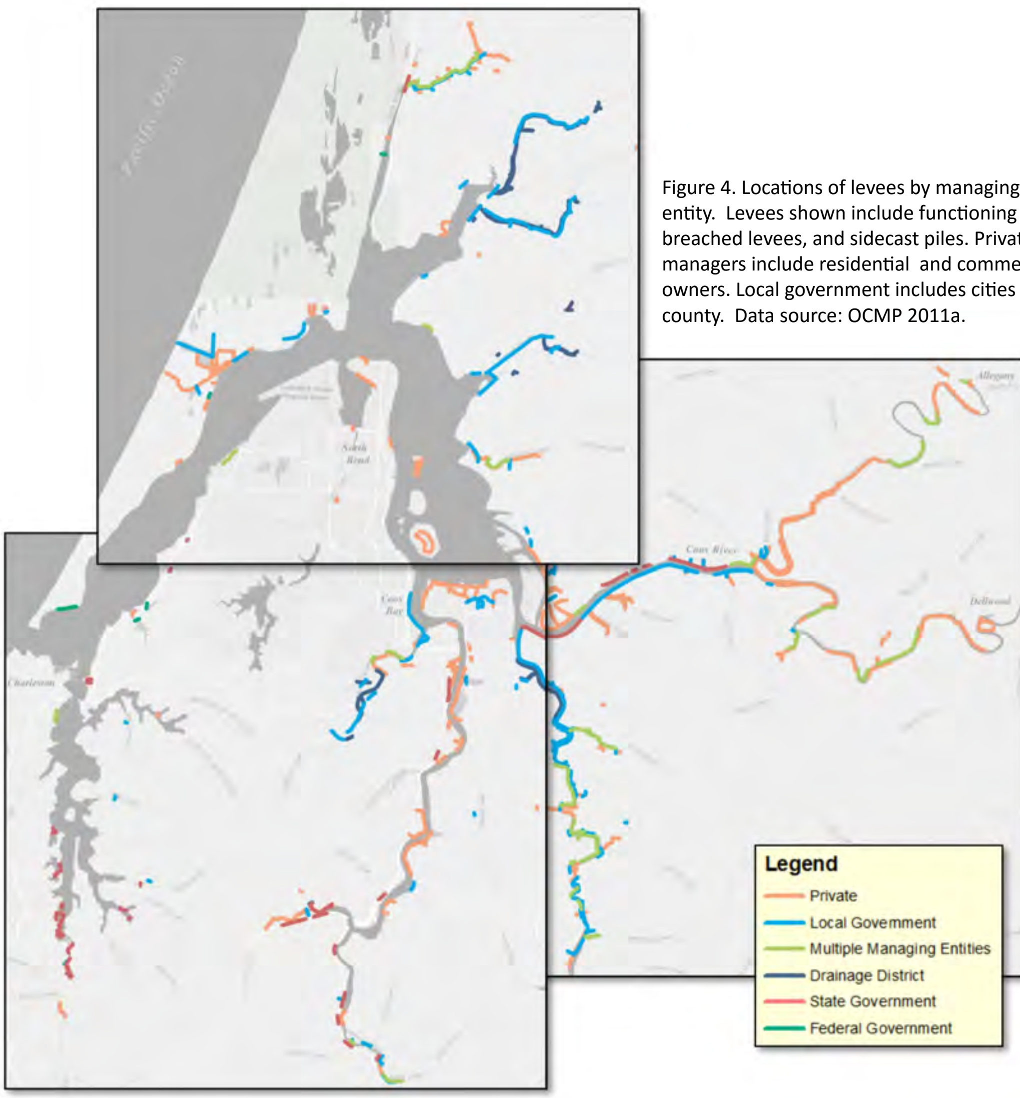



Figure 4. Locations of levees by managing entity. Levees shown include functioning and breached levees, and sidecast piles. Private managers include residential and commercial owners. Local government includes cities and county. Data source: OCMP 2011a.


Figure 5. Lands (based on tax lots) that are currently or were historically protected by levees. Data source: OCMP 2011b.

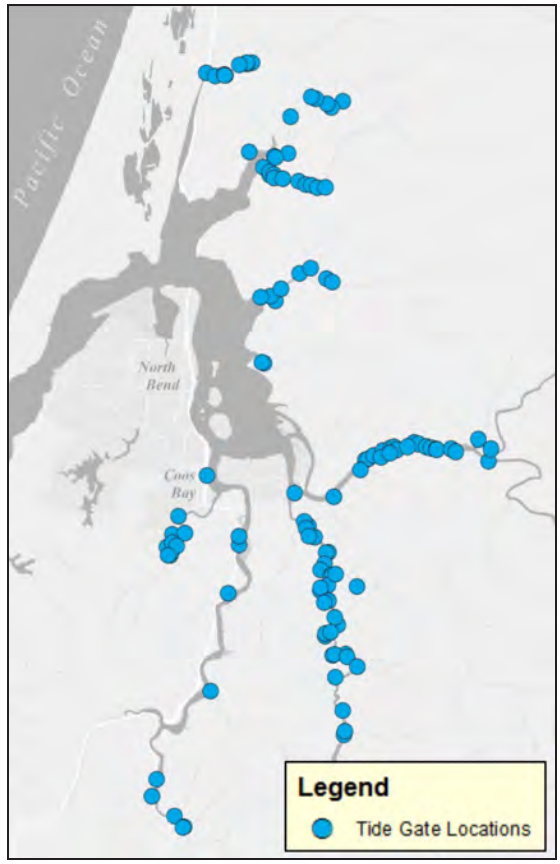



Figure 6. Tide gate locations in the Coos watershed identified during Oregon Coastal Management Programs levee inventory. Data source: OCMP 2011c.

enced lands. Using these data, we calculate that the project area includes over 17,300 acres (27 $mi^2$) of land parcels, some portion of which are or were excluded from tidal flooding by levees (Figure 5).

Additionally, we mapped OCMP (2011c) tide gate locations for the project area (Figure 6). In 2009, there were 138 tide gates in the project area. Most of those were concentrated along Coos River and Catching Slough tributaries.

<u>Impervious Surfaces</u>

Impervious surfaces are the paved surfaces and structures that prevent the natural infiltration of precipitation into soils. By preventing soils from absorbing precipitation during storms, impervious surfaces can indirectly create large volumes of surface runoff that have the potential to adversely affect natural habitats and human development (e.g., delivering sediment to salmon spawning gravels, eroding developed shorelines)(USEPA 2014; NOAA 2010; Flinker and Millar 2010).

The United States Environmental Protection Agency (USEPA) has established an impervious surface threshold range of 4-6% of the total watershed area beyond which they estimate water quality degradation and impairments to aquatic biota can begin to become apparent (USEPA 2014).

Others have established commonly used impervious surface thresholds to describe the degree of risk to stream health. Impairment to stream water quality becomes evident when 1-10% of the watershed is covered with impervious surfaces; and impairment to

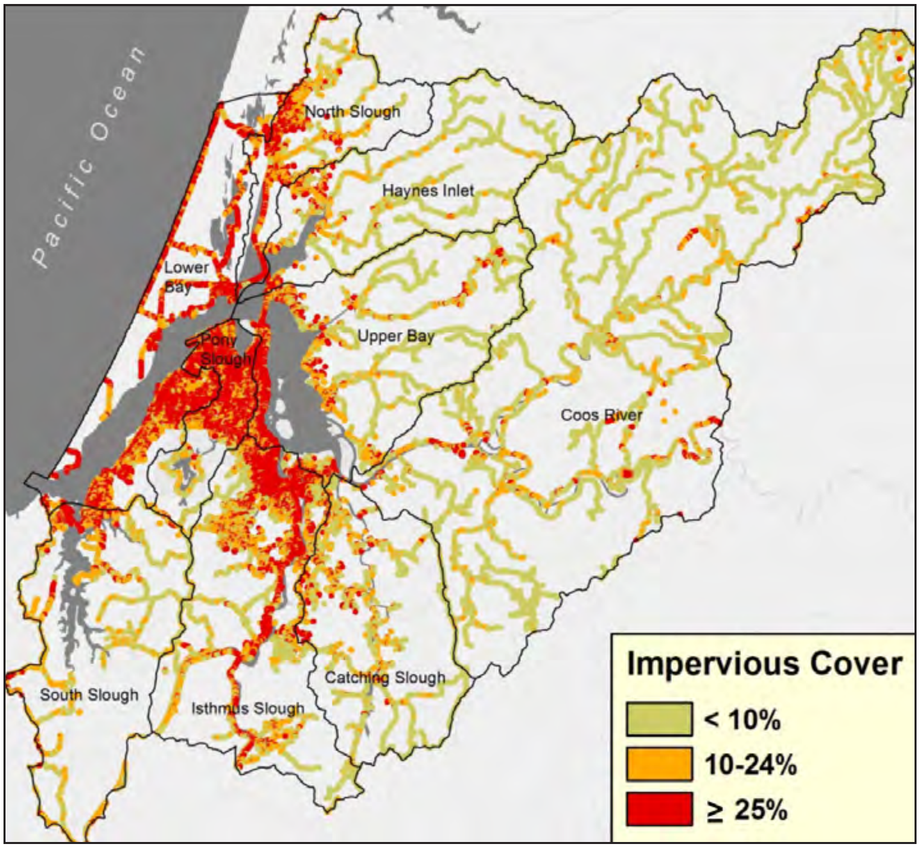



Figure 7. Distributions of impervious surfaces covering the project area in 2011, in three categories of severity for causing water quality degradation. Subsystems are labeled.

Data: MRLC 2015

stream water quality becomes severe when the watershed is covered with greater than 25% impervious surfaces (NHEP 2007; Flinker and Millar 2010; citations within Exum et al. 2005; Schueler 2003). In this section, we will refer to these thresholds as the moderate and severe thresholds, respectively.

According to the National Oceanic and Atmospheric Administration (NOAA 2010), impervious surfaces cover about 0.5% of Coos County, and about 0.68% of the Coos watershed as a whole, both well below the impervious surface thresholds described above.

The National Land Cover Dataset (NLCD), provided by the Multi-Resolution Land Characteristics Consortium, began to include impervious surface data in 2001, and is updated every five years (MRLC 2015). A comparison between project area subsystems using the NLCD spatial data indicates that Pony Slough has the greatest percentage of impervious surface coverage with 43% of the Pony Slough subsystem area above the moderate threshold, and 33% exceeding the severe threshold (Figures 7 and 8).

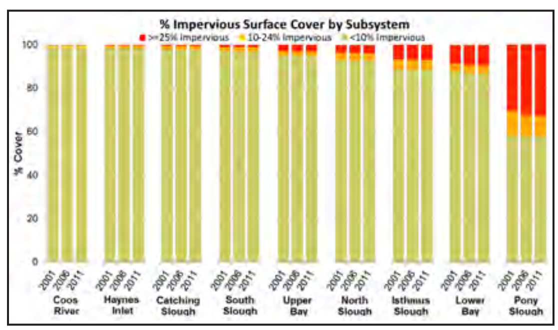



Figure 8. Percentage of impervious cover for each subsystem over the course of a decade. Data: MRLC 2015

Significant impervious surface area above the moderate threshold exist in the Lower Bay (13%), Isthmus Slough (11%), North Slough (7%), Upper Bay (6%), and South Slough (3%) subsystems. Impervious surfaces above the moderate threshold comprise less than 2% of the area in the Catching Slough, Haynes Inlet, and Coos River subsystems.

Between 2001 and 2011, total impervious cover above the severe threshold increased slightly in all subsystems and in the project area as a whole (Figures 8 and 9). The growth rate in impervious surface area was generally faster in the period between 2001 and 2006 than between 2006 to 2011, with the highest total acreage, and the most rapid increase, occurring in Pony Slough. The smallest changes to impervious surface cover occurred in Haynes Inlet, Catching Slough, Coos River and South Slough.

Over the decade for which data are available (2001-11), more than 500 acres (0.8 $mi^2$) of impervious cover were added to the severe (≥25%) category in the project area, totaling 6,500 acres (10 $mi^2$) by 2011 (Figure 9).

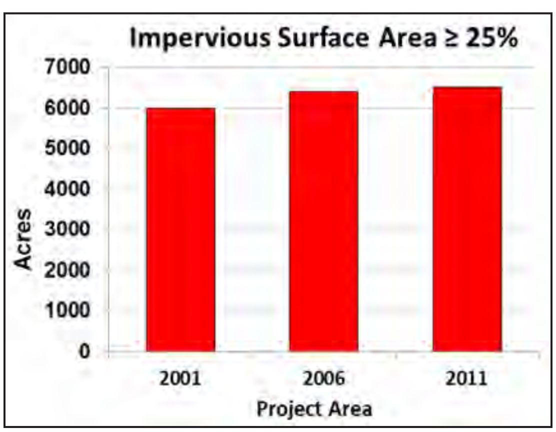



Figure 9. Total impervious surface cover (in acres) for the project area that was greater or equal to 25%. Data: MRLC 2015

Areas already covered by 10-24% impervious surface (over the moderate threshold but under severe) accounted for most of those gains, rather than areas of lower impervious surface cover reaching levels of greater imperviousness. Greater growth in impervious surface area occurred between 2001-2006 compared with 2006-2011.

Surface runoff and the related pollutants are positively correlated with impervious surface area. Urban runoff, often unfiltered, is commonly directed into storm drains which empty directly into the estuary, creek or other water body at specific discharge points, or outfalls. Storm drain outfall locations in the cities of North Bend and Coos Bay are mapped in Figure 10.

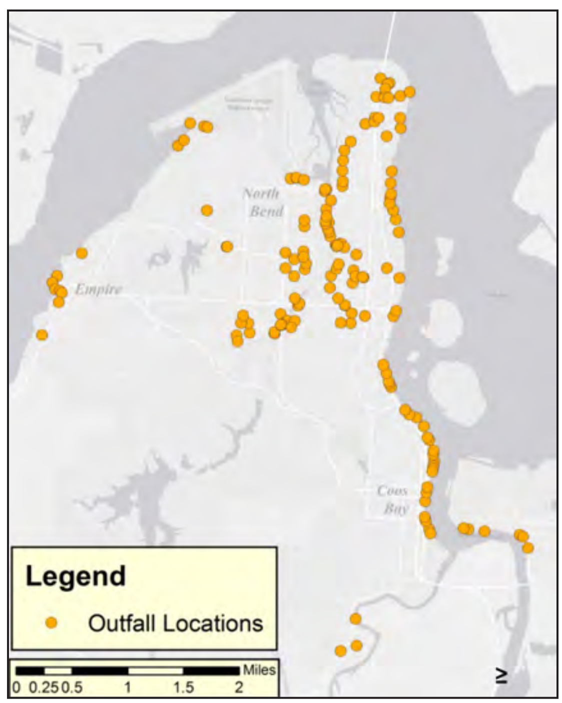



Figure 10. Outfall locations within Coos Bay and North Bend city limits. Data: City of Coos Bay n.d.; City of North Bend 2005.

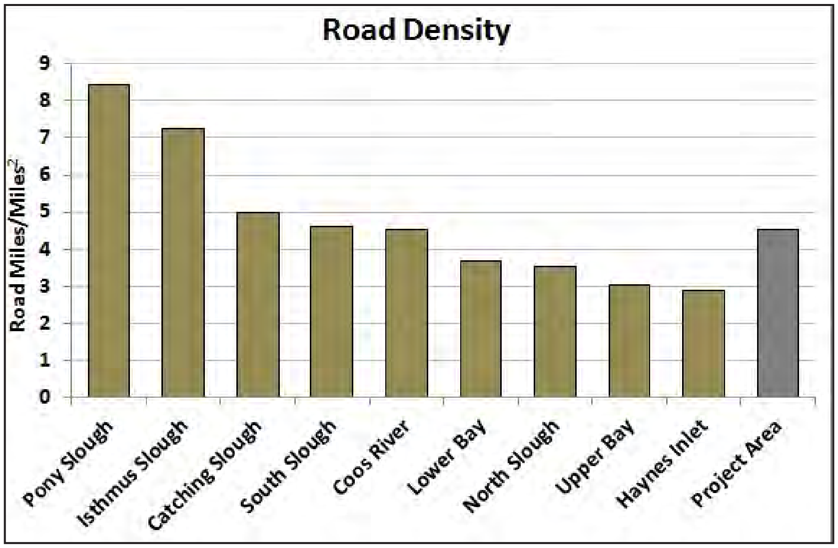



Figure 11. Road density by subsystem and total project area. The exceedance criteria of 1 mile/mile$^2$, above which degradation to ecological systems occurs, is shown (red line). ODOT 2014.

<u>Roads</u>

Like impervious surface area, road density is a measure used to evaluate the environmental conditions in a watershed. While roads obviously provide critical support to a wide variety of human activities, they do affect the same natural systems upon which coastal communities and their economies rely. Too many roads, for example, will affect the movement of wildlife, fracture wildlife populations, and disrupt hydrological networks and natural fire regimes (Forman and Hersperger 1996). They have also historically degraded or eliminated tidal and non-tidal wetlands and fish-bearing streams (Forman and Hersperger 1996). Watersheds with road densities higher than 1 mi/mi$^2$ (0.6 km/km$^2$) are considered at great risk of water quality and wildlife population degradation (Carnefix and Frissell 2009; Forman and Alexander 1998). Densities of roughly 4 mi/mi$^2$ (2.5 km/km$^2$) have been correlated with drastic increases to peak stream flows (Forman and Alexander 1998).

While these estimated thresholds may be useful for understanding the general effects of too many roads in a watershed, they do not take into account road width, pavement type, traffic density or road network connectivity (Forman and Alexander 1998). Forman and Alexander (1998) suggest the structure of road networks is an important consideration; large areas with very low road density adjacent to high road density areas provide the least ecological damage, compared with more evenly distributed road networks that cause more widespread habitat fragmentation.

The Oregon Department of Transportation (ODOT) regularly compiles statewide data from multiple sources to create a comprehensive road data set. Their most current data (ODOT 2014) indicate 1,429 miles of road in the project area (includes all road types – e.g., forest roads, urban streets). This represents a road density of over 4.5 mi/mi$^2$ (2.8 km/km$^2$) in the project area, far above the estimated thresholds suggested by Carnefix and Frissell (2009) and Forman and Alexander (1998)(Fig-

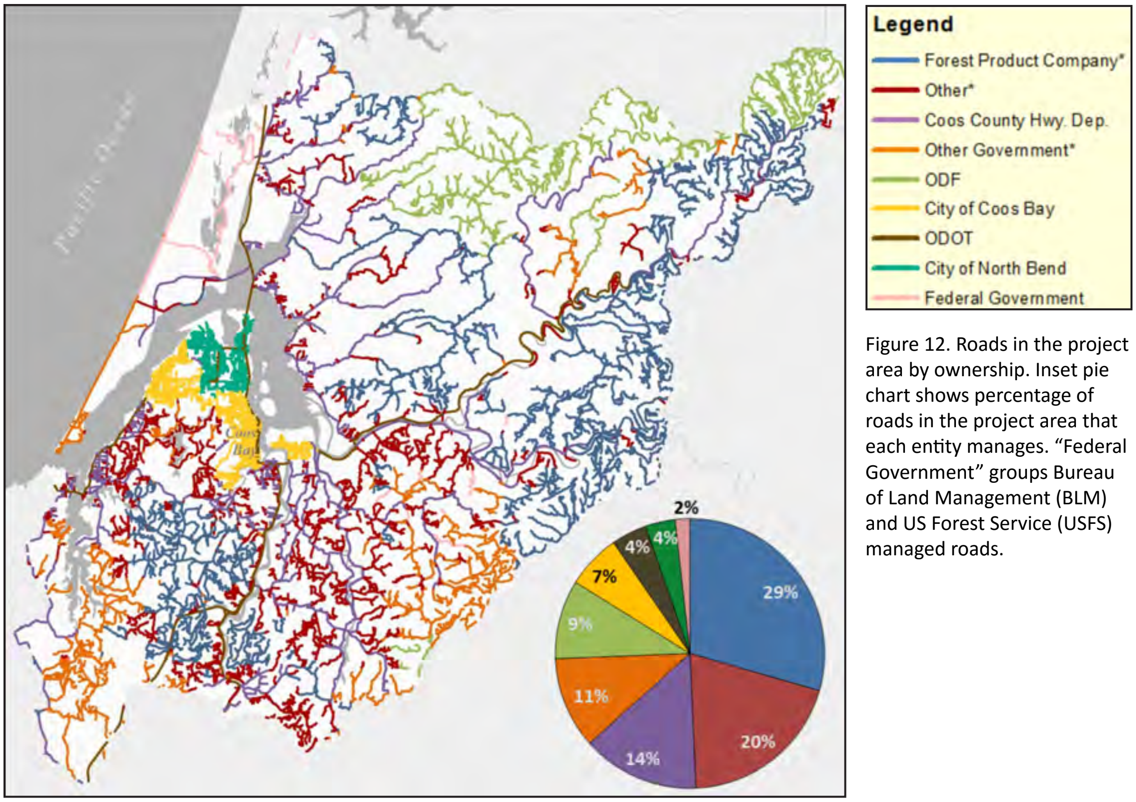



Figure 12. Roads in the project area by ownership. Inset pie chart shows percentage of roads in the project area that each entity manages. "Federal Government" groups Bureau of Land Management (BLM) and US Forest Service (USFS) managed roads.

*ODOT's "Other" category was further broken down by cross-referencing with land ownership (tax lots). "Other" now includes roads on tribal, corporate, water board, Port of Coos Bay, and private residential lands. "Other Government" represents roads on lands owned by the Cities of Coos Bay and North Bend, Coos County, Oregon Department of State Lands, and federal government. "Forest Product Company" represents roads on lands owned by Menasha Forest Products, Roseburg Forest Products and Weyerhauser. Data source: ODOT 2014.

ure 11). Although the ODOT road density data are the most accurate estimate available for the project area, they likely under-represent current conditions as new roads (especially forest roads) have been created since those data were compiled.

By subsystem, road densities were highest in Pony and Isthmus Sloughs (densities of 8.5 and 7.2 mi/mi$^2$ respectively, or 5.3 and 4.5 km/km$^2$)(Figure 11). These also happen to be subsystems with high impervious surface coverage. The Haynes Inlet subsystem shows the lowest road density at 2.9 mi/mi$^2$.

The ODOT data also provide information on road ownership, compiled from multiple sources (Figure 12). This information is limited and so we supplemented their category of unknown ownership with land ownership information (based on tax assessor maps)(it should be noted that land ownership does not always indicate who manages lands and associated roads). Lands owned by forest product companies (e.g., Weyerhauser) hold nearly 30% (414 mi) of the roads in the project area; Coos County Highway Department owns 14% (200 mi); and Oregon Department of Forestry owns 9% (135 mi).

**Background**

Levees and Tide Gates

Originally built starting in the 1800's to extend and protect agricultural, urban and residential lands in coastal Oregon, many levees are now in danger of being over-topped during winter storm tides, which are expected to cause more flooding as sea levels rise. Just as important, the area of remaining tidal wetlands (critical nursery habitat for many recreational and commercial aquatic life such as Dungeness crab) may be in danger of declining as levees prevent inland migration of those wetlands in response to sea level rise.

Good (2000) estimates that over 65% of Coos estuary tidal wetlands were converted from tidal wetland habitat to agriculture, urban, and residential uses between 1870 and 1970. Miles of levees and hundreds of tide gates were constructed to maintain those lands in their converted states. Since 1970, some of the tidal wetland losses have been reversed when willing landowners have removed levees to restore lands to their original tidal wetland functions (Good 2000).

Tide gated culverts eliminate tidal flooding while allowing creeks to continue emptying into the estuary during low tide. Water flow is controlled by tide gates fitted with hinged doors on the culvert's downstream end (outside the levee on the estuary side). Passively regulated by difference in water levels on either side of the levee, tide gated culverts allow water to flow into the estuary but not back into the protected lands (Bass 2010).

For estuarine-dependent and anadromous fish species, tide gates often pose nearly impassable barriers during high tides each day, restricting access to habitat and altering migratory timing (Bass 2010). For example, sub-yearling Coho salmon may be unable to cross between upstream and downstream habitats since tide gates create high water velocities and outlet waterfalls while the tide gate is open that can often prove dangerous or impassable in both directions for small fish (Bass 2010). Additionally, tide gates can be detrimental to downstream migrating juvenile salmon that abruptly experience high estuarine salinities as they move through the tide gate, instead of being allowed to acclimate to gradually increasing salinities as they are in natural systems.

Furthermore, disconnecting upstream aquatic habitats from the estuary alters their natural temperature and salinity regimens. Giannico and Souder (2004) discuss how estuarine wetland soil salinities change, effecting soil pH and its capacity to sequester heavy pollutants (e.g., lead, copper, cadmium). This sequestration is important, as the pollutants remain relatively harmless when chemically bound to wetland soils (Giannico and Souder 2004).

Newer tide gate designs are fitted with side-hinged openings designed to open wider to reduce turbulence and water velocity, and stay open longer to allow brackish water to circulate above the gate and reduce the abrupt transition between the salty and fresh sides of the gate. (Giannico and Souder 2004).

Impervious Surfaces

Negative effects of impervious surfaces (e.g., increased stormwater runoff volume, velocity, and peak flow; reduced groundwater availability; increased channel erosion; impairments to biota; and increased sediments, nutrients, and pollutants) can appear in watersheds with as little as 4-6% impervious surface coverage (USEPA 2014; NOAA 2010).

A New Hampshire Estuaries Project (NHEP) fact sheet summarizes several effects of impervious surface coverage in watersheds, such as the alteration of natural water flow, elevated water temperatures, aquatic habitat loss, pollutant delivery, and loss of biologic diversity (NHEP 2007). Ordinances controlling urban development and managing stormwater runoff are among the socio-economic issues associated with managing the effects of impervious surface coverage. For example, a community wishing to protect local streams from the potentially overwhelming effects of urban stormwater run-off could regulate the density and placement of new housing developments using a USEPA-designed approach (USEPA 2006).

Other ways to address issues associated with impervious surface coverage include the use of permeable pavements. Permeable pavements use newly developed materials that allow water to move through the pavement surfaces. This process reduces runoff and allows trapping and filtering of suspended solids and pollutants along the way. During storms, virtually all rainwater permeates and flows through these new types of pavements, instead of running off their surfaces, even after six years of heavy parking use (Brattebo and Booth 2003). Additionally, Brattebo and Booth (2003) found that waterborne pollutants (copper, zinc, lead, motor oil, diesel fuel) were nonexistent or significantly reduced after flowing through permeable pavements compared with surface runoff analyzed from a typical asphalt-covered area. Unfortunately, because permeable pavement is more expensive than regular pavement it is not yet widely used.

Roads

A large percent of impervious surfaces serve automobile traffic (Brattebo and Booth 2003). Essential for transporting both people and goods, the term "roads" broadly encompasses everything from private and lower capacity roads (e.g., alley or street), to high capacity highways. Road surfaces are also highly variable and are frequently made of gravel (e.g., forest roads), asphalt, or concrete.

According to Forman and Alexander (1998), roads allow human access to remote areas, sometimes with unintended consequences. For example, diseases (e.g., Port Orford cedar root rot) or invasive species expand their range past normal distribution bounds to remote areas via vehicular transport on remote roads. Forman and Alexander also raise the issue of an increase in human-caused wild fires as road density increases. However, remote fires are smaller on average in areas of higher road density, likely due to relatively easy access for fire fighters and the roads' natural contribution to the creation and maintenance of fire breaks.

A National Research Council (NRC 2005) report found that paved roads threaten the survival and reproductive success of wildlife populations. The most direct connection is direct mortality to animals (i.e., vehicle collisions), which can affect survival probability of local populations. Additionally, roads are barriers to wildlife movement. They fragment, isolate, or even extirpate some populations (especially fish). Noise from high-traffic roads can reduce breeding success of many bird species, as far as 1,500 meters (~1 mi) from the road.

NRC (2005) described that when surrounding landscapes are altered by human development (i.e., agriculture, timber or residential), buffers along roadsides often act as last remaining habitats for native plant, insect, bird and small mammal species. Yet roads themselves change the native composition of plant/animal communities, as these species need to be able to cope with vehicular pollution, high sunlight exposure, dry and sometimes dusty soils and chemical spraying or mowing maintenance.

In addition, NRC (2005) described effects of road-related pollution. Pollution from roads can reduce wetland biodiversity as far as 2 km (~1.2 mi) away. Road-related pollution can poison wildlife, such as birds, mammals and amphibians. Pollutants generated from vehicles, such as lead, copper, and zinc, accumulates on impervious roads, entering waterways during rain events. Other pollutants come from road maintenance activities (e.g., road salt, herbicide spraying), and have similarly damaging effects to aquatic systems, vegetation and wildlife.

**References**


Bass, A. L. 2010. Juvenile Coho Salmon Movement and Migration through Tide Gates. Thesis (M.S.)--Oregon State University, 2010.

Brattebo, B. O., and D. B. Booth. 2003 "Long-term Stormwater Quantity and Quality Performance of Permeable Pavement Systems." *Water Research 37(18*): 4369-4376.

Carnefix, G., and C. Frissell. 2009. Aquatic and Other Environmental Impacts of Roads: the Case for Road Density as an Indicator of Human Disturbance and Road-Density Reduction as Restoration Target.  Pacific Rivers Council Science Publication 09-001. Retrieved 9 April 2015.

City of Coos Bay. n.d. [Storm Sewer Outfalls Locations]. GIS shapefiles.

City of North Bend. 2005. Storm Drain Outfalls. GIS shapefiles.

Exum, L. R.; Bird, S. L.; Harrison, J,; Perkins, C. A. 2005. Estimating and Projecting Impervious Cover in the Southeastern United States. U.S. Environmental Protection Agency. 133p.

Flinker, P. and Millar, S (Ed.) 2010. The Need to Reduce Impervious Cover to Prevent Flooding and Protect Water Quality. Retrieved 7 May 7 2015: http://www.dem.ri.gov/programs/bpoladm/suswshed/pdfs/imperv.pdf

Forman, R. T., and L. E.  Alexander.  1998. Roads and Their Major Ecological Effects. *Annual review of ecology and systematics,* 207-C2.

Forman, R. T., and A. M. Hersperger. 1996. Road Ecology and Road Density in Different Landscapes, with International Planning and Mitigation Solutions. No. FHWA-PD-96-041. pp1-22.

Giannico, G.R. and J.A. Souder. 2004. The effects of tide gates on estuarine habitats and migratory fish. Oregon Sea Grant, Oregon State University. Corvallis, OR. 9pp.

Good, J. W. 2000. 'Summary and Current Status of Oregon's Estuarine Ecosystems', in *Oregon State of the Environment Report 2000,* Oregon Progress Board, Salem, Oregon.

Multi-Resolution Land Characteristics Consortium (MRLC). 2015. National Land Cover Database (NLCD). Accessed 31 March 2015: http://www.mrlc.gov/index.php

New Hampshire Estuaries Project (NHEP). 2007. The impacts of impervious surfaces on water resources. Factsheet. University of New Hampshire.

National Oceanographic and Atmospheric Administration (NOAA). 2010. Coastal Services Center, Land Cover Data Sheet, Coos County, Oregon. Accessed 24 April 2015: www.coast.noaa.gov/ccapatlas

National Research Council (NRC). 2005. Assessing and Managing the Ecological Impacts of Paved Roads. Washington, D.C.: National Academies Press.

Oregon Coastal Management Program (OCMP). 2011a. Estuarine Levees Inventory. GIS database, accessed 5 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BB794DBD7-4775-4BCC-932A-EA7B35334E8F%7D

Oregon Coastal Management Program (OCMP). 2011b. Estuarine Levees Protected Lands. GIS database, accessed 5 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7BC448FFE2-E1DC-4CA7-8506-E64D83285A76%7D

Oregon Coastal Management Program (OCMP). 2011c.Tide gates in Oregon Estuaries. GIS database, accessed 5 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7B654F9538-7971-494A-98ED-54928923E284%7D

Oregon Department of Transportation (ODOT). 2014. Oregon Transportation Network – 2014. GIS database, accessed 11 May 2015: http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7B2DADDE86-9546-4B88-A793-7D15F86C08AB%7D

Schueler, T. 2003. "Impacts of Impervious Cover on Aquatic Systems." Center for Watershed Protection. Ellicott City, MD.

United States Environmental Protection Agency (USEPA). 2006. Protecting water resources with higher-density development. EPA 231-R-06-001. Accessed 06 October 2015: http://www2.epa.gov/sites/production/files/2014-03/documents/protect_water_higher_density1.pdf

United States Environmental Protection Agency (USEPA). 2014. Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for Massachusetts Small MS4 Permit. Retrieved March 26, 2015 from: http://www.epa.gov/region1/npdes/stormwater/ma/MADCIA.pdf

# **Chapter 9:** Water Quality in the Coos Estuary and Lower Coos Watershed

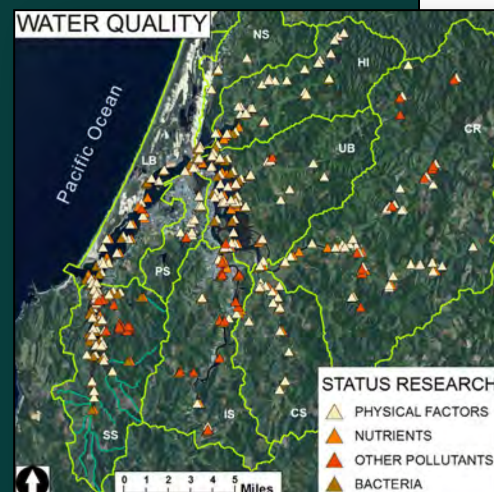
*Jenni Schmitt, Erik Larsen, Ali Helms, Colleen Burch Johnson, Beth Tanner, Ana Andazola-Ramsey - South Slough NERR*

***Physical Factors***: *Multiple waterways in the project area are considered water quality-limited under the Clean Water Act for high temperatures and low dissolved oxygen.*

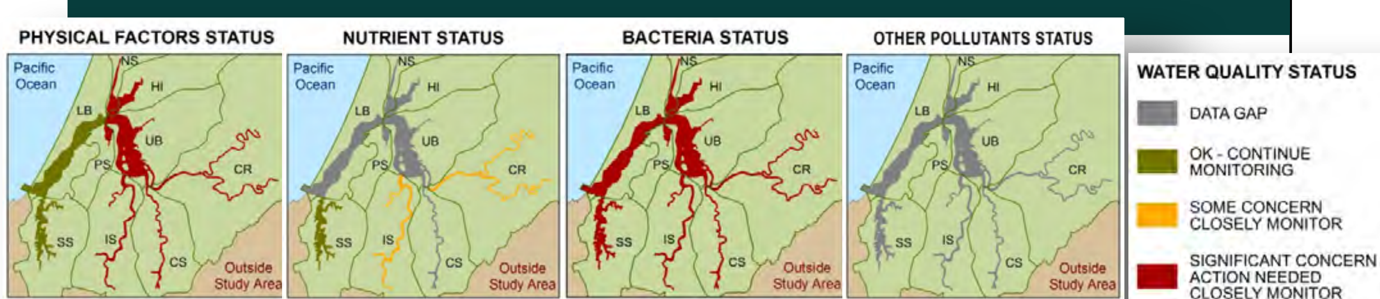
***Nutrients***: *Phosphorous levels are higher near the mouth and nitrogen levels are higher after precipitation events; however, nutrient levels appear to be generally healthy.*

***Bacteria***: *Approximately 20% of monitored sites have maximum bacteria levels exceeding state bacteria criteria for fish and shellfish.*

***Other Pollutants***: *Previously operational point sources of pollution (e.g., former marina on Isthmus Slough) may still pose a threat to water quality. Remaining estuarine waters remain essentially unstudied.*




Subsystems: CR- Coos River, CS- Catching Slough, HI- Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay




## Chapter 9: Water Quality in the Coos Estuary and Lower Coos Watershed

*This chapter includes four data summaries: **Physical Factors, Nutrients, Bacteria, and Other Pollutants** – each describing the most current research on the status and trends (where the data allow) of water quality in the Coos Estuary.*

Physical Factors: The most comprehensive information for physical water quality parameters (dissolved oxygen, water temperature, pH, salinity, turbidity, depth) comes from long-term continuous water quality monitoring efforts (i.e., data recorded by automated data collectors every 15 to 30 minutes). South Slough National Estuarine Research Reserve (SSNERR) staff began continuous monitoring efforts in 1995 and now have five water quality data collection stations in the South Slough estuary (SWMP 2014).

Data from these stations have been analyzed previously (O'Higgins and Rumrill 2007; Cornu et al. 2012) and are reported here with the benefit of additional analyses of the most recent data.

In the fall 2013, SSNERR staff installed four additional continuous monitoring stations in the Coos estuary. Data from these new stations are also summarized for this inventory (SSNERR 2014).

The Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI) began almost identical continuous water quality monitoring in the lower Coos estuary in 2006. Their data are collected in annual reports which have been summarized in the Physical Factors section (CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013).

In addition, the National Oceanic and Atmospheric Administration (NOAA) operates a meteorological and oceanographic station at the mouth of South Slough, which has been collecting water temperature data since 1993 (NOAA 2014). Hourly raw data were downloaded from NOAA and analyzed.

Short-term continuous data can also inform our understanding of water quality. Data used in this report include the following:

- A regional eelgrass study that collected water temperature data every hour from summer 1998 to fall 2001 at four sites in the Coos estuary (Thom et al. 2003); and
- Stream water quality data from summer 2011 monitoring at 15 sites in the South Slough watershed described in Cornu et al. (2012).

The description of the status of stream water quality was additionally informed by several short-term data collection efforts in the Coos River subsystem by ODEQ (ODEQ 2006b, 2006d, 2007a, 2009b).

Several datasets from long-term monitoring "grab" efforts (i.e., single, manually collected samples) were analyzed, including:

- Monthly sampling of salinity and temperature data taken by Oregon Department of Agriculture (ODA) as part of their ongoing fecal coliform sampling program (ODA 2011); and
- Daily data collection from 1966-1997 near the mouth of the Coos estuary collected for the Shore Station Program, a collaboration between the University of San Diego and various institutions across the Pacific Northwest, including the Oregon Institute of Marine Biology (OIMB) in Charleston, Oregon (Shore Stations Program 1997).

The remaining data discussed in this report come from studies which used data collected during very short-term data collector deployments or grab sampling, including the following: CoosWA 2002, 2006, 2008; Hayslip et al. 2006; Lee II and Brown 2009; Shanks et al. 2011; Sigmon et al. 2006; and Weybright 2011, along with the following unpublished sources: 1) Quality-checked data collected by ODEQ for various projects downloaded from their Laboratory Analytical Storage and Retrieval (LASAR) database and reviewed for this summary (ODEQ 2005b, 2005c, 2006a, 2006b, 2006c, 2007a, 2007c, 2009c); 2) Oregon Department of Fish and Wildlife's (ODFW's) annual fish monitoring seine program (ODFW 2013); and 3) A joint study from Marshfield High School and Oregon State University (Coastnet 1999).

<u>Nutrients</u>: The nutrient summary is partially based on an ODEQ report that assessed water quality in the Coos estuary and other Oregon estuaries (Sigmon et al. 2006). In addition, raw data collected during later years of the same project were analyzed in this section (ODEQ 1999, 2001a, 2004, 2005a, 2006a).

Several raw datasets were analyzed and summarized for this inventory including monthly quality-checked nutrient sampling in the South Slough (SWMP 2012) and data from several ODEQ projects (ODEQ 2006d, 2007c, 2009c).

Annual reports from CTCLUSI provided information on two sites in the lower Coos estuary, and information on a single site in the upper estuary (CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013).

Stream nutrients information was provided by a "State of the Watersheds" assessment of the South Slough watershed (Cornu et al. 2012).

<u>Bacteria</u>: The bacteria summary is based on several data sources including several ODEQ studies (ODEQ 2005a, 2007b).

ODA's monthly fecal coliform data from shellfish growing areas were analyzed and summarized for this inventory (ODA 2014).

Similarly, data from SSNERR's System-Wide Monitoring Program (SWMP) provided monthly *E. coli* and total coliforms bacteria information (SSNERR 2013).

Other reports on estuarine bacteria included here are: Souder 2003 and annual reports by CTCLUSI (CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013).

Stream bacteria data in South Slough were also derived from Cornu et al. 2012.

Other Pollutants: Only relatively sparse data sets describing dissolved metal concentrations are available for the Pony Slough, Coos River, and Isthmus Slough subsystems (ODEQ 1995, 1998, 2002, 2006a, 2006c, 2006d, 2007c, 2007d, 2009a, 2009b; Water Board 2012).

More robust dissolved metal concentration data are available for South Slough from ODEQ's groundwater well monitoring program at the former site of Coos County's Joe Ney Landfill. The most recent data come from 2012.

ODEQ has monitored total organic carbon (TOC) in the South Slough, Isthmus Slough, and Coos River subsystems (ODEQ 2001b, 2007d, 2009a, 2009b) on a "sporadic" basis; the most recent data were collected in 2009.

Additionally, the Coos Bay/North Bend Water board monitored TOC from 2010-2012 in Pony Slough (Pony Creek and Merritt Lake) and Lower Bay (North Spit) subsystems as part of their drinking water program (Water Board 2012).

Data for assessing dissolved herbicides, pesticides, and other persistent organic pollutants (POPs) are sparse. The Coos Bay/North Bend Water board monitors for eight POPs at Merritt Lake, all of which are internationally recognized for their high potential for environmental damage (Water Board 2012; Stockholm Convention 2008).

**Data Gaps and Limitations**

Physical Factors: Continuous water quality monitoring (automated data collection on a regular interval [e.g., 15 minutes]) provides the best characterization of physical water quality parameters. These continuously recorded data are most complete in the South Slough estuary and the lower bay. New stations recently installed in the upper bay by the Coquille Indian Tribe and SSNERR at McCullough Bridge, Isthmus Slough, Catching Slough and Coos River will provide a more complete picture of those parts of the Coos estuary in years to come.

Water temperature data from NOAA's Tides and Currents site in Charleston are raw data and have not been subjected to quality control or quality assurance procedures. NOAA states that these data "do not meet the criteria and standards of official National Ocean Service data. They are released for limited public use as preliminary data to be used only with appropriate caution".

Data from the Shore Stations Program were checked for key entry errors only and not analyzed for overall quality. We analyzed and reported on these data as-is.

Aside from the long-term monitoring efforts described above, most of the physical factors data used in this inventory come from short-term studies. Short term studies provide only a snapshot of water quality. Because most physical factors (e.g., turbidity) fluctuate widely relative to external factors (e.g., precipitation events), results vary drastically depending on when a sample was taken. The "snapshot" quality of these short-term data sets can sometimes limit our overall sense of the status of water quality in the Coos estuary. However, some short term data collection is still important because it can provide information about parameters under the most relevant conditions. For example, ODEQ's storm-related bacteria monitoring is collected during periods of high runoff and turbidity; the Coos Watershed Association's (CoosWA's) summertime-only monitoring is collected during the warmest months for stream temperature.

Subsystems lacking permanent water quality monitoring stations (e.g., North Slough; Pony Slough) have very little comprehensive information available to assess the status of physical water quality.

<u>Nutrients</u>: Much of the data used for this summary (e.g., ODEQ 1999, 2001a, 2004, 2005a, 2006a, 2006d, 2007c, 2009c) came from limited duration studies that sampled only during the dry season. For some parts of the estuary, our understanding of nitrogen, phosphorus and chlorophyll *a* levels during the wet season is therefore largely incomplete.

For several subsystems there exists little or no nutrients information (e.g., North Slough). Stream nutrient data included three sites in South Slough's upper watershed. All other subsystems are lacking in any stream (freshwater) nutrient information.

Silica data provided by ODEQ were frequently limited by the sensitivity of laboratory analysis techniques. Therefore, many of the silica data are listed as "below levels of detection" and provide little quantitative information.

<u>Bacteria</u>: There were limited data available to assess the Coos River, North Slough and Pony Slough subsystems.

Data sets were inconsistent based on sampling frequencies ranging from monthly to three times per year. Seasonal trends (e.g., wet vs. dry seasons) can be established for data sets with monthly sampling frequencies. However, there are limitations even with monthly sampling because many estuarine environmental water quality variables that influence bacteria are driven by tidal forces or precipitation events and can change multiple times in a day.

In addition, one state of Oregon standard for *E. coli* requires at least five samples over a 30 day period, which we were unable to fully assess in this report due to lack of data.

<u>Other Pollutants</u>: Large information gaps make it difficult to fully assess the status of dissolved pollutants in the Coos system. Information is only available in five of the nine subsystems. Available data are often collected at irregular intervals for a limited duration.

Additionally, the most recent dissolved pollutants data are from 2012.

The sensitivity of instruments used to collect and analyze the samples also presents a challenge. In many cases data values were below detectable limits, and United States Environmental Protection Agency (USEPA) water quality standards are close to many of these limits. To estimate the mean concentration of dissolved metals in the study area, we assumed “undetectable” observations were equal to the average of zero and the limit of detection. For example, an entry of “< 1.0 µg/L” was assigned the average value of 0.5 µg/L. If the true values of the undetectable observations differ from assumed values, then the true mean will differ from the estimated mean.

Evaluating the status of dissolved pollutants in the study area is further complicated by the uncertainty involved in applying appropriate water quality guidelines. Water quality standards for dissolved metals are often a function of site-specific parameters. For example, water “hardness,” a measure of water’s mineral content, may affect both acute and chronic criteria guidelines. In many cases, nationally recommended parameters that “can be effectively implemented on a broader level across any waters with roughly the same physical and chemical characteristics” have been adopted in order to facilitate analyses (USEPA 1993).

Exposure to dissolved metals adversely affects both aquatic life and human health. However, the exact effect of these toxins on aquatic life varies widely by species and environmental conditions (USEPA 1980). For example, USEPA explains that the toxicity of copper to aquatic life varies according to the species-specific biochemical receptors responding only to that metal (USEPA 2007).

They also note that copper toxicity is critically dependent on the characteristics of the water in which it is dissolved (e.g., temperature, dissolved organic compounds, pH, etc.). Due to the complexity of the physiological response to toxins in aquatic life, the Other Pollutants data summary focuses on the human health aspects of dissolved metals.

The mobility and availability of pollutants in estuaries are influenced by many factors, including chemical, geological and physical processes (oxidation, precipitation, sedimentation, tidal inundation, etc.)(Carroll et al. 2002, Bauer and Bianchi 2011, Williams et al. 1994). In addition to natural processes, pollutant cycling is affected by human land use activities, which can further complicate an already complex process (Bauer and Bianchi 2011). Because dissolved pollutants in the water column interact with sediment deposits on the estuary bottom, we suggest also examining the Contaminants data summary in “Chapter 10: Sediment in the Coos Estuary and the Lower Coos Watershed”. Interpreting both together offers a more comprehensive indicator of the overall status of pollutants in the Coos estuary.

**References**

Bauer J. E. and T. S. Bianchi. 2011. Dissolved Organic Carbon Cycling and Transformation. In: Wolanski E. and McLusky D.S. (eds.) Treatise on Estuarine and Coastal Science, Vol 5, pp. 7–67. Waltham: Academic Press. Retrieved from: http://aquaticbiogeochem.osu.edu/sites/aquaticbiogeochem.osu.edu/files/Bauer%20and%20Bianchi%20(2012)%20TECS-DOC%20Cycling.pdf

Carroll, Susan, Peggy A. O'Day, Brad Esser, and Simon Randal. 2002. Speciation and Fate of Trace Metals in Estuarine Sediments under Reduced and Oxidized Conditions, Seaplane Lagoon, Alameda Naval Air Station (USA). Geochemical Translations (3): 81.

Coastnet. 1999. [Marshfield Highschool - Oregon State University Sea Grant Program]. Unpublished QA/QC data.

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2007. Tribal Water Quality Assessment Report: October 2005-September 2006. CTCLUSI Department of Natural Resources, Coos Bay OR. 40 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2008. Tribal Water Quality Data Summary: October 2006-September 2007. CTCLUSI Department of Natural Resources, Coos Bay OR. 40 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2009. Confederate Tribes of the Coos, Lower Umpqua, and Siuslaw Indians Water Quality Data Summary: October 2007-September 2008. CTCLUSI Department of Natural Resources, Coos Bay OR. 33 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2010. Intermediate Tribal Water Quality Assessment Report. CTCLUSI Department of Natural Resources, Coos Bay OR. 33 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2011. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 37 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2012. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2013. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Coos Bay North Bend Water Board (Water Board). 2012. [Drinking Water Program Data]. Unpublished raw data. Accessed 15 April 2014 from the Estuarine and Coastal Sciences Laboratory of the South Slough National Estuarine Research Reserve.

Coos Watershed Association (CoosWA). 2002. Lower Pony Creek Watershed Assessment and Potential Action Plan. Coos Watershed Association, Charleston, OR. 11 pp. Retrieved from: http://www.cooswatershed.org/Publications/pony_creek_white_paper.pdf

Coos Watershed Association (CoosWA). 2006. Coos Bay Lowland Assessment and Restoration Plan. Coos Watershed Association, Charleston, OR. 263 pp. Retrieved from: http://www.cooswatershed.org/pubsciass

Coos Watershed Association (CoosWA). 2008. Catching Slough, Daniel's Creek and Heads of Tide Sub-basin Assessment and Restoration Opportunities. Coos Watershed Association, Charleston, OR. 144 pp. Retrieved from: http://www.cooswatershed.org/Publications/Assessment%20Body-%20Catching%20Daniels%20HoT%2003-2009.pdf

Cornu, C.E., and J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Hayslip, G., L. Edmond, V. Partridge, W. Nelson, H. Lee, F. Cole, J. Lamberson , and L. Caton. 2006. Ecological Condition of the Estuaries of Oregon and Washington. EPA 910-R-06-001. U.S. Environmental Protection Agency, Office of Environmental Assessment, Region 10, Seattle, Washington.

Lee II, H. and C. A. Brown. (eds.) 2009. Classification of Regional Patterns of Environmental Drivers And Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division.

National Oceanographic and Atmospheric Administration (NOAA). 2014. [Tides and Currents Water Temperature at Charleston, OR station]. Unpublished raw data. Retrieved from: http://tidesandcurrents.noaa.gov/physocean.html?id=9432780

O'Higgins, T. and S. Rumrill. 2007. Tidal and Watershed Forcing of Nutrients and Dissolved Oxygen Stress within Four Pacific Coast Estuaries: Analysis of Time-Series Data Collected by the National Estuarine Research Reserve System-Wide Monitoring Program (2000-2006) within Padill Bay (WA), South Slough (OR), Elkhorn Slough (CA) and Tijauna River (CA). South Slough National Estuarine Research Reserve, Charleston, Oregon.

Oregon Department of Agriculture (ODA). 2011. [Coos Bay and South Slough Bacteria Sampling for Shellfish Growing Areas, 1999-2011]. Unpublished raw data.

Oregon Department of Agriculture (ODA). 2014. [Coos Bay and South Slough Bacteria Sampling for Shellfish Growing Areas, 1999-2014]. Unpublished raw data.

Oregon Department of Environmental Quality (ODEQ). 1995. [Joe Ney Monitoring Well Data 1995]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 1998. [Joe Ney Monitoring Well Data 1998]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 1999. [CEMAP 1999 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/;

Oregon Department of Environmental Quality (ODEQ). 2001a. [CEMAP 2001 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/;

Oregon Department of Environmental Quality (ODEQ). 2001b. [Coos and Millicoma River]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2002. [Joe Ney Monitoring Well Data 2002]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2004. [CEMAP 2004 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2005a. [CEMAP 2005 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2005b. [Coos River Basin 2005 Water Temperature Study - TMDL (NPS) Development]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2005c. [South Fork Coos River Temperature Study - TMDL (NPS) Development]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006a. [CEMAP 2006 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006b. [Coos Bay TMDL Summer 2006 Temperature Continuous Monitoring]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006c. [Joe Ney Monitoring Well Data 2006]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006d. [South Fork Coos River Temperature Study – TMDL (NPS) Development]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007a. [2007 Coos Basin Temp Project]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007b. [Coos Bay Water Quality Storm Related Bacteria Sampling ]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007c. [Isthmus Slough/South Fork Coos DO Study]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007d. [South Fork Coos River Summer Synoptic 2007]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009a. [Joe Ney Landfill Subproject-Groundwater Monitoring Data]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009b. [Joe Ney Monitoring Well Data 2009]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009c. [Millicoma River TMDL DO Study 2009]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Fish and Wildlife (ODFW). 2013. [Coos fish monitoring seine program]. Unpublished raw data.

Shanks, A., S. Schroeder, and B. Dlouhy. 2011. Appendix F.3 – January 2011: Report on the Zooplankton Sampling Adjacent to the Proposed Jordan Cove LNG Terminal. In: FERC Application and Resource Reports – Jordan Cove Energy Project. Retrieved from: http://www.jordancoveenergy.com/ferc_application_and_resource_reports_1-13.htm

Shore Stations Program. 1997. [Charleston Station – Salinity and Temperature 1966-1997]. Unpublished raw data. Retrieved from: http://shorestation.ucsd.edu/historical/index_historical.html

Sigmon C. L. T., L. Caton, G. Coffeen, and S. Miller. 2006. Coastal Environmental Monitoring and Assessment Program. The Condition of Oregon's Estuaries in 1999, a Statistical Summary. Oregon Department of Environmental Quality, Laboratory.

Souder, JA. 2003. Report on the Analyses of Bacteriological Contributions to Direct Bay Tributary Streams in the Coos Estuary Using Traditional Public Health Indicators and DNA Analyses of *E. coli*. Coos Watershed Association Assessment Reports. 9 pp.

South Slough National Estuarine Research Reserve (SSNERR). 2013. [System-Wide Monitoring Program -Monthly *E. coli* and Total Coliform Bacteria Sampling, 2004-2013]. Unpublished raw data.

Stockholm Convention. 2008. What are POPs. Retrieved 24 July, 2014, from http://chm.pops.int/TheConvention/ThePOPs/tabid/673/Default.aspx

System-Wide Monitoring Program (SWMP). 2012. [South Slough Nutrient Data, 2002-2012]. Unpublished raw data.

System-Wide Monitoring Program (SWMP). 2014. [South Slough Abiotic Water Quality Data (1995-2014)]. Retrieved from: http://cdmo.baruch.sc.edu/

Thom, R. M., A. B. Borde, S. Rumrill, D. L. Woodruff, G. D. Williams, J. A. Southard, and S. L. Sargeant. 2003. Factors Influencing Spatial and Annual Variability in Eelgrass (*Zostera marina L.*) Meadows in Willapa Bay, Washington, and Coos Bay, Oregon, Estuaries. Estuaries. 26 (4): 1117-1129.

United States Environmental Protection Agency (USEPA). 1980. Ambient Water Quality Criteria for Arsenic. Accessed 12 June 2014. Retrieved from: http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_arsenic80.pdf

United States Environmental Protection Agency (USEPA). 1993. Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria. [online via USEPA National Recommended Water Quality Criteria Tables]. Accessed 20 May 2014. Retrieved from: http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#gold

United States Environmental Protection Agency (USEPA). 2007. Aquatic Life Ambient Freshwater Quality Criteria- Copper. Accessed 20 May 2014. Retrieved from: http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/copper/upload/2009_04_27_criteria_copper_2007_criteria-full.pdf

Weybright, A. D. 2011. Juvenile Coho Salmon Movement, Growth and Survival in a Coastal Basin of Southern Oregon. Thesis (M.S.) -- Oregon State University, 2011.

Williams, T.P., J.M. Bubbs, and J.N. Lester. 1994. Metal Accumulation within Salt Marsh Environments: A Review. Marine Pollution Bulletin. 28(5): 277-290.

# How the Local Effects of Climate Change Could Affect Water Quality in the Coos Estuary and Lower Coos Watershed

*Several climate-related changes expected on the Oregon coast could affect water quality in the Coos estuary and lower Coos watershed:*

- *Sea level rise will likely shift estuarine plant and animal communities as tidal inundation and salinity regimes change over time.*
- *More severe winter storm events may cause increased bank erosion in exposed sections of the bay, increasing turbidity and land-derived bacteria and nutrient inputs.*
- *Should decreases in summertime precipitation occur, the reduced availability of freshwater could result in seasonal increases in stream water temperatures and turbidity, localized increases in salinity in tidal areas, and decreases in dissolved oxygen concentrations.*

Low flow on the West Fork Millicoma River

Pacific storm

The local effects of climate change will likely: 1) affect winter storm patterns and associated delivery of freshwater inputs to the Coos estuary; 2) result in sea level rise and associated tidal inundation regimes (already well under way); 3) change ocean and estuarine water chemistry; and 4) affect coastal upwelling; all of which have potential to alter water quality, which in turn will alter the ecosystem services provided by estuaries. However, distinguishing the effects of climate change on water quality variables versus those of human-gen-

*Changes in Precipitation Timing, Frequency and Intensity*

*In the future, precipitation in coastal Oregon is expected to remain a predominately wintertime phenomenon (i.e., most precipitation will continue to occur in the winter). However, the extent to which precipitation timing, frequency and intensity on the Oregon coast may change in the future remains uncertain. There is evidence that high-intensity storms are becoming more frequent, and that the frequency of weak to moderate-strength storms is declining.*

*Sources: Sharp 2012; OCCRI 2010; OSU 2005*

erated change is difficult. Possible effects specifically derived from climate change are described below.

**Change in Hydrologic Conditions**

Climate-related hydrologic changes (i.e., changes to water movement, such as river flow, ocean inundation, estuary flushing, etc.) will likely be the most significant cause of variations in water quality.

The timing and quantity of freshwater contributions to estuaries from coastal creeks and rivers will change depending on climate-related changes to precipitation patterns. For example, climate modeling of a maritime watershed in British Columbia, where spring/summer precipitation is expected to decrease while fall/winter precipitation is expected to become increasingly intense, floods will become more common in fall/winter while droughts would become more prolonged during spring/summer (Loukas et al. 2002). In fact, summertime drought conditions could be further exacerbated in estuaries where water managers divert more water to reservoirs in response to dryer conditions (Scavia et al. 2002).

While no strong evidence yet exists to suggest significant future changes in Oregon coastal precipitation patterns (Sharp 2012), some scientists are suggesting communities prepare for an increase in the frequency of high intensity winter storms and longer summertime drought conditions (OCCRI 2010, OSU 2005) which could result in the following:

- Lower summer flows could add to decreased dissolved oxygen levels and increased temperatures, especially in the upper reaches of the estuary (see Increasing Hypoxia Events and Increasing Temperatures below).
- Heavier winter storm flows could increase the frequency of large scale slope failures in coastal watersheds, resulting in high turbidity levels. According to Whitehead et al. (2009), the increased frequency and

*<u>Uncertainty in Predicting Local Effects of Climate Change</u>*

*There is inherent uncertainty in predicting what the local effects of climate change are likely to be. The uncertainties generally fall into three categories: 1) Natural variability of the earth's climate; 2) Climate sensitivity (how the earth's climate system responds to increases in future greenhouse gas levels); and 3) Future greenhouse gas emissions.*

*To manage for these uncertainties, climate scientists use multiple models ("multi-model ensembles") that incorporate the estimated range of possible natural variability, climate sensitivity, and future greenhouse gas emission values when investigating climate-related change. The models typically generate a range of values for potential future air temperatures, ocean surface temperatures, sea level rise, etc., which naturally become increasingly variable the longer into the future the model predicts. This approach gives communities a range of projections to consider when developing climate change vulnerability assessments and adaptation plans.*

*Sources: Sharp 2012; Hawkins and Sutton 2009*

intensity of coastal storms could also lead to the re-mobilization of heavy metals and contaminants from the sediment to the water column.

- Higher seasonal flood waters could heighten terrestrially-derived bacteria and nitrogen inputs, which, combined with expected decrease of spring/summer flushing, may create conditions for the development of hypoxic (low dissolved oxygen) zones in estuarine waterways (Scavia et al. 2002).
- Increased winter flows and reduced summer flows will affect the estuarine salinity regime. According to the 2010 Oregon Climate Change Research Institute (OCCRI) report, dry season salinity can be expected to increase over time, which will likely change estuarine plant and animal communities, and possibly create openings for the establishment of new or spread of existing invasive species.

Precipitation shifts are also expected to: 1) increase storm-driven hydrologic exchange (flushing) in estuarine and coastal waterways during the rainy season; and 2) decrease summertime flushing (Moore et al. 1997 as cited in Scavia et al. 2002). Decreased flushing can cause a buildup of nutrient-laden waters, which in turn will allow phytoplankton blooms to occur, possibly leaving the estuary more susceptible to eutrophication in the future (Scavia et al. 2002).

*Ocean Acidification*

*Since the late 18th century, the worldwide average ocean surface pH levels have decreased by about 0.1 pH units, a decrease of pH from about 8.2 before the industrial revolution to about 8.1 today. A 0.1 change in pH is significant because it represents about a 30 percent increase in ocean acidity (the pH scale is logarithmic, meaning that for every one point change in pH, the actual concentration changes by a factor of ten). Scientists estimate that by 2100 ocean waters could be nearly 150% more acidic than they are now, resulting in ocean acidity not experienced on earth in 20 million years. The best Pacific Northwest ocean acidification data we have so far are from the Puget Sound area, where pH has decreased about as much as the worldwide average (a decrease ranging from 0.05 to 0.15 units).*

*Sources: Feely et al. 2010, NOAA PMEL Carbon Program 2013*

**Ocean Acidification**

Increasing ocean acidity is expected to have major consequences for aquatic life such as plankton and mollusks (e.g., clams, oysters) that incorporate calcium carbonate into their shells (OCCRI 2010). These life forms are particularly sensitive to low pH waters which thin their shells by dissolving the calcium carbonate.

The effects of acidification in the Coos estuary are still being investigated. Estuarine carbonate chemistry is more complicated than ocean acidification due to watershed influences, aquatic respiration, and primary production from submerged aquatic vegetation (e.g., eelgrass). Researchers at the South Slough National Estuarine Research Reserve (SSNERR) recorded pH levels actually climbing (become less acidic) in South Slough waters but determined it was a relative short duration trend and possibly part of the larger pH variability in the estuary. This long-term monitoring and research is actively improving our community's ability to understand trends in Coos estuary pH levels.

**Increasing Temperatures**

Overall, Oregon estuaries are predicted to experience an increase in water temperature consistent with warming ocean waters (OCCRI 2010). According to the OCCRI report (2010), the influence of increasing ocean temperatures may be compounded by decreased freshwater flow in summer should summertime drought conditions become more frequent on the Oregon coast. Those same

*Increasing Ocean Temperatures*

*Worldwide, ocean temperatures rose at an average rate of 0.07° C (0.13° F) per decade between 1901 and 2012. Since 1880, when reliable ocean temperature observations first began, there have been no periods with higher ocean temperatures than those during the period from 1982 – 2012. The periods between 1910 and 1940 (after a cooling period between 1880 and 1910), and 1970 and the present are the times within which ocean temperatures have mainly increased.*

*Describing how the worldwide trend translates to trends off the Oregon coast is a complicated matter. Sea surface temperatures are highly variable due to coastal upwelling processes and other climatic events that occur in irregular cycles (e.g., El Niño events). We do have 27 years (1967-1994) of water temperature data collected from near the mouth of the Coos estuary that indicate through preliminary analyses a very weak trend towards warming water temperatures. Fifteen years (1995-2010) of data from multiple stations further up the South Slough estuary show very little water temperature change.*

*Sources: USEPA 2013, SSNERR 2013, Cornu et al. 2012*

drought conditions (low stream flows, elevated air temperatures) will likely exacerbate the poor water quality in Coos estuary tributary streams already approaching or exceeding state water temperature standards.

**Increasing Hypoxia Events**

Hypoxia is commonly defined as dissolved oxygen (DO) levels less than 2.0 mg/L, although stress to organisms begins before reaching that benchmark (USEPA 2000).

Decreases in DO are common during warm summer conditions in the relatively shallow Coos estuary and frequently drop below Oregon Department of Environmental Quality's (ODEQ) DO standards. According to the OCCRI report (2010), DO levels could further decrease with higher water temperatures (warm waters hold less oxygen than cool waters) and other hydrologic changes (e.g., decreased estuary flushing).

Further, increased advection of low-oxygen ocean water into the lower portions of the estuary during periods of intense summertime upwelling could potentially lower dissolved oxygen levels in the estuary (OCCRI 2010). Especially hazardous are occurrences of severe ocean hypoxia (<0.7 mg/L)(PISCO 2008) which have been observed in recent years off the Oregon coast. Chan et al. (2008) found no evidence of nearshore severe hypoxia prior to 2000, but severe hypoxia events have become relatively common in Oregon's nearshore ocean since 2006. Severe hypoxia was seen in August, 2014 along the 15 m ocean bottom

*Sea Level Rise*

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, the National Research Council (NRC), predicted SLR rates as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100 for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary).*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

contour line and deeper (F. Chan and J. Barth pers. com. August 20, 2014).

**Sea Level Rise**

Rising sea levels will be an important factor affecting estuarine functions. According to the OCCRI report (2010), estuarine salinity is expected to increase due to increased sea-water intrusion from rising sea levels; the location along the estuarine salinity gradient will be a key factor in determining levels of oceanic water intrusion for individual sites. Even small salinity increases are expected to shift the spatial distribution of estuarine plant and animal communities, affecting dominant tidal marsh plant communities (Callaway et al. 2007).

OCCRI (2010) further reports that rising sea levels will be compounded by strong El Niño events, resulting in increased flooding and bank erosion, which in turn will cause an increase in water turbidity. For example, in Yaquina Bay, monthly mean water levels in the winter months (November-March) were on average 30 cm higher during strong El Niño years, causing increased erosion and turbidity.

**Change in Oceanographic Conditions**

Based on the upwelling index at our latitude in the northeastern Pacific, upwelling-inducing winds are expected to increase in intensity and generate stronger upwelling events (Bakun 1990). The OCCRI report (2010) also predicts intensification of coastal upwelling which is expected to affect nutrient inputs to Oregon's estuaries.

In the Coos estuary, tidally driven inundation during strong upwelling coupled with sea level rise would allow phosphate-rich oceanic water to intrude further into estuarine environments, and would especially increase summertime nutrient inputs.

Likewise, cold waters with low DO levels may also intrude farther up the Coos estuary during strong summertime upwelling events . Brown and Power (2011) found that cold flood tide waters near the mouth of the Yaquina estuary contained severely low dissolved oxygen levels (minimum value of 0.4 mg/L) during summer upwelling events.

*Local Effects of Changing Ocean Conditions:*

*Physical conditions in an estuary are sensitive to changes in long-term oceanographic fluctuations. O'Higgins and Rumrill studied the physical response of the South Slough estuary to changes in the Pacific Decadal Oscillation (PDO) index by monitoring South Slough water quality from 2000 to 2006. Their data show a positive and statistically significant relationship between temperature and the PDO index but a negative and statistically significant relationship between dissolved oxygen and the PDO index. This suggests that local estuaries are both anomalously warm and less oxygenated during the warmer (positive) phases of the PDO. Similarly, Hamilton has studied the relationship between the physical conditions of local waters and El Niño Southern Oscillation (ENSO) events between 2004 and 2010. Her data demonstrate a positive and statistically significant relationship between temperature and a multivariate ENSO index at stations in Charleston, South Slough's Valino Island, and South Slough's Winchester Creek.*

*Sources: O'Higgins and Rumrill 2007, Hamilton 2011*

Findings from the OCCRI report (2010) indicate the intensification of North Pacific storms will bring increased wave heights to Oregon's outer coast beaches and lower estuarine shorelines. Larger waves propagating up the estuary to exposed shorelines would likely cause increased erosion leading to higher turbidity levels for lower estuarine waters.

**References**

Bakun, A. 1990. Global Climate Change and Intensification of Coastal Ocean Upwelling. Science. 247(4939): 198-201.

Brown, C.A., and J.H. Power. 2011. Historic and recent patterns of dissolved oxygen in the Yaquina Estuary (Oregon, USA): Importance of anthropogenic activities and oceanic conditions. Estuarine, Coastal and Shelf Science. 92 (3): 446-455.

Callaway, J. C., P. V. Thomas, M. C. Vasey, and L. M. Schile. 2007. Emerging Issues for the Restoration of Tidal Marsh Ecosystems in the Context of Predicted Climate Change. Madroño. 54 (3): 234-248.

Chan, F., J. A. Barth, J. Lubchenco, A. Kirincich, H. Weeks, W. T. Peterson, and B. A. Menge. 2008. Emergence of Anoxia in the California Current Large Marine Ecosystem. Science. 319 (5865): 920.

Cornu, C.E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Feely, R.A., S. R. Alin, J. Newton, C. L. Sabine, M. Warner, A. Devol, C. Krembs, and C. Maloy. 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. Estuarine, Coastal and Shelf Science. 88 (4): 442-449.

Hamilton, J. 2011. SWMP Bio-monitoring: Final Report (2004-2010). South Slough National Estuarine Research Reserve. Charleston, OR.

Hawkins, E. and R. Sutton. 2009. The potential to narrow uncertainty in regional climate predictions, Bulletin of the American Meteorological Society (BAMS) 90, 1095-1107, doi:10.1175/2009BAMS2607.1

Loukas, A., V. Lampros, and N.R. Dalezios. 2002. Potential Climate Change Impacts on Flood Producing Mechanisms in Southern British Columbia, Canada Using the CGCMA1 Simulation Results. Journal of Hydrology. 259:163-188.

Moore, M. V., M. L. Pace, J. R. Mather, P. S. Murdoch, R. W. Hogwarth, C. L. Folt, C. Y. Chen, H. F. Hemond, P. A. Flebbe, and C. T. Driscoll. 1997. Potential effects of climate change on freshwater ecosystems of the New England/mid-Atlantic region. Hydrological Processes 11:925-947.

National Oceanic and Atmospheric Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL) Carbon Program. 2013. What is Ocean Acidification? Retrieved from: http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

NOAA Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Retrieved from: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. The National Academies Press, Washington, DC. 201 pp.

O'Higgins, T. and S. S. Rumrill. 2007. Tidal and Watershed Forcing of Nutrients and Dissolved Oxygen Stress Within Four Pacific Coast Estuaries: Analysis of Time-Series Data Collected by the National Estuarine Research Reserve System-Wide Monitoring Program (2000-2006) Within Padilla Bay (WA), South Slough (OR), Elkhorn Slough (CA), and the Tijuana River Estuary (CA). Final Report Submitted to the NOAA/University of New Hampshire Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET).

Oregon Climate Change Research Institute (OCCRI). 2010. "Chapter 6. Impacts of Climate Change on Oregon's Coasts and Estuaries", in Oregon Climate Assessment Report. K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Oregon State University (OSU). 2005. Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest. Unpublished report no. 2004-3. Corvallis OR. Retrieved from: http://ir.library.oregonstate.edu/jspui/handle/1957/113

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO). 2008. Hypoxia off the Pacific Northwest Coast. Retrieved from http://www.piscoweb.org/files/hypoxia_general%20low-res.pdf

Scavia, D., J. C. Field, D. F. Boesch, R. W. Buddemeier, V. Burkett, D. R. Cayan, M. Fogarty, et al. 2002. Climate Change Impacts on U.S. Coastal and Marine Ecosystems. Estuaries. 25 (2): 149-164.

Sharp, D. 2012. Climate Change and the Lower Coquille Watershed. Unpublished report. Oregon Climate Change Research Institute/ EcoAdapt. Retrieved from: http://ecoadapt.org/data/documents/CoquilleClimate_02nov2012_FINAL.pdf

South Slough National Estuarine Research Reserve (SSNERR). 2013. Unpublished raw data. System-Wide Monitoring Program (SWMP). Retrieved from: http://cdmo.baruch.sc.edu/

United States Environmental Protection Agency (USEPA). 2000. Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras. Office of Water, Washington, D.C. 55 p.

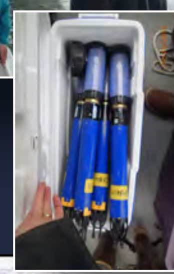
United States Environmental Protection Agency (USEPA). 2013. Climate change indicators in the United States. Retrieved from: http://www.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html

Whitehead, P. G., R. L. Wilby, R. W. Battarbee, M. Kernan, and A. J. Wade. 2009. A review of the Potential Impacts of Climate Change on Surface Water Quality". Hydrological Sciences Journal. 54 (1): 101-123.

# Water Quality in the Coos Estuary and Lower Coos Watershed: Physical Factors

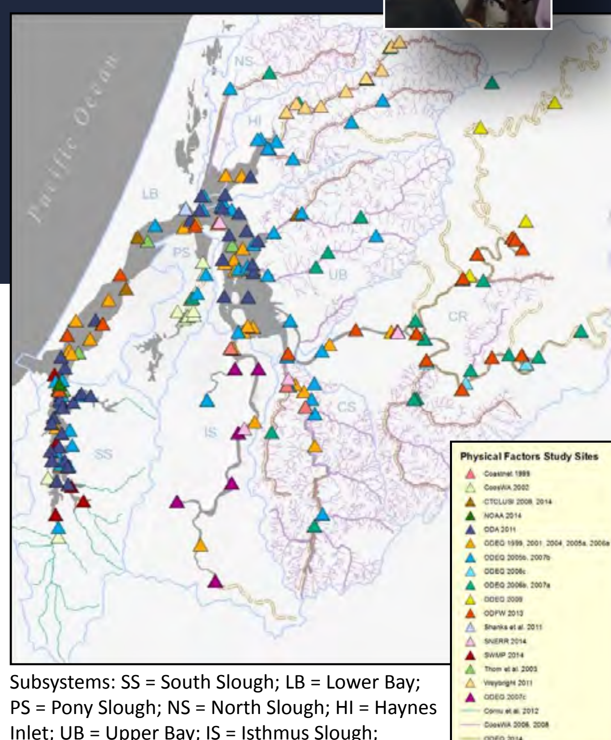
*Summary:*

- *<u>Dissolved Oxygen</u>: Dry season dissolved oxygen levels often drop into unhealthy levels in upper regions of the estuary.*
- *<u>Temperature</u>: Summertime water temperatures frequently exceed state criteria for healthy waters in most sectors of the project area.*
- *<u>pH</u>: In general, the waters of the Coos estuary and contributing tributaries have healthy pH levels.*
- *<u>Turbidity</u>: Compared to other Oregon estuaries, turbidity levels in the Coos estuary are high. Turbidity levels often peak above healthy levels after heavy wintertime precipitation events.*



**Evaluation**

Dissolved oxygen, and temperature levels are in need of significant action and should be closely monitored.




Subsystems: SS = South Slough; LB = Lower Bay; PS = Pony Slough; NS = North Slough; HI = Haynes Inlet; UB = Upper Bay; IS = Isthmus Slough; CS = Catching Slough; CR = Coos River

**What's happening?**

Physical water properties such as dissolved oxygen (DO), temperature, salinity, pH and turbidity affect the chemistry, solubility, and availability of nutrients and contaminants in water. These parameters change in relation to each other and in response to environmental variables (e.g., precipitation or tidal cycle).

The following summary describes the results of multiple monitoring and research efforts focused on Coos estuary habitats. We first describe conditions in the Coos estuary in general, then focus on specific subsystems organized into three groups: 1) South Slough/ Lower Bay; 2) Upper Bay/Pony Slough/North Slough/Haynes Inlet; and 3) Isthmus Slough/ Catching Slough/Coos River.

Sites listed as impaired under the Clean Water Act are discussed along with Oregon Department of Environmental Quality's (ODEQ's) criteria for maintaining water quality conditions suitable for aquatic life (Table 1).

Estuary Wide

Coos estuary water quality data have been collected by various researchers in the following studies. Additional studies will be referenced in subsequent sections.

CEMAP: Water quality in the Coos estuary was assessed by the U.S. Environmental Protection Agency's (USEPA) Coastal Environmental Monitoring and Assessment Program (CEMAP), initiated in 1999 and continued until 2007 by ODEQ (Hayslip et al. 2006; Sigmon et al. 2006). This study provided raw "grab sample" data for DO, temperature, pH, and salinity collected over several days during July, August, or September each year (ODEQ 1999, 2001, 2004, 2005a, 2006a). The averages of multiple samples at each station are used in this report.

SWMP: South Slough National Estuarine Research Reserve (SSNERR) has a network of System-Wide Monitoring Program (SWMP) long-term water quality monitoring stations located in South Slough. In 2013, SSNERR add-

| Form | What is it? | Water Quality Standards | Water Quality Standard Source |
|---|---|---|---|
| Dissolved Oxygen (DO) | Amount of oxygen dissolved in water | For estuarine* water: > 6.5 mg/L ;<br>For active spawning areas: > 11.0 mg/L;<br>For cold-water aquatic life (e.g., salmon): > 8.0 mg/L;<br>For cool-water aquatic life (e.g., sturgeon, lamprey): > 6.5 mg/L | OAR 340-041-0016 |
| pH | The amount of free hydrogen in the water. A value of 7 is neutral with more hydrogen (or values < 7) being acidic and less hydrogen (or values > 7) being basic. | Estuarine and Fresh water: 6.5-8.5 | OAR 340-041-0021 |
| Water Temperature | How hot or cold the water is | For spawning use: < 13.0 oC (7d moving avg);<br>For salmon rearing/migration: < 18 oC (7d moving avg) | OAR 340-041-0028 |
| Turbidity | The amount of particulate matter (e.g., clay or microscopic organisms) suspended in water | < 50 NTU | OWEB 1999 |
| Salinity | Measure of salt dissolved in the water, mainly sodium and chloride ($NaCl_2$) - ocean water has a salinity of 35 | NA | |
| * Estuarine waters defined as those with conductivity >200 µS/cm | | | |

Table 1. Physical water quality parameters commonly measured and the standards set for each to indicate unhealthy waters.

ed four new long-term water quality monitoring stations to the four already in place; these new stations are located in the Upper Bay, Isthmus Slough, Catching Slough, and Coos River (Figure 1). All stations collect continuous data (every 15 minutes) describing DO, water temperature, salinity, pH, turbidity, and depth (SSNERR 2014). Daily averages of these data are used in this report and combined with similar long term water quality data collected at three sites operated by the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI)(Figure 1).

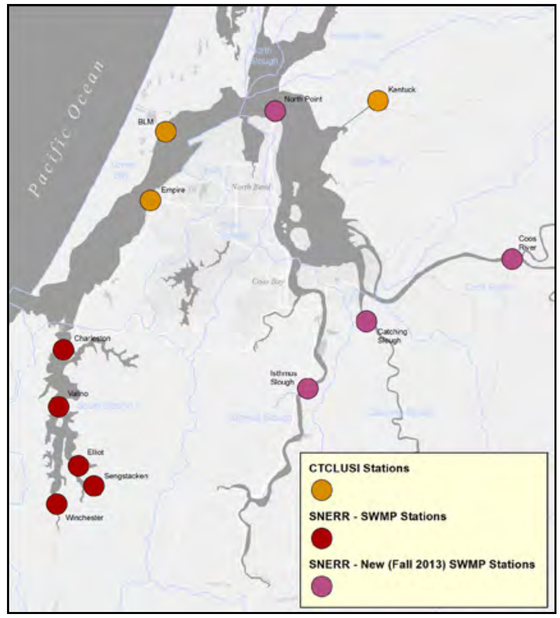



Figure 1. Location of continuous water quality monitoring stations run by CTCLUSI and SSNERR. Project area subsystems are delineated and labeled in blue. Labeled symbols refer to site names within this report.

<u>ODEQ TMDL</u>: Researchers monitored water temperature at 30 minute intervals at 26 sites during two monitoring efforts in 2006 and 2007 to assess total maximum daily loads (TMDL) for impaired waters (Figure 2)(ODEQ 2006b, 2007a). Monthly averages of the data are used in this report.

<u>ODA Fecal Coliform</u>: Oregon Department of Agriculture (ODA) monthly salinity and temperature data (1999-2011) from its 33 fecal coliform sampling stations are included in this report (Figures 2 and 7)(ODA 2011).

<u>Brown and Folger (2009)</u>: Researchers compared the Coos estuary to six other Oregon estuaries based on seven Coos estuary stations where DO, salinity, and total suspended solids (TSS) were measured at 15 minute intervals, June-August 2005 (Figure 2).

<u>Thom et al. (2003)</u>: Researchers in this eelgrass study collected water temperature data every hour from summer 1998 to fall 2001 at

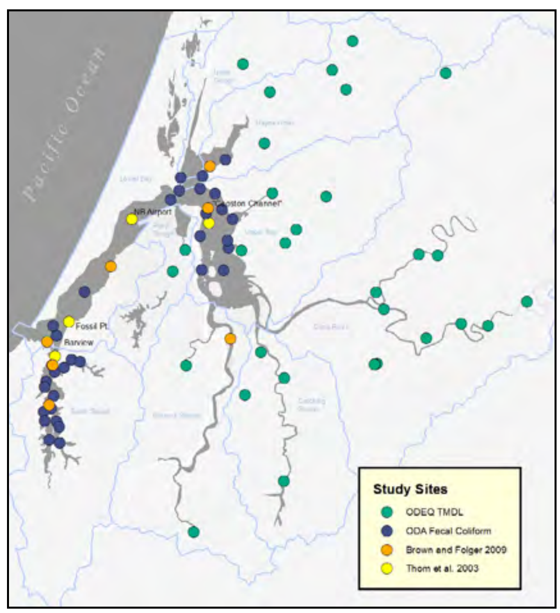



Figure 2. Location of ODEQ, ODA, Brown and Folger and Thom et al. study/monitoring sites. Project subsystems are delineated and labeled in blue. Labeled symbols refer to site names used in this document. Note that Cooston Channel is in quotes because it's a mis-located site name used by Thom et al. (2003). The actual Cooston channel is located at the mouth of the Coos River.

two sites in the Lower Bay and one site each in the Upper Bay and South Slough (Figure 2).

Further, temperature data were sporadically collected during Oregon Department of Fish and Wildlife's (ODFW) long-term seining program (ODFW 2013). Not all sites were sampled on every trip or in every year, thus only a single sample was taken at many sites. Averages of summer (May-October) data were used at sites with more than single samples taken.

Finally, some turbidity data were gleaned from ODEQ's storm-related bacteria monitoring efforts (ODEQ 2005b, 2007b).

Results

*Dissolved Oxygen*

Water samples taken for ODEQ's CEMAP project met the state DO standard for aquatic life (≥6.5 mg/L) at stations in the lower Coos estuary (e.g., South Slough, Lower Bay, Haynes Inlet subsystems) but frequently were below that standard further up the estuary (Figure 4A). The lowest DO levels were sampled at a site midway along Isthmus Slough, with an average of 3.9 mg/L in August 2001. The highest average DO levels were found at three stations near the mouth of the Coos estuary and one in the Upper Bay subsystem (>8.0 mg/L).

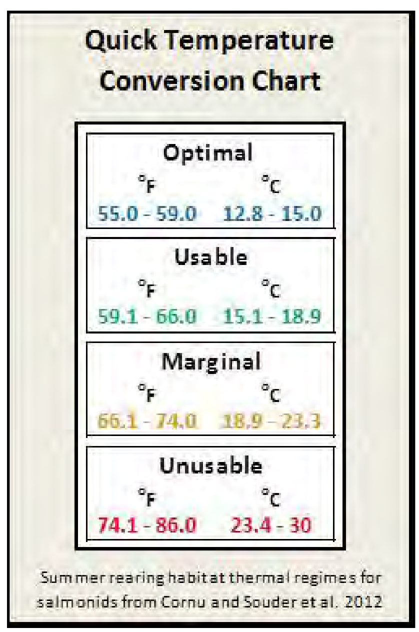
Preliminary DO data from the new SSNERR North Point station in the Upper Bay (blue line in Figure 5A) indicate generally healthy levels. However, this dataset spans less than a full year, and lacks late summer data, when DO is generally lowest. Isthmus Slough, Catching Slough and Coos River stations show healthy DO levels for the first winter of monitoring but dipped below the 6.5 mg/L standard in mid-June (Coos River) or mid-July (Catching Slough and Coos River) and remained low.

In the Brown and Folger study (2009)(Figure 2), no dissolved oxygen measurements were below 5 mg/L at any of the seven stations sampled.

*Water Temperature*

The majority of ODEQ CEMAP stations exceeded the state temperature standard of ≤18° C (64.4° F), especially those sites furthest upstream (Figures 3, 4B). Samples at six sites showed average temperatures over 20° C (68° F). The highest average temperature (21.1° C [70° F] in September 2005) was found at the uppermost CEMAP site on Isthmus Slough.

Figure 3. Juvenile salmonid stream temperature requirements



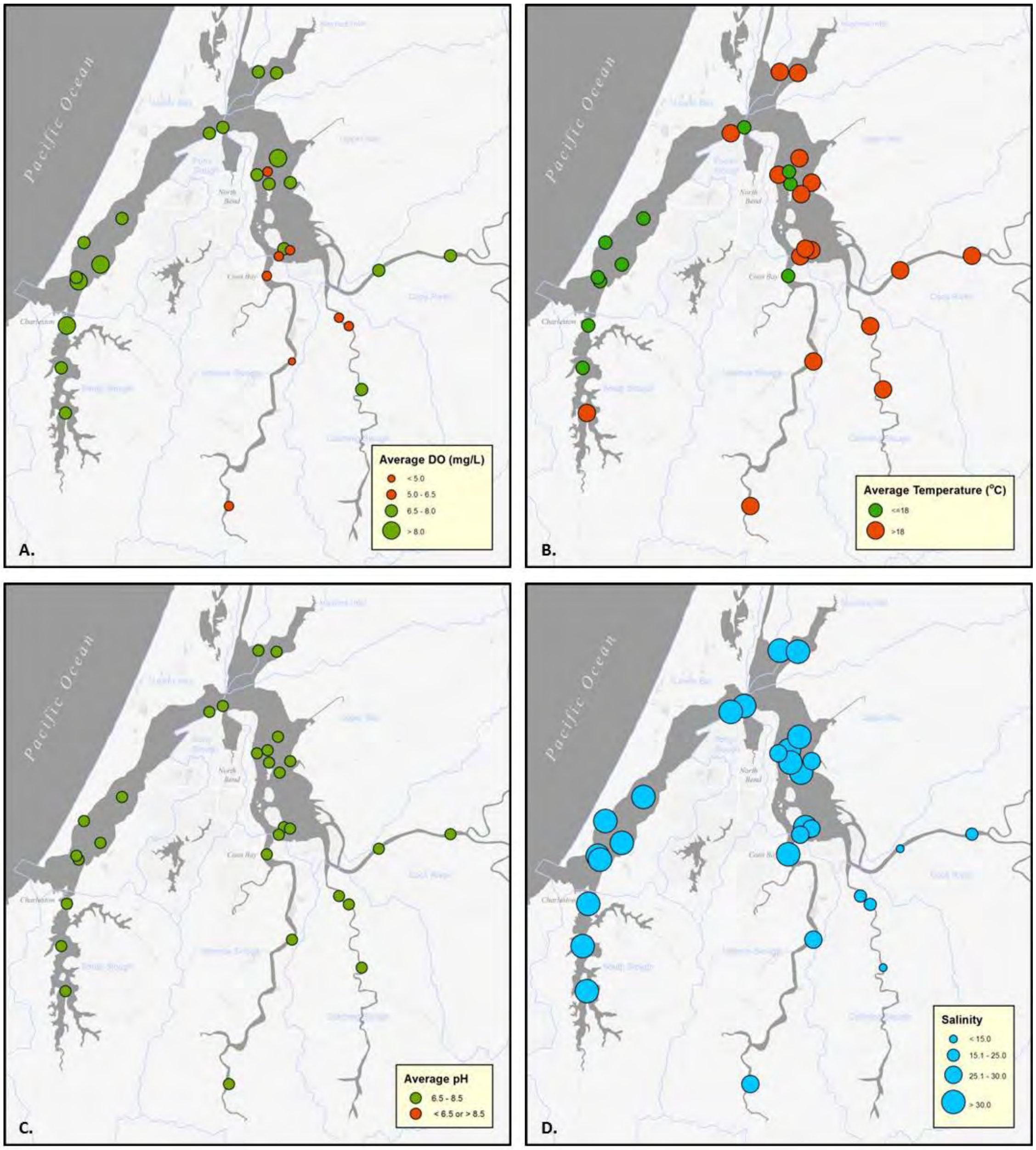



Figure 4. Coos estuary CEMAP data: A. Dissolved oxygen, B. Temperature, C. pH, and D. Salinity. Green symbols meet water quality standards; red exceed standards, blue have no standards. Data: ODEQ 1999, 2001, 2004, 2005a, 2006a.

The lowest temperatures were sampled near the mouth of the Coos estuary, at different stations and various years, with 10.6° C (51.1° F) in 1999 being the lowest temperature recorded.

Although the available data from the SSNERR North Point station indicate healthy temperatures, they do not yet include the late summer months, when temperatures are generally warmest (Figure 5B). Temperatures at Isthmus Slough, Catching Slough and Coos

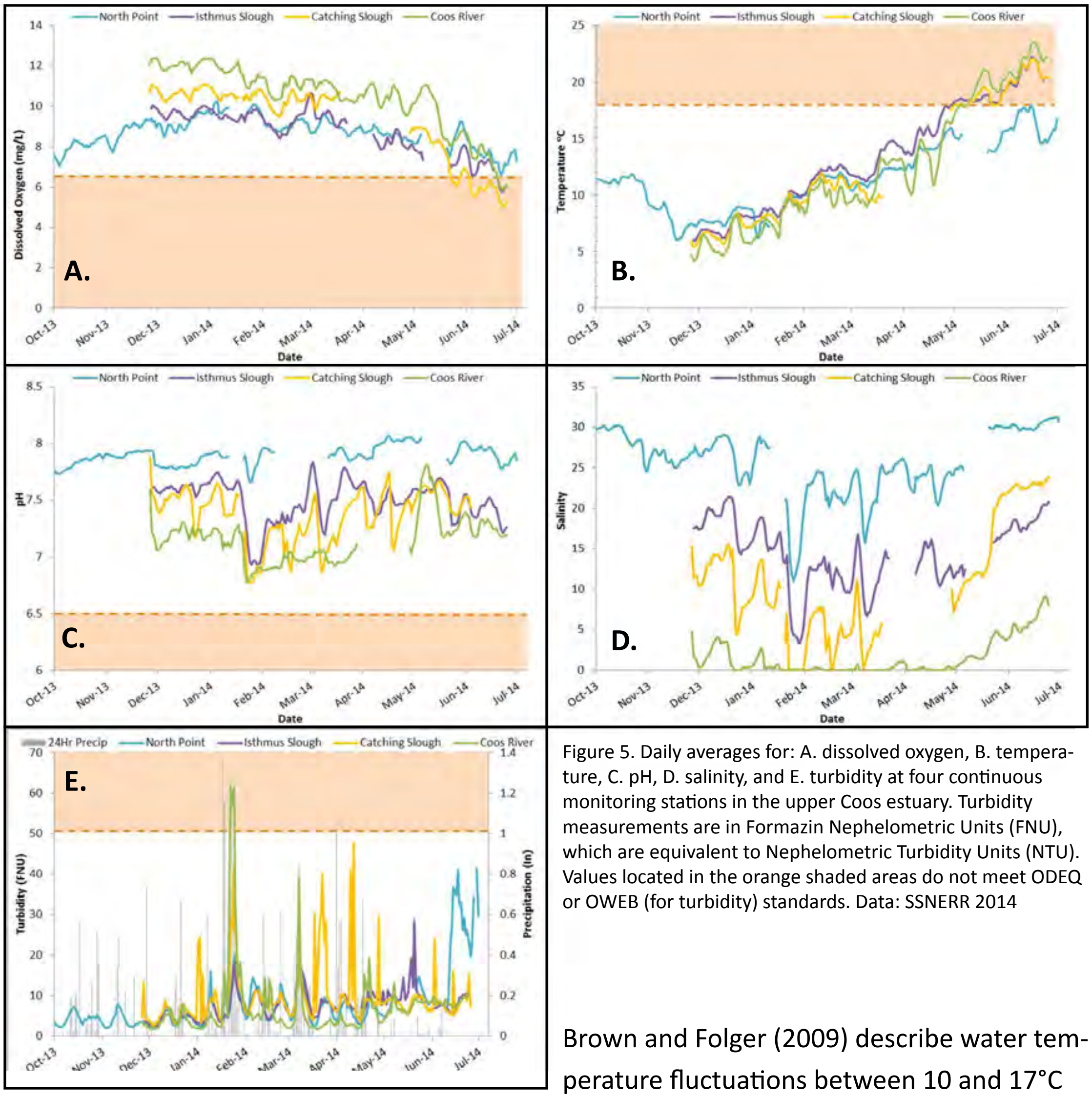



Figure 5. Daily averages for: A. dissolved oxygen, B. temperature, C. pH, D. salinity, and E. turbidity at four continuous monitoring stations in the upper Coos estuary. Turbidity measurements are in Formazin Nephelometric Units (FNU), which are equivalent to Nephelometric Turbidity Units (NTU). Values located in the orange shaded areas do not meet ODEQ or OWEB (for turbidity) standards. Data: SSNERR 2014

River stations all exceed state criteria beginning mid-May. The highest daily average thus far is 23.6° C (74.5° F )(July 8, 2014) at the Coos River Station, which tends to have both the highest and lowest seasonal temperatures. In contrast, the North Point station is the least variable with warm winter and cool summer temperatures.

Brown and Folger (2009) describe water temperature fluctuations between 10 and 17°C (50-63° F) being common until mid-July, after which temperatures remained between 8 and 10° C (46-50° F).

Figure 6 shows the ODEQ Coos basin temperature monitoring results. In general, temperatures are higher in floodplain waters near the estuary and lower further upstream. The highest maximum monthly average was in July 2006 at Ross Slough (22.2° C [72° F]), a tributary to Catching Slough, followed by two tributaries of Isthmus Slough, Coalbank Creek

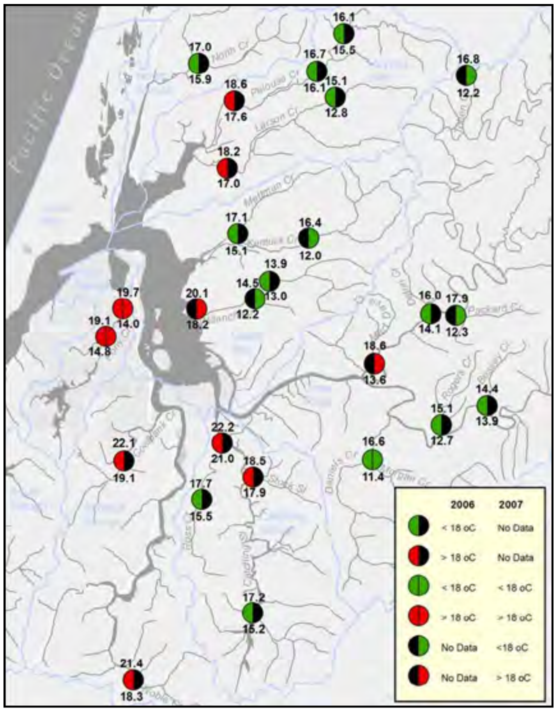



Figure 6. Location and average temperatures at continuous water temperature monitoring sites in summer 2006 (sampled in 30 minute intervals June-September) and summer/early fall 2007 (June-October). The red color indicates at least one monthly average during sampling period exceeding the state standard of 18° C. Numbers above symbols are maximum monthly average temperatures at that location; numbers below signify minimum monthly averages. All temperatures are in °C. Bodies of water with sampling sites are labeled. Data: ODEQ 2006b, 2007a

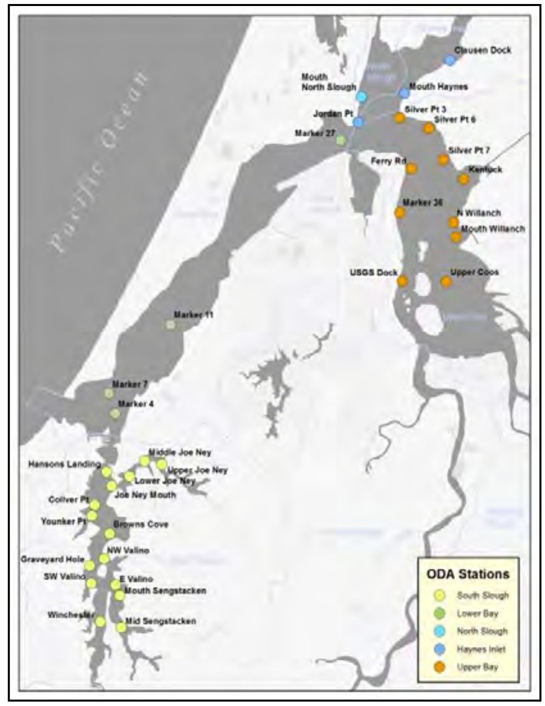



Figure 7. Sampling stations for the ODA shellfish growing areas sampling stations in the Coos estuary. Project area subsystems are delineated and labeled in blue. Labeled symbols refer to site names within this report. Data: ODA 2011

(22.1° C [71.8° F]) and Noble Creek (21.4° C [70.5° F]) also in July 2006. Highest minimum monthly averages were again at Ross Slough (21.0° C [69.8° F]), Coalbank Creek (19.1° C [66.4° F]) and Noble Creek (18.3° C [64.9° F]) all in September of 2006. Sampling at these sites, along with the mouth of Willanch Creek, demonstrated consistently the high temperatures that characterize summertime conditions at those sites, with averages never below the state 18° C (64° F) standard. Two upper Willanch Creek sample sites and the Bessey Creek site had the lowest maximum monthly temperatures at 13.9° C (57° F) in July 2006, 14.5° C (58.1° F) in July 2007, and 14.4° C (57.9° F) in July 2006 respectively. The lowest minimum monthly average was 11.4° C (52.5° F) in October 2007 at the confluence of Daniels and Morgan Creeks.

For year-round, median water temperatures, all ODA stations met ODEQ criteria for healthy waters (Figures 7 and 8). The highest median temperatures were at the Willanch Mouth and Clausen Dock stations, both at 17.1° C (62.8° F), closely followed by the Silver Point 6 and Kentuck sites (16.9° C [62.4° F] and 16.85° C [62.3° F], respectively).

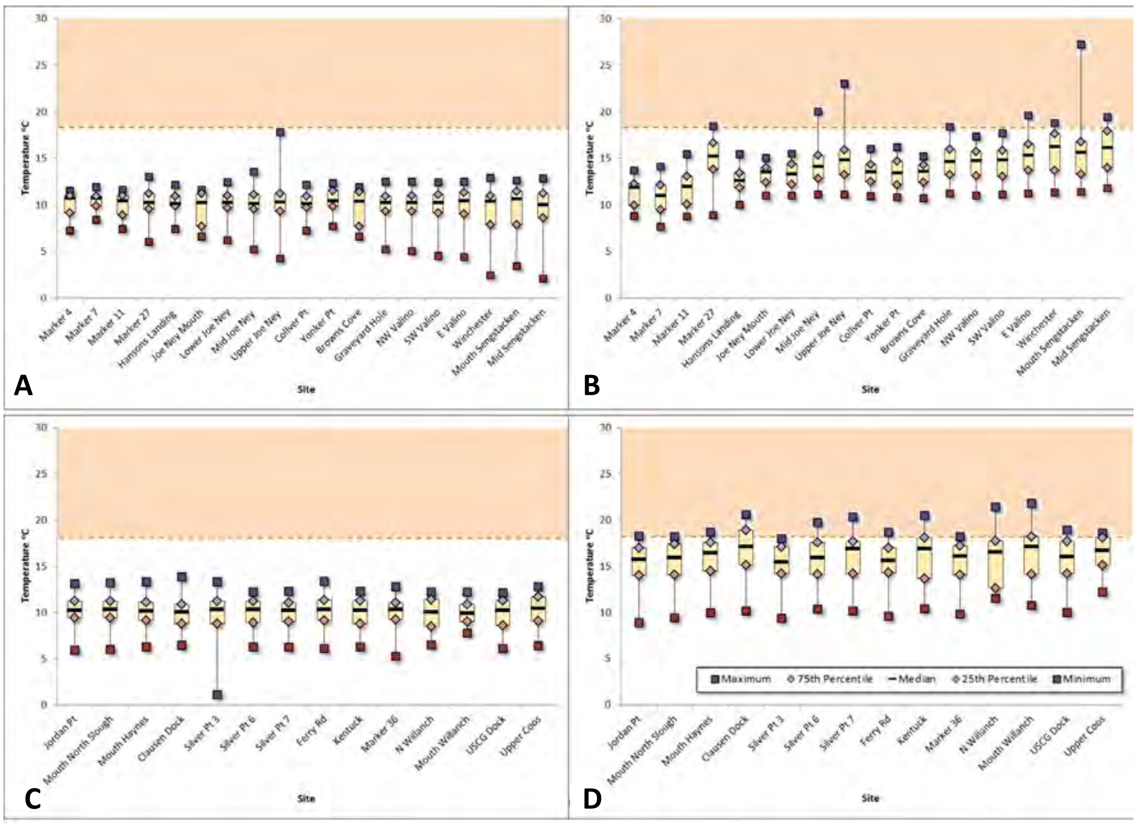
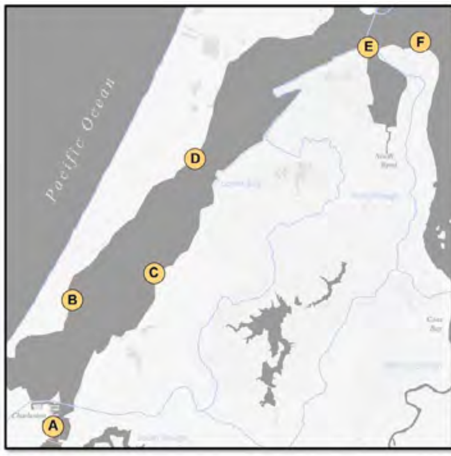



Figure 8. Temperature box plots summarizing minimum, maximum, median and central 50% of data (yellow boxes) at: A. lower bay and South Slough stations in wet season (November-April), B. Lower Bay and South Slough stations in dry season (November-April), C. North Slough, Haynes Inlet and upper bay stations: in wet season (November-April), D. North Slough, Haynes Inlet and Upper Bay stations: in dry season (May-October) from 1999-2011 (dates vary by station). Shaded orange area is above ODEQ standards and considered unhealthy. Data: ODA 2011

Maximum dry season temperatures exceeded the state standard at 21 of 33 sites. The Sengstacken mouth station had the highest max temperature (27.2° C [81° F] in June 2003)(Figure 8B). Dry season temperatures are slightly more variable than wet season temperatures. Continuous water temperatures taken by Thom et al. (2003) show seasonal fluctuations with Barview and Fossil Pt. having the lowest seasonal range in temperature (9-15° C [48-59° F]) while two sites further up the estuary (North Bend Airport and the misnamed “Cooston Channel”-see Figure 2) had much higher annual fluctuations (5-18° C [41-64° F])(Figure 2). Also, Barview and Fossil Pt. had smaller variability and lower summertime temperatures (10.0-16.7° C [50-62.1° F] and 13.1-16.7° C [55.6-62.1° F] respectively) than the North Bend Airport and the misnamed “Cooston Channel” stations (15.4-18.6° C [59.7-65.5° F] and 17.0-20.1° C [62.6-68.2° F] respectively).

Based on the limited data gathered by ODFW, the highest average summertime temperature was about 14° C (about 57° F), and none of the stations averaged higher than the ≤18° C (64° F) ODEQ aquatic life standard. However, these values should be considered with



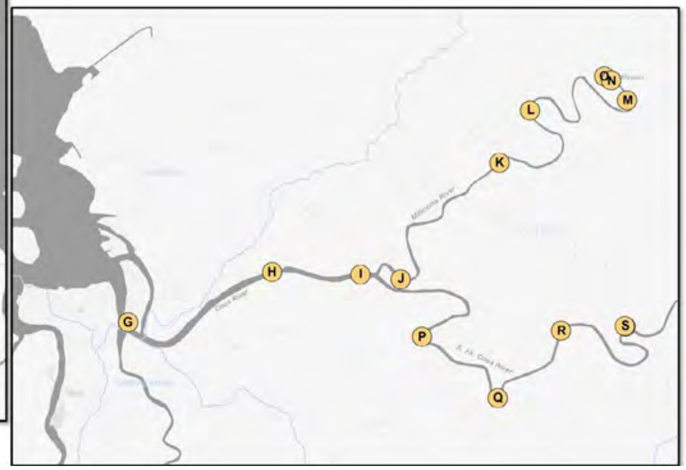
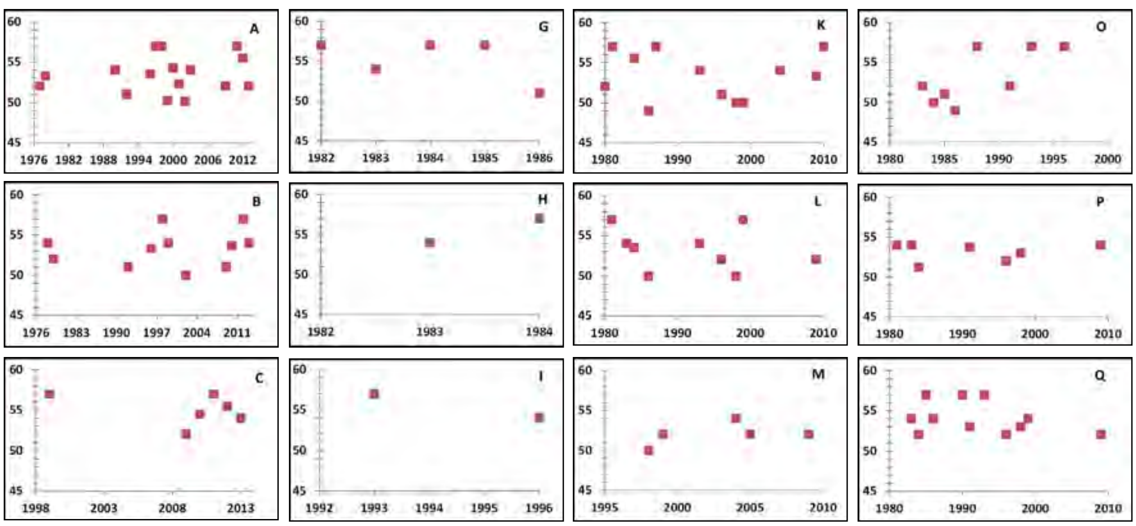
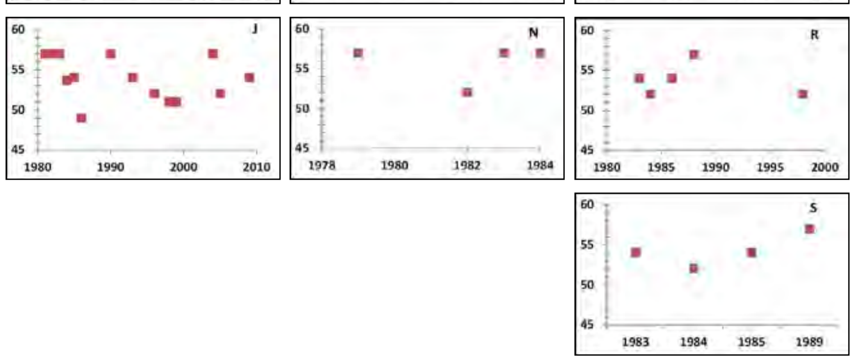



Figure 9. Maps (above) and graphs (below). Annual summer average temperatures in °F (y-axis in scatterplot graphs below). Scatterplots shown for stations where multiple years of data exist; sites with only one year are shown in chart format (i.e., sites D, E, F). Not all sites were measured each year (i.e., x-axis varies by site). For display purposes, stations that were close in proximity and not influenced by a separate body of water (e.g., a tributary) were averaged together and the most central station displayed on the map. Data: ODFW 2013.




| Station | Temperature | Year |
|---|---|---|
| D | 57 | 1999 |
| E | 57 | 1996 |
| F | 51 | 1980 |



caution because many stations were sampled only once and lack corroborating measurements (Figure 9).

*pH*

All ODEQ CEMAP stations met state standards for healthy pH levels (>6.5 and <8.5), with a combined, multi-year average of 7.6 (Figure 4C). Water with pH levels below 6.5 are strongly acidic, and with levels above 8.5 are strongly alkaline.

In addition, pH values fell within state standards at all the new Coos estuary SWMP stations, and on all sampling dates (Figure 5C). North Point had the highest overall average pH (7.9), followed by Isthmus Slough (7.5 average), Catching Slough (7.4 average) and Coos River (7.1 average).

*Salinity*

The Coos estuary is shallow, with an average depth of 2m below Mean Lower Low Water (MLLW), which allows for a thorough mixing of fresh and saltwater most of the year. However, stratification can occur, particularly in deeper portions of the estuary (e.g., the dredged shipping channel) with seasonally high contributions of fresh water (Rumrill 2006). The Coos is a drowned river mouth estuary dominated by river discharges in the wet season (i.e., influx of fresh water) and dominated by ocean water in the dry season (i.e., influx of salt water). Brown and Folger (2009) classified the Coos estuary as the most marine-dominated of the seven Oregon estuaries they investigated (Alsea, Nestucca, Yaquina, Salmon River, Coos, Umpqua River and Tillamook), based on salinities and normalized freshwater inflows.

Summertime data from the ODEQ CEMAP study indicate the highest salinities are near the mouth, and decrease upstream to the lowest salinity (13.3) on the Coos River (Figure 4D)(Note that salinity values are now expressed with no units.). Ocean-derived salinities (roughly 35) were found as far up the estuary as Haynes Inlet.

Year round, salinity values were highest at the new SSNERR North Point station (fluctuating between 30’s and low teens), followed by Isthmus Slough, Catching Slough, and the Coos River (Figure 5D). As expected, salinity is lowest in winter months, when precipitation is heaviest, and gradually increases into summer months.

Salinity data from the 33 ODA stations were also consistently higher in the dry season than the wet season (Figures 7 and 10). Dry season salinities were less variable and markedly skewed towards higher values than in the winter months. As expected, stations further from the mouth of the Coos estuary (e.g., “Marker 27”) have lower median salinities and are more variable than sites closer to the ocean (e.g., “Marker 4”).

*Turbidity*

At all SSNERR stations, turbidity remains low most of the time, but peaks after precipitation events (Figure 5E). The highest turbidity levels occurred at the Coos River station

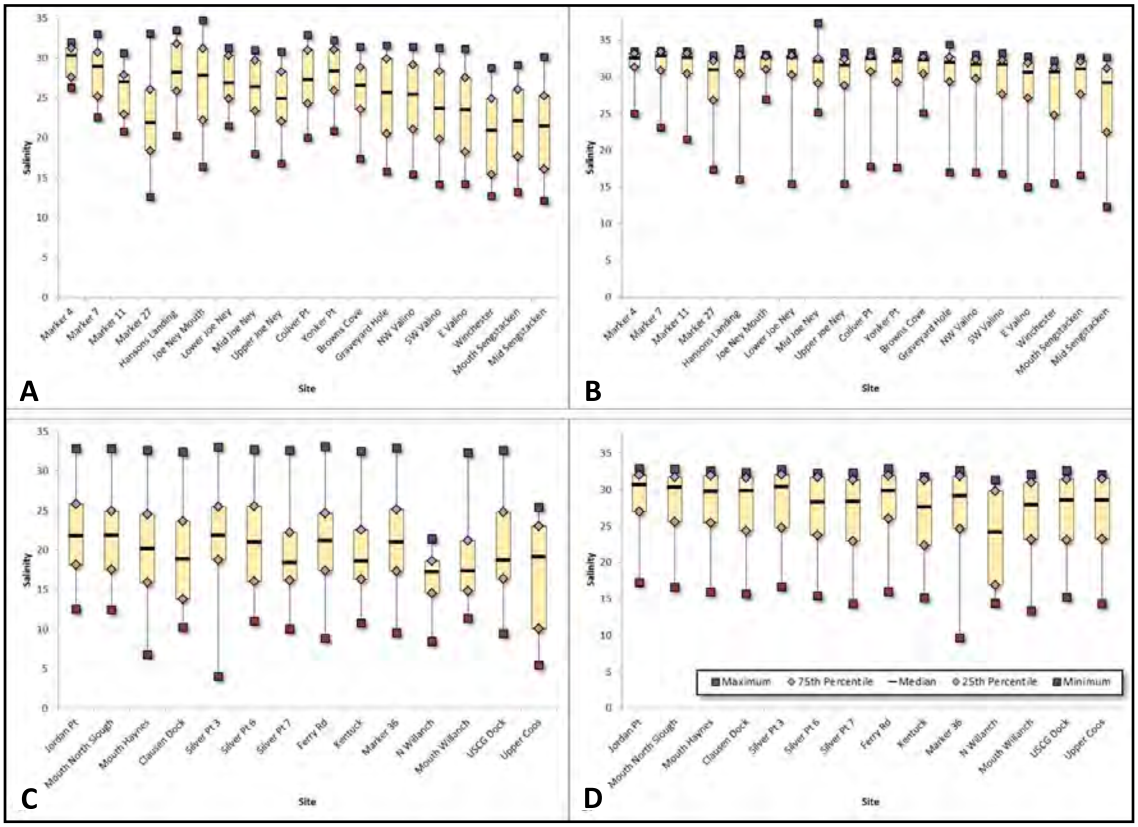



Figure 10. Salinity box plots summarizing minimum, maximum, median and central 50% of data (yellow boxes) at A: Lower Bay and South Slough stations in wet season (November-April); B: Lower Bay and South Slough stations in dry season (November-April); C: North Slough, Haynes Inlet and Upper Bay stations in wet season (November-April); and D: North Slough, Haynes Inlet and Upper Bay stations in dry season (May-October) all from 1999-2011 (dates vary by station). Ocean salinity is ~35. Data: ODA 2011.

following a two-day rain event (62.0 FNU). Turbidity is measured in Formazin Nephelometric Units (FNU), which are equivalent to Nephelometric Turbidity Units (NTU).

Some turbidity peaks are not associated with rain events, but are caused by biofouling (plant and animal growth) on the surface of the sensors, usually during summer months. Biofouling is often difficult to identify in the data, but for this report, single occurrences of anomalously high values and values above 50 FNU in the dry season were assumed to be caused by biofouling (or by a creature crawling across the optical turbidity sensor) and were removed from our analyses. Despite this adjustment, high turbidity levels in the dry season, especially at the most heavily fouled station (North Point) are understood to be overestimates of actual conditions.

Compared with six other Oregon estuaries sampled by Brown and Folger (2009), the Coos had the highest median Total Suspended Solids, another measure of turbidity (13.8 mg/L).

Secchi depth measurements of turbidity by Thom et al. (2003) indicated the “Cooston Channel” site had the most turbid conditions while the Fossil Pt. site had the least.

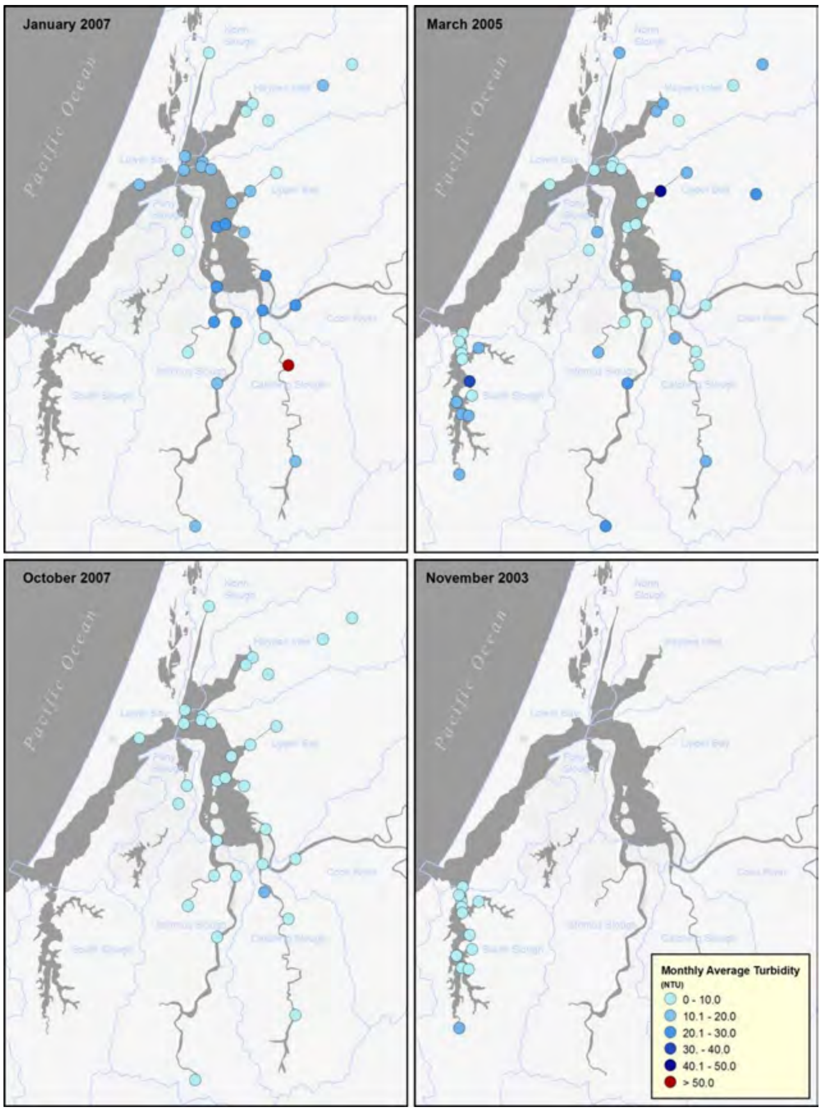



Figure 11. Monthly average turbidity data sampled in four different months and three different years as part of ODEQ's storm-related bacteria monitoring. Monthly averages at each site are shown. Not all sites were measured each time period and some sites were more intensely monitored within a single month than others (the number of sites and samples sizes varied between sites ; between 1 and 5 samples were collected at each site per month). Data: ODEQ 2005b, 2007b

Some turbidity data were retrieved from ODEQ's storm-related bacteria monitoring (ODEQ 2005b, 2007b) but the collection locations and dates were irregular (Figure 11). Sampling events are triggered by predicted or actual precipitation levels (1.5 inches in 24 hours or 2.5 inches in 3 days) sufficient to close shellfish growing areas to harvesting activities (per ODA regulations) during storm runoff conditions when watershed soils are saturated. ODEQ's data indicated that turbidity values were highest in January, which was the only month turbidity values exceeded ODEQ's turbidity standard (<50 NTU) at a single site in the Catching Slough subsystem (Figure 11). High turbidity values were also found during ODEQ's March sampling, especially along the extremities of the estuary. In January the highest turbidity values were found in the main part of the estuary. A possible explanation for this contrast is differing tidal levels (i.e., ocean influence) at the time of each sampling event but more data would be needed to confirm that interpretation. Turbidity was uniformly low throughout the estuary in October and in November at some sites in South Slough.

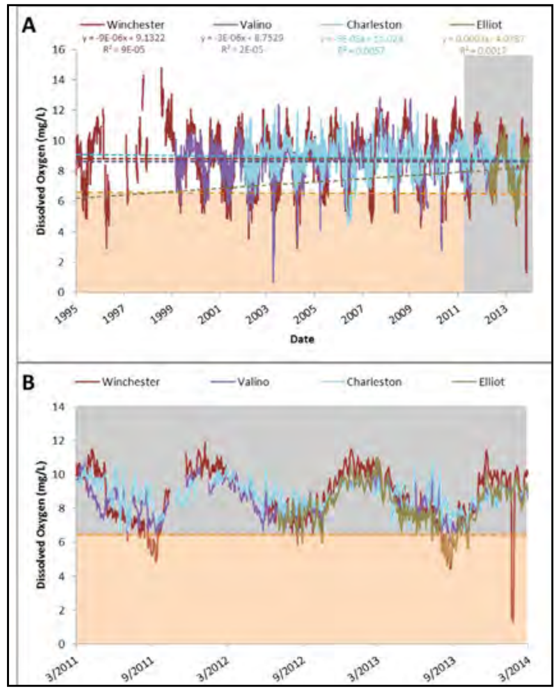



Figure 12. A: Daily dissolved oxygen levels at four sites in South Slough. The orange area defines DO concentrations below ODEQ's DO standard (6.5 mg/L). The four stations have up to 19 years of data and the color-coded dashed lines represent regression trend lines for each station. The Elliot station dataset spanned too few years to generate a trend line. The gray area delineates the timeframe expanded for a more detailed display in graph B (below). B: Comparison of seasonal DO variation in recent years at the four sites. Data: SWMP 2014.

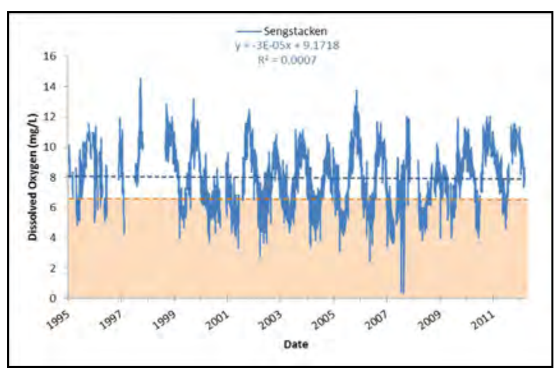



Figure 13. Daily dissolved oxygen at Sengstacken Station in the South Slough from 1995-2012. Orange area defines DO concentrations below ODEQ's DO standard (6.5 mg/L). Blue dashed line is the regression trend line for the Sengstacken station Data: SWMP 2014.

## South Slough and Lower Bay

### *Dissolved Oxygen*

Although regression analyses suggest a very slight decline, DO concentrations appear to have remained relatively consistent between 1995-2014 at four of five South Slough long term water quality monitoring stations (SWMP 2014)(Figure 12A). DO levels generally drop below ODEQ's aquatic life standard (6.5 mg/L) during the dry summer months (Figure 12B).

A similar, but more variable pattern, occurred at a fifth site, the Sengstacken station– displayed separately for ease of reading (Figure 13)(the Sengstacken station was moved to a different location in 2012 because the original site drained completely during extreme low tides, leaving data collector's sensors high and dry, unable to record water quality conditions during those tides).

For all five South Slough stations, the combined 2009-2014 data revealed that median DO concentrations met or exceeded ODEQ's standards (Figure 14). Winchester and Sengstacken stations have the most variability, while the Charleston station is the least

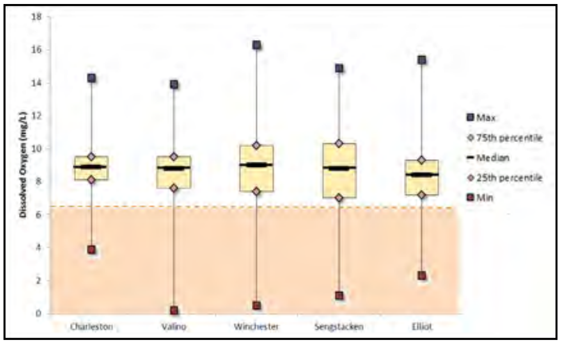



Figure 14. Box plot of dissolved oxygen concentrations at the five SWMP stations in South Slough between 2009-2014. Orange area defines DO concentrations below ODEQ's DO standard (6.5 mg/L). Data: SWMP 2014.

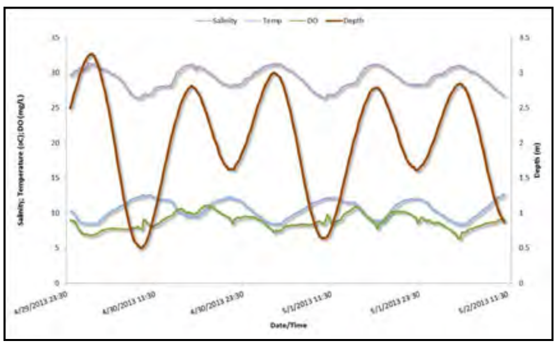



Figure 15. Relationships between water depths (tide levels) and salinity, temperature, and dissolved oxygen at the Charleston SWMP station over the course of 2 consecutive spring days in 2013. Data: SWMP 2014.

variable (Figure 14). Measurements at the Charleston station also suggest DO is weakly correlated with tide level (DO arguably decreases with lower water depths)(Figure 15). Dissolved oxygen is also negatively related to water temperature, because cold water holds more dissolved oxygen than warm water (Figure 15).

CTCLUSI reported the average, minimum, and maximum DO values at their two lower bay stations (BLM and Empire). Average values at both stations are well above ODEQ's DO standard during both winter and summer seasons, although generally higher in the winter (Figure 16A). DO concentrations at both stations sometimes drop below the ODEQ standard, but CTCLUSI reports that these values are not encountered consistently and are likely anomalies attributed to seasonal variability or localized site conditions.

*Water Temperature*

Water temperatures are more variable at the upper estuary SWMP stations (i.e., Sengstacken, Winchester, Elliot) than those at the two lower estuary stations closer to the ocean (i.e., Valino and Charleston)(Figure 17). Also, not surprisingly, water temperatures are higher during summer months (dry season) at all sites (Figure 17). Temperature values are typically below ODEQ's standard for salmon rearing and migration (≤18° C [64° F]) during the wet season, but more frequently reach or exceed this standard during the dry season at the three most upstream stations (Sengstacken, Winchester, and Elliot). At all stations, the highest 25% temperatures are above 20° C (68° F)(temperatures above 23° C [73° F] inhibit salmon rearing).

At the South Slough SWMP stations, average water temperatures appear to be trending downward over time, but the statistical correlation is weak (e.g., Valino station linear regression: $y = -0.0003x + 21.833$, $R^2 = 0.0297$).

As expected, water depth and water temperature follow opposite sinusoidal ("S" wave) patterns, reinforcing the notion that temperature has an inverse relationship with tide levels (Figure 15).

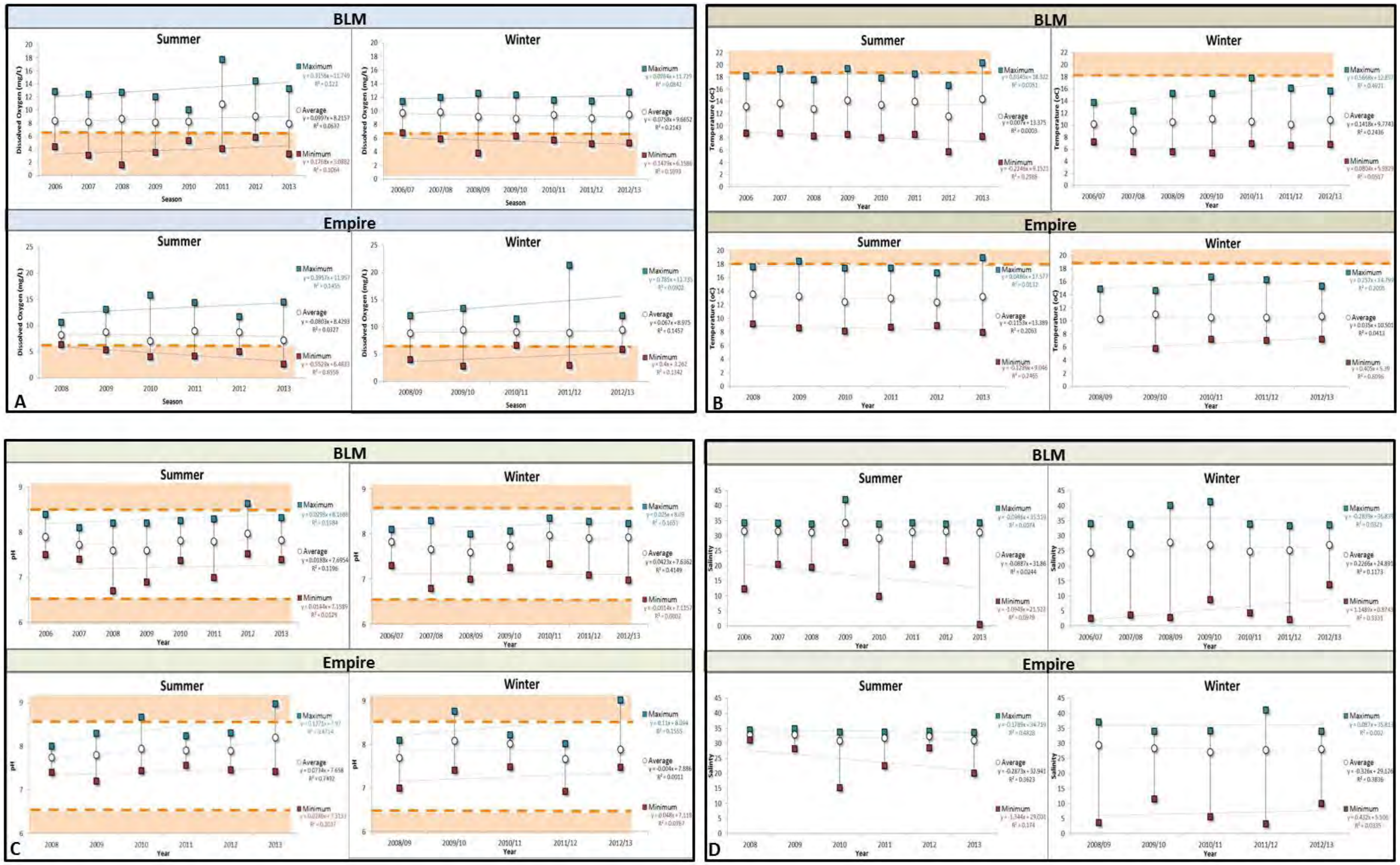



Figure 16. Seasonal averages, minimum and maximum values along with corresponding regression trendlines at two stations in the Lower Bay (2008-2013) for DO (A); temperature (B); pH (C); and salinity (D). Summer months are May-October; winter months are November-April. Values in orange shading do not meet ODEQ standards. Data: CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014.

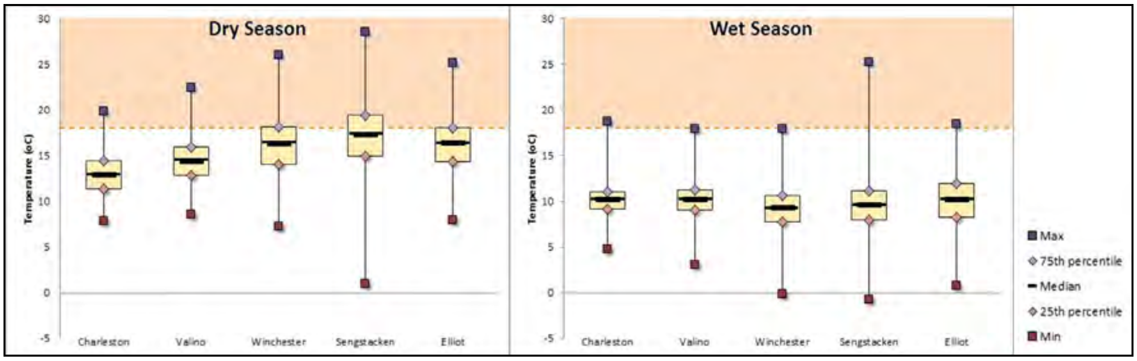



Figure 17. Box plot of dry season and wet season temperatures taken at the five SWMP stations in South Slough from 2009-2014. Values 18°C and higher (in orange shading above dashed line) are considered unhealthy for salmon rearing and migration by ODEQ. Data: SWMP 2014.

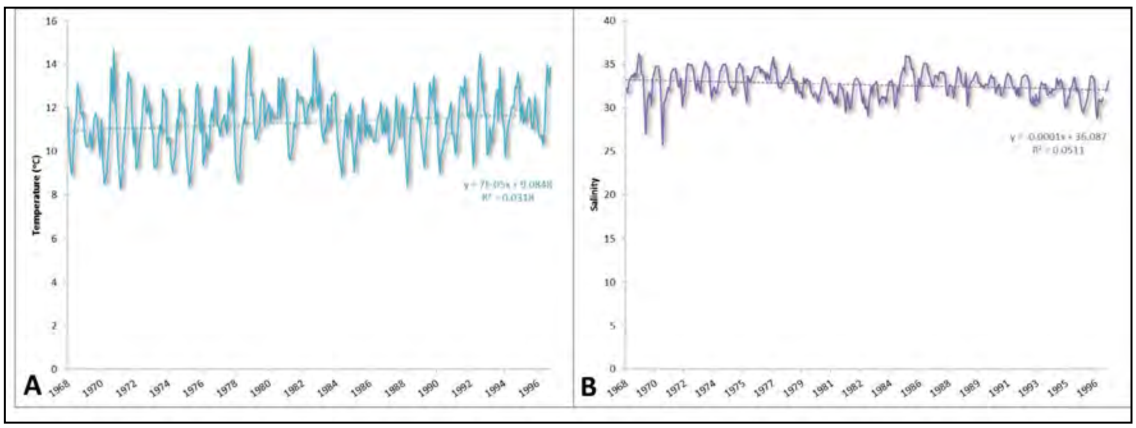



Figure 18. Monthly averages for A: temperature, and B: salinity near the mouth of the Coos estuary (1966-1997). Regression lines (dashed) and equations shown. Data: Shore Stations Program 1997.

Seasonal averages at the two lower bay CTCLUSI stations are healthy (≤18° C [64° F]), though summer maximums occasionally rise above that threshold (Figure 16B). For the 2009 water year, CTCLUSI reported the maximum temperature measured at Empire was 18.4° C (65.1° F), but this site only exceeded 7 day maximum daily averages once. The BLM station maximum temperature was 19.4° C (66.9° F) and exceeded 7 day averages only twice.

Five year water temperature trends (2008-13) for the Empire station have trended downward slightly during summer months, while winter averages show a slightly increasing trend (Figure 17). Across the channel at the BLM station, summer water temperature averages are trending slightly upwards along with similar upward water temperature trends during winter months.

Likewise, long-term temperature data at the Shore Stations (1997) site near the mouth of the Coos estuary show a weak increasing trend (Figure 18A). The Shore Stations program, a collaboration between the Oregon Institute of Marine Biology (OIMB) and the

University of San Diego included the daily collection of water temperature and salinity data near the mouth of the Coos estuary for 31 years (1966-1997)(quality checks were limited to key-entry stroke errors only; monthly averages were calculated and displayed for this data summary).

The highest temperatures at this site only exceeded 18° C (64° F) on a handful of occasions (not unexpected given its proximity to the ocean) while monthly averages were consistently well below this standard.

Summer stream temperature monitoring in the Sough Slough, recorded as part of the State of the Watersheds effort (Cornu et al. 2012), indicate healthy temperatures at the majority of South Slough stream sites sampled in 2011 for the project (Figures 19 and 20). The three highest 7-day average maximums associated with this effort were

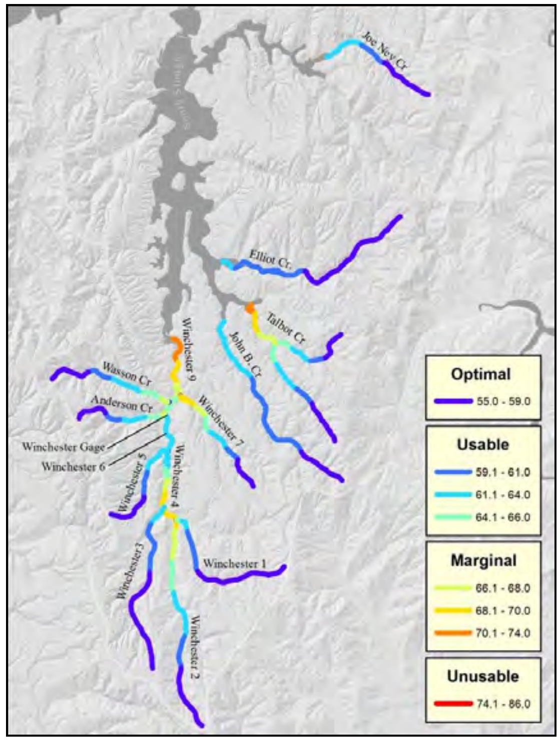



Figure 19. 7-day average maximum and minimum temperatures (°F) at stream monitoring stations in the South Slough watershed during summer 2011. Legend indicates salmonid summer rearing habitat thermal regimes. Amended from: Cornu et al. 2012

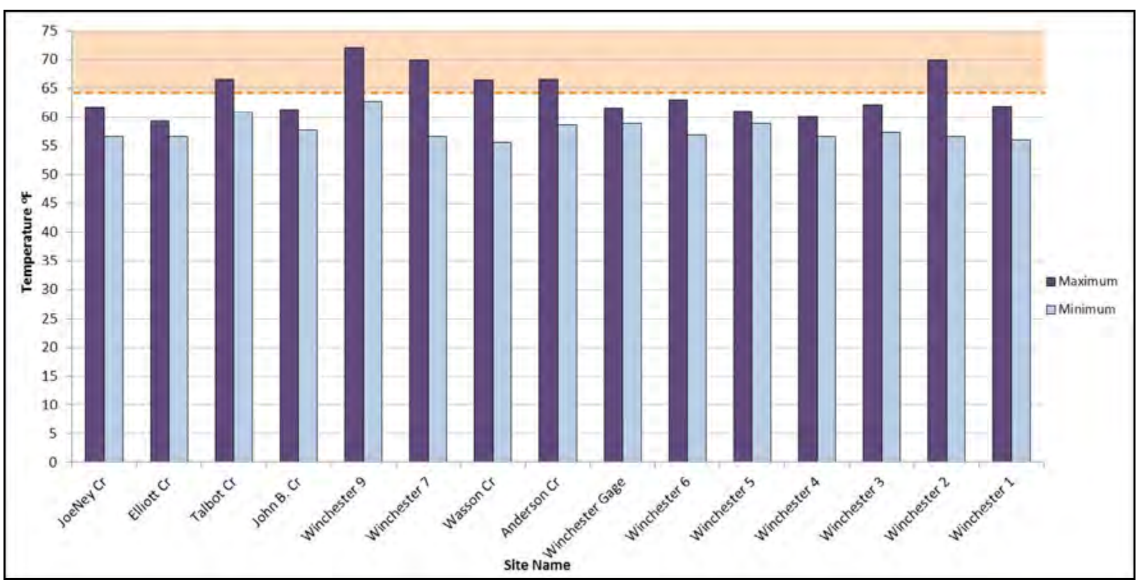



Figure 20. Comparison of 7-day average maximum and minimum temperatures at stream monitoring stations (ordered north to south) in the South Slough watershed during summer 2011. Shaded orange area indicates temperatures exceeding ODEQ standards. Amended from: Cornu et al. 2012.

on tributaries of Winchester Creek, with the most downstream segment (Winchester 9) having the highest 7-day maximum (23.6° C [74.4° F]). Additionally, this reach had the highest number of summer days exceeding 18° C (64° F). Anderson, Talbot and Wasson Creeks also had 7-day averages that exceeded the state standard.

Raw data (1993-2014) from NOAA's National Water Level Observation Network Station (Charleston, at the mouth of South Slough) are displayed using boxplots to minimize the effects of outliers with unknown causes (Figure 21). The results, again not surprisingly, show lower water temperatures in the estuary during the wet season than the dry season. Average monthly temperatures never exceeded the 18° C (64° F) standard, indicating healthy year-round temperatures at that location.

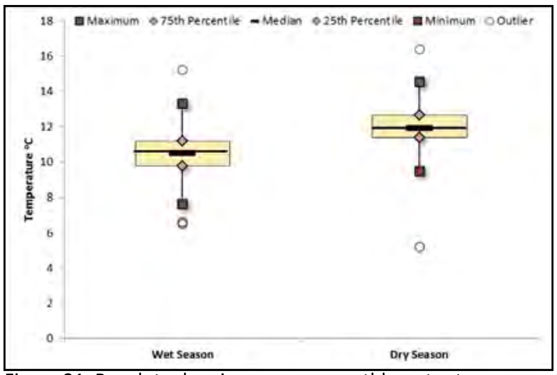


Figure 21. Boxplots showing average monthly water temperature at NOAA's National Water Level Observation Network Station in Charleston, OR from 1993-2014. Wet season (November-April) and Dry Season (May-October) values are displayed separately. Yellow boxes represent middle 50% of the data. Maximum and minimum shown in this figure include 99.3% of normal distribution data. Outliers outside this coverage are shown. National Ocean Service data used for this report were raw (i.e., no quality assurance checks) and were released as preliminary data only. Processing for this figure included removing values <5 oC and greater than 25 oC before analysis. Data: NOAA 2014.

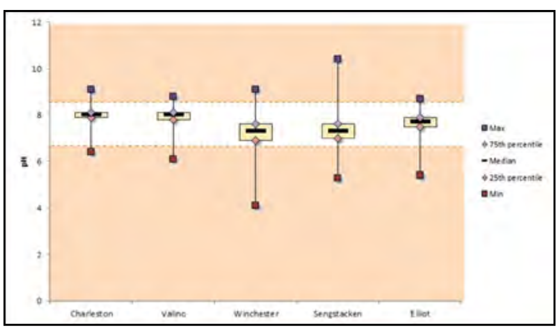


Figure 22. Box plot of pH at the five SWMP stations in South Slough (2009-2014). Values between 6.5 and 8.5 are considered healthy levels by ODEQ. Data: SWMP 2014.

### *pH*

pH at South Slough SWMP stations over the past five years is generally well within ODEQ's standard for healthy estuarine waters with occasional episodic dips outside this range (Figure 22). In the past, it has been reported that long-term water quality data for South Slough pH has been increasing (getting less acidic), although the trendlines were near 0 and a weak positive relationship was indicated (opposite the decreasing trend in ocean pH – i.e., ocean acidification). Although an overall weak positive trend still exists, further analyses now indicate that the rise in pH shifted to a decline in pH sometime around 2010 (Figure 23).

Average pH at the two CTCLUSI lower bay stations range between 7.6 and 8.1 with no difference between winter and summer levels (Figure 16C). Maximum pH at these sites has occasionally exceeded ODEQ's criteria for healthy estuary waters.

### *Salinity*

At SWMP stations lower in the slough (Valino and Charleston) salinities are higher and have

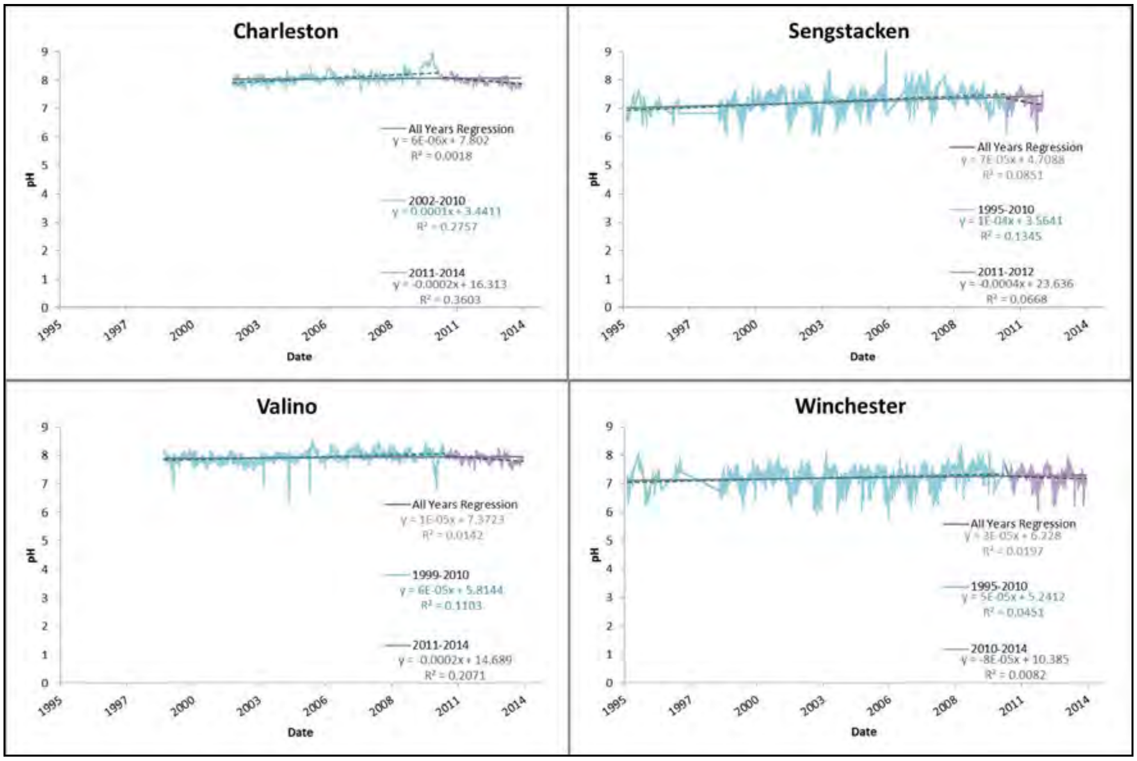



Figure 23. Average daily pH levels at four stations in the South Slough estuary. At each station, values in blue indicate those values taken before 2010 and describe an increasing trend in pH. Values in purple indicate pH taken after 2010 and show a decrease in pH. Elliot station was excluded due to its relatively short-term dataset. Data: SWMP 2014.

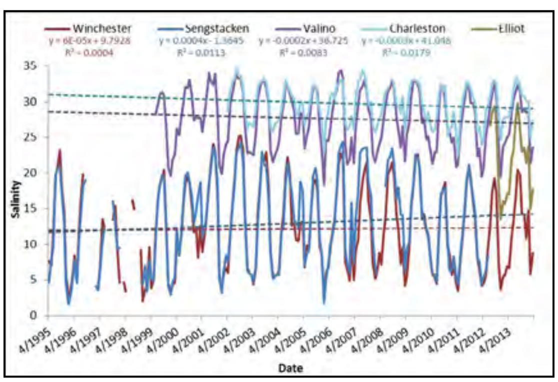



Figure 24. Average monthly salinity at five stations in the South Slough estuary. Dashed lines represent linear regression trendlines. Elliot station trends are excluded due to the relatively short time span of data collection. Data: SWMP 2014.

shown a weak trend towards decreasing salinity over time (Figure 24). As expected, the stations higher up the slough (Sengstacken and Winchester) have lower salinities due to proximity to freshwater inputs. These upper stations indicate an increasing trend over time. When overlaid with depth (an indicator of tidal stage), salinity follows a similar sinusoidal signal (Figure 15).

At the two CTCLUSI lower bay sites (BLM and Empire), average salinity tends to be higher in the summer (~31) and lower in the winter (~25)(Figure 16D). Maximum salinities reach ocean salinity (> 35) even in the winter but this area of the Coos estuary can also experience very fresh water; salinities recorded as low as 2.2 at the BLM station in the winter of 2011/12.

Salinity data from the Shore Stations site near the mouth of the bay show a weak decreasing trend over 31 years (Figure 18B), like the decreasing trend described by the 18 year SWMP data. Salinity values sampled at this site tend to be near full ocean salinity, but some monthly averages were as low as 25.

*Turbidity*

Long-term trends in South Slough SWMP station turbidity show a slight increase at four stations, while the Winchester shows a slight decrease (Figure 25). High turbidity levels are more common in the winter (rainy) months, yet overall levels were generally below Oregon Watershed Enhancement Board's (OWEB) criteria of less than 50 NTU for healthy estuarine and fresh waters. Summer peaks are likely associated with increases in biofouling (i.e., attachment of organisms blocking the sensors), although no formal analysis to separate out fouling from natural turbidity has been made.

Turbidity in the lower bay generally averages low, even in the winter, at both CTCLUSI stations (Table 2). High summer maximums are again likely due to biofouling.

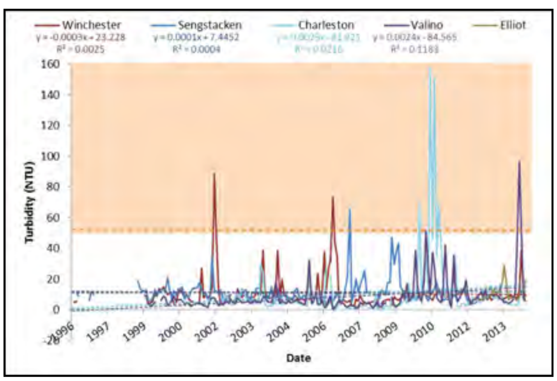



Figure 25. Average monthly turbidity levels at five sites in the South Slough estuary. Dashed color-matched lines represent linear regression trendlines at each station. Elliot trendlines are not included due to the relatively short period of data collection at that site. Values above 50 NTU (shaded region) are considered unhealthy levels in estuarine and fresh waters by OWEB. Data: SWMP 2014.

<u>Upper Bay/Pony Slough/North Slough/Haynes Inlet</u>

*Dissolved Oxygen*

Kentuck Slough is a water body in the upper Coos estuary which is listed as DO-limited under the Clean Water Act (section 303(d)) (ODEQ 2014)(Figure 26).

| Season | Year | Min | Average | Max |
|---|---|---|---|---|
| | | BLM | | |
| Summer | 2006 | -1 | 37.52 | 1000 |
| Summer | 2007 | -1 | 3.768333333 | 1063 |
| Summer | 2008 | -1 | 3.292 | 1055 |
| Summer | 2009 | 0 | 4 | 907 |
| Summer | 2010 | -1 | 101 | 999 |
| Summer | 2011 | -1 | 4 | 260 |
| Summer | 2012 | -0.5 | 8 | 945 |
| Summer | 2013 | -1 | 8 | 933 |
| Winter | 2006/07 | 0 | 3.465 | 510 |
| Winter | 2007/08 | 0 | 3.51 | 286 |
| Winter | 2008/09 | 0 | 3 | 994 |
| Winter | 2009/10 | 0.1 | 6 | 956 |
| Winter | 2010/11 | -1 | 9 | 988 |
| Winter | 2011/12 | -0.7 | 5 | 906 |
| Winter | 2012/13 | -1 | 4 | 781 |
| | | Empire | | |
| Summer | 2008 | -1 | 2.55 | 109 |
| Summer | 2009 | 0 | 5 | 741 |
| Summer | 2010 | -0.6 | 7 | 925 |
| Summer | 2011 | -1 | 3 | 921 |
| Summer | 2012 | -0.5 | 3 | 295 |
| Summer | 2013 | 0 | 32 | 999 |
| Winter | 2008/09 | 0 | 4 | 545 |
| Winter | 2009/10 | 0 | 4 | 958 |
| Winter | 2010/11 | 7 | 8 | |
| Winter | 2011/12 | -0.3 | 4 | 372 |
| Winter | 2012/13 | -1 | 4 | 529 |

Table 2. Minimum, average and maximum turbidity summary during summer and winter at two lower bay stations. Orange bars indicate relative averages across dates. Data: CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014.


Figure 26. Streams listed as impaired for dissolved oxygen (303 (d) listed) under USEPA's Clean Water Act. Red dot signifies the start of the stream segment that is listed. Report subsystems delineated and labeled in blue. Data: ODEQ 2014

Kentuck station, monitored semi-monthly in 2007 by CTCLUSI had minimal differences between high and low tide sampling (Figure 27). At no time during sampling did values drop below ODEQ's criteria of 6.5 mg/L.

*Water Temperature*

There are seven water bodies in this part of the project area that are currently 303(d) listed for year-round high temperatures in salmon rearing habitat (Figure 28). Kentuck station, monitored by CTCLUSI

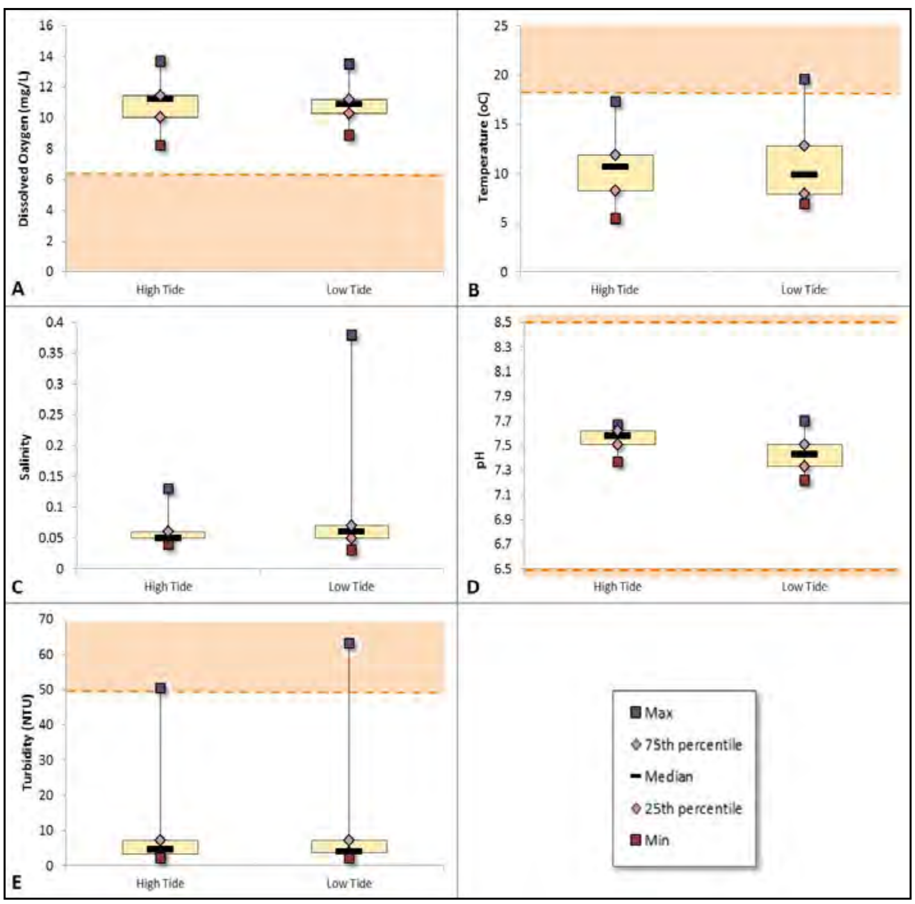



Figure 27. Box plots summarizing low and high tide minimum, maximum, median and central 50% of data fall (yellow boxes) during 2007 water year at Kentuck station for: A. dissolved oxygen, B. temperature, C. salinity, D. pH, and E. turbidity.Values in orange shaded areas and bounded by orange dashed line are considered unhealthy by ODEQ or OWEB standards. Data: CTCLUSI 2008.

(2008), averaged healthy temperatures during water year 2007. Low tide maximums exceeded ODEQ's criteria for healthy waters (Figure 27B).

Summertime temperature monitoring in Pony Creek by the Coos Watershed Association (CoosWA) shows maximum temperatures below ODEQ's standard (18° C [64° F]) and daily temperature fluctuations of 2-3° F (4-5° C) in four of five upstream stations (those closest to the reservoir dam)(Figure 29)(CoosWA 2002). CoosWA measured water temperature every 30 minutes from June to September in 2001 as part of their Pony Watershed Assessment (CoosWA 2002)(The CoosWA later completed assessments in North Slough, Haynes Inlet, and parts of the Upper bay (CoosWA 2006). The later assessments lack specific location information to protect private landowner interests, but general conclusions about water quality conditions are included later in this data summary).


Figure 28. Streams listed as impaired for water temperature (303(d) listed) under USEPA's Clean Water Act. Red dot signifies the start of the stream segment that is listed. Report subsystems delineated and labeled in blue. Data: ODEQ 2014

Maximum temperatures and daily temperature fluctuations were quite a bit higher at downstream stations. Of all the sites, the North Bend High School had the highest maxi-

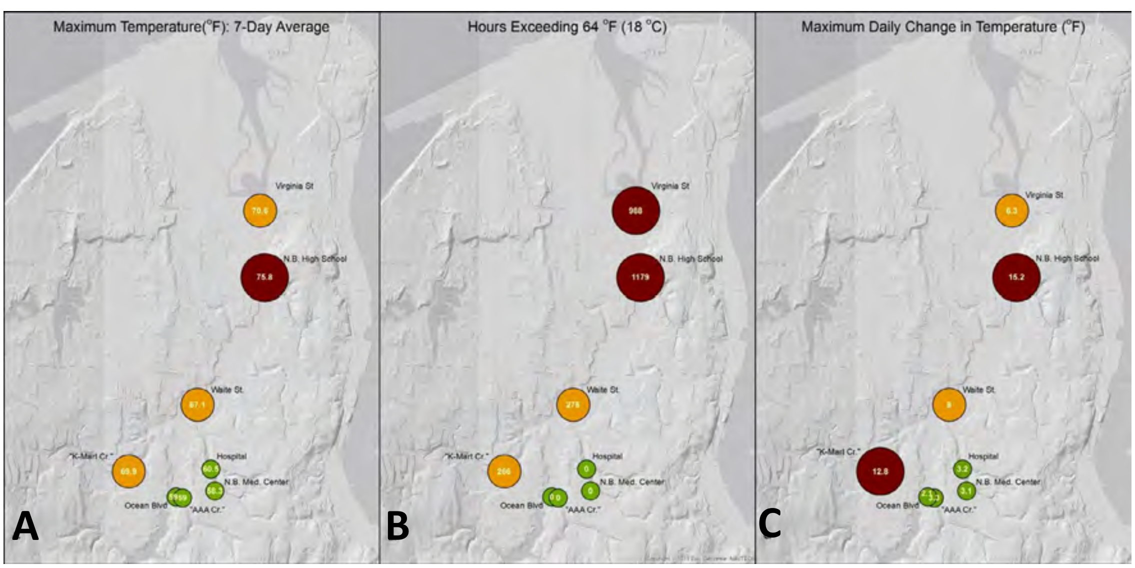



Figure 29. Water temperature results from 2001 sampling at 8 sites on Pony Creek. A: Maximum temperatures over a 7-day moving average; B: number of hours that exceeded 64°F (18°C) over the three and a half month sampling period; C: maximum daily temperature fluctuations over a 7-day moving average. Symbol size/color is relative to the value within (e.g., large red dots have the highest values, small green dots the lowest): Data: CoosWA 2002

| Subsystem | Waterbody | # sites Max Temp > 64 °F * | Max Days > 64 °F | Max Days > 70 °F | Max Daily Δ Temp | Source | Sample Year(s) |
|---|---|---|---|---|---|---|---|
| North Slough | North Slough Cr | 10 of 10 | 102 | 65 | 12.4 | CoosWA 2006 | 2003/2004 |
| Haynes Inlet | Palouse Cr | 6 of 7 | 110 | 89 | 15.5 | CoosWA 2006 | 2003/2004 |
| Haynes Inlet | Larson Cr | 5 of 5 | 98 | 38 | 14.7 | CoosWA 2006 | 2003/2004 |
| Upper Bay | Kentuck Cr/Mettman Cr | 5 of 6 | 110 | 72 | 9.9 | CoosWA 2006 | 2003/2004 |
| Upper Bay | Willanch Cr | 4 of 10 | 58 | 14 | 16.2 | CoosWA 2006 | 2003/2004 |
| Upper Bay | Echo Cr | 1 of 2 | 33 | 1 | 4.5 | CoosWA 2006 | 2003/2004 |
| Catching Slough | Catching Sl/Ross Sl/Stock Sl/Matson Cr/Wilson Cr/Seelander Cr/Boone Cr | 17 of 20 | 96 | 55 | 18.3 | CoosWA 2008 | 2006 |
| Coos River | Daniels Cr/Morgan Cr/Wren Smith Cr | 4 of 8 | 101 | 66 | 13.1 | CoosWA 2008 | 2006 |
| Coos River | Packard Cr/Rogers Cr | 9 of 11 | 94 | 68 | 20.5 | CoosWA 2008 | 2002/2003/2004/2005 |

Table 3. Water temperature results from water bodies sampled continuously over the dry season (May-Sept), including sites where maximum temperatures exceeded 64° F (18° C)(*over a 7-day moving average) and maximum daily temperature fluctuations. See Figure 30 map for creek locations. Data: CoosWA 2006, 2008

mum temperatures (peaking at 75.8° F [24.3° C], nearly 12° F [6.3° C] higher than ODEQ's standard), the most hours exceeding the 64° F (18° C) standard (1,179 hours/over 49 days), and the highest maximum daily temperature changes (15.2° F [8.5° C]). Further downstream, the Virginia St. station had lower maximum temperatures and less daily fluctuation, most likely due to tidal input from Pony Slough.

In their lowlands assessment report, CoosWA summarized several summers of water temperature data at seven different creeks from the North Slough, Haynes Inlet, and Upper Bay subsystems (CoosWA 2006). Of the 40 sites sampled, maximum temperatures over a 7-day moving average exceeded the 64° F (18° C) standard at all but nine sites (Table 3, Figure 30). The highest daily temperature fluctuation was 16.2° F (9.0° C) on Willanch Creek. Days with stream temperatures exceeding the standard varied by site. A North Slough creek site exceeded the standard the most frequently (102 days). Many sites exceeded 70° F (21.1° C) on multiple days.

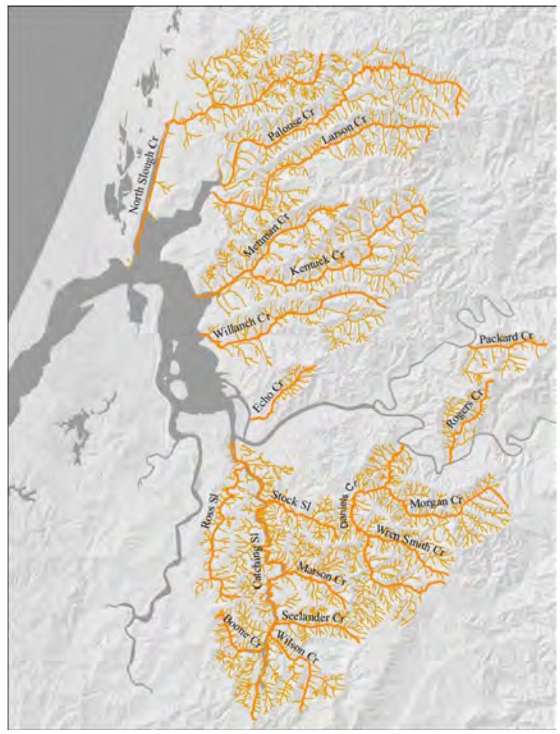



Figure 30. Streams referenced in Coos Watersheds assessment reports. Exact site locations for water temperature measurements were not included in the reports, to protect landowner privacy.

Weybright (2011) collected summer stream temperature data at sites along Palouse Creek in 2009 and 2010 (Figure 31). Nearly every site in both years exceeded the state standard. The highest maximum weekly temperatures were found at the site closest to the mouth (25.5° C [77.9° F] in 2009 and 23.5° C [74.3° F] in 2010). The site on Bear Cr. (a tributary to Palouse) had the lowest maxi-

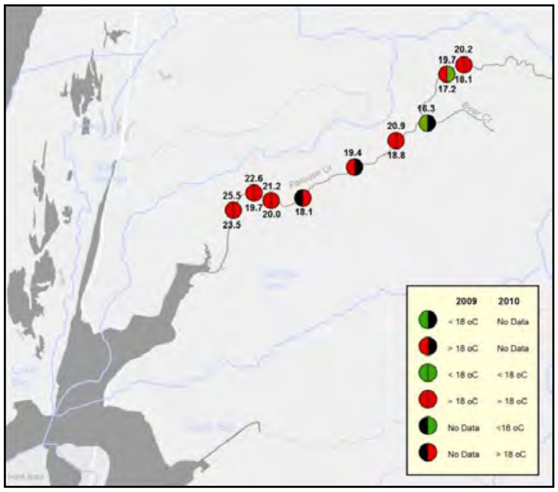


Figure 31. Location and condition of nine sites on Palouse Cr. in 2009 and 2010. Condition based on monthly water temperature average. Numbers above and below symbols denote maximum 7-day moving average values from 2009 and 2010 respectively. All temperatures are in °C. Data: Weybright 2011.

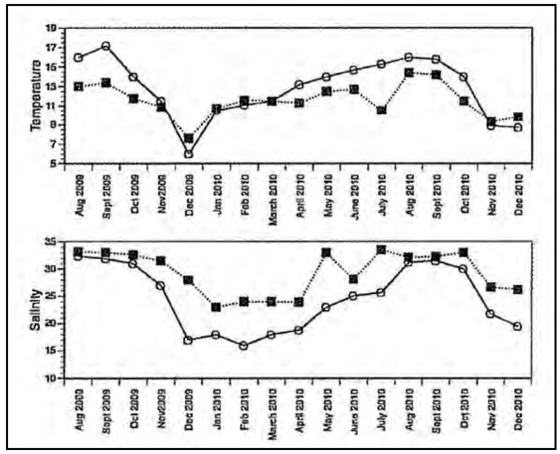



Figure 32. Monthly low tide (open circles) and high tide (black squares) surface temperature and salinity at Jordan Cove. From Shanks et al. 2011.

mum weekly temperature (16.3° C [61.3° F] in 2009).

In the Jordan Cove area, Shanks et al. (2011) found higher temperatures in the dry season than wet season at both low and high tides over one and a half years of sampling (Figure 32). The lowest temperatures measured (<7° C [45° F]) were in December 2009 when cold air temperatures rapidly cooled the estuary. Maximum temperature observed (~17° C [63° F]) occurred at low tide in September of that same year.

*pH*

Grabs taken by CTCLUSI in 2007 at their Kentuck station indicated healthy pH levels (Figure 27D).

*Salinity*

The Kentuck site monitored in 2007 by CTCLUSI indicated a freshwater location, with an average salinity near 0 (Figure 27C).

At the Jordan Cove study site, Shanks et al. (2011) reported a dramatic drop in salinity during the rainy season at both low and high tides, but especially during falling tides (Figure 32). Salinities during this period averaged ~25 at high tide and <20 at low tide.

*Turbidity*

At CTCLUSI's Kentuck station, levels were generally low, although peaks above OWEB's criteria for healthy turbidity levels have occurred (Figure 27E).

<u>Isthmus Slough/Catching Slough/Coos River</u>

*Dissolved Oxygen*

Isthmus Slough is 303(d) listed, considered an impaired waterway for low DO levels under the Clean Water Act (ODEQ 2014)(Figure 26). Low DO levels affect resident fish, juvenile

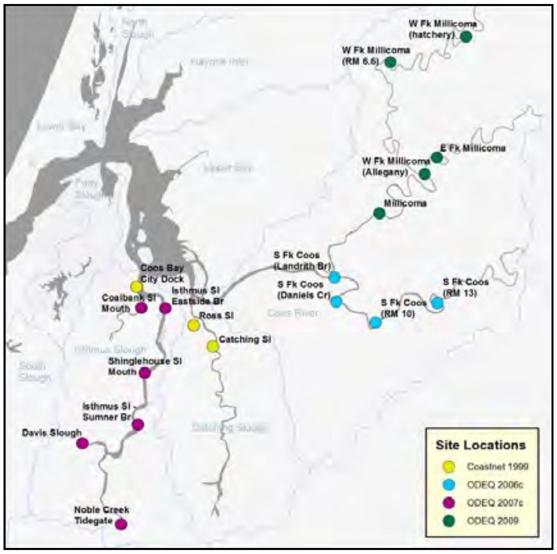



Figure 33. Site map for several studies or monitoring sites in the Isthmus Slough, Catching Slough and Coos River subsystems. Labeled symbols are site names referred to in this data summary.

salmon rearing, and aquatic life in general. Catching Creek has been 303(d) listed as DO limited for salmon rearing; the Millicoma River from miles 0 to 8.9 and the South Fork Coos River from miles 0 to 2.6 are also 303(d) listed for low DO levels.

Water quality samples were also collected as part of Marshfield High School's Coastnet program in 1998-99 at three sites (Figure 33), closely supervised by MHS biology teacher, George Tinker. Although generally above 6.5 mg/L, DO dipped into unhealthy levels at all three Coastnet sites – Coos Bay City dock (July, September 1998), Catching Slough (July 1998) and Ross Slough (Jul-November 1998)

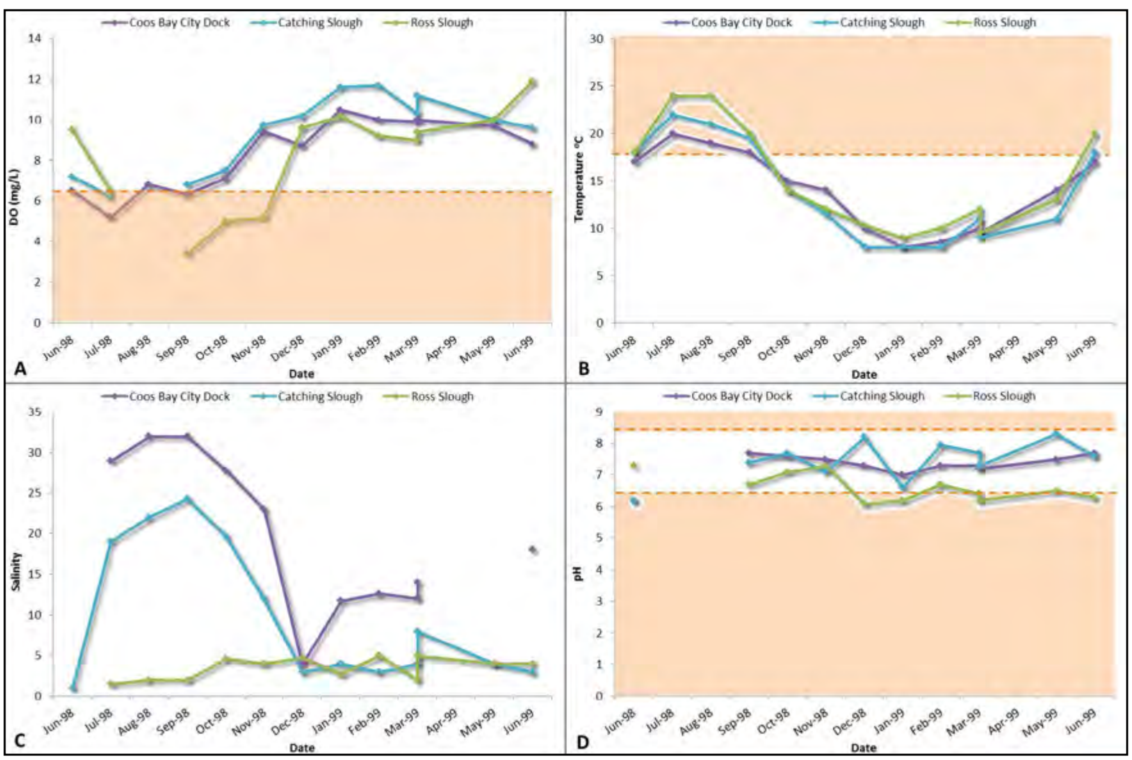



Figure 34. Average monthly samples (triplicate sampling 1x/month) at three sites in the Coos estuary: A: DO (mg/L); B: Temperature ($^{o}$C); C: Salinity; D: pH. Data that appear in shaded orange areas do not meet ODEQ standards. Data: Coastnet 1999.

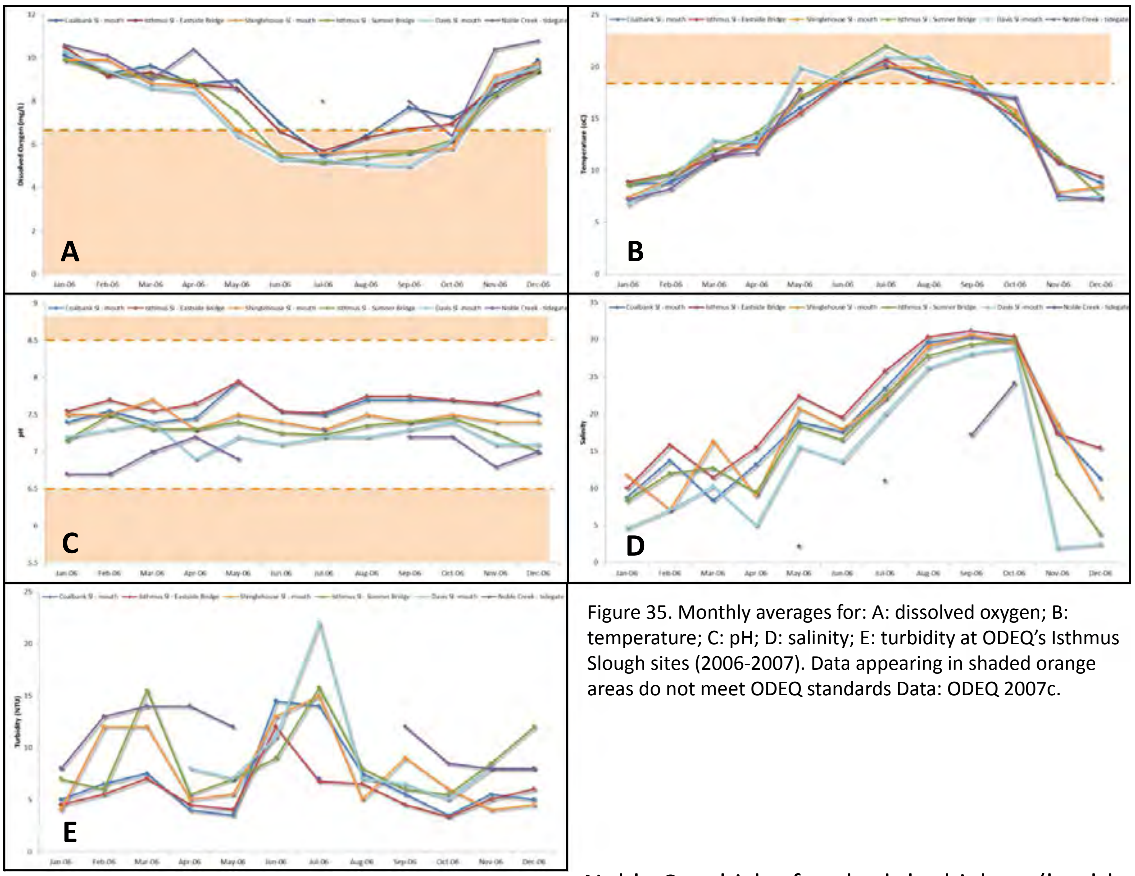



Figure 35. Monthly averages for: A: dissolved oxygen; B: temperature; C: pH; D: salinity; E: turbidity at ODEQ's Isthmus Slough sites (2006-2007). Data appearing in shaded orange areas do not meet ODEQ standards Data: ODEQ 2007c.

(Figure 34A). Lowest levels (3.4 mg/L) occurred at Ross Slough in September 1998.

Short duration continuous monitoring data have been collected during various projects by ODEQ including a year-long Isthmus Slough study (ODEQ 2007c), three days at four sites on the South Fork Coos River (ODEQ 2006c), and four days of data collection (15 min intervals) on the Millicoma River (ODEQ 2009) (Figure 33).

At ODEQ's Isthmus Slough study sites, DO levels fell below the ODEQ standard at all stations during part or all of the dry season (May-Oct)(Figure 35A). With the exception of Noble Cr, which often had the highest (healthiest) DO, sites closer to the mouth of Isthmus had higher DO levels than sites further up the slough.

Two ODEQ sites on the South Fork Coos River were monitored continuously over three days for DO; they had nearly identical DO levels (Figures 33 and 36A)(ODEQ 2006c). Both sites were just above the ODEQ standard for healthy DO levels in estuarine waters. The upper site (S Fk Coos [RM 10]) had slightly higher (healthier) DO levels, averaging 6.76 mg/L over the entire period, compared with 6.64 mg/L at S Fk Coos (Daniels Cr).

Mid-October monitoring by ODEQ in 2009 demonstrated unhealthy DO levels (based on

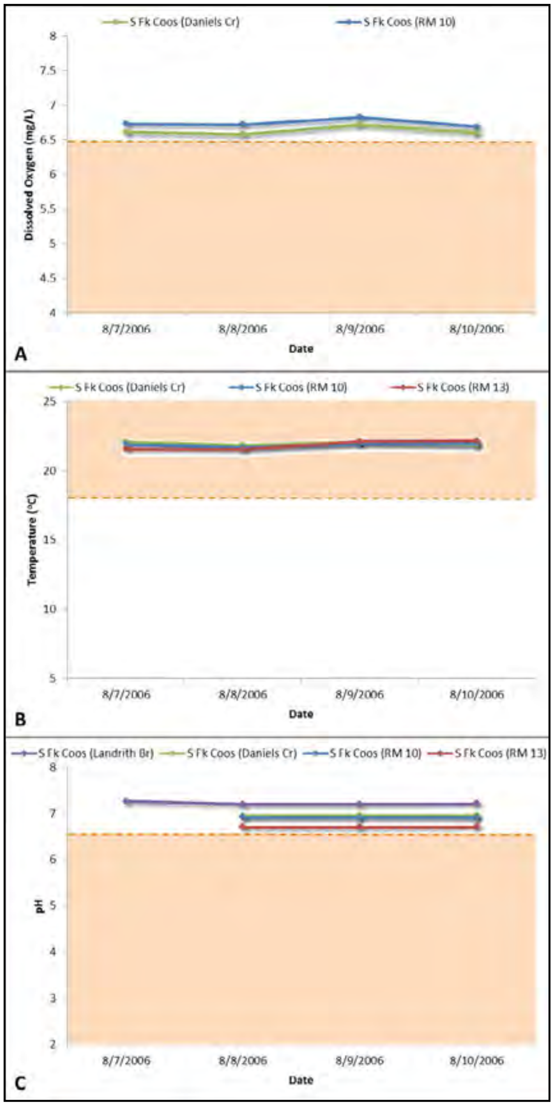



Figure 36. Daily averages of A: DO; B: temperature; C: pH from three days of continuous monitoring at four sites in 2006. Data in shaded orange area do not meet ODEQ standards. Data: ODEQ 2006c.

ODEQ's more stringent standard of 11 mg/L for cold-water aquatic life bearing waters during spawning season) at all fives sites on the Millicoma River (Figures 33 and 37A) (ODEQ 2009). Sites further downstream had lower levels of DO, beginning at the Millicoma River site (7.9 mg/L).

*Water Temperature*

Noble Creek, a tributary to Isthmus Slough, and multiple tributaries to the Coos River, including large sections of the South Fork Coos River (miles 0-31.1) and the West Fork Millicoma River (miles 0-34.8) have been 303(d) listed under the Clean Water Act as limited for salmon rearing due to high water temperatures (ODEQ 2014)(Figure 28).

In their assessment report, CoosWA summarized water temperature data at multiple creeks in Catching Slough and Coos River (CoosWA 2008). Of the 39 sites sampled, maximum temperatures over a 7-day moving average exceeded the 64° F (18° C) standard at all but nine sites (Figure 30 and Table 3). The highest daily temperature fluctuation was 20.5° F (11.4° C)(in 2005 at Roger's Cr). Total days with temperatures over the standard varied by site. The site with the most days, Daniel's Creek, exceeded the standard on 102 days; other sites' stream temperatures were over 70° F (21° C) on multiple occasions.

Dry season (May- October) temperatures at all three Coastnet stations were higher than in the wet season, and often rose into unhealthy levels (i.e., >18° C [64° F])(Figures 33 and 34B). Highest temperatures were found

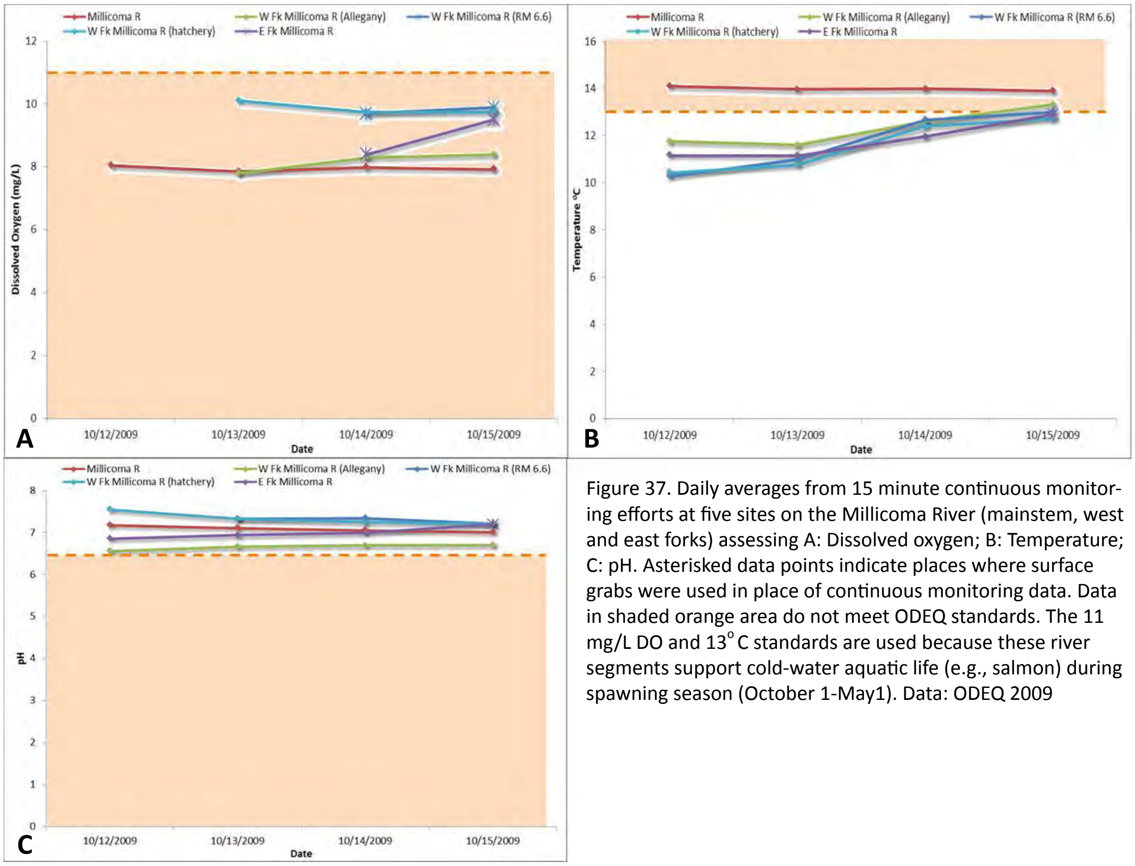



Figure 37. Daily averages from 15 minute continuous monitoring efforts at five sites on the Millicoma River (mainstem, west and east forks) assessing A: Dissolved oxygen; B: Temperature; C: pH. Asterisked data points indicate places where surface grabs were used in place of continuous monitoring data. Data in shaded orange area do not meet ODEQ standards. The 11 mg/L DO and 13° C standards are used because these river segments support cold-water aquatic life (e.g., salmon) during spawning season (October 1-May1). Data: ODEQ 2009

at Ross Slough in the dry season, peaking at 24° C (75° F) in both July and August 1998.

The one-year study by ODEQ on Isthmus Slough indicated healthy water temperatures during the wet season, but heightened levels during the dry season (May-Oct)(Figures 33 and 35B). Monthly averages frequently exceeded the ODEQ's <18° C (64° F) standard during the dry season.

High water temperatures exceeded ODEQ's <18° C (64° F) standard at three sites monitored continuously over three days on the South Fork Coos River (Figures 33 and 36B). All three sites averaged nearly 22° C (72° F) over the entire sample period.

Temperature data collected by ODEQ on the Millicoma River exceeded their <13° C (55° F) standard (established in salmonid spawning reaches) at three of five stations (Figures 33 and 37B)(ODEQ 2009). The station closest to the estuary (Millicoma River) exceeded the standard on all four days of monitoring, averaging 13.9° C (57° F) over the entire sampling period. Slightly lower temperatures were found at upstream sampling stations.

*pH*

All six stations monitored for one year on Isthmus Slough by ODEQ met their pH standard in all months sampled (Figures 33 and 35C). In general, sites closer to the mouth had higher (more alkaline/less acidic) pH than sites further upstream. The four ODEQ South Fork Coos River stations monitored in August 2006 were all within healthy levels (Figures 33, 36C). Three of the four stations were slightly more acidic than pure water (which has a pH of 7) with South Fork Coos River (mile 13) having the lowest overall average pH (6.7 mg/L).

Likewise, all five stations ODEQ monitored on the Millicoma River for four days in October 2009 were within healthy levels (Figures 33 and 37C). The West Fork Millicoma River (Allegany) site had the lowest pH, averaging 6.7 over the entire sampling period.

At Catching Slough and Coos Bay City Dock Coastnet sampling sites, pH levels remained within ODEQ criteria for healthy waters (Figures 33 and 34D). Ross Slough station frequently dropped below 6.5 mg/L into unhealthy (acidic) pH levels.

*Salinity*

Not surprisingly, the Isthmus Slough sites monitored by ODEQ for a year all had lower salinity during the wet season than the dry (May-Oct) when salinities neared 30 at the mouth (Figures 33 and 35D). As expected, sites closer to the mouth of Isthmus Slough had consistently higher salinities than those further upstream.

Of the three Coastnet stations, Ross Slough station had lowest salinities (<5) year-round (Figures 33 and 34C). Catching Slough and Coos Bay City Dock stations varied with the season, with much higher salinities July-November (10-25 at Catching and 25-30 at Coos Bay City Dock) than the rest of the year (~5 at Catching, ~10 at Coos Bay City Dock).

*Turbidity*

All six Isthmus Slough stations monitored by ODEQ over the course of a year demonstrated healthy turbidity levels (Figures 33 and 35E).

**Background**

*Dissolved Oxygen*

Dissolved oxygen (DO) is the amount of unbound oxygen dissolved in water. This is the oxygen available for aquatic fauna (e.g. fish and clams) to breathe. Hypoxia, low DO levels, is lethal at different concentrations depending on species. A study by Vaquer-Sunyer and Duarte (2008) found median lethal DO levels was ~0.75 mg/L for gastropods, ~1.75 mg/L for fish and bivalves and ~2.0 mg/L for crustaceans. Median lethal oxygen concentrations were as high as 8.6 mg/L in one larval crab species and ~5.0 for one bivalve species. Ghost and mud shrimp are two species in our estuary that are particularly sensitive to low DO (Lee II and Brown 2009).

Slow moving, higher temperature water tends to contain less dissolved oxygen than cool, fast flowing waters. This can be seen in Figure 5A and 5B where DO in the faster flowing Coos River is high during the cooler parts of the year and lower during the warmer times of the year compared with the North Point SWMP station data. Slow flowing, higher water temperature conditions combined with accumulations of organic material (sometimes caused by an overabundance of nutrients in the water column- see Water Quality in the Coos Estuary: Nutrients) can cause blooms of oxygen-metabolizing decomposers in waterways.Large scale decomposition activity in water reduces the availability of dissolved oxygen which, in turn, can affect a variety of aquatic animals (mentioned previously) while also decreasing the water clarity needed for submerged aquatic vegetation to grow.

There have been occurrences of severe hypoxia along the inner continental shelf off central Oregon during the past decade, allowing for these low oxygen waters to be advected into adjacent estuaries (Grantham et al. 2004 and Chan et al. 2008 as cited in Brown and Power 2011). Data collected near the mouth of Coos estuary show low DO at cooler water temperatures, implying that low DO in the estuary is related to ocean conditions (Brown and Power 2011). Flood tide DO higher than ebb tide DO would further demonstrate the influence of ocean upwelling on estuarine DO.

*Water Temperature*

Different aquatic organisms have different preferred temperature ranges, some more sensitive than others. For example, water temperature is a significant component of salmon distribution, health, and survival (USEPA 2003). Cooling water temperatures in fall months serve as a cue for upstream migration and spawning. Juvenile Coho salmon growth can cease in water temperatures above 20° C (68° F) and water temperatures of 25° C (77° F) can be lethal to fishes (Reiser and Bjornn 1971 as cited in Weybright 2011; ODEQ 2000 as cited in CoosWA 2008).
Daily and seasonal water temperature fluctuations determine which organisms will inhabit particular aquatic habitats in particular locations. In waters where temperature regimes have shifted, the composition of associated biological communities has also shifted (Booth et al. 2011).

Other key water temperature-related points (USEPA 2003):

- Temperature is closely linked to water chemistry, with warmer waters dissolving more minerals and allowing less oxygen saturation (see DO section).
- Runoff from the impervious surfaces associated with human development that direct enters streams, rivers and estuaries can contribute to “thermal loading” (raise water temperatures).
- Along streams, loss of riparian vegetation significantly affects stream temperatures.
- Bank erosion and resultant sedimentation in adjacent water bodies leads to increased temperatures (wider/shallower streams).

*pH*

pH is a measure of hydrogen ions in the water; it determines the level of water acidity or alkalinity. Pure water has a pH of 7 at 25° C (77° F). Solutions less than 7 are considered acidic (e.g. acid rain = ~4) and those greater than 7 are considered basic or alkaline (e.g., baking soda = 9). Most marine organisms function in a narrow pH range of 6.5 to 8.0. At low pH (<6.5), egg hatch and juvenile growth in some fish species can be significantly reduced (Menendez 1976).

pH affects many chemical and biological processes including the solubility and biological availability of dissolved nutrients and heavy metals. For example, metals tend to be more soluble at lower pH and are therefore more toxic to organisms. The form of nutrients in the water can be helpful or toxic to organisms, partly determined by pH. For example, ammonia ($NH_3$) is toxic to fish in very small amounts but at low pH converts readily to the non-toxic form, ammonium ($NH_{4+}$). Solubility of calcium carbonate, important for shell-forming organisms such as clams and corals, is affected by pH – waters that are too acidic inhibit shell growth. In the face of declining ocean pH, it is critical to establish baseline pH records in the Coos estuary (Randall and Tsui 2002).

*Salinity*

Like temperature, salinity affects community composition with some organisms able to tolerate freshwater only, some able to tolerate salt water only and some a mixture. Several species, such as salmon, can physiologically change their needs and survive in fresh water and salt water at different life stages.

*Turbidity*

High turbidity levels are often associated with heavy rain events, when sediment runoff and more turbulent waters stir up sediment and contaminants from river and stream beds, estuary channels, and mudflats. As such, turbidity is often an indicator of potential pollution in a water body. High turbidity also makes the water opaque which can negatively affect recreational use (Osmond et al. 1995).

In particular, high turbidity levels can significantly affect aquatic species and the habitat in which they live. For example, chronic turbidity impairs growth of juvenile salmon compared to those reared in clear waters (Sigler et al. 1984). Additionally, decreased light availability in chronically turbid water bodies has detrimental impacts to aquatic vegetation such as eelgrass (Moore et al. 1997).

**References**

Booth, D. J., N. Bond, and P. Macreadie. 2011. Detecting Range Shifts Among Australian Fishes in Response to Climate Change. Marine and Freshwater Research. 62: 1027–1042.

Brown, C. A. and C. L. Folger. 2009. "Chapter 4: Water Quality Surveys in Seven Target Estuaries", in Lee II, H. and Brown, C.A. (eds.) Classification of Regional Patterns of Environmental Drivers and Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division.

Brown, C. A. and J. H. Power. 2011. Historic and recent patterns of dissolved oxygen in the Yaquina Estuary (Oregon, USA): Importance of anthropogenic activities and oceanic conditions. Estuarine, Coastal and Shelf Science. 92 (3): 446-455.

Chan, F., J. A. Barth, J. Lubchenco, A. Kirincich, A. Weeks, W. T. Peterson, and B. A. Menge. 2008. Emergence of anoxia in the California Current large marine ecosystem. Science 319, 920.

Coastnet. 1999. [Marshfield Highschool - Oregon State University Sea Grant Program]. Unpublished QA/QC data.

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2007. Tribal Water Quality Assessment Report: October 2005-September 2006. CTCLUSI Department of Natural Resources, Coos Bay OR. 40 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2008. Tribal Water Quality Data Summary: October 2006-September 2007. CTCLUSI Department of Natural Resources, Coos Bay OR. 40 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2009. Confederate Tribes of the Coos, Lower Umpqua, and Siuslaw Indians Water Quality Data Summary: October 2007-September 2008. CTCLUSI Department of Natural Resources, Coos Bay OR. 33 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI). 2010. Intermediate Tribal Water Quality Assessment Report. CTCLUSI Department of Natural Resources, Coos Bay OR. 33 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2011. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 37 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2012. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2013. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2014. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 30 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Coos Watershed Association (CoosWA). 2002. Lower Pony Creek Watershed Assessment and Potential Action Plan. Coos Watershed Association, Charleston, OR. 11 pp. Retrieved from: http://www.cooswatershed.org/Publications/pony_creek_white_paper.pdf

Coos Watershed Association (CoosWA). 2006. Coos Bay Lowland Assessment and Restoration Plan. Coos Watershed Association, Charleston, OR. 263 pp. Retrieved from: http://www.cooswatershed.org/pubsciassl

Coos Watershed Association (CoosWA). 2008. Catching Slough, Daniel's Creek and Heads of Tide Sub-basin Assessment and Restoration Opportunities. Coos Watershed Association, Charleston, OR. 144 pp. Retrieved from: http://www.cooswatershed.org/Publications/Assessment%20Body-%20Catching%20Daniels%20HoT%2003-2009.pdf

Cornu, C.E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Grantham, B. A., F. Chan, K. J. Nielsen, D. S. Fox, J. A. Barth, A. Huyer, J. Lubchenco, and B. A. Menge. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific. Nature 429, 749-754.

Hayslip, G., L. Edmond, V. Partridge, W. Nelson, H. Lee, F. Cole, J. Lamberson , and L. Caton. 2006. Ecological Condition of the Estuaries of Oregon and Washington. EPA 910-R-06-001. U.S. Environmental Protection Agency, Office of Environmental Assessment, Region 10, Seattle, Washington.

Lee II, H. and Brown, C.A. (eds.) 2009. Classification of Regional Patterns of Environmental Drivers And Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division.

Menendez, R. 1976. Chronic Effects of Reduced pH on Brook Trout (*Salvelinus fontinalis*). Journal of the Fisheries Board of Canada. 33: 118-123.

Moore, K. A, R. L. Wetzel, and R. J. Orth. 1997. Seasonal Pulses of Turbidity and their Relations to Eelgrass (*Zostera marina L.*) Survival in an Estuary. Journal of Experimental Marine Biology and Ecology. 215 (1): 115-134.

National Oceanographic and Atmospheric Administration (NOAA). 2014. [Tides and Currents Water Temperature at Charleston, OR station]. Unpublished raw data. Retrieved from: http://tidesandcurrents.noaa.gov/physocean.html?id=9432780

Oregon Department of Agriculture (ODA). 2011. [Coos Bay and South Slough Bacteria Sampling for Shellfish Growing Areas, 1999-2011]. Unpublished raw data.

Oregon Department of Environmental Quality (ODEQ). 1999. [CEMAP 1999 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2000. Water Quality Monitoring Technical Guide Book (version 2.0). The Oregon Plan for Salmon and Watersheds.

Oregon Department of Environmental Quality (ODEQ). 2001. [CEMAP 2001 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2004. [CEMAP 2004 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2005a. [CEMAP 2005 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2005b. [Coos Bay Bacteria TMDL 2001-2005]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006a. [CEMAP 2006 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006b. [Coos Bay TMDL Summer 2006 Temperature Continuous Monitoring]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006c. [South Fork Coos River Temperature Study - TMDL (NPS) Development]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007a. [2007 Coos Basin Temperature Project]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007b. [Coos River Storm Related Bacteria TMDL]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007c. [Isthmus Slough/South Fork Coos DO Study]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009. [Millicoma River TMDL DO Study 2009]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2014. Oregon's Draft 2012 Integrated Report: Assessment Database and 303(d) List. Retrieved from: http://www.deq.state.or.us/wq/assessment/rpt2012/search.asp

Oregon Department of Fish and Wildlife (ODFW). 2013. [Coos fish monitoring seine program]. Unpublished raw data.

Oregon Watershed Enhancement Board (OWEB). 1999. "Chapter VIII: Water Quality Assessment". In Oregon Watershed Assessment Manual (p. VIII1-21). Salem, OR. Retrieved from: http://www.oregon.gov/OWEB/pages/docs/pubs/or_wsassess_manuals.aspx

Osmond, D.L., D.E. Line, J.A. Gale, R.W. Gannon, C.B. Knott, K.A. Bartenhagen, M.H. Turner, S.W. Coffey, J. Spooner, J. Wells, J.C. Walker, L.L. Hargrove, M.A. Foster, P.D. Robillard, and D.W. Lehning. 1995. WATERSHEDSS: Water, Soil and Hydro-Environmental Decision Support System - Turbidity. Retrieved from: http://www.water.ncsu.edu/watershedss/info/turbid.html

Randall, D. J., and T. K. Tsui. 2002. Ammonia Toxicity in Fish. Marine Pollution Bulletin.45 (1-12): 17-23.

Rumrill, S. 2006. The Ecology of the South Slough Estuary, Oregon: Site Profile of a National Estuarine Research Reserve. South Slough National Estuarine Research Reserve, Charleston, OR. 258p.

Shanks, A., S. Schroeder, and B. Dlouhy. 2011. Appendix F.3 – January 2011: Report on the Zooplankton Sampling Adjacent to the Proposed Jordan Cove LNG Terminal. In: FERC Application and Resource Reports – Jordan Cove Energy Project. Retrieved from: http://www.jordancoveenergy.com/ferc_application_and_resource_reports_1-13.htm

Shore Stations Program. 1997. [Charleston Station – Salinity and Temperature 1966-1997]. Unpublished raw data. Retrieved from: http://shorestation.ucsd.edu/historical/index_historical.html

Sigler, J. W., T.C. Bjornn, and F. H. Everest. 1984. Effects of Chronic Turbidity on Density and Growth of Steelheads and Coho Salmon. Transactions of the American Fisheries Society. 113 (2): 142-150.

Sigmon C.L.T., Caton L., Coffeen G., Miller S. 2006. Coastal Environmental Monitoring and Assessment Program. The Condition of Oregon's Estuaries in 1999, a Statistical Summary. Oregon Department of Environmental Quality, Laboratory.

South Slough National Estuarine Research Reserve (SSNERR). 2014. [Greater Coos Bay stations, 2013- 2014)]. Unpublished raw data.

System-Wide Monitoring Program (SWMP). 2014. [South Slough Abiotic Water Quality Data (1995-2014)]. Retrieved from: http://cdmo.baruch.sc.edu/

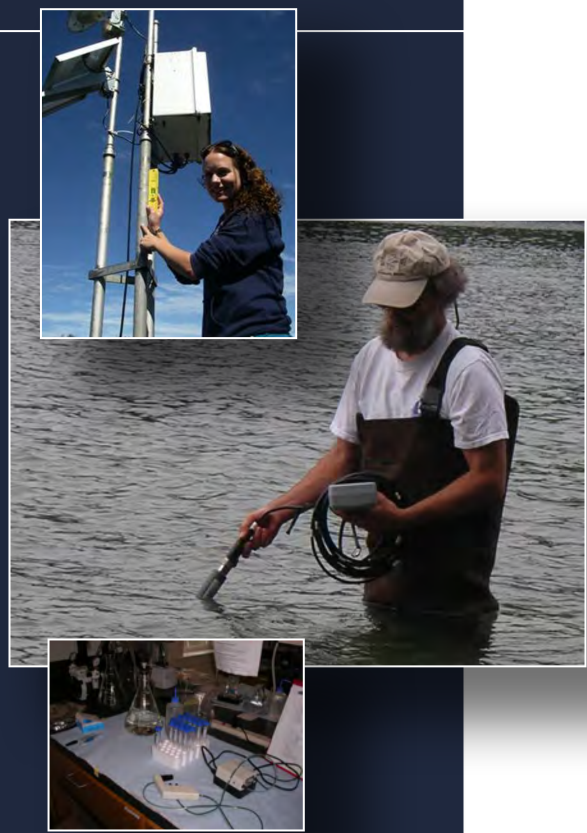
Thom, R. M., A. B. Borde, S. Rumrill, D. L. Woodruff, G. D. Williams, J. A. Southard, and S. L. Sargeant. 2003. Factors Influencing Spatial and Annual Variability in Eelgrass (*Zostera marina L.*) Meadows in Willapa Bay, Washington, and Coos Bay, Oregon, Estuaries. Estuaries. 26 (4): 1117-1129.

United States Environmental Protection Agency (USEPA). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.
University of San Diego – SCRIPPS (UCSD). 2000. [Shore Stations Program – Charleston, Oregon Station, 1966-2000]. Unpublished raw data.

Vaquer-Sunyer R, Duarte CM. 2008. Thresholds of Hypoxia for Marine Biodiversity. Proceedings of the National Academy of Sciences of the United States of America. 105: 15452–15457.

Weybright, A. D. 2011. Juvenile Coho Salmon Movement, Growth and Survival in a Coastal Basin of Southern Oregon. Thesis (M.S.) -- Oregon State University, 2011.

# Water Quality in the Coos Estuary: Nutrients



*Summary:*

- *Available datasets indicate that, for the most part, nutrient concentrations in the Coos estuary meet or exceed human health standards set by the Oregon Department of Environmental Quality and the U.S. Environmental Protection Agency.*
- *The ocean-dominated portion of the Coos estuary experiences moderate concentrations of total dissolved inorganic nitrogen and high concentrations of phosphorus.*
- *The river-dominated portion of the Coos estuary is considered "phosphorus limited," because the bioavailability of phosphorus (rather than nitrogen) constrains the growth of photosynthetic organisms such as emergent tidal wetland vegetation and algae*
- *Additional data are needed for a more complete evaluation.*

### Evaluation

Status of water quality due to nutrient concentrations appears to be relatively good and should continue to be monitored.

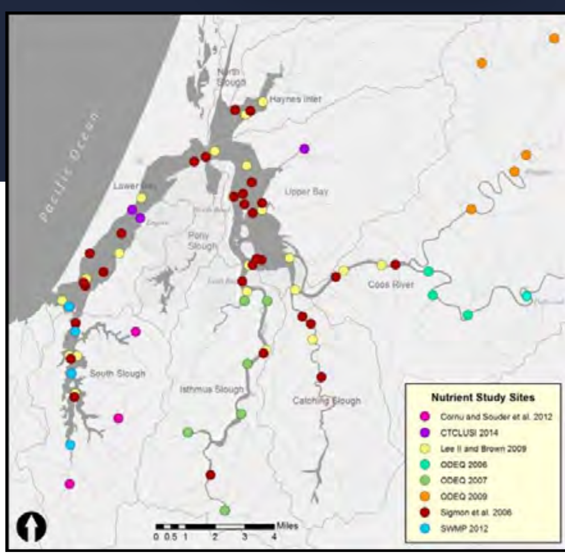



Figure 1. Water column nutrient study sites.

**What's happening?**

In water, nutrients exist in many different forms. Whether nutrient concentrations are ecologically beneficial or detrimental depends on the nutrient's form and concentration, both of which are influenced by a variety of environmental factors (e.g., salinity, pH, temperature). Estuarine nutrient concentrations also vary due to the timing and intensity of coastal upwelling, precipitation patterns, estuarine geomorphology, and tidal flushing.

In this document, we summarize available information on nitrogen, phosphorus, silica, and chlorophyll *a* concentrations (and their various forms) in the Coos estuary (Figure 1). The forms in which nutrients are found in the Coos estuary are listed in Table 1.

After a brief overview, this document summarizes nutrient water quality data for each project area subsystem (e.g., South Slough, Lower Bay, Upper Bay, Isthmus Slough, etc.).

**Overview**

In terms of both human and ecological health, nutrient levels in the Coos estuary are generally satisfactory, although additional data are needed for a complete evaluation. Available datasets indicate that nutrient concentrations meet or exceed human health standards set by the Oregon Department of Environmental Quality (ODEQ) and the United States Environmental Protection Agency (USEPA). The concentrations of both nitrogen and phosphorus in the Coos estuary remained at acceptable levels throughout most

*Nutrients in Estuaries*

*Nutrients are key water quality parameters. According to the United States Environmental Protection Agency (USEPA), nutrients in estuarine waters directly affect plant growth and biological productivity, and indirectly influence dissolved oxygen concentrations, water clarity, and sedimentation rates.*

*Nutrients enter estuaries from terrestrial point and non-point sources, atmospheric, and groundwater sources. Nutrient sources are both naturally occurring and human-caused.*

*When nutrients are excessive in estuarine waters, a process called "eutrophication" may result, causing excess plant production (phytoplankton or algae), which may lead to decreased water clarity and low dissolved oxygen concentrations, both of which are detrimental to aquatic plants and animals.*

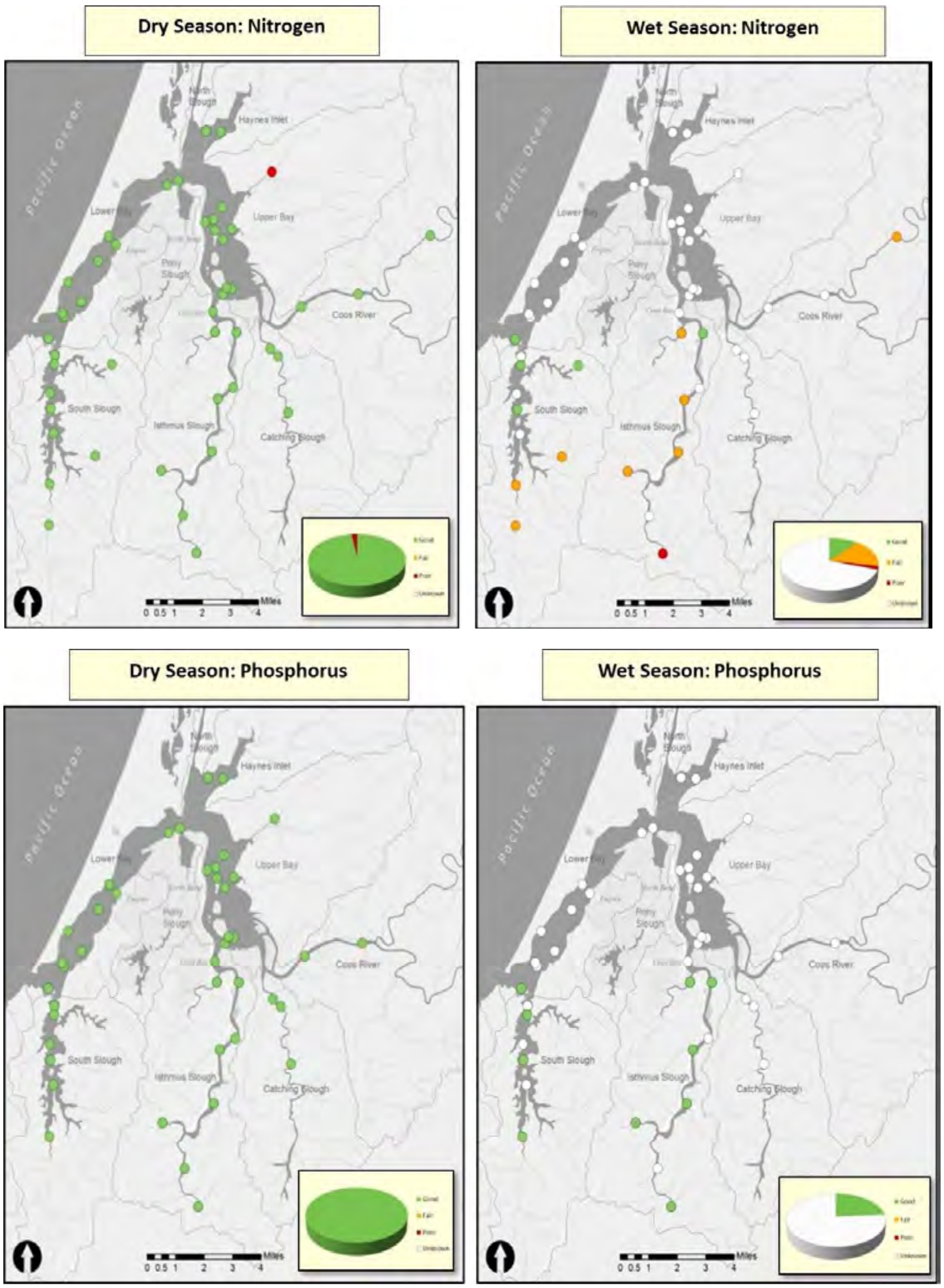
*Sources: USEPA 2010, 2012*

| Form | Symbol | What is it? | Primary Source | Water Quality Standard | Water Quality Standard |
|---|---|---|---|---|---|
| **Nitrogen** | | | | | |
| **Nitrate** | $NO_3^-$ | Most common form in surface waters. High levels can lead to eutrophication. | Argriculture fertilizer runoff | Total Nitrate (Nitrate/Nitrite): <0.30 mg/L = good | OWEB 1999 |
| **Nitrite** | $NO_2^-$ | Toxic to fish in high amounts, but readily oxidizes into nitrate. | Nitrates reduce to nitrite in anaerobic conditions | Total Nitrate (Nitrate/Nitrite): <0.30 mg/L = good | OWEB 1999 |
| **Ammonium** | $NH_4^+$ | Nontoxic form of ammonia. | Animal waste; natural breakdown of organic material in soil | see TAN below | |
| **Ammonia** | $NH_3$ | Toxic in small amounts, but readily converts to ammonium, especially in lower pH and lower temperature conditions. | Animal waste (e.g., sewage or pasture runoff) | see TAN below | |
| **Total Kjeldahl Nitrogen** | TKN | Organic nitrogen + ammonia | Animal waste products; organic nitrogens form in water by phytoplankton. | | |
| **Total Dissolved Inorganic Nitrogen** | TIN or DIN | Nitrate + Nitrite + ammonium | | <0.5 mg/L = good; 0.5-1.0 mg/L = fair; >1.0mg/L = poor | USEPA 2012 |
| **Total Ammonia Nitrogen** | TAN | Ammonia + ammonium. Elemental ammonia (toxic) is hard to measure, but is directly proportional to amount of ammonium in water. So, TAN is used as a proxy for ammonia. | | Depends on pH, salinity and temperature, see source for chart | USEPA 2013 |
| **Total Nitrogen** | TN | Organic and Inorganic nitrogen | | | |
| **Phosphorus** | | | | | |
| **Dissolved Organic Phosphate** | DOP | Phosphate group that is bound to plant or animal tissue. Available for use by some algae species. Converted to orthophosphate through enzyme and bacterial processes. | Plant and animal waste as well as decomposition of dead plants and animals | | |
| **Orthophosphate** | $PO_4^{3-}$ | Simplest polyphosphate grouping. Extremely soluable and bioavailable form of inorganic phosphorus required by primary producers. | Fertilizers, detergents | see DIP below | |
| **Polyphosphate** | Varies by compound | More complex chains of phosphate groups that readily convert to orthophosphate in water. | Detergents, soaps, industrial discharges | see DIP below | |
| **Dissolved Inorganic Phosphorus** | DIP | Dissolved orthophosphate + dissolved polyphosphate. Indicator of total inorganic phosphorus in solution. | | < 0.07 mg/L = good; 0.07-1.0 mg/L = fair; >1.0mg/L = poor | USEPA 2012 |
| **Total Phosphorus** | TP | Dissolved and particulate forms of both organic and inorganic phosphorus. Indicator of all compounds containing phosphorus. | | < 0.05 mg/L = good | OWEB 1999 |
| **Silicon** | | | | | |
| **Silica** | $SiO_2$ | Soluable form of silicon. Required by diatoms and other "siliceous" plankton species for growth and development. | Weathering and erosion of rocks and soil. | | |
| **Chlorophyll** | | | | | |
| **Chlorophyll alpha** | Chlorophyl l a | Chlorophyll is a pigment found in algae and plants. Chlorophyll a is the pigment that is most closely associated with photosythesis. Indicator of primary production. | Phytoplankton | < 15 µg/L = good | Brown et al. 2007 |

Table 1. Nutrient forms found in aquatic systems. The table also provides formulas, brief descriptions, sources, and relevant water quality standards.

years available for investigation. Based on the USEPA's West Coast Criteria (USEPA 2012), all Coos estuary study sites (Figure 1) were ranked as "good" for total dissolved inorganic nitrogen (DIN) and orthophosphates ($PO_4$ ) at < 0.5 mg/L and < 0.07 mg/L, respectively. Similarly, based on USEPA research (Brown et al. 2007), chlorophyll *a* was ranked as "good" at < 15 µg/L (Figure 2).

The ocean-dominated portion of the Coos estuary (salinity > 25) comprises about 42% of the entire system and has moderate concentrations of DIN (0.1-1.0 mg/l) and high concentrations of phosphorus (≥ 0.1 mg/L). The highest concentrations of both nutrients occur during April-June (NOAA 1998).




The upper, more river-dominated portion of the Coos estuary is considered “phosphorus limited,” because the bioavailability of phosphorus (rather than nitrogen) constrains the growth of photosynthetic organisms such as emergent tidal wetland vegetation and algae (known in ecological terms as “primary producers”)(Quinn et al. 1991).

Chlorophyll *a* concentrations in the Coos estuary generally meet USEPA standards

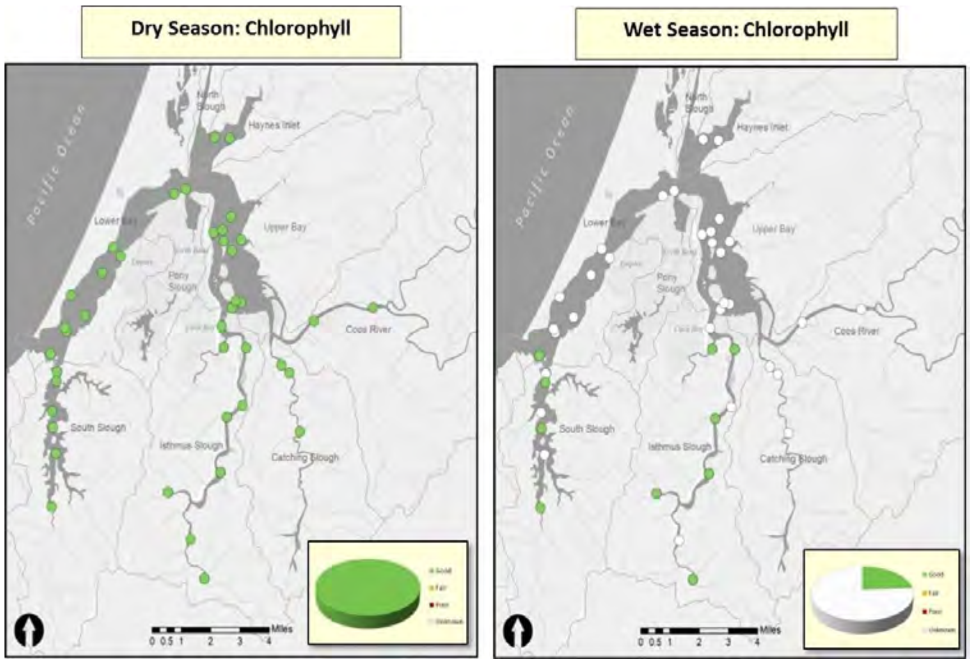



Figure 2. This series of maps (previous page and above) summarizes wet and dry season nitrogen, phosporous and chlorophyll *a* conditions at Coos estuary water quality data collection sites. Green represents “good” nutrient concentrations that meet all USEPA standards; Orange represents “fair” nutrient concentrations that meet all but the most stringent USEPA standards; Red represents “poor” nutrient concentrations that do not meet any USEPA standard; and White represents data gaps, which occur at stations only sampled in the dry season (May-October). Data were compiled from : CTCLUSI 2013, 2014; ODEQ 1999, 2001, 2004, 2006, 2007; SWMP 2012.

(USEPA 2012) except for rare occasions in the riverine/freshwater zone of the estuary (see Figure 11 Winchester and Valino sites)(ODEQ 2007; SWMP 2012).

Silica concentrations in the Coos estuary range from approximately 0-18 mg/L, with the highest concentrations occurring in the riverine/freshwater zone of Isthmus Slough (SWMP 2012; ODEQ 2007, 2009). Silica exhibits seasonal patterns, with peak levels during the rainy season for riverine/freshwater sites and peaks for marine/polyhaline sites in the dry season (SWMP 2012). USEPA has not established water quality guidelines for silica.

**Nutrients in Coos Estuary Subsystems: South Slough**

<u>Lower South Slough Watershed</u>

Since 2002, the science staff at the South Slough National Estuarine Research Reserve (SSNERR) has monitored nutrient concentrations at four sites as part of the System-Wide Monitoring Program (SWMP)(Figures 3 and 4) (SWMP 2012). Additional sources of nutrient information for South Slough include: USEPA, ODEQ, local tribes (Coquille; the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians [CTCLUSI]), and the Coos Watershed Association (CoosWA).

Nitrogen

The 10 year record (2002-2012) of SWMP data in South Slough reveals a strong seasonal pattern in total dissolved inorganic nitrogen (DIN) which is high during wet months (November – April) and low during dry months (May – October)(Figure 5)(SWMP 2012).

Regression analyses of SWMP data also reveal a statistically significant ($p < 0.001$) relationship between precipitation and DIN at all stations (Figure 6). Precipitation explains 50% of DIN variation near South Slough's mostly freshwater site ( $R^2$= 0.497 at Winchester Creek). However, it explains an increasingly smaller share of DIN variation as salinity increases (i.e., sites closer to the mouth of the estuary). It should be noted that the statistical significance of these relationships may be somewhat inflated due to potential "serial correlation" in the data (when anomalies associated with one time period carry over into future time periods).

DIN concentrations were generally higher and varied more at the riverine/freshwater sampling site (Winchester) than at the marine/polyhaline sites (Boathouse, Charleston, and Valino)(Figure 7a). These results appear to be consistent over time (Figure 5).

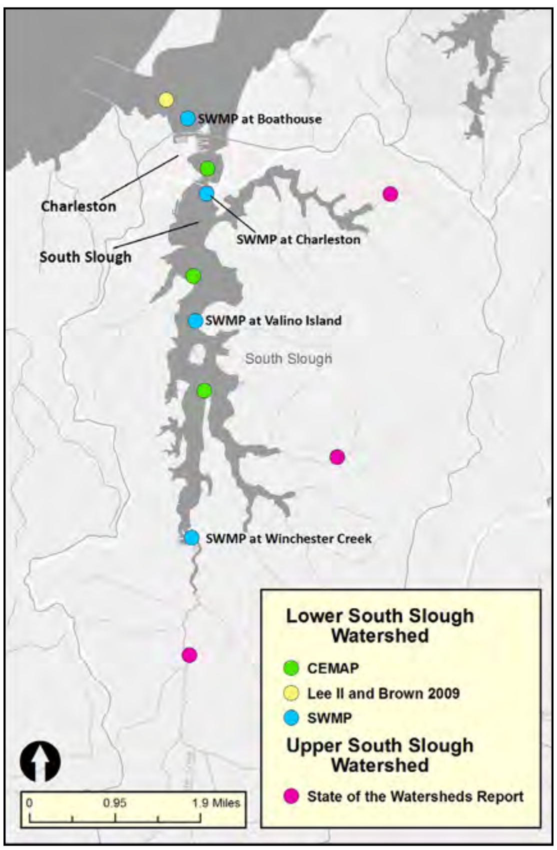



Figure 3. South Slough water column nutrients study sites. CEMAP refers to data from Sigmon et al. 2006. State of Watersheds Report refers to Cornu et al. 2012.

Figure 4. SSNERR staff member deploying a water quality data sonde at the Charleston SWMP station.

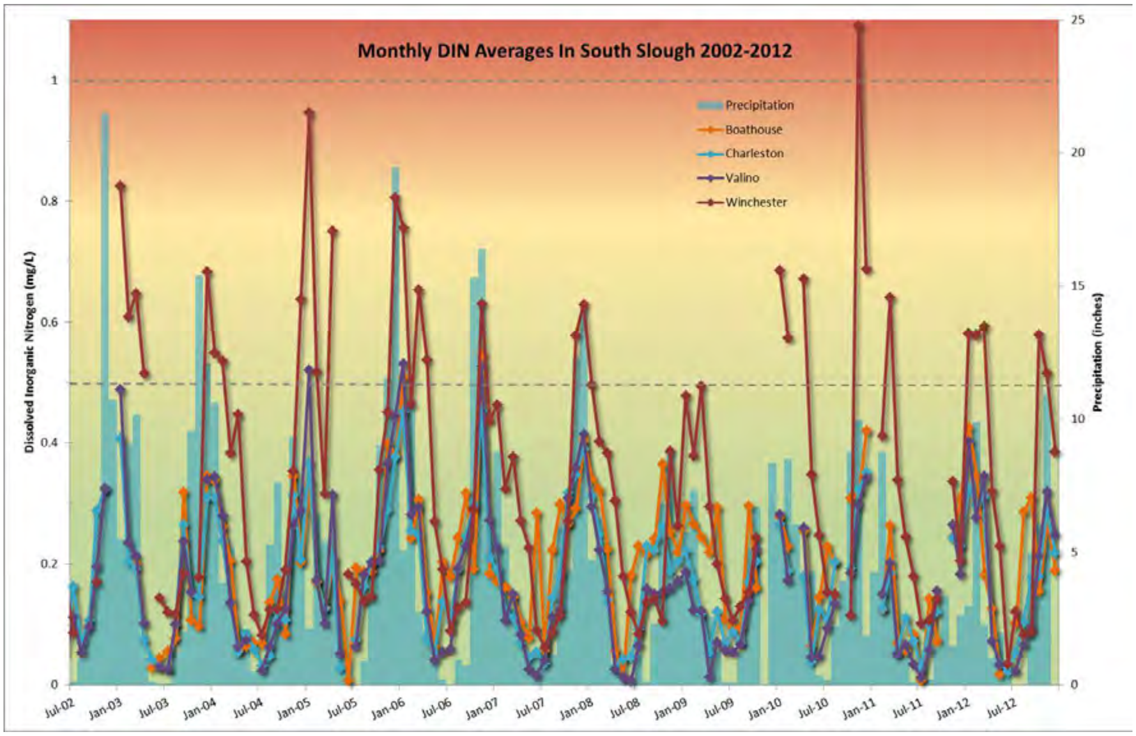



Figure 5. Average monthly DIN at South Slough sites (SWMP stations) 2002-2012. The horizontal dashed lines represent USEPA's water quality criteria. Values below 0.5 mg/L (in green area) indicate good condition, while values above 1.0 mg/L (red area) indicate poor condition. The legend is in order of decreasing salinity from Boathouse (marine) to Winchester (freshwater) sites. Data from SWMP 2012

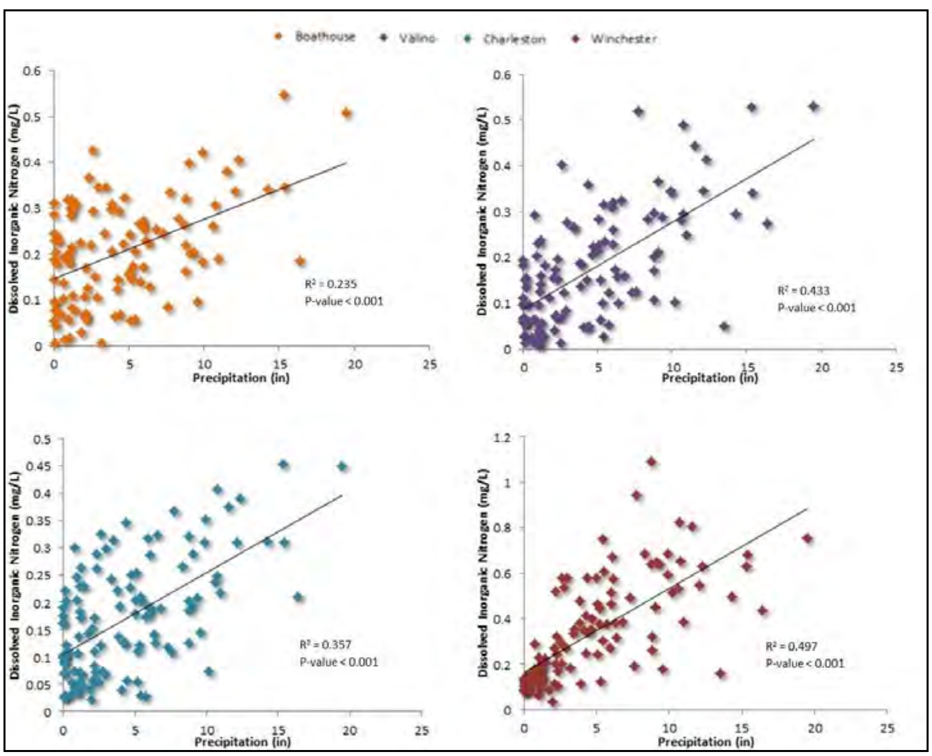



Figure 6. Regression plots of precipitation and DIN at each of the four nutrient sites in the South Slough. $R^2$ and p-values shown. Data: SWMP 2012

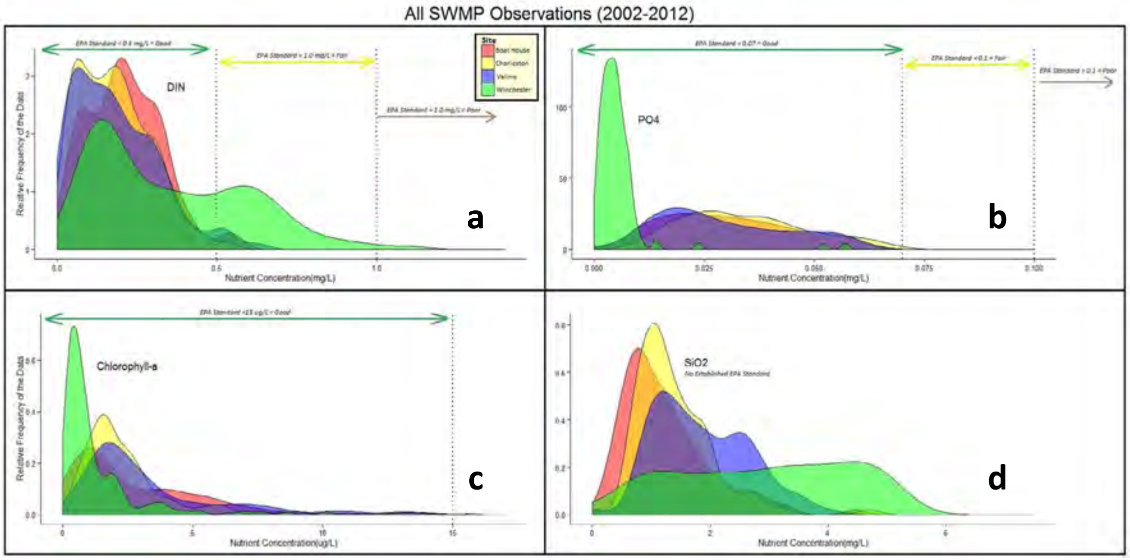



Figure 7. Density estimates describing the mean and variance of total dissolved nutrients at SWMP nutrient sampling sites during 2002-2012. Graph A: DIN; B: $PO_4$; C: CHL*a*: D: SiO2. Sites listed in order of most marine (Boat House) to most freshwater (Winchester) sites. Density functions with higher mean values have peaks shifted further to the right; functions with more variance are wider.

ODEQ collected nutrient data at three South Slough sites in 1999, 2001, and 2004 (Figure 8a). Similar to the SWMP data, ODEQ's results indicate that average summertime DIN concentrations in South Slough clearly meet USEPA's "good" water quality benchmark. Of the three South Slough sites, the highest DIN concentrations were observed the Boathouse marine/polyhaline site (Figure 8b). Because these observations were made during the dry season, they represent South Slough DIN during a time when freshwater inputs are least influential (Sigmon et al. 2006).

<u>Phosphorus</u>

South Slough orthophosphate ($PO_4$) concentrations are high in the dry season and low during the rainy season (Figure 9). $PO_4$ in the riverine/freshwater zone (Winchester monitoring station) are consistently lower than concentrations in marine/polyhaline sites (Figures 9 and 7b). Maximum $PO_4$ concentrations at all sites met USEPA's "good" water quality benchmark (< 0.07 mg/L). However, $PO_4$ concentrations at the Boathouse station met the "fair" benchmark ( > 0.07 mg/L) once during 2002-2012 (USEPA 2012).

The ODEQ data from 1999 and 2001 at South Slough also show $PO_4$ concentrations regularly met USEPA standards (Figure 8c)(Sigmon et al. 2006).

<u>Silica</u>

Silica concentrations display seasonal patterns that vary across South Slough's salinity gradient. At the marine/polyhaline sampling sites, silica concentrations decreased during the dry season and peaked during the rainy season. The pattern is reversed at the riverine/freshwater sampling site, with silica concentrations cresting during the dry season and falling in the wet season (Figure 10). The variability of

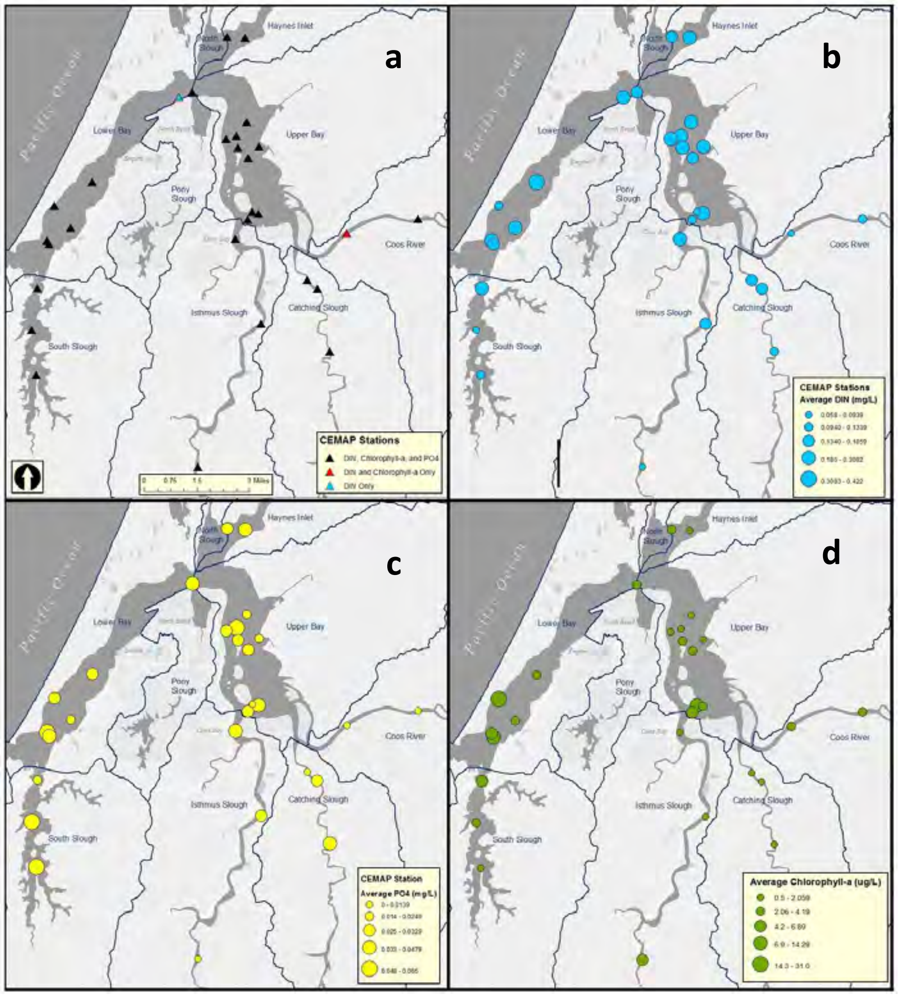



Figure 8. Site location map of CEMAP sampling stations (A) and average DIN (B), $PO_4$ (C), and chlorophyll *a* (D) during 1999, 2001, 2004. South Slough sites are mapped along with stations in the Lower Bay, Upper Bay, Haynes Inlet, Isthmus Slough, Catching Slough, and Coos River Subsystems. No data are available for the Pony Slough and North Slough Subsystems. Data from the CEMAP program by ODEQ, retrieved from: http://deq12.deq.state.or.us/lasar2/

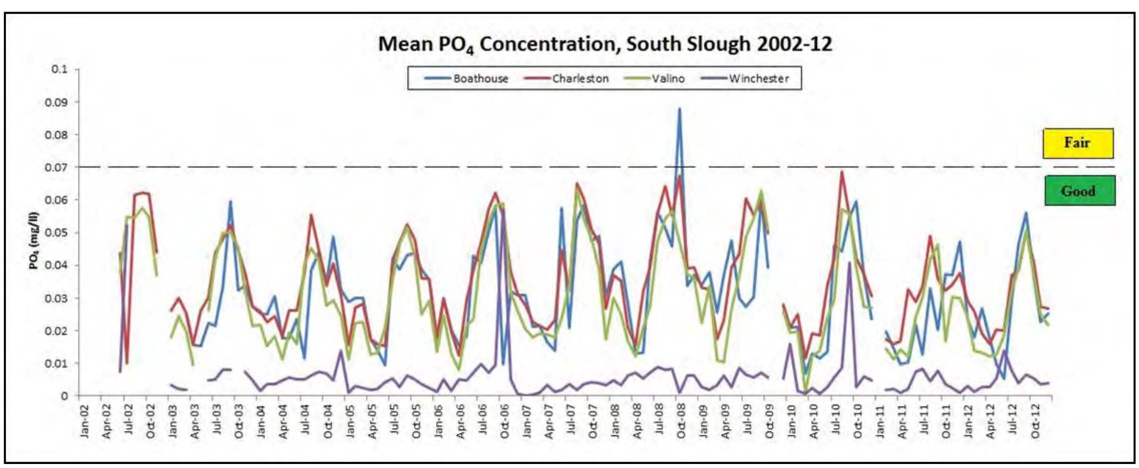



Figure 9. Average monthly $PO_4$ levels at South Slough sites (SWMP stations) during 2002-2012. Dashed lines represent USEPA's criteria. Values below 0.7 mg/L (green) are considered good. The legend lists sites in order of marine to fresh. Data: SWMP 2012

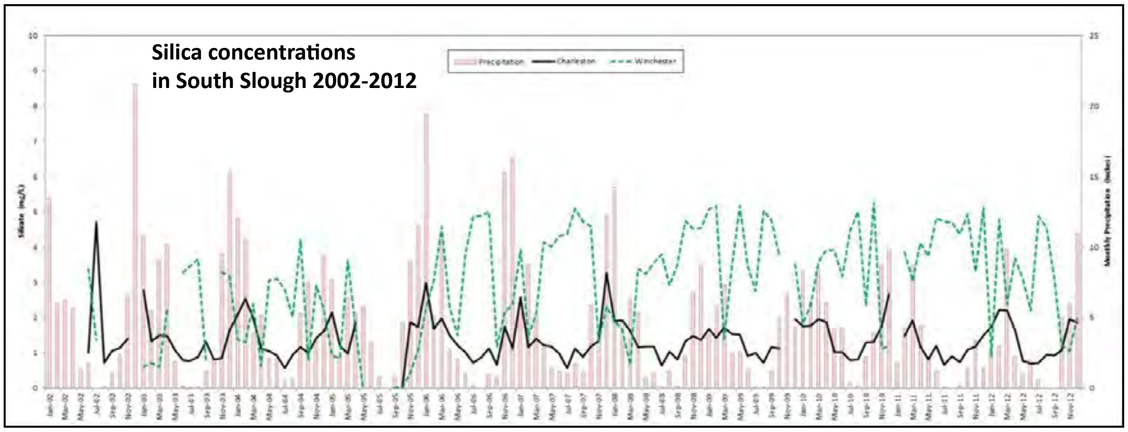



Figure 10. Seasonal patterns in silica concentrations in the marine/polyhaline zone (black) and the riverine/freshwater zone (green) of the South Slough plotted against precipitation (red). Nutrient data: SWMP 2012; Precipitation data: NWS 2014.

silica concentrations is also a function of salinity, with riverine/freshwater sites fluctuating less than marine/polyhaline sites (Figure 7c).

<u>Chlorophyll *a*</u>

South Slough chlorophyll *a* concentrations peak in late-spring and summer (Figure 11) (SWMP 2012). The concentrations are generally below the Oregon estuarine water quality criteria standard (15 µg/L) except for a few seasonal peaks at Valino Island and Winchester Creek in 2006 and the Boathouse station in 2007.

Chlorophyll *a* concentrations are relatively uniform throughout South Slough's salinity gradient, with the exception of higher variance and a slightly higher mean concentration at the Winchester station in the riverine/freshwater zone (Figure 7d).

<u>Upper South Slough Watershed Nutrients</u>

The Partnership for Coastal Watersheds' State of the Watersheds assessment (Cornu et al. 2012) recorded variable nutrient concentrations in South Slough's upper watershed streams from September 2010 to January 2012 (see sampling site locations in Figure 3).

Nutrients in South Slough's upper watershed are well correlated with precipitation (Cornu et al. 2012). Concentrations of phosphate, ammonium, and silica increased during periods of low rainfall, and declined during the rainy season. Other nutrients, such as nitrate and nitrite, followed the opposite pattern (Figure 12).

Nitrate concentrations in South Slough's upper watershed met ODEQ standards (1.0 mg/L) but did not meet the USEPA's recommended 0.09 mg/L benchmark during the rainy season at Winchester Creek.

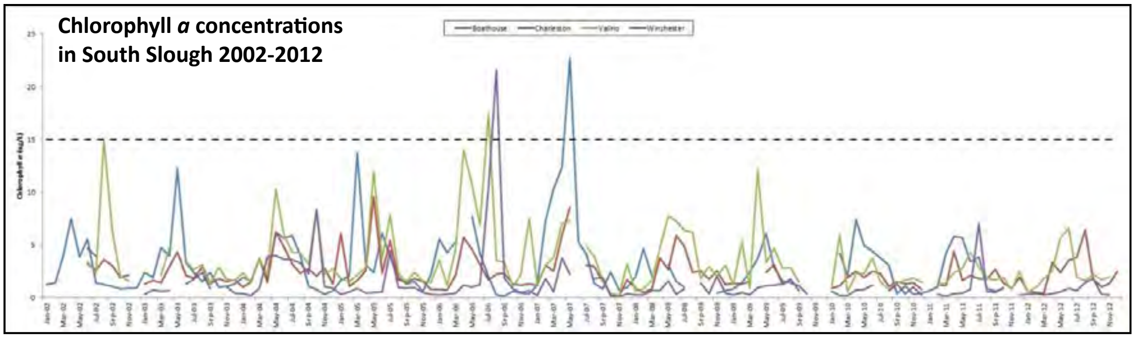



Figure 11. Average monthly chlorophyll *a* levels at South Slough sites (SWMP stations) during 2002-2012. Dashed lines represent Oregon estuarine water quality standards. Values below 15 µg/L are considered good. The legend lists sites in order of marine to fresh: Boathouse (blue), Charleston (red), Valino (yellow), Winchester (purple).
Data: SWMP 2012; Water quality standards: Brown et al. 2007.

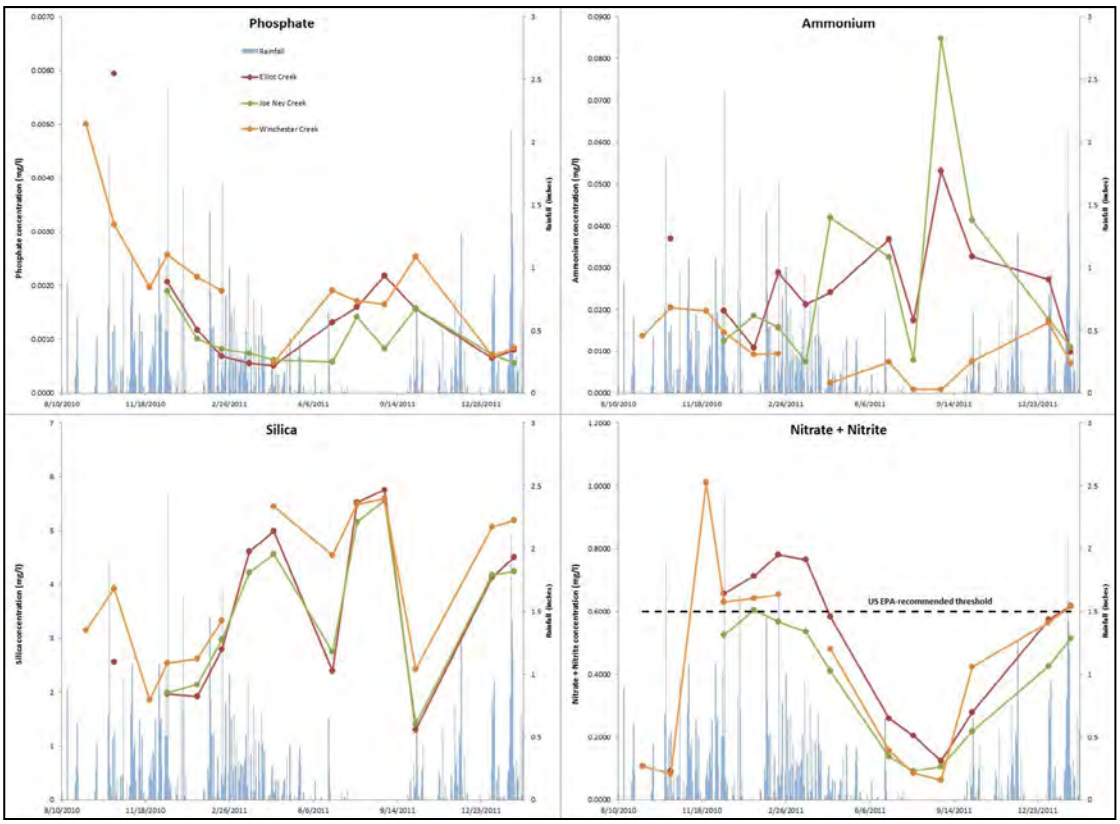



Figure 12. Monthly ammonium levels for upper South Slough watershed streams (September 2010 - February 2012). Rainfall (blue), Elliot Creek site (red), Joe Ney Creek site (green), Winchester Creek site (yellow). Graphic: Cornu et al. 2012.

Statistical Analysis of South Slough SWMP Water Column Nutrient Data

Statistical analysis of four years of SWMP nutrients data (2002-2006) by O'Higgins and Rumrill (2007) showed that of the four West Coast NERRS (Padilla, WA, South Slough, OR, Elkhorn Slough, CA, and Tijuana, CA), South Slough showed least evidence of human-generated nutrient concentrations.

Linear regressions of nitrogen concentrations in South Slough with salinity indicated strong seasonal patterns. Freshwater inflows were the primary nitrogen source during the rainy season, but marine nitrogen sources were increasingly important in the dry season. O'Higgins and Rumrill note that seasonal nitrogen patterns were particularly apparent in South Slough due to the high spatial variability in salinity.

They also concluded that seasonal phosphorus patterns in South Slough were less pronounced than the nitrogen patterns. Marine phosphorus sources were dominant during the rainy season whereas freshwater was the primary phosphorus source during the dry season. They suggest that this anomalous pattern may be due to localized human-generated phosphorus sources from the town of Charleston.

O'Higgins and Rumrill's research further suggested that the relationship between chlorophyll *a* and other nutrient concentrations is statistically significant. For example, increases in DIN were correlated with increases in chlorophyll *a*. The same is true of $PO_4$ and chlorophyll *a* at Winchester Creek (riverine/freshwater zone).

With the benefit of six additional years of South Slough nutrients data, we evaluated 10 total years of data using a technique known as "dummy variable regression" (Table 2) to determine the statistical significance of seasonal nutrient concentration patterns in South Slough. Nitrogen, phosphorous, silica, and chlorophyll *a* concentrations for each month were compared with January nutrient concentrations (which served as rainy season reference values) for each year to identify any statistically significant differences ($p < 0.05$). To control for serial correlation, the data were lagged by one year.

There was strong statistical evidence that nitrogen is highest in January at both riverine/freshwater and marine/brackish sampling sites (Table 2). Dry season phosphorous concentrations are statistically higher than wet season concentrations at marine/brackish sites, but this difference is not observed at riverine/freshwater sites. During the dry season, silica concentrations experience a statistically significant decrease at marine sites and a significant increase at freshwater sites. However, the evidence supporting this conclusion is somewhat weak because it requires a generous interpretation of the "dry season" at marine sites (April – November) and a conservative definition (exclusively August) at freshwater sites. Dry season peaks in chlorophyll *a* are statistically significant at both riverine/freshwater and marine/brackish sampling sites.

| Zone | Nitrogen: Month | Direction of Relationship | p Value | ♦ Significant Diff. (95% Conf.) | Phosphorus: Month | Direction of Relationship | p Value | ♦ Significant Diff. (95% Conf.) |
|---|---|---|---|---|---|---|---|---|
| Boathouse-Marine Zone | February | Negative | > 0.01 | ♦ | February | Positive | 0.96 | |
| | March | Negative | > 0.01 | ♦ | March | Negative | 0.36 | |
| | April | Negative | > 0.001 | ♦ | April | Negative | 0.08 | |
| | May | Negative | > 0.001 | ♦ | May | Negative | 0.10 | |
| | June | Negative | > 0.001 | ♦ | June | Positive | 0.84 | |
| | July | Negative | > 0.001 | ♦ | July | Positive | 0.61 | |
| | August | Negative | > 0.001 | ♦ | August | Positive | 0.02 | ♦ |
| | September | Negative | > 0.01 | ♦ | September | Positive | > 0.001 | ♦ |
| | October | Negative | 0.16 | | October | Positive | > 0.01 | ♦ |
| | November | Positive | 0.80 | | November | Positive | 0.08 | |
| | December | Positive | 0.99 | | December | Positive | 0.75 | |
| Winchester-Riverine/Brackish Zone | February | Negative | 0.07 | | February | Negative | 0.63 | |
| | March | Negative | 0.04 | ♦ | March | Negative | 0.65 | |
| | April | Negative | 0.04 | ♦ | April | Negative | 0.92 | |
| | May | Negative | > 0.001 | ♦ | May | Negative | 0.82 | |
| | June | Negative | > 0.001 | ♦ | June | Positive | 0.52 | |
| | July | Negative | > 0.001 | ♦ | July | Positive | 0.06 | |
| | August | Negative | > 0.001 | ♦ | August | Positive | 0.67 | |
| | September | Negative | > 0.001 | ♦ | September | Positive | 0.08 | |
| | October | Negative | > 0.001 | ♦ | October | Positive | 0.11 | |
| | November | Negative | > 0.01 | ♦ | November | Positive | 0.87 | |
| | December | Negative | 0.76 | | December | Positive | 0.89 | |

| Zone | Silica: Month | Direction of Relationship | p Value | ♦ Significant Diff. (95% Conf.) | Chorophyll a: Month | Direction of Relationship | p Value | ♦ Significant Diff. (95% Conf.) |
|---|---|---|---|---|---|---|---|---|
| Boathouse-Marine Zone | February | Negative | 0.07 | | February | Positive | 0.76 | |
| | March | Negative | 0.06 | | March | Positive | 0.32 | |
| | April | Negative | 0.04 | ♦ | April | Positive | 0.05 | |
| | May | Negative | > 0.001 | ♦ | May | Positive | > 0.001 | ♦ |
| | June | Negative | > 0.01 | ♦ | June | Positive | > 0.01 | ♦ |
| | July | Negative | > 0.001 | ♦ | July | Positive | > 0.001 | ♦ |
| | August | Negative | > 0.001 | ♦ | August | Positive | > 0.001 | ♦ |
| | September | Negative | > 0.001 | ♦ | September | Positive | 0.08 | |
| | October | Negative | > 0.01 | ♦ | October | Positive | 0.40 | |
| | November | Negative | 0.03 | ♦ | November | Positive | 0.75 | |
| | December | Negative | 0.34 | | December | Positive | 0.73 | |
| Winchester-Riverine/Brackish Zone | February | Negative | 0.99 | | February | Positive | 0.83 | |
| | March | Positive | 0.86 | | March | Positive | 0.84 | |
| | April | Positive | 0.43 | | April | Positive | 0.34 | |
| | May | Positive | 0.21 | | May | Positive | 0.39 | |
| | June | Positive | 0.06 | | June | Positive | 0.24 | |
| | July | Positive | 0.06 | | July | Positive | > 0.01 | ♦ |
| | August | Positive | > 0.01 | ♦ | August | Positive | > 0.01 | ♦ |
| | September | Positive | 0.13 | | September | Positive | 0.39 | |
| | October | Positive | 0.14 | | October | Positive | 0.27 | |
| | November | Positive | 0.93 | | November | Positive | 0.73 | |
| | December | Positive | 0.41 | | December | Positive | 0.92 | |

Table 2. Seasonal trends in South Slough nutrient dynamics in the marine zone (blue) and the riverine/brackish zone (red). Significant differences are indicated by the black diamonds. Data: SWMP 2012 .

## Nutrients in Coos estuary Subsystems: Lower Bay, Upper Bay, Haynes Inlet, and Catching Slough

### Nitrogen

DIN concentrations were measured by ODEQ staff at USEPA's Coastal Environmental Monitoring and Assessment Program (CEMAP) sites in Lower Bay, Upper Bay, Haynes Inlet, and Catching Slough subsystems during the dry seasons of 1999-2006 (Figure 13). The resulting average DIN concentrations met USEPA standards for "good" water quality (Figure 14)(Sigmon et al. 2006).

### Phosphorus

The mean $PO_4$ concentrations at CEMAP sites in the same subsystems also met USEPA standards for "good" water quality (< 0.07 mg/L) (Sigmon et al. 2006; USEPA 2012)(Figure 14).

The highest mean $PO_4$ concentrations were recorded in the Upper Bay subsystem near downtown Coos Bay, Haynes Inlet and at the southern end of the Lower Bay (Figure 8c).

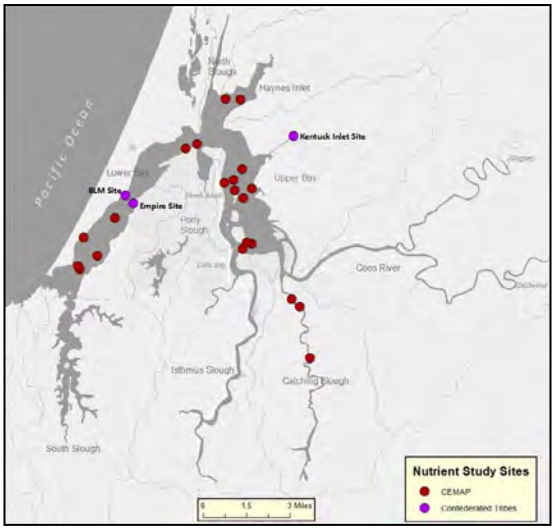



Figure 13. Site location map of CEMAP sampling stations in the Lower Bay, Upper Bay, Haynes Inlet, and Catching Slough subsystems. Source: Sigmon et al. 2006; CTCLUSI 2010, 2012, 2013, 2014

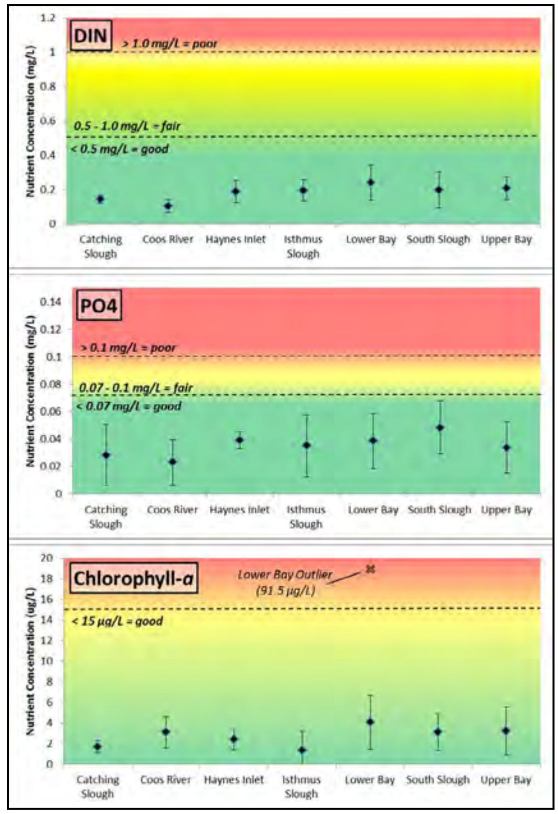



Figure 14. Average total DIN, $PO_4$, and chlorophyll *a* at CEMAP stations (1999-2006). Symbols represent sampling sites averaged within each subsystem. Error bars define ±1 standard deviation. Lower values (green background) represent healthier levels than higher values (red background). Data from the CEMAP program by ODEQ, retrieved from: http://deq12.deq.state.or.us/lasar2/

<u>Chlorophyll *a*</u>

All CEMAP sites in the Lower Bay, Upper Bay, and Haynes Inlet subsystems met the USEPA standards ( < 15 µg/L) for chlorophyll *a* (Sigmon et al. 2006; Brown et al. 2007)(Figure 14). Chlorophyll *a* concentrations were highest near the mouth of the estuary in the Lower Bay subsystem and near downtown Coos Bay in the Upper Bay subsystem (Figure 8d).

It should be noted that CEMAP data were only collected during the dry season when $PO_4$ concentrations are typically the highest, DIN concentrations are the lowest, and chlorophyll *a* concentrations are the highest in the riverine/brackish water zone and the lowest in the marine zone. Wet season data are needed to more fully characterize nutrient concentrations in Coos estuary subsystems.

Phosphorus, nitrogen, and chlorophyll *a* concentrations were sampled (also during the dry season only) in the Upper and Lower Bay subsystems by the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI) at three stations (Figure 13).

Their data indicate consistently elevated concentrations of nitrogen at the Kentuck Slough station in the Upper Bay subsystem (Table 3) (CTCLUSI 2010). The Kentuck sampling site is downstream from agricultural lands and

| Date | Site | Phosphorus mg/L | Nitrogen mg/L | Chlorophyll ug/l |
|---|---|---|---|---|
| May-2007 | BLM | 0.035 | 0.285 | |
| Jun-2008 | BLM | 0.07 | 0.4 | |
| Jun-2009 | BLM | 0.035 | 0.275 | |
| Sep-2011 | BLM | [illegible] | 0.3741 | |
| Sep-2012 | BLM | 0.0023 | 0.0269 | 1.8 |
| May-2013 | BLM | 0.0472 | 0.2706 | 2.8 |
| Sep-2013 | BLM | 0.1085 | 0.3404 | 2.4 |
| May-2007 | Kentuck | 0.05 | 1.38 | |
| Jun-2008 | Kentuck | [illegible] | 1.73 | |
| Jun-2009 | Kentuck | 0.045 | 1.28 | |
| Sep-2011 | Kentuck | 0.0505 | 0.5692 | |
| Sep-2012 | Empire | 0.0022 | 0.026 | 1.3 |
| May-2013 | Empire | 0.0488 | 0.2643 | 3.5 |
| Sep-2013 | Empire | [illegible] | 0.3164 | 1.7 |

Table 3: Nutrient concentrations at each of three CTCLUSI sampling stations. The BLM and Empire stations are in the Lower Bay; Kentuck is about one mile up Kentuck Slough, adjoining the Upper Bay subsystem. Shaded bars indicate relative nutrient concentrations. Numbers in orange represent values in the "fair" health range (0.07-0.1 for phosphorus; 0.5-1.0 for nitrogen). Numbers in red indicate values that exceed criteria for healthy waters (>0.1 for phosphorus; > 1.0 for nitrogen; >15 for chlorophyll *a*). Data from: CTCLUSI 2010, 2012, 2012, 2013, 2014.

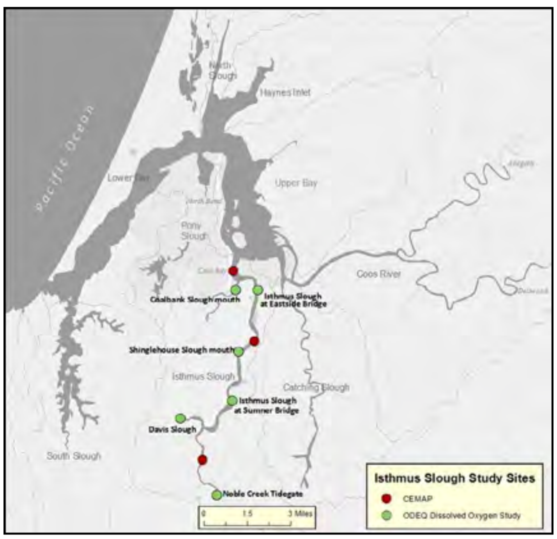



Figure 15. Isthmus Slough site location map. Source: ODEQ 2007; Sigmon et al. 2006)

directly adjacent to a golf course, which may explain the high nitrogen concentrations there. Nutrient sampling at this site was discontinued in 2012, and a new site in the Lower Bay subsystem was established (Figure 13 "Empire Station"). Further investigation is needed to help understand the elevated phosphorus concentrations at the Empire Station in the 2013 sampling season.

**Nutrients in Coos estuary Subsystems: Isthmus Slough**

Nitrogen

For a ODEQ (2007) dissolved oxygen (DO) study in Isthmus Slough, scientists sampled nitrogen (DIN), phosphorus, and silica among a larger suite of water quality parameters at six ODEQ sites (Figure 15, Table 4).

Except for the most upstream site at the Noble Creek tide gate (in the riverine/brackish water zone), average annual DIN concentrations met USEPA standards (<0.5 mg/L)(USEPA 2012)(Figure 16). As expected, monthly mean DIN concentrations for all sites were low in the dry season and high during the rainy season and mostly remained between USEPA's "good" and "poor" water quality standards (Figure 16).

In contrast to the ODEQ DO study, CEMAP dry season data (2001 and 2005) at three Isthmus Slough stations (Figure 15) indi-

| Sample Date | Coalbank Slough Mouth: Nitrate/nitrite as N (mg/L) | Silicon as $SiO_2$ (mg/L) | Total Phosphorus (mg/L) | Chlorophyll *a* (µg/L) | Isthmus Slough at Eastside Bridge: Nitrate/nitrite as N (mg/L) | Silicon as $SiO_2$ (mg/L) | Total Phosphorus (mg/L) | Chlorophyll *a* (µg/L) | Shinglehouse Slough Mouth: Nitrate/nitrite as N (mg/L) | Silicon as $SiO_2$ (mg/L) | Total Phosphorus (mg/L) | Chlorophyll *a* (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **April 5, 2006** | 0.254 | 7.1 | 0.03 | 0.8 | 0.254 | 6.5 | 0.03 | 0.8 | **0.315** | 8.2 | 0.03 | 1.15 |
| **April 25, 2006** | 0.235 | <7.5 | 0.03 | 1.2 | 0.186 | <7.5 | 0.03 | 2.2 | | | | |
| May 9, 2006 | 0.0612 | <7.5 | 0.03 | 6.3 | 0.0521 | <7.5 | 0.03 | 6.8 | | | | |
| May 31,2006 | 0.0566 | <6.0 | 0.03 | 2.3 | 0.0447 | <6.0 | 0.04 | 2.25 | 0.0632 | <6.0 | 0.04 | 2.45 |
| June 13,2006 | 0.0634 | 4.9 | | 2.6 | 0.0387 | <4.5 | | 2.2 | 0.0237 | <4.5 | | 1.8 |
| June 27, 2006 | 0.0249 | <6.0 | 0.05 | 6.5 | 0.03 | <6.0 | 0.04 | 5.9 | | | | |
| July 11,2006 | 0.043 | <6.0 | **0.07** | 2.9 | 0.0377 | <6.0 | 0.05 | 4.1 | | <6.0 | | 2.2 |
| July 25, 2006 | | | | | 0.0503 | <6.0 | 0.05 | 4 | | | | |
| July 26,2006 | | | | | 0.0387 | <6.0 | 0.05 | 3.4 | | | | |
| July 28, 2006 | 0.0385 | <6.0 | **0.06** | 3.4 | 0.044 | <6.0 | 0.05 | 2.9 | | | | |
| August 8,2006 | 0.0219 | <6.0 | 0.05 | 3.1 | 0.0222 | <6.0 | **0.06** | 1.9 | 0.0229 | <6.0 | 0.06 | 2.6 |
| August 28,2006 | 0.0873 | <6.0 | 0.05 | 3.3 | 0.0917 | <6.0 | **0.06** | 3.3 | | | | |
| September 5,2006 | 0.0739 | <6.0 | 0.05 | 5.1 | 0.0804 | <6.0 | **0.06** | 4.5 | | | | |
| September 19, 2006 | 0.114 | <7.5 | 0.04 | 5.3 | 0.14 | <7.5 | 0.05 | 4 | 0.132 | <7.5 | 0.04 | 2.8 |
| October 10, 2006 | | <7.5 | | 1.9 | | <7.5 | | 2.5 | | <7.5 | | 2.1 |
| October 11, 2006 | | | | | | <7.5 | | 2.5 | | | | |
| October 24, 2006 | 0.102 | <7.5 | 0.05 | 2.7 | 0.103 | <7.5 | 0.05 | 2.6 | | | | |
| **November 7, 2006** | **0.342** | <7.5 | 0.05 | | **0.343** | <7.5 | **0.06** | | | | | |
| **November 29, 2006** | **0.548** | 10.6 | 0.03 | | **0.548** | 10 | 0.03 | | **0.53** | 9.4 | 0.03 | |
| **December 19, 2006** | **0.526** | <7.5 | 0.04 | | **0.427** | <7.5 | 0.05 | | **0.526** | 8.2 | 0.03 | |
| **January 9, 2007** | **0.632** | 12.9 | 0.03 | | **0.56** | 10.5 | 0.04 | | | | | |
| **January 24, 2007** | **0.375** | 12.3 | 0.04 | | **0.366** | 10.2 | 0.04 | | **0.421** | 10.5 | 0.04 | |
| **February 12, 2007** | 0.173 | <7.5 | 0.03 | | 0.178 | <7.5 | 0.03 | | | | | |
| **February 21, 2007** | **0.396** | 9.2 | 0.03 | | **0.352** | 7.8 | 0.04 | | **0.383** | 8.9 | 0.04 | |
| **March 7, 2007** | **0.483** | 10.8 | 0.03 | | **0.468** | 10.6 | 0.03 | | | | | |
| **March 20, 2007** | 0.279 | 9.3 | 0.05 | | 0.237 | <7.5 | 0.04 | | 0.245 | 8 | 0.04 | |

| Sample Date | Isthmus Slough at Sumner Bridge: Nitrate/nitrite as N (mg/L) | Silicon as SiO2 (mg/L) | Total Phosphorus (mg/L) | Chlorophyll *a* (µg/L) | Davis Slough: Nitrate/nitrite as N (mg/L) | Silicon as SiO2 (mg/L) | Total Phosphorus (mg/L) | Chlorophyll *a* (µg/L) | Noble Creek Tidegate: Nitrate/nitrite as N (mg/L) | Silicon as SiO2 (mg/L) | Total Phosphorus (mg/L) | Chlorophyll *a* (µg/L) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **April 5, 2006** | **0.351** | 9.1 | 0.03 | 1.6 | **0.402** | 10.4 | 0.03 | | **0.647** | 16.8 | 0.05 | 1.4 |
| **April 25, 2006** | 0.227 | <7.5 | 0.03 | 2.7 | | | | | | | | |
| May 9, 2006 | 0.0666 | <7.5 | 0.03 | 2.9 | | | | | | | | |
| May 31,2006 | 0.0552 | <6.0 | 0.04 | 3.8 | 0.058 | <6.0 | 0.04 | 3.3 | 0.246 | 17 | 0.06 | 3.9 |
| June 13,2006 | 0.0186 | <4.5 | | 1.5 | 0.0198 | <4.5 | | 2.5 | | | | |
| June 27, 2006 | 0.012 | <6.0 | 0.04 | 4.6 | | | | | | | | |
| July 11,2006 | | <6.0 | | 2.8 | 0.0264 | <6.0 | 0.05 | 3.1 | 0.0136 | <6.0 | 0.04 | 4.1 |
| July 25, 2006 | | | | | | | | | | | | |
| July 26,2006 | | | | | | | | | | | | |
| July 28, 2006 | 0.0139 | <6.0 | 0.05 | 4.5 | | | | | | | | |
| August 8,2006 | 0.0197 | <6.0 | 0.04 | 3.2 | 0.0186 | <6.0 | 0.04 | 2.6 | | | | |
| August 28,2006 | 0.0567 | <6.0 | 0.05 | 5.9 | | | | | | | | |
| September 5,2006 | 0.044 | <6.0 | 0.04 | 5.3 | | | | | | | | |
| September 19, 2006 | 0.126 | <7.5 | 0.03 | 2.2 | 0.102 | <7.5 | 0.04 | 2.1 | 0.0721 | 9.1 | 0.05 | 4.7 |
| October 10, 2006 | | <7.5 | | 1.8 | | <7.5 | | 2.1 | | <7.5 | | 2.1 |
| October 11, 2006 | | | | | | | | | | | | |
| October 24, 2006 | 0.108 | <7.5 | 0.03 | 2.5 | | | | | | | | |
| **November 7, 2006** | **0.413** | <7.5 | 0.05 | | | | | | | | | |
| **November 29, 2006** | **0.629** | 15.6 | 0.04 | | **0.675** | 13.1 | 0.04 | | **1.13** | 17.2 | 0.03 | |
| **December 19, 2006** | **0.704** | 11.9 | 0.04 | | **0.748** | 11.6 | 0.03 | | **1.12** | 17.6 | 0.03 | |
| **January 9, 2007** | **0.732** | 13 | 0.04 | | | | | | | | | |
| **January 24, 2007** | **0.499** | 11.7 | 0.03 | | **0.586** | 12.7 | 0.03 | | **0.861** | 18.8 | 0.04 | |
| **February 12, 2007** | 0.205 | 8.1 | 0.03 | | | | | | | | | |
| **February 21, 2007** | **0.363** | 8.5 | 0.04 | | | | | | | | | |
| **March 7, 2007** | **0.701** | 13.4 | 0.05 | | **0.35** | 9.2 | 0.04 | | **0.782** | 17.5 | 0.04 | |
| **March 20, 2007** | 0.269 | 7.8 | 0.05 | | **0.307** | 8.4 | 0.03 | | **0.494** | 15.1 | 0.06 | |

| Key: Color Gradient Based on Cell Value. More Color (Longer Color Bar) Corresponds to Higher Values. | Parameter |
|---|---|
| (purple bar) | Nitrate/nitrite as N (mg/L) |
| (blue bar) | Dissolved Silicon as SiO2 (mg/L) |
| (orange bar) | Total Phosphorus (mg/L) |
| (green bar) | Cholorphyll *a* (µg/L) |

Table 4. All values for nutrients sampled during ODEQ's Isthmus Slough/South Fork Coos River DO Study. Values in bold red font indicate values that exceeded the Oregon Watershed Enhancement Board (OWEB) recommended evaluation criteria for total nitrates or total phosphorus. Dates in bold black font indicate wet season sample events. Data: ODEQ 2007

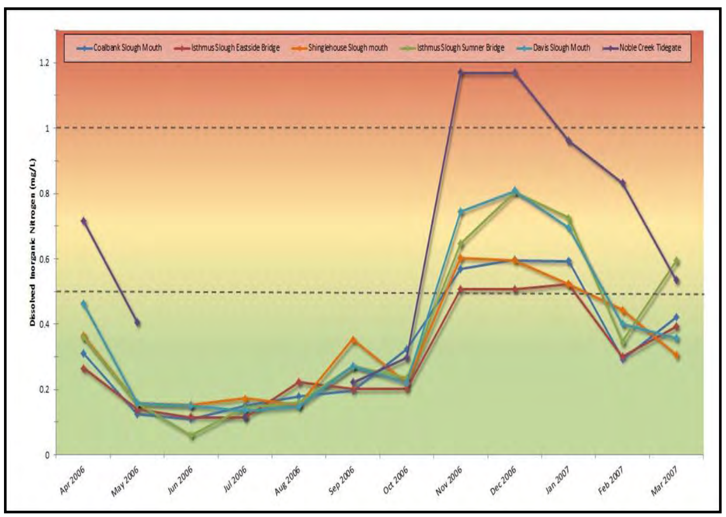



Figure 16. Average monthly DIN at all Isthmus Slough sites (2006-2007). Dashed lines represent USEPA's criteria with values below 0.5 mg/L (green) considered good and values above 1.0 mg/L (red) considered poor water quality. The legend lists sites in order of marine to fresh (left to right). Data: ODEQ 2007

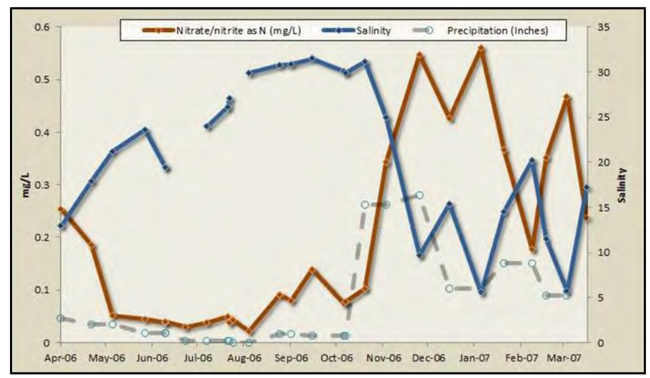



Figure 17. Seasonal variation of nitrate/nitrite and salinity for the Isthmus Slough at the Eastside Bridge site (2006-2007). The data exhibit a strong negative correlation between salinity and nitrate/nitrite concentrations, with high seasonal salinity (blue line) peaks (dry seasons) corresponding with seasonal decreases in low nitrogen (red line) in the dry season (May-October) and low salinity (rainy season) corresponding with high nitrogen concentrations. Data: ODEQ 2007

cated low DIN concentrations at the most upstream stations and high DIN concentrations near the mouth of the slough (Sigmon et al. 2006).

This difference may reflect seasonal patterns in nitrogen sources (e.g., Figure 17) as also documented in a study of South Slough by O'Higgins and Rumrill (2007), who concluded that marine nitrogen sources become increasingly important during the dry season months. All CEMAP data in Isthmus Slough met USEPA DIN standards (< 0.5 mg/L) (USEPA 2012).

Phosphorus

ODEQ's 2007 $PO_4$ Isthmus Slough data follow the opposite seasonal pattern to nitrogen, with peak $PO_4$ concentrations mostly occurring in the dry months and lower concentrations during the rainy season (Figure 18, Table 4).

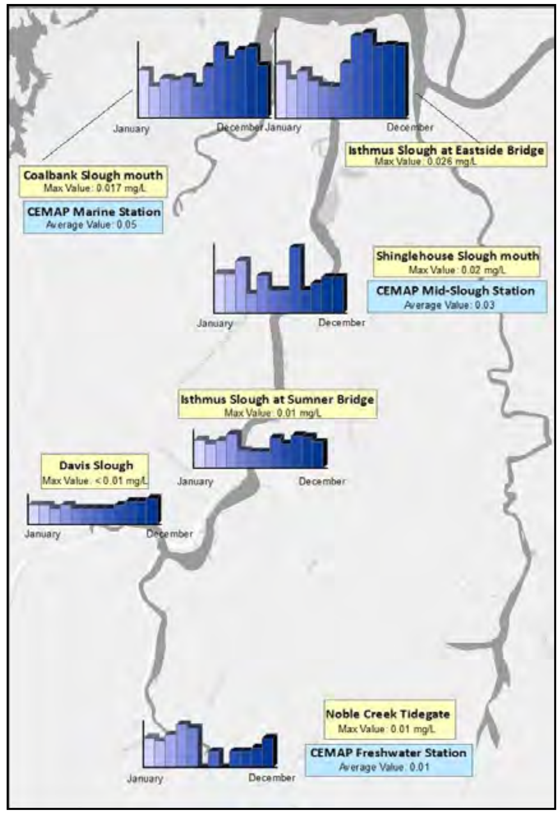



Figure 18. Location of ODEQ monitoring sites in Isthmus Slough and mean monthly $PO_4$ concentrations (April 2006 – March 2007). Omitted data bars indicate months for which there are no data. Data: ODEQ 2007

Based on one year of data, the seasonal $PO_4$ shift in Isthmus Slough is less distinct than in South Slough, particularly during the rainy season. At the freshwater Isthmus Slough sites, $PO_4$ concentrations appear to either increase or remain unchanged during the rainy season (Figure 18 , Table 4). Data from additional years could clarify the seasonal patterns.

Mean $PO_4$ concentrations at the three Isthmus Slough CEMAP monitoring stations were higher at the marine station (0.0473 mg/L) than at both the mid-slough station (0.03 mg/L) and the freshwater station (0.011 mg/L)(see blue boxes Figure 18)(Sigmon et al. 2006). Average CEMAP observations at all three Isthmus Slough sites met USEPA's "good" water quality standard (< 0.07 mg/L).

In Isthmus Slough, the relationship between salinity levels and $PO_4$ concentrations is statistically significant ($p < 0.01$) near the mouth of the slough (marine/polyhaline zone). The relationship, however, is less clear/not significant for upstream sites (riverine/freshwater zone). This suggests that the ocean is a substantial source of $PO_4$ for sites near the mouth of the slough, but less influential at upstream sites (Figure 19).

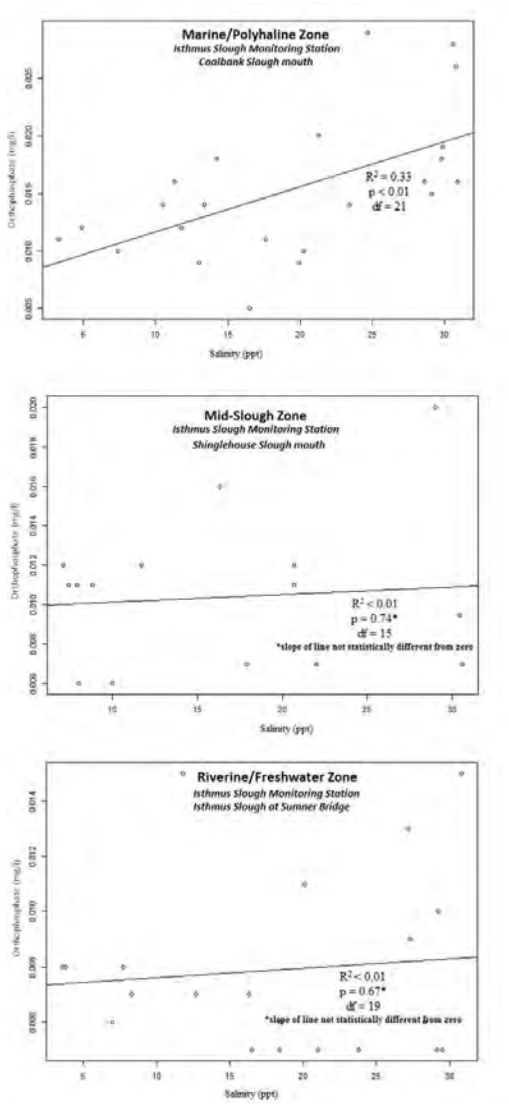


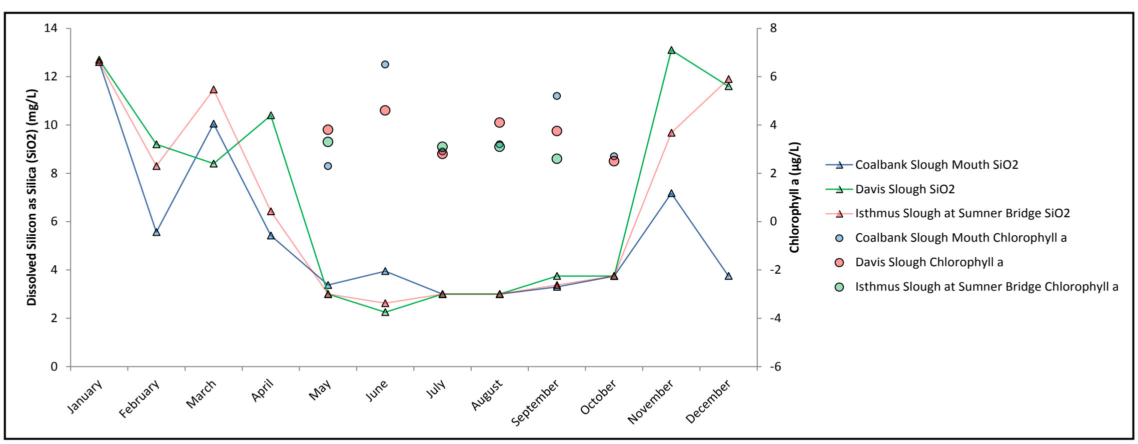

Figure 19. Relationship between $PO_4$ levels and salinity at three Isthmus Slough sites. Data: ODEQ 2007

## Chlorophyll *a*

Although ODEQ data (2007) for chlorophyll *a* in Isthmus Slough are relatively sparse, available data (and logic) suggest that chlorophyll *a* increases through summer months when chlorophyll-bearing phytoplankton are abundant in estuaries. Maximum chlorophyll *a* concentrations at all ODEQ Isthmus Slough monitoring sites were approximately 8 µg/L, well within the USEPA water quality standards ("good" < 15 µg/L)(Brown et al. 2007). Chlorophyll *a* concentrations do not seem related to a salinity gradient or proximity to the mouth of the slough.

An interesting relationship can be seen between chlorophyll *a* and silica concentrations. Periods of high phytoplankton abundance in summer months (including diatoms), correlate to greater chlorophyll *a* abundance and lower concentrations of silica, due to diatoms' silica uptake for shell formation (Figure 20).

Figure 20. Chlorophyll *a* concentrations plotted with $SiO_2$ abundance at three Coos estuary sites (2007). Data: ODEQ 2007



**Nutrients in Coos estuary Subsystems: Coos River**

<u>Nitrogen</u>

Nitrogen was monitored in the Millicoma and Coos Rivers by ODEQ from 1997-2012 (Figure 21).

For the Millicoma River sites, the seasonality of nitrogen concentrations is evident judging particularly from the one sampling site where fifteen years of data are available- the Rook Higgins boat ramp. Nitrate/nitrite concentrations were very low at all sampling sites during the dry summer months and peaked in the rainy season. Figure 22 shows the seasonal nitrate/nitrite concentration pattern from 1997-2012. At that site, peak summertime concentrations routinely exceeded USEPA's "fair" water quality standard ( > 0.5 mg/L) and occasionally exceeded USEPA's "poor" standard (> 1.0 mg/L)(USEPA 2012).

Ammonia concentrations were frequently below detectable limits on the Millicoma River (USEPA 2012).

DIN concentrations, measured on the Coos River at two CEMAP project sites (Figure 21), were very low (mean = 0.104 mg/L)(Sigmon et al. 2006).

<u>Phosphorus</u>

$PO_4$ was measured at two Coos River CEMAP sites (Figure 21) and the mean $PO_4$ concentrations (0.005 mg/L) were well within USEPA standards (< 0.07 mg/L = "good")(Sigmon et al. 2006; USEPA 2012).

ODEQ (2006, 2009) also measured $PO_4$ on

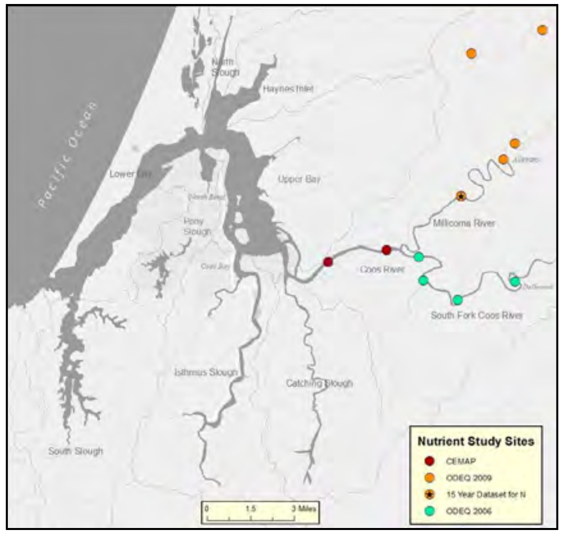



Figure 21. Coos River sampling site location map. Source: ODEQ 2006, 2009; Sigmon et al. 2006.

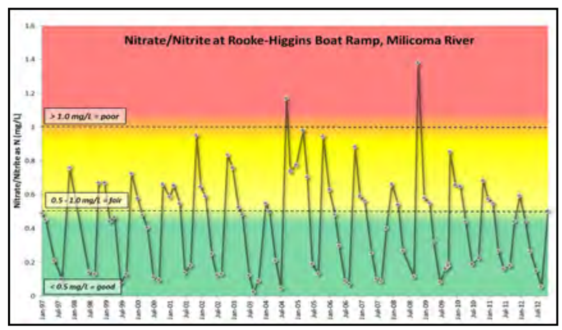



Figure 22. Seasonal variation (January/winter; July/summer) of nitrate/nitrite for the Rook Higgins boat ramp station on the Millicoma River (1997-2012). Lower values (green background) represent healthier levels than higher values (red background). Data from ODEQ, retrieved from: http://deq12.deq.state.or.us/lasar2/

both the Millicoma and South Fork Coos Rivers (Figure 21). Similar to CEMAP, these observations suggest that $PO_4$ concentrations have met USEPA standards.

<u>Silica</u>

Silica was sampled by ODEQ during two consecutive days in August 2006 for their South Fork Coos River Summer Synoptic Study (Figure 21: "ODEQ 2006" sites). Concentrations of $SiO_2$ ranged from 7.42 mg/L to 8.42 mg/L, averaging 7.95 mg/L (<6.0mg/L – <7.5mg/L) (ODEQ 2006).

Generally, Coos River silica concentrations were higher than South Slough concentrations, which were about 2 mg/L on average (Figure 10), and also higher than Isthmus Slough concentrations, which averaged approximately 6 mg/L (Figure 18).

ODEQ also sampled silica during three consecutive days in October, 2009 for the Millicoma River TMDL Dissolved Oxygen Study (Figure 21: "ODEQ 2009" sites). The concentration of $SiO_2$ in the Millicoma River during the three day sample event ranged from 2.76 mg/L to 8.38 mg/L, averaging 5.33 mg/L.

**Why is it happening?**

<u>Nitrogen</u>

Nitrogen concentrations in the Coos estuary and associated tributaries change as a result of wet season runoff from the Coos watershed. Lee II and Brown (2009) suggest that the Coos estuary's main nitrogen source is non-point source inputs from forested lands, which is common in most West Coast estuaries (Quinn et al. 1991). This helps explain the observed seasonal patterns in this summary: high nitrogen concentrations during the wet season and low concentrations during the dry season.

The relative contribution of nitrogen from upland forests is influenced by the plant communities in the riparian zone. Red alders (*Alnus rubra*), for example, are "nitrogen fixers" (plants able to convert atmospheric nitrogen into usable compounds). They store nitrogen in nodules on their roots which, in turn, enriches surrounding soils and ultimately surrounding wetlands and waterways. Riparian areas dominated by red alders can be responsible for over 80% of riverine nitrogen loading, as often occurs in Oregon Coast Range stream systems (Brown and Ozretich 2009). Low nitrogen concentrations in the Coos system indicate local riparian zones with relatively few alders or other deciduous trees (Lee II and Brown 2009).

During the dry season, ocean conditions are responsible for nitrogen contributions to the estuary. Spring and summer upwelling events, which draw nutrient-rich bottom waters to the ocean surface, elevate nitrate (and phosphate) concentrations in the estuary (see sidebar). This is particularly true near the mouth of the estuary, or "ocean-estuary interface" (Lee II and Brown 2009).

In August 2005, Lee II and Brown (2009) used a nitrogen isotope extracted from macroalgae to determine nitrogen sources at various locations in the Coos estuary (Figure 23).

Lee II and Brown found that for mid and upper bay sites in Haynes Inlet, North Bend, and Cooston Channel, roughly 90% of the nitrogen was ocean-sourced, about 10% from waste water treatment facilities or septic systems, and about 2% was river-sourced.
Similarly, ocean-sourced nitrogen dominated the nutrient profile at the Lower Bay and South Slough sites (about 85% ocean).

*Ocean Upwelling*

*Ocean upwelling is a wind-driven phenomenon that influences seasonal nutrient abundance in coastal ocean waters. Upwelling occurs when strong north winds drive surface ocean water along the coast and offshore in a process called "Ekman transport". Cold, nutrient-rich ocean water from the depths rises up to the surface to replace surface water transported by the wind.*

*Typically during the months of April through September, Oregon coast winds cause coastal upwelling events. This upwelling results in the enrichment of near-shore waters, which promotes plankton growth. Abundant plankton supports marine life which in turn supports seabirds, marine mammals, and various fisheries, including Dungeness crab, Pacific sardines, Chinook salmon, albacore tuna, and halibut.*

*Sources: Peterson et al. 2013, Iles et al. 2011, Dalton et al. 2013*

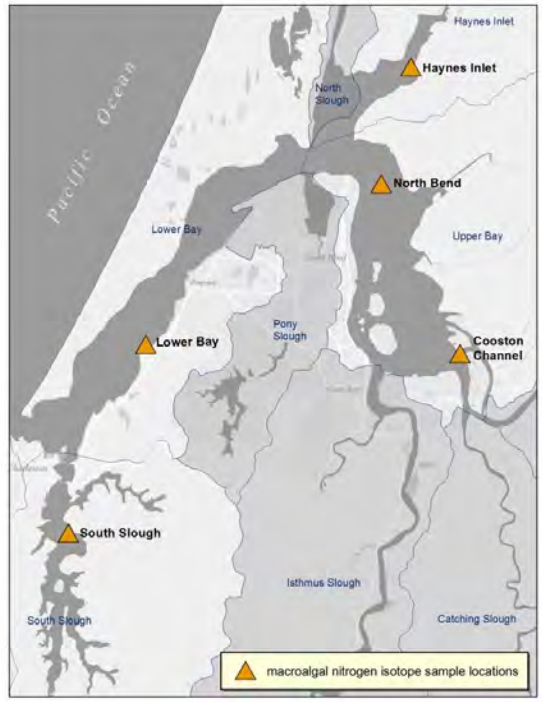



Figure 23. Station locations of macroalgae samples taken for δ15 N, an isotope used to determine nitrogen sources. Project area subsystems are named and outlined in blue. Shaded subsystems had no data from this source. Data: Lee II and Brown 2009.

## Phosphorus

As noted in the summary above, seasonal patterns of $PO_4$ concentrations in the Coos system are characterized by higher concentrations in the dry season and lower concentrations in the rainy season (opposite to nitrogen). High $PO_4$ concentrations result from ocean upwelling events (see sidebar).

Rainy season $PO_4$ concentration declines can be explained by the absence of upwelling-driven nutrients and simple dilution by freshwater inputs from swollen rivers with naturally low $PO_4$ concentrations (O' Higgins and Rumrill 2007, Cornu et al. 2012).

Quinn et al. (1991) found that point sources (i.e., land-based wastewater treatment and industrial facilities) contributed approximately 60% of the $PO_4$ in the Coos estuary. Because the watershed contains relatively few urbanized areas to contribute phosphates, concentrations remain relatively low during wet winter months (Cornu et al. 2012).

Silica

Seasonal silica patterns are complex, because they depend on many factors and change along the salinity gradient (Figure 10). In the wet season, precipitation and rapid runoff dilute silica concentrations (Sigleo and Frick 2003). In the dry season, the interaction of nutrient delivery from upwelling, diatom uptake, and river discharge rates determine whether silica increases or decreases.

In the summer/dry season, silica concentrations are affected by natural events such as ocean upwelling and diatom uptake. Prolonged exposure to sunlight fuels increased primary production and corresponds to peak diatom abundance during the summer months. Because diatoms use silica to develop shell-like structures called "frustules" (see sidebar), silica concentrations vary with diatom abundance. This pattern is observed in the SMWP data as well as its correlation with chlorophyll *a* concentrations (a measure of primary production)(Figure 24).

The response to increased primary production during the dry season varies across the salinity gradient. Although diatoms are more abundant during the summer months in all

*Diatoms*

*Diatoms are a group of abundant, single-celled algae in marine, estuarine, and freshwater environments. They are a major component of the phytoplankton community, which includes microscopic plants, bacteria, and protists.*

*Diatoms play a crucial role in the maintenance of aquatic food webs and are central to nutrient dynamics. For example, diatoms account for approximately 20% of the global carbon fixation (conversion of carbon dioxide and water into sugars).*

*Diatoms require silica to develop their characteristic shell called a "frustule." Because silica is often a limiting nutrient for diatom growth, it is an important factor in primary production (i.e., plant growth) in estuarine waters.*

*Sources: Martin-Jezequel et al. 2000, Round et al. 1990, Armbrust et al. 2004, Otzen 2012.*

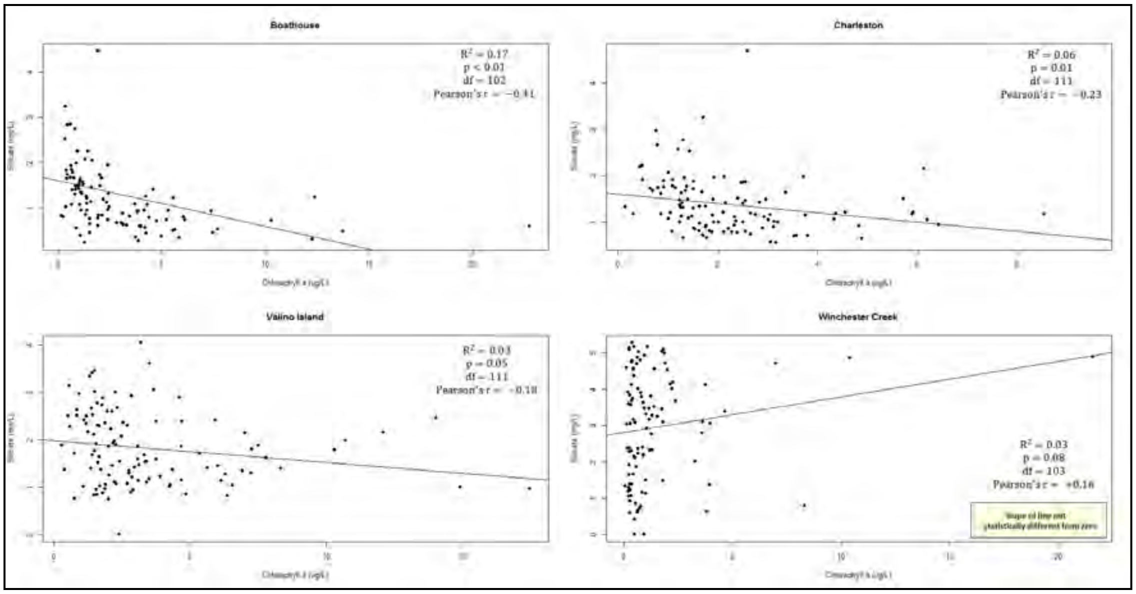



Figure 24. Significant relationships ($p < 0.05$) between $SiO_2$ concentrations and chlorophyll *a* levels in South Slough.
Data: SWMP 2012

estuarine environments, peak diatom abundance is greatest in the lower estuary (e.g. near the ocean where diatoms are naturally more prevalent than in upland freshwater streams)(Figure 25). As the populations of diatoms increase during the dry season in the lower estuary, their uptake of silica to build frustules also increases. If the rate of uptake outpaces silica delivery from upwelling, silica in the water will decrease (e.g., In Figure 10, the Charleston site displays low $SiO_2$ in the dry season). In contrast, a net increase in silica occurs if the rate of nutrient delivery from upwelling exceeds diatom uptake during the dry season. This increase in silica is observed in the upper estuary where diatoms are less abundant (e.g., Figure 10: Winchester site).

Seasonal patterns in diatom abundance and silica concentrations are also affected by river flow. For example, Colbert and McManus

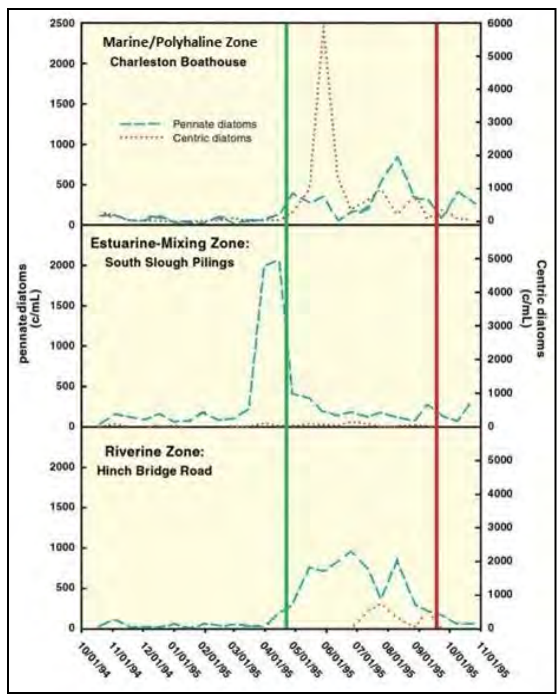



Figure 25. Seasonal patterns for two diatom species. Pennate diatom (dashed) and centric diatom (dotted) abundance at the marine-estuarine interface (top), the estuarine-mixing zone (middle), and the riverine zone (bottom) are plotted against estimated dates of spring transition (green), which marks the start of summer upwelling events, and fall transition (red), which representes at the end of the summer upwelling season.
Data: Rumrill 2003

(2003) reported that phytoplankton (diatoms) in Isthmus Slough were rapidly flushed from the estuary during high river flows and therefore had no significant effect on silica during the wet season. As river discharge rates progressively decrease from winter through summer, the residence time for diatoms lengthens and increases their effect on silica concentrations.

**Background**

The nutrients described in this data summary are essential life-sustaining compounds, but excessive nutrients in estuarine waters are a type of pollution.

For example, both phosphorus and nitrogen are necessary for the growth of marsh plants, algae, and phytoplankton which forms the base of the estuarine food web (USEPA 2012). Both elements are also key components of chemical fertilizers used on agriculture lands, golf courses, and lawns. Because phosphorus and nitrogen are highly soluble and readily mobilize in both surface and ground waters, excess nutrients can accumulate in rivers, lakes, and estuaries. These high nutrient concentrations negatively affect water quality by contributing to eutrophication (i.e., excessive primary productivity -such as phytoplankton or algae blooms- in estuarine waters) and related deficiencies in dissolved oxygen (DO) that are called "hypoxic" when DO is low in the water column and "anoxic" when DO is absent. Eutrophication and hypoxic/anoxic conditions directly and indirectly affect fish, wildlife, and human communities.

Another nutrient, silica, is a product of geological weathering and erosion. Silica is also used by planktonic organisms that are vitally important to the ocean/estuarine food web. DeMaster (1991) estimated that "siliceous" biota (i.e. plants and animals that require silica for proper physiological development) account for as much as one-third of the world's oceans' primary productivity.

Silica is also an indicator of water quality in estuaries. For example, "silica-limiting" systems (i.e., estuaries in which the limited availability of silica constrains primary production) are often associated with the over-enrichment of nitrogen or phosphorus (USEPA 2014).

Further, the availability of silica in estuarine waters ensures a healthy mix of plankton species, reducing the likelihood that shifts in plankton communities will have deleterious consequences. When both nitrogen and phosphorus are overabundant and silica is limited, the disproportionate growth of non-diatom populations may produce harmful algal blooms such as toxic red and brown tides (Schaffner et al. 2007).

Lastly, chlorophyll *a* is a measure of phytoplankton biomass in the estuary. Like land plants, phytoplankton growth requires carbon dioxide, sunlight, and nutrients. Nutrient enrichment in the estuary causes phytoplankton and other plankton populations to expand rapidly (plankton blooms), which provide higher taxa (e.g., invertebrates, fish, whales) with an abundant food source. However, overly large plankton blooms can cause an accumulation of dead phytoplankton that leads to a subsequent bloom in oxygen-metabolizing decomposers. Large scale decomposition in the water column reduces the availability of dissolved oxygen which, in turn, affects higher taxa while also decreasing the water clarity needed for submerged aquatic vegetation to grow.

In studies of nutrient-related water quality, the Coos estuary, for the most part, compares well with other Oregon estuaries. In a 2009 report by USEPA's Western Ecology Division, Lee II and Brown reported that rainy season DIN concentrations in the Coos estuary were generally lower than six other Oregon coast estuaries. Conversely, during the dry season, Coos estuary ammonium concentrations ranked 2nd highest. The Coos estuary was ranked 4th for combined dry season nitrate and nitrites at salinities greater than 5. For phosphorus, the Coos system has the lowest loading by volume of the seven Oregon estuaries sampled but had the highest dry season orthophosphate ranking ($PO_4$ median = 0.9 µM)(Lee II and Brown 2009).

**References**


Armbrust, E.V., J.A. Berges, C. Bowler, C.R. Green, D. Martinez, N.H. Punam, et al. 2004. The genome of the diatom *Thalassiosira pseudonana*: ecology, evolution, and metabolism. Science 306. 5693: 79-86.

Brown, C.A., W.G. Nelson, B.L. Boese, T.H. DeWitt, P.M. Eldridge, J.E. Kaldy, H. Lee II, J.H. Power, and D.R. Young. 2007. An Approach to Developing Nutrient Criteria for Pacific Northwest Estuaries: A Case Study of Yaquina Estuary, Oregon. USEPA Office of Research and Development, National Health and Environmental Effects Laboratory. Western Ecology Division. Retrieved from: http://www.epa.gov/wed/pages/publications/authored/EPA600R-07046AnApproachToDevelopingNutrientCriteria.pdf

Brown, C.A. and R.J. Ozretich. 2009. [as cited from Lee II and Brown 2009] Coupling between the coastal ocean and Yaquina Bay, Oregon: importance of oceanic inputs relative to other sources. Estuaries and Coasts 32: 219-237.

Colbert, D. and J. McManus. 2003. Nutrient Biochemistry in an Upwelling-Influenced Estuary of the Pacific Northwest (Tillamook Bay, Or.). Estuaries. 26.5: 1205-1219.

Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI). 2010. Intermediate Tribal Water Quality Assessment Report. CTCLUSI Department of Natural Resources, Coos Bay OR. 33 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2012. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2013. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2014. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 30 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Dalton, M. M., P. W. Mote, and A. K. Snover [Eds.]. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC:

DeMaster, D. J. 1991. Measuring biogenic silica in marine sediments and suspended matter. Geophysical Monograph Series, 63, 363-367.

Iles, Alison C., Tarik C. Gouhier, Bruce A. Menge, Julia S. Stewart, Alison J. Haupt, and Margaret C. Lynch. 2011. Climate-driven Trends and Ecological Implications of Event-scale Upwelling in the California Current System. Climate Change Biology. 18: 783-796.

Lee II, H. and Brown, C.A. (eds.) 2009. Classification of Regional Patterns of Environmental Drivers And Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. EPA/600/R-09/140.

Martin-Jezequel, V., M. Hildebrand, and M.A. Brzezinski. 2000. Silicon metabolism in diatoms: implications for growth. Journal of Phycology, 36 (5). pp. 821-840.

National Oceanic and Atmospheric Administration (NOAA). 1998. NOAA's Estuarine Eutrophication Survey, Volume 5: Pacific Coast Region. Silver Spring, MD: Office of Ocean Resources Conservation and Assessment. 75 pp.

National Oceanographic and Atmospheric Administration, National Weather Service (NWS). 2014. [KOTH station, North Bend, OR]. Raw data. MesoWest (distributor). Retrieved from: http://mesowest.utah.edu/cgi-bin/droman/download_ndb.cgi?stn=KOTH&hour1=22&min1=56&timetype=LOCAL&unit=0&graph=0

O'Higgins, T. and S. S. Rumrill. 2007. Tidal and Watershed Forcing of Nutrients and Dissolved Oxygen Stress within Four Pacific Coast Estuaries: Analysis of Time-Series Data collected by the National Estuarine Research Reserve System-Wide Monitoring Program (2000-2006) within Padilla Bay (WA), South Slough (OR), Elkhorn Slough (CA), and Tijuana River estuary (CA). Final Report Submitted to the NOAA/UNH Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET).

Oregon Department of Environmental Quality (ODEQ). 1999. CEMAP 1999 Water. [Raw data]. Available online http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2001. [CEMAP 2001 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2004. [CEMAP 2004 Water]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006. [South Fork Coos River Summer Synoptic 2006]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007. [Isthmus Slough/South Fork Coos DO Study]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009. [Millicoma River TMDL DO Study 2009]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Watershed Enhancement Board (OWEB). 1999. "Chapter VIII: Water Quality Assessment". In Oregon Watershed Assessment Manual (p. VIII1-21). Salem, OR. Retrieved from: http://www.oregon.gov/OWEB/pages/docs/pubs/or_wsassess_manuals.aspx

Otzen, Daniel. 2012. The role of proteins in biosilicifation. Scientifica 2012. [article ID 867562]. Accessed 17 June, 2014. Retrieved from: http://www.hindawi.com/journals/scientifica/2012/867562/abs/

Peterson, William T., Cheryl A. Morgan, Jay O. Peterson, Jennifer L. Fisher, Brian J. Burke, and Kurt Fresh. 2013. Ocean Ecosystem Indicators of Salmon Marine Survival in the North California Current. [Prepared by the Northwest Fisheries Science Center of NOAA and Oregon State University]. Accessed 12 June, 2014. Available http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/documents/Peterson_etal_2013.pdf

Quinn, H., D. T. Lucid, J. P. Tolson, C. J. Klein, S. P. Orlando, and C. Alexander. 1991. Susceptibility and Status of West Coast Estuaries to Nutrient Discharges: San Diego Bay to Puget Sound. Summary Report. NOAA/EPA. Rockville, MD. 35 p.

Round, F. E., R. M. Crawford, and D. G. Mann. 1990. The Diatoms. Cambridge University Press, Cambridge.

Rumrill, S. S. 2003. The Ecology of the South Slough Estuary: Site Profile of the South Slough National Estuarine Research Reserve. South Slough National Estuarine Research Reserve, Charleston, OR. 258 p.

Schaffner, L.C., I. C. Anderson, M. M. Z. Brylawski, J. W. Stanhope and D. J. Gillett. 2007. Assessing shallow water habitat quality and ecosystem function in estuaries: Chesapeake Bay example. DVD produced for the Strategic Environmental Research and Development Program. Project CS-1335. Virginia Institute of Marine Science, The College of William and Mary. Retrieved from: http://web.vims.edu/bio/shallowwater/physical_characteristics/nutrients.html

Sigleo, A. and W. Frick. 2003. Seasonal Variations in River Flow and Nutrient Concentrations in a Northwestern Watershed. Proceedings of the First Interagency Conference on Research in the Watersheds, Benson, Ariz, pp. 370-376.Retrieved from: http://www.tucson.ars.ag.gov/icrw/Proceedings/Sigleo.pdf

Sigmon C.L.T., L. Caton, G. Coffeen, and S. Miller. 2006. Coastal Environmental Monitoring and Assessment Program. The Condition of Oregon's Estuaries in 1999, a Statistical Summary. Oregon Department of Environmental Quality, Laboratory.

System-Wide Monitoring Program data (SWMP). 2012. SWMP: South Slough Nutrient Data (2002-2012). Accessed March, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

United States Environmental Protection Agency (USEPA). 2010. Nutrients in Estuaries: A Summary Report of the National Estuarine Experts Workgroup 2005-2007. Retrieved from: http://www2.epa.gov/sites/production/files/documents/nutrients-in-estuaries-november-2010.pdf

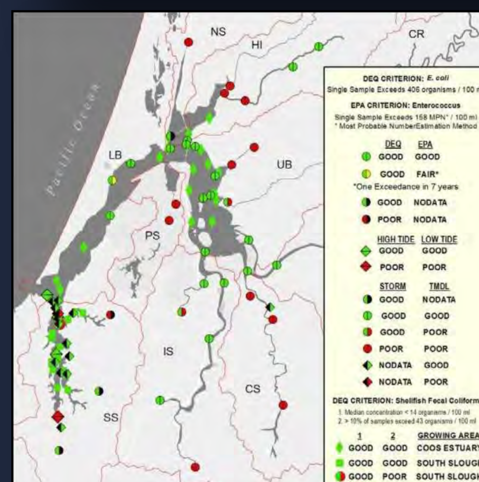
United States Environmental Protection Agency (USEPA). 2012. National Coastal Condition Report IV. US EPA Office of Wetlands, Oceans and Watersheds, Washington DC. 334p. Retrieved from: http://water.epa.gov/type/oceb/assessmonitor/nccr/

United States Environmental Protection Agency (USEPA). 2014. "Chapter 4: Variables and Measurement Methods To Assess and Monitor Estuarine/Marine Eutrophic Conditions". In Nutrient Criteria Technical Guidance Manual: Estuarine and Coastal Waters (p4-1 - 4-17). Retrieved from: http://www2.epa.gov/nutrient-policy-data/nutrient-criteria-technical-guidance-manual-estuarine-and-coastal-waters

# Bacteria in the Coos Estuary


*Summary:*

- *Bacteria concentrations are highly variable depending on the sampling location in the Coos estuary and surrounding stream systems.*
- *Approximately 20% of the sampling sites (17 of 84) did not meet state standards established for commercial fishing (including shellfish cultivation).*
- *Higher bacteria concentrations are typically correlated to areas of lower salinity and where land uses are likely sources of fecal coliform bacteria (e.g., sewage treatment, stormwater outfalls, grazing lands, areas where wildlife congregate).*


Subsystems: SS = South Slough; LB = Lower Bay; PS = Pony Slough; NS = North Slough; HI = Haynes Inlet; UB = Upper Bay; IS = Isthmus Slough; CS = Catching Slough; CR = Coos River

**Evaluation**

Several sites in the Coos estuary and associated streams do not meet state water quality standards while some do and others are stable or are improving. Bacteria sampling should continue to be monitored.

**What's happening?**

Several types of fecal bacteria are monitored as indicators of water quality status (Table 1). These bacteria are not generally harmful but they can indicate the presence of disease-causing bacteria, viruses, and protozoans that also inhabit animal and human feces. Methods for determining the presence of disease-causing pathogens in water are difficult, costly and time consuming. Therefore, rela-

| Form | What is it? | Water Quality Standards | Water Quality Standard Source |
|---|---|---|---|
| *Escherichia coli (E. coli)* | A species of fecal coliform specific to humans and warm blooded animals | In non-shellfish* growing waters: 30-day log mean no > 126 organisms/ 100 mL; No single sample > 406 organisms/ 100 mL; Oregon state standard. | Bohaboy 2011 |
| *Enterococci* spp. | Several species of this bacteria can be found in intestines of humans and other warm blooded animals. Largely used to monitor ocean waters. | Geometric mean of 35 organisms/ 100 mL; No single sample > 104 organisms/100 mL at designated bathing beaches; Federal (EPA) standard | Bohaboy 2011 |
| Fecal Coliform | Any coliform bacteria that live in animal intestines | For shellfish* growing waters: median no > 14 organisms per 100 ml; No more than 10% > 43 organisms/100 mL; Oregon state standard | Bohaboy 2011 |
| Total coliform | All coliform bacteria, including those that live in soils. High counts are typical relative to any other form as this group is not specific to animals. | N/A | |

** The term "shellfish" refers to molluscs only (e.g., clams, oysters, mussels).*

Table 1. Accepted standards and explanation of common bacterial forms that are monitored for water quality purposes.

tively easy and cost-effective tests using the presence and abundance of fecal coliforms and *Enterococci spp.* (all found in human and animal feces) are used as indicators of pathogens to evaluate water quality.

This data summary describes the results of current and historic bacteria monitoring in the Coos estuary. We report on streams listed by the United States Environmental Protection Agency (USEPA) for high bacteria concentrations, analyze and report on data indicating the presence of storm runoff-enhanced bacteria levels, and summarize research investigating the local sources of bacteria (both human-generated and natural). We also analyze and report on data collected by the Oregon Department of Agriculture (ODA) (related to shellfish growing waters), the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI)(focused on sites in the lower bay and South Slough), and the South Slough National Estuarine Research Reserve (SSNERR)(focused on South Slough). Limited stream data are reported for three streams in the South Slough watershed.

<u>Listed Streams</u>

All project area subsystems include water bodies that are 303(d) listed under USEPA's Clean Water Act for high bacteria concentrations (Figure 1). High fecal coliform levels are a concern for waters where commercial shellfish are grown, while *E. coli* listings indicate human contact concerns in recreational waters. In all subsystems, eight water bodies totaling approximately 30 miles are considered impaired for *E. coli*. For fecal coliform, 28 water bodies and nearly 158 miles of water are impaired. Five water bodies are listed as having insufficient data to determine if they are meeting bacteria standards (i.e., they may

*<u>Total Maximum Daily Load (TMDL)</u>*

*According to USEPA's website TMDL is "a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards."*

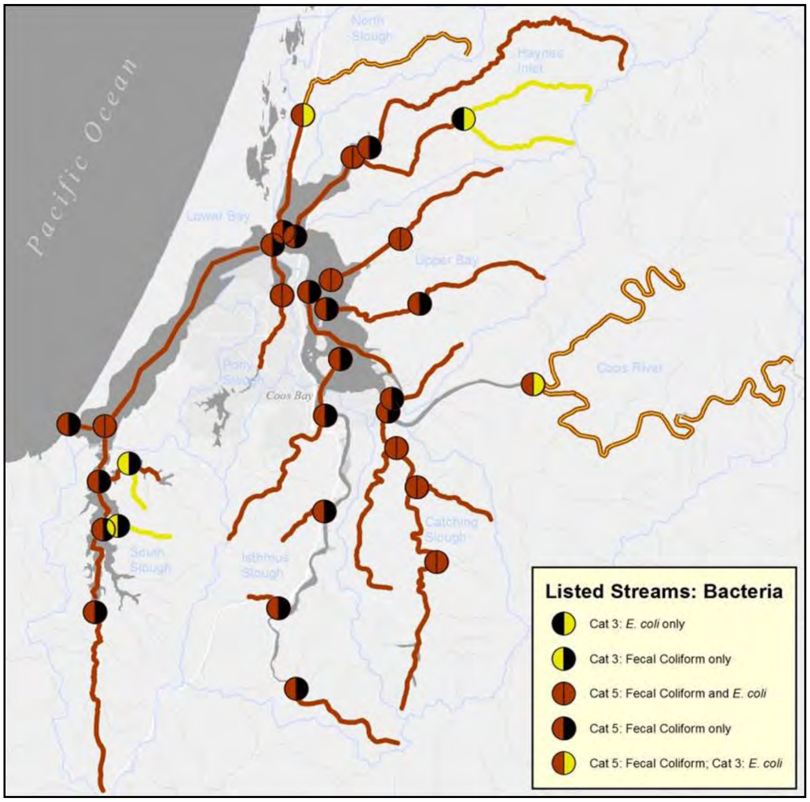



Figure 1. Streams listed as impaired for bacteria (303 (d) listed) under the Clean Water Act. Dot signifies the start of the stream segment that is listed while line shows extent of impaired stream. Category 3 indicates streams where insufficient data exist to make a determination if the water body is meeting water quality standards; category 5 indicates streams that are water quality impaired for bacteria. Report subsystems delineated and labeled in blue. Data: ODEQ 2014

Storm-Related Bacteria and Total Maximum Daily Load Bacteria Data

We summarized Coos Bay Storm-Related Bacteria and Total Maximum Daily Load (TMDL-see sidebar) datasets from the Oregon Department of Environmental Quality (ODEQ 2006, 2007)(Figures 2-5). The storm-related bacteria data were collected in January and October 2007 and the TMDL data were collected in February, March, April, November, and December 2001-2005 (months vary depending on the year) and June, August, and September 2006. South Slough results only included TMDL data.

Bacteria concentrations associated with storm events were not higher than the TMDL samples. Indeed, results here show that storm-related bacteria concentrations were lower than TMDL for many sites, such as Larson Creek (LCB), Willanch Creek (WCM), and Ross Slough (RS) in Figures 2, 3, and 4. Although not specifically associated with storms, most of the TMDL samples (2001-2005) were taken during the rainy season (Nov –Apr) with the exception of 2006 samples (Jun-Sept), so sample timing may be one reason the difference between the two is not especially great. Generally, sites with high levels of bacteria during storm-associated sampling also had high levels in the TMDL samples (Fig. 2-4). There was more variability in bacteria levels in the TMDL datasets for all three bacteria

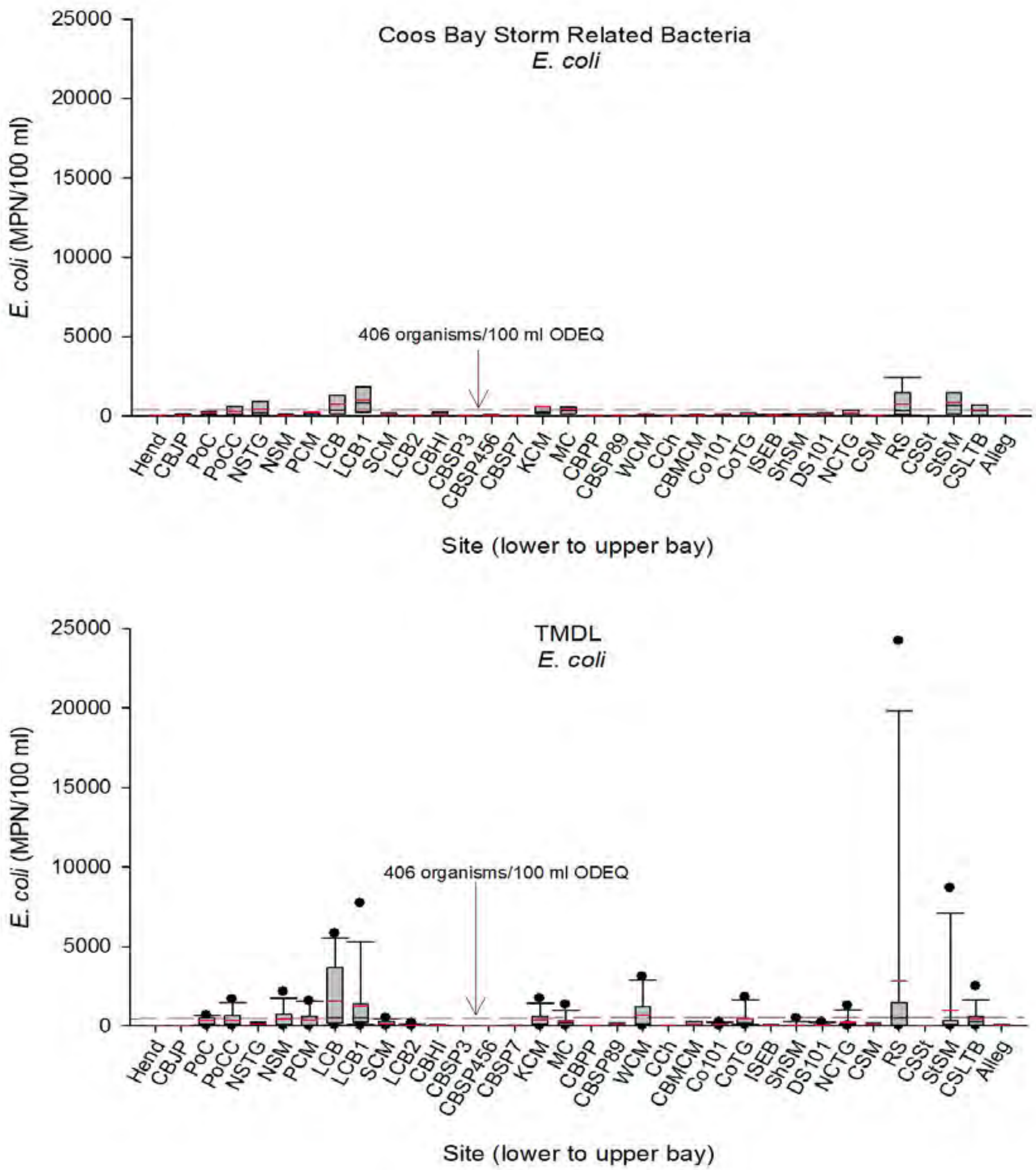



Figure 2. Box plots of *E. coli* concentrations for ODEQ Storm Related Bacteria in 2007 compared to ODEQ TMDL datasets 2001-2006 for Coos estuary sites, ordered from lower to upper Coos Bay. Gray boxes represent middle half of the dataset (top boundary is 25th percentile; bottom is 75th). Red lines within boxes indicate mean bacteria concentrations and black lines are median concentrations. Error bars represent 90th (top) and 10th (bottom) percentiles for sites with 9 samples or more. Black circles are outliers. Dark red dash line indicates ODEQ criteria for *E. coli*: No single sample may exceed 406 organisms/100 ml. See Figure 6/ Table 2 for map and site codes. Data: ODEQ 2006, 2007.

types compared to the storm-related datasets - likely due to seasonal variation.

Storm-related *E. coli* bacteria results fell short of meeting state bacteria standards (see Table 1) at 12 sites: Pony Creek south of North Bend High School (PoC), Pony Slough at Coca Cola Bottling Plant (PoCC), North Slough upstream of tide gate (NSTG), Palouse Creek at mouth (PCM), Larson Creek at mouth (LCB), Larson

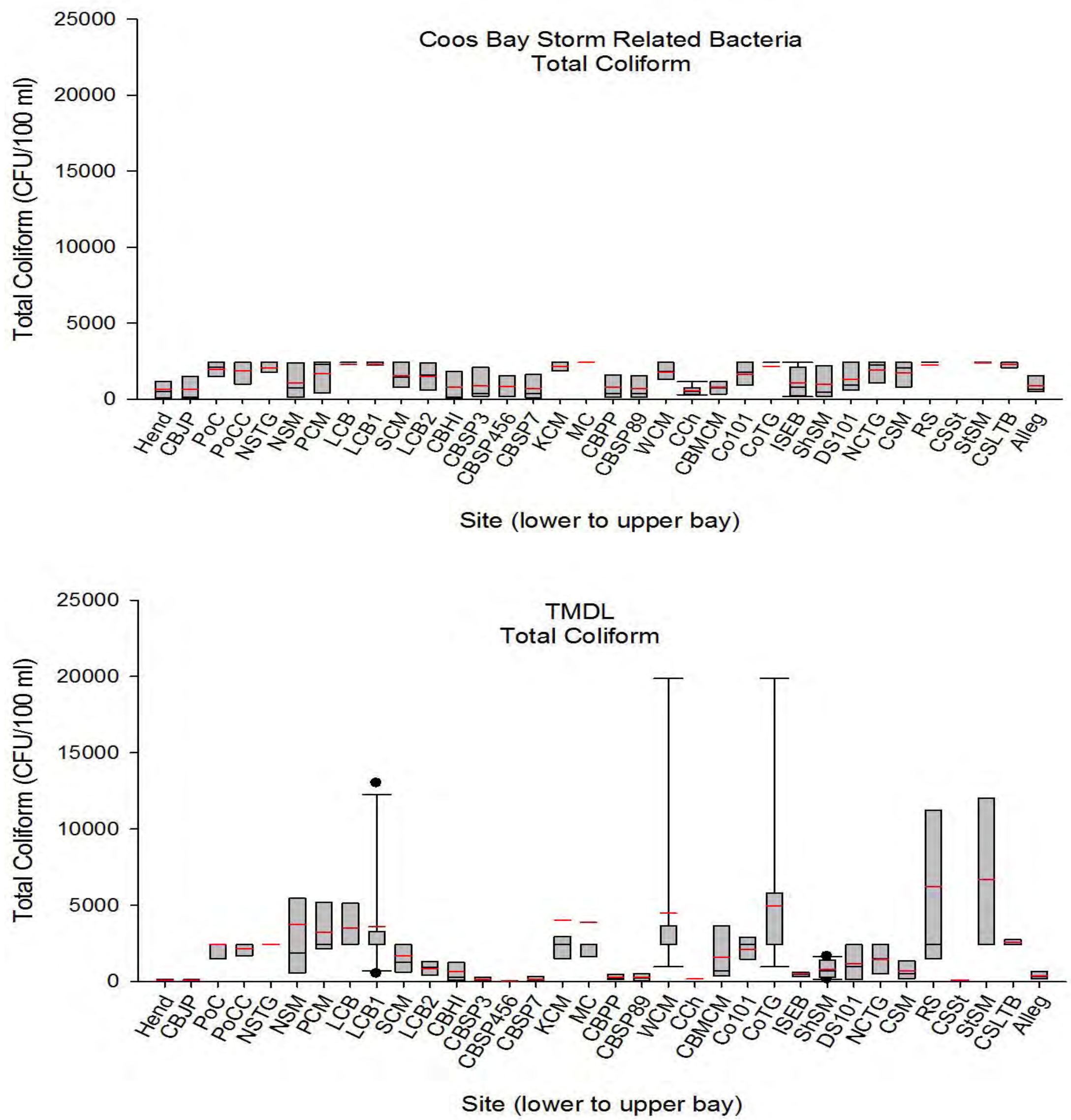



Figure 3. Box plots of Total Coliform concentrations for ODEQ Storm Related Bacteria in 2007 compared to ODEQ TMDL datasets 2001-2006 for Coos estuary sites, ordered from lower to upper Coos Bay. Gray boxes represent middle half of the dataset (top boundary is 25% percentile; bottom is 75th). Red lines within boxes indicate mean bacteria concentrations and black lines are median concentrations. Error bars represent 90th (top) and 10th (bottom) percentiles for sites with 9 samples or more. Black circles are outliers. See Figure 6/Table 2 for map and site codes. Data: ODEQ 2006, 2007.

Creek at first bridge upstream of mouth (LCB1), Kentuck Creek at mouth (KCM), Mettman Creek at mouth (MC), Noble Creek at tide gate (NCTG), Ross Slough at Ross Slough Road (RS), Stock Slough at mouth (StSM), and Catching Slough at Lone Tree Bridge (CSLTB) (Figures 2 and 6). These sites are located higher in the watershed and thus bacteria levels are likely driven by land use and facilitated by lower salinities than sites located in the estuary or lower watershed.

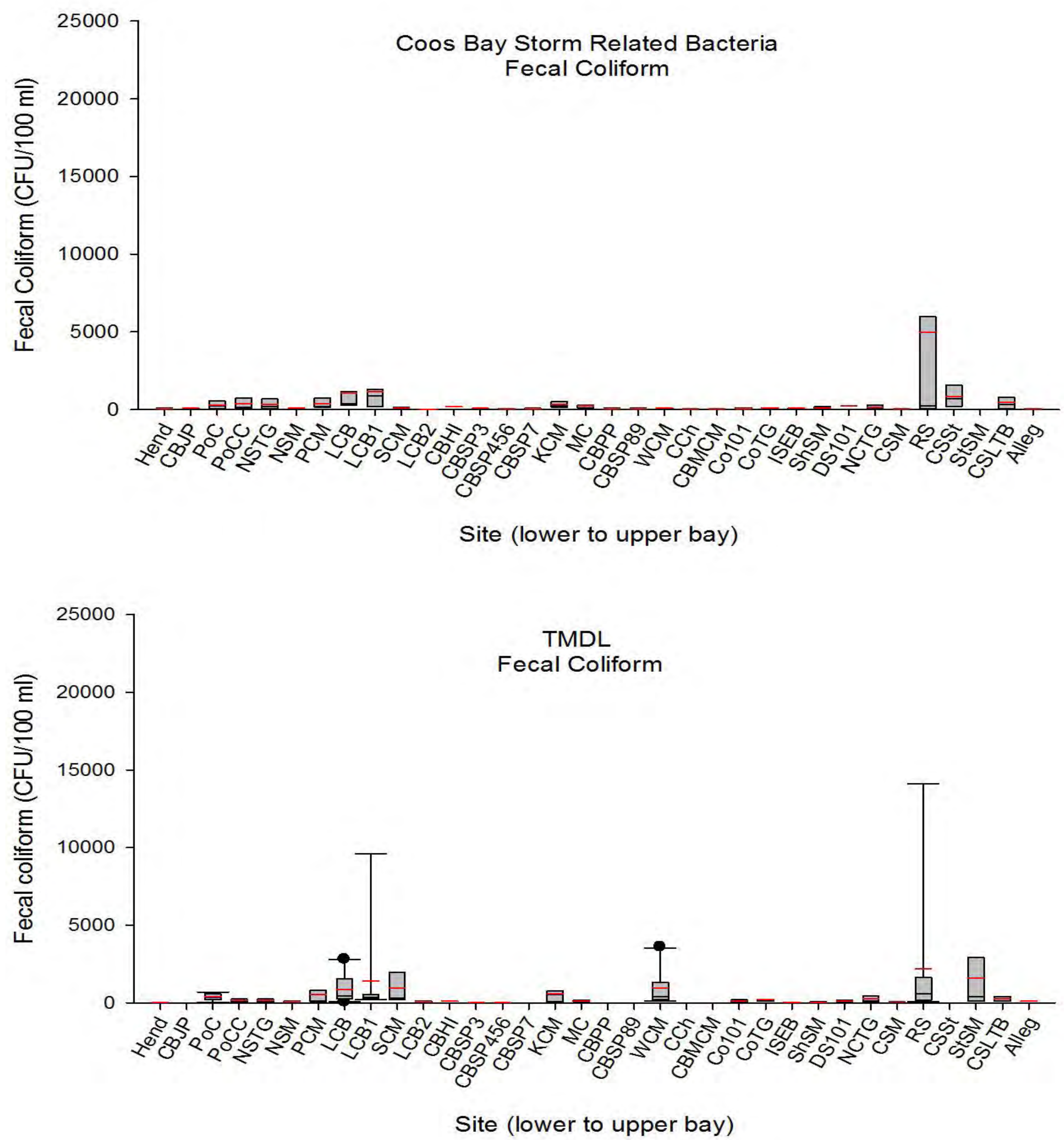



Figure 4. Box plots of Fecal Coliform concentrations for ODEQ Storm Related Bacteria in 2007 compared to ODEQ TMDL datasets 2001-2006 for Coos estuary sites, ordered from lower to upper Coos Bay. Gray boxes represent middle half of the dataset (top boundary is 25% percentile; bottom is 75th). Red lines within boxes indicate mean bacteria concentrations and black lines are median concentrations. Error bars represent 90th (top) and 10th (bottom) percentiles for sites with 9 samples or more. Black circles are outliers . See Figure 6/Table 2 for map and site codes. Data: ODEQ 2006, 2007.

TMDL *E. coli* bacteria results fell short of meeting state bacteria standards at 18 sites: Pony Creek south of North Bend High School (PoC), Pony Slough at Coca-Cola Bottling Plant (PoCC), North Slough at mouth (NSM), Palouse Creek at mouth (PCM), Larson Creek at mouth (LCB), Larson Creek at first bridge upstream of mouth (LCB1), Sullivan Creek at mouth (SCM), Kentuck Creek at mouth (KCM), Mettman Creek at mouth (MC), Willanch Creek at mouth (WCM), Coalbank Slough at tide gate (CoTG), Shinglehouse Slough at mouth (ShSM), Noble Creek at tide gate (NCTG), Ross Slough at Ross Slough Road

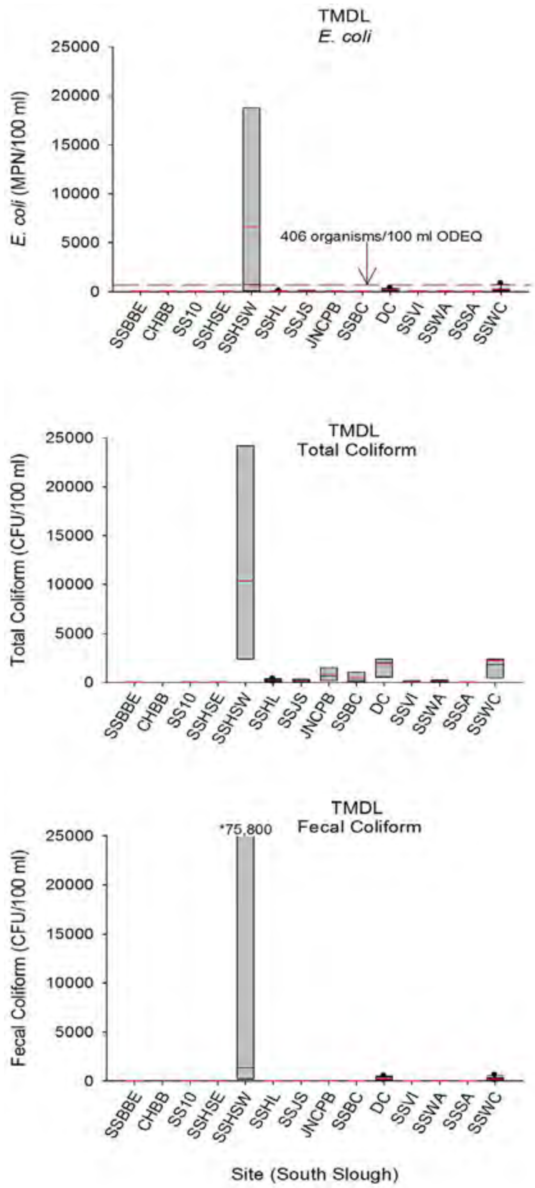



Figure 5. Box plots of *E. coli,* Total Coliform, and Fecal Coliform concentrations for ODEQ TMDL datasets 2001-2006 for South Slough; sites are ordered from north to south. Gray boxes represent middle half of the dataset (top boundary is 25th percentile; bottom is 75th). Red lines within boxes indicate mean bacteria concentrations and black bars are median concentrations. Error bars represent 90th (top) and 10th (bottom) percentiles for sites with 9 samples or more. Black circles are outliers. Dashed line (top graph only) indicates ODEQ criteria for *E. coli*: No single sample may exceed 406 organisms/100 ml. See Figure 6/Table 2 for map and site codes. Data: ODEQ 2006, 2007.

*Box Plots (or Whisker and Box Plots)*

*Useful for graphing data that are highly variable, box plots help compare a range of data values (i.e., distribution) and identify outliers. Box plots also show median values in the data, which can be useful for interpreting highly variable results.*

*The "box" indicates the middle 50% of the data values; the full range of values from the rest of the data is indicated as "whiskers" that in normal box and whisker plots, or in Tukey-style box plots, are an additional 1.5 x the width of the box (i.e., 1.5 x the "interquartile" range).*

*In Tukey-style box plots outliers outside the range of the whiskers are also shown (represented by points outside the box and whisker plot).*

(RS), Stock Slough at mouth (StSM), Catching Slough at Lone Tree Bridge (CSLTB), and two South Slough sites, Hallmark Seafood on South Slough West Side (SSHSW) and Winchester Creek at Hinch Rd Bridge (SSWC)(Fig. 2, 5, 6). With the exception of 4 sites (SCM, WCM, CoTG, ShSM), those sites with high levels of *E. coli* bacteria in storm-related sampling also had high levels in TMDL sampling. Many of these sampling sites are higher in the watershed and more heavily influenced by land use and characterized by fresher water than lower estuary sites. In general, South Slough, Coos estuary, and sites in the lower

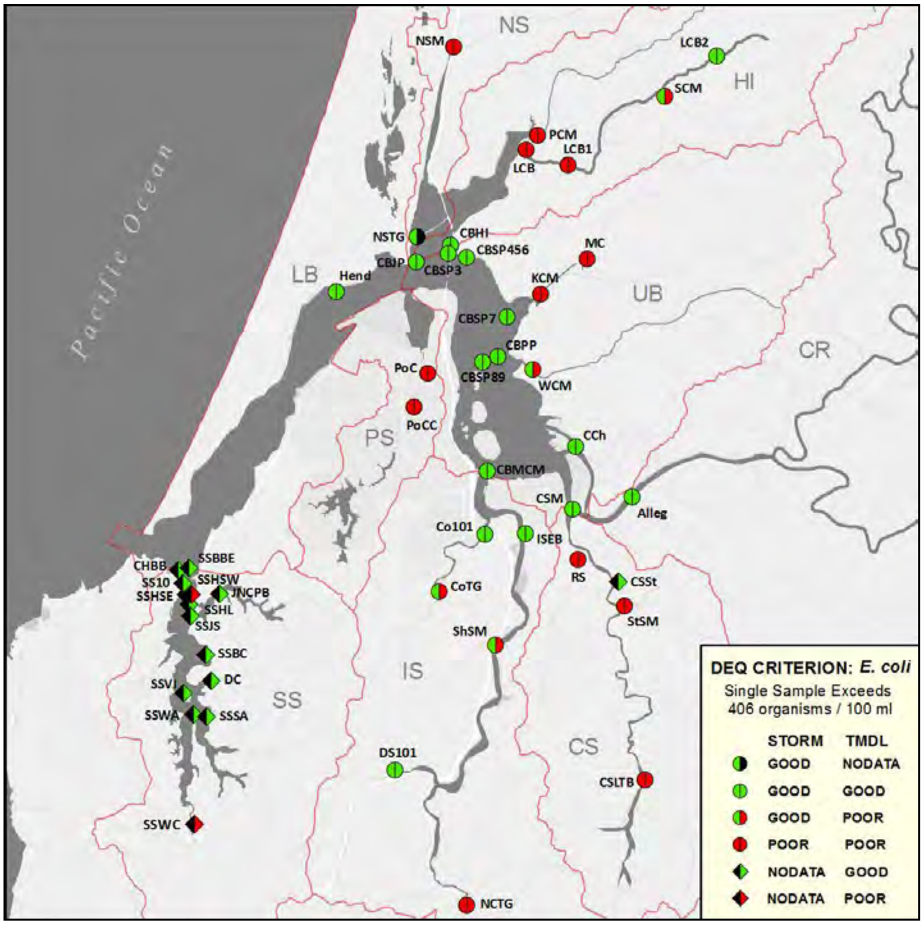



Figure 6. (left) Location and condition of Storm-Related and TMDL *E. coli* bacteria sampling sites.

Table 2. (below). Site codes and names for Storm-Related and TMDL bacteria sampling sites.

| Site Codes | Site Name | Site Codes | Site Name |
|---|---|---|---|
| Alleg | Coos River at Allegany Road Bridge (Eastside) | LCB2 | Larson Creek at second bridge upstream of dairy |
| CBHI | Coos Bay at entrance to Haynes Inlet at Marker #1 | MC | Mettman Creek at mouth |
| CBJP | Coos Bay at Jordan Point | NCTG | Noble Creek at tide gate |
| CBMCM | Coos Bay Marshfield Channel Mouth | NSM | North Slough at mouth (Causeway Bridge) |
| CBPP | Coos Bay at Pierce Point Channel | NSTG | North Slough upstream of tide gate |
| CBSP3 | Coos Bay at Silver Point 3 | PCM | Palouse Creek at mouth |
| CBSP456 | Coos Bay at Silver Point 4,5,6 | PoC | Pony Creek south of North Bend High School |
| CBSP7 | Coos Bay at Silver Point 7 | PoCC | Pony Slough at Coca Cola bottling plant |
| CBSP89 | Coos Bay at Silver Point 8,9 | RS | Ross Slough at Ross Slough Road |
| CCh | Cooston Channel at south end | SCM | Sullivan Creek at Mouth |
| CHBB | Charleston Boat Basin at east end | ShSM | Shingle House Slough at mouth |
| Co101 | Coalbank Slough at Hwy 101 (Coos Bay) | SS10 | South Slough at Buoy #10 - Charleston Triangle |
| CoTG | Coalbank Slough at Tide gate | SSBBE | South Slough at entrance to Charleston Boat Basin |
| CSLTB | Catching Slough at Lone Tree Bridge | SSBC | South Slough In Brown's Cove |
| CSM | Catching Slough at Mouth | SSHL | South Slough at Hanson's Landing |
| CSSt | Catching Slough at dock downstream of Stock Slough | SSHSE | Hallmark Seafood on South Slough East Side |
| DC | Day Creek upstream of foot bridge | SSHSW | Hallmark Seafood on South Slough West Side |
| DS101 | Davis Slough at Highway 101 | SSJS | South Slough 50 yards west of Joe Ney Slough |
| Hend | Coos Bay at Marker #23 (Henderson Marsh) | SSSA | South Slough at head of Sengstacken Arm |
| ISEB | Isthmus Slough at Eastside Bridge | SSVI | South Slough at west side of Valino Island |
| JNCPB | Joe Ney Slough at Crown Point Bridge | SSWA | South Slough at head of Winchester Arm |
| KCM | Kentuck Creek at mouth (upstream of tide gate) | SSWC | Winchester Creek at Hinch Rd Bridge |
| LCB | Larson Creek at mouth | StSM | Stock Slough at mouth |
| LCB1 | Larson Creek at first bridge upstream of mouth | WCM | Willanch Creek at mouth (tide gate) |

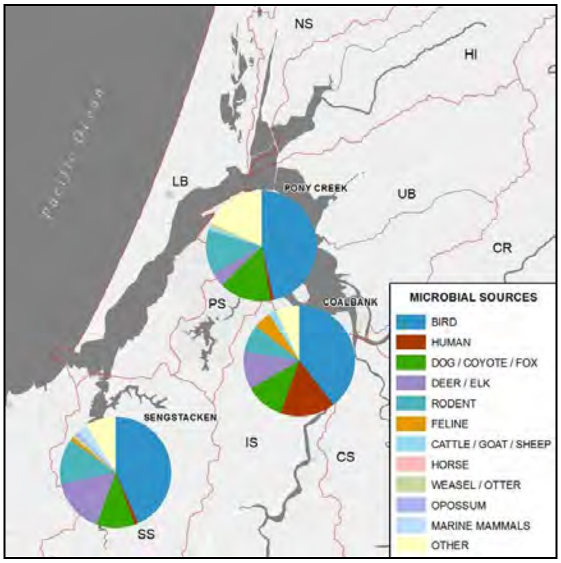



Figure 7. *E. coli* microbial source tracking results shown as a percentage of bacterial samples collected in Pony Creek, Coalbank Slough, and Sengstacken arm of South Slough. Data: Souder 2003.

watershed show much lower bacteria concentrations compared to smaller sloughs and upper watershed creek sites (Figures 2-6). Mean and median *E. coli* levels fell below 215 MPN/100 mL for Coos Bay lower watershed and main estuary sites and South Slough with the exception of one site, Hallmark Seafood on South Slough West Side (SSHSW)(Fig. 2, 5).

Overall, highest total coliform and fecal coliform mean values occurred at Ross Slough (RS) and Stock Slough (StSM)(Fig. 3, 4 TMDL); and Hallmark Seafood on South Slough West Side (SSHSW)(Fig. 5). In addition, Coalbank Slough at tide gate (CoTG), North Slough at mouth (NSM), Kentuck Creek at mouth (KCM), Larson Creek at first bridge upstream of mouth (LCB1), Mettman Creek at mouth (MC) and Willanch Creek at mouth (WCM) all had high levels of total coliforms for TMDL data (Fig. 3). Some of the lowest fecal coliform levels were at South Slough sites (<60 CFU/100 mL), with the exception of Day Creek (DC)(mean = 208 CFU/100 mL), Winchester Creek Bridge (SSWC)(mean = 236 CFU/100 mL), and Hallmark Seafood (SSHSW)(mean = 48,517 CFU/100 mL)(Fig. 5).

*<u>What does CFU/100 mL and MPN/100 mL mean?</u>*

*CFU stands for 'Colony Forming Units' and refers to the number of viable bacterial cells in a sample per unit of volume (i.e., only live cells). For example: 50 CFU/100 mL means 50 Colony Forming Units per 100 mL of sample.*

*MPN stands for 'Most Probable Number' and refers to a method that uses dilution cultures and a probability calculation to determine the approximate number of viable cells in a given volume of sample; this measurement is useful when samples contain too few organisms for agar plates to be used or when organisms will not grow on agar.*

*Bacteria units – including CFU, counts, organisms, and MPN – are considered equivalent measures of bacteria concentration.*

*Sources: APHA 1998, USEPA 2001*

<u>Bacteria Sources</u>

A joint study conducted by the Coos Watershed Association (CoosWA), SSNERR, and

| Statistic | Pony Creek | | | Coalbank Slough | | | Sengstaken Arm | | |
|---|---|---|---|---|---|---|---|---|---|
| | TC | FC | EC | TC | FC | EC | TC | FC | EC |
| Arithmetic Mean | 5,089 | 246 | 182 | 3,130 | 349 | 237 | 342 | 36 | 26 |
| Standard Deviation | 6,709 | 129 | 103 | 3,498 | 292 | 204 | 318 | 31 | 21 |
| Geometric Mean* | 2,297 | 206 | 139 | 2,105 | 215 | 138 | 149 | 14 | 19 |
| Est. 90$^{th}$ Percentile* | 4,910 | 230 | 182 | 2,790 | 379 | 280 | 972 | 49 | 25 |
| * Calculated according to procedures in *Guidance Document A.7. – Estimating the Ninetieth Percentile*. | | | | | | | | | |

Table 3. Summary statistics from the traditional public health bacteria indicators at the three *E. coli* DNA sample locations. TC = Total coliform; FC = Fecal coliform; EC = *E. coli*. TC and EC units are MPN/100 mLs; FC units are CFU/100 mLs. Arithmetic Mean is the average. From: Souder 2003.

Marshfield High School investigated bacteria concentrations and sources in three locations in the Coos estuary: Pony Creek, Coalbank Slough, and the Sengstacken arm of South Slough (Figure 7)(Souder 2003). Investigators used DNA-based microbial source tracking methods to compare total coliforms, fecal coliforms, and *E. coli* concentrations in estuary water samples from July 2000 to June 2002.

Overall, Pony Creek had the highest average total coliform (5,089 MPN/100 mL), while Coalbank Slough had the highest average concentrations of fecal coliform and *E. coli* (349 CFU/100 mL and 237 MPN/100 mL respectively)(Table 3). Sengstacken arm consistently had lowest bacteria levels of all three sites.

Microbial source tracking results found that the most common source of bacteria at all three sites was from birds (avian sources) – responsible for 46% of all bacteria at Pony Creek, 39% at Coalbank Slough and 43% at Sengstacken arm (Figure 7).

Pony Creek also had high concentrations of bacteria from canines (15% dogs, coyotes, foxes) and rodents (13%) while Coalbank Slough had high concentrations from humans (16%), canines (11%), and deer/elk (11%), and Sengstacken from deer/elk (16%), rodents (16%), and canines (11%)(Figure 7).

Bacteria in Shellfish Growing Areas

Oregon Department of Agriculture (ODA) samples for fecal coliforms at several sites near commercial shellfish cultivation areas in the Coos estuary (including the Upper Bay, Lower Bay, North Slough, Haynes Inlet, and South Slough subsystems)(Figure 8) once per month on average. During shellfish harvest, the fecal coliform samples must meet ODEQ bacteria criteria for marine and estuarine shellfish growing waters; they cannot have a median concentration higher than 14 organisms per 100 mL, and no more than 10% of samples may exceed 43 organisms per 100 mL. Data summarized below are from 1999-2014.

Overall, median bacteria concentrations were relatively low and met regulatory standards. In Coos Bay (all non-South Slough sampling sites), the average concentration of fecal coliform bacteria at all sites was between 3 and 14 organisms/100 mL. The median concentra-

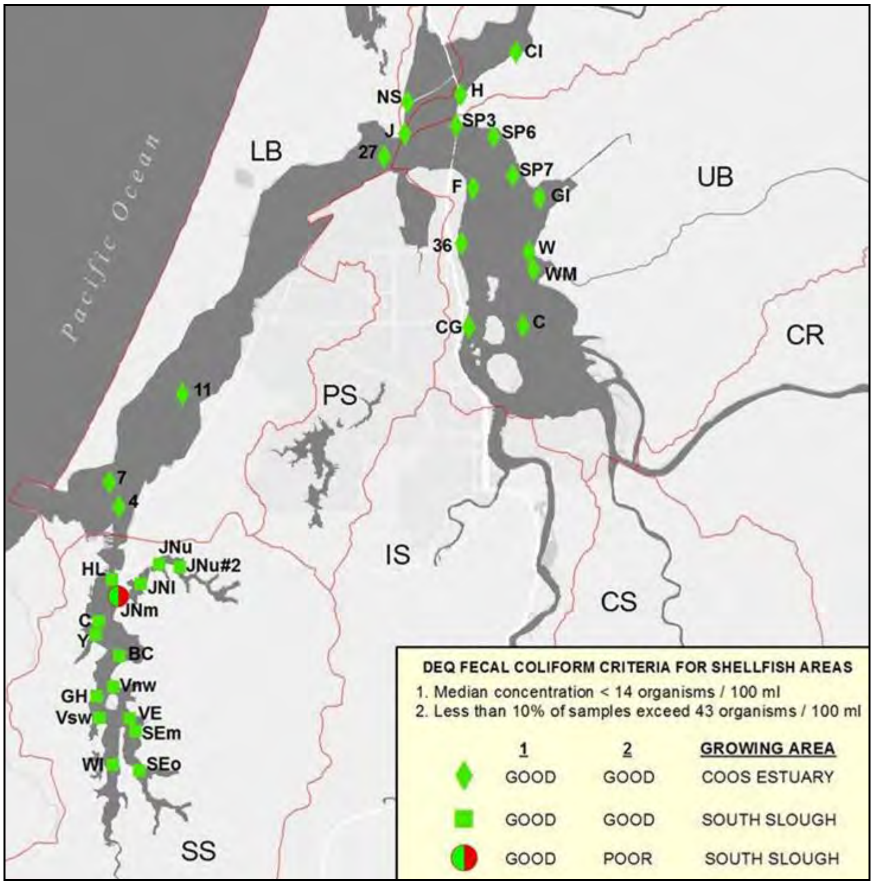



Figure 8. ODA Fecal Colifrm sampling sites in Coos Bay and South Slough. Green symbols indicate sites that met ODEQ standards shellfish growing waters; Red symbols indicate sites that did not meet the standards.

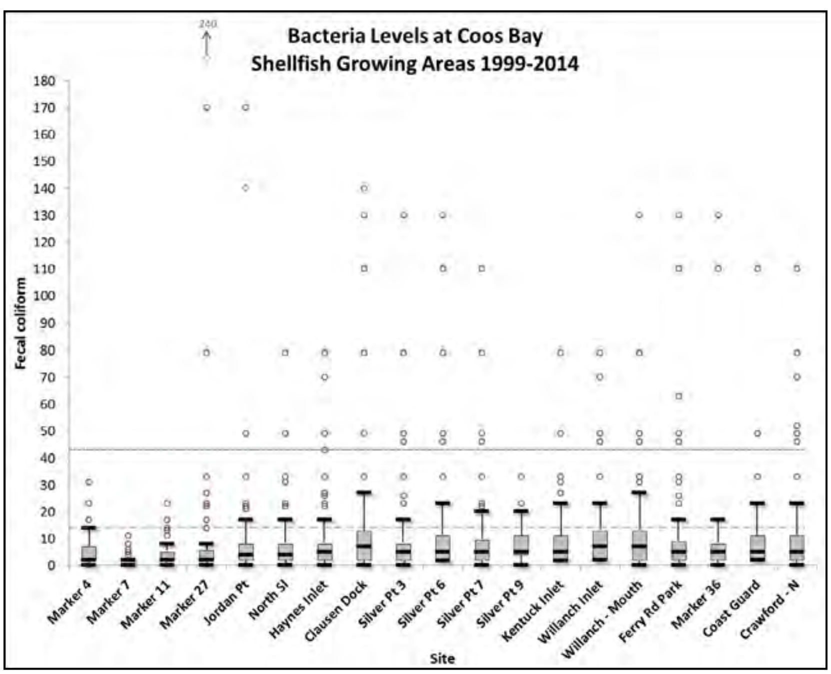



Figure 9. Tukey-style box plots of fecal coliform concentrations from ODA Coos Bay shellfish growing sampling sites from 1999-2014. Shaded gray box represents middle 50% of the data. Central black line (within gray box) indicates median value. Upper and lower black bars bound 99.3% of normal distribution data. Outliers outside this coverage are shown as open red circles. One outlier was outside the scale of this figure; value is indicated above arrow at the top. Short blue dashed line indicate ODEQ standard: 10% of samples may not exceed 43 organisms/10mL. Long blue dash line indicate ODEQ standard of median 14 organisms/100mL. Data: ODA 2014

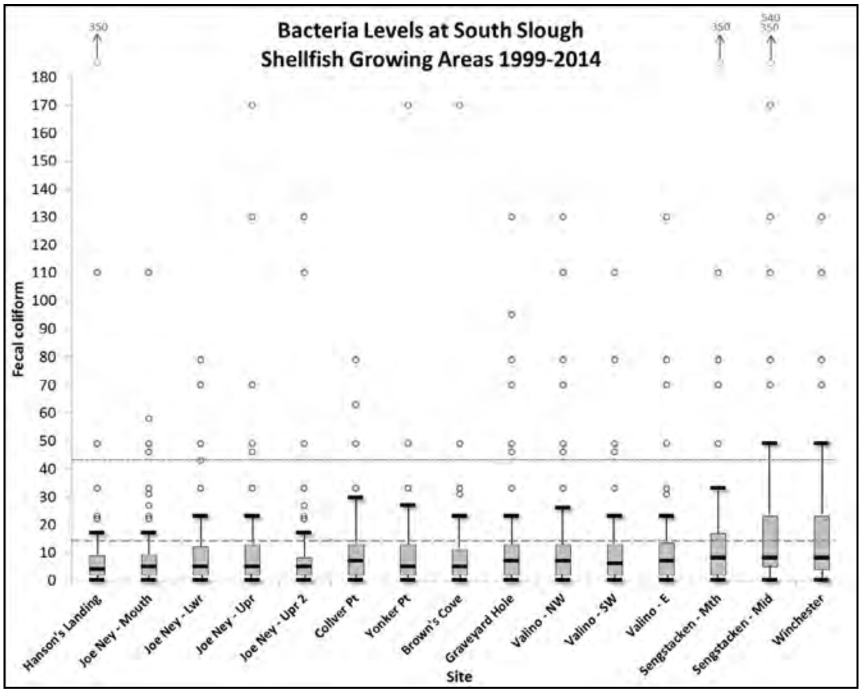



Figure 10. Tukey-style box plots of fecal coliform concentrations from ODA South Slough shellfish growing sampling sites from 1999-2014. Shaded gray box represents middle 50% of the data. Black line within gray box indicates median value. Upper and lower bars bound 99.3% of normal distribution data. Outliers outside this coverage are shown as open red circles. Several outliers were outside the scale of this figure and values are indicated above arrows at the top. Short blue dashed line indicate ODEQ standard: 10% of samples may not exceed 43 organisms/10mL. Long blue dash line indicate ODEQ standard of median 14 organisms/100mL. Data: ODA 2014

tions were between 2 and 7 organisms/100 mL (Figure 9). The percent of samples that were greater than 43 organisms/mL (all years combined) were low and ranged from 0-7%, at no time exceeding the criterion of greater than 10% of samples. Similarly, for South Slough, the average concentration of fecal coliform bacteria at all sites ranged from 5 to 21 organisms/100 mL (Figure 10). The median concentrations fell between 4 and 8 organisms/100 mL. The percent samples greater than 43 organism/mL were low and

A.

**Median Monthly Fecal Coliform Values at ODA's Coos Bay Sampling Sites 1999-2014**

| | Marker 4 | Marker 7 | Marker 11 | Marker 27 | Jordan Pt | North Sl | Haynes Inlet | Clausen Dock | Silver Pt 3 | Silver Pt 6 | Silver Pt 7 | Silver Pt 9 | Kentuck Inlet | Willanch - Inlet | Willanch - mouth | Ferry Rd Park | Marker 36 | Coast Guard | Crawford Pt |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 2 | 5 | 5 | 5 | 8 | 8 | 6 | 8 | 7 | 8 | 8 | 6.15 | 5 | 13 | 11 | 7.5 | 17 | 5.8 | 13 |
| Feb | 2 | 2 | 2 | 5 | 2 | 3.5 | 5 | 7 | 7 | 11 | 5 | 5 | 8 | 6.5 | 7.8 | 8 | 2 | 5 | 10.5 |
| Mar | 2 | 2 | 2 | 6.5 | 5 | 5 | 8 | 7 | 5 | 11 | 5 | 5 | 5 | 12 | 7 | 7.5 | 7 | 8 | 5 |
| Apr | 4.5 | 2 | 2 | 2 | 2 | 2 | 5 | 6.5 | 2 | 2 | 2 | 11 | 4.5 | 6.4 | 6.4 | 6 | 5 | 4.5 | 5.5 |
| May | 2 | 2 | 2 | 2 | 4.5 | 2 | 2 | 4.5 | 2 | 2 | 3.5 | 7.8 | 7 | 7.9 | 4 | 4 | 5 | 5 | 3 |
| Jun | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 5 | 2 | 2 | 5 | 4.5 | 5 | 2 | 5 | 5 | 4 | 6 | 4.5 |
| Jul | 3.5 | 2 | 2 | 2 | 3.25 | 4 | 5 | 5 | 3 | 2 | 5 | 13.9 | 4.25 | 5 | 5 | 2 | 5 | 7 | 5 |
| Aug | 8 | 2 | 3 | 2 | 4.25 | 2 | 2 | 5 | 2 | 2 | 4.5 | 2 | 2 | 4.25 | 4 | 4.75 | 5 | 5 | 2 |
| Sep | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 6 | 2 | 5 | 4.5 | 3.25 | 4.5 | 8 | 7 | 2 | 7 | 6.5 | 5 |
| Oct | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4.5 | 2 | 3.5 | 2 | 6 | 6 | 4.75 | 2 | 3.25 | 4.25 | 5 | 2 |
| Nov | 3.5 | 2 | 2 | 4.25 | 8 | 7 | 5 | 5 | 5 | 13 | 8 | 5 | 6.5 | 10 | 13 | 12 | 7 | 8 | 11 |
| Dec | 6 | 3.5 | 3.5 | 10.5 | 6 | 5 | 5 | 8 | 5 | 5 | 8 | 7 | 11 | 8 | 11 | 13 | 7.4 | 11 | 5 |

B.

**Median Monthly Fecal Coliform Values at ODA's South Slough Sampling Sites 1999-2014**

| | Hanson's Landing | Joe Ney Mouth | Joe Ney - Lwr | Joe Ney - Upr 1 | Joe Ney - Upr 2 | Collver Pt | Yonker Pt | Brown's Cove | Graveyard Hole | Valino - NW | Valino - SW | Valino - E | Sengstacken Mouth | Sengstacken - Mid | Winchester |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan | 5 | 8 | 5 | 6 | 2 | 8 | 3.5 | 7 | 5 | 13 | 7.9 | 5 | 5 | 9.5 | 5 |
| Feb | 2 | 2 | 5 | 5 | 2 | 5 | 5 | 2 | 5 | 5 | 6.5 | 3.5 | 5 | 2 | 3.5 |
| Mar | 2 | 5 | 4 | 2 | 2 | 5 | 2 | 2 | 2 | 5 | 4.5 | 5 | 6 | 8 | 8 |
| Apr | 5 | 5 | 4.5 | 2 | 4 | 7 | 7 | 2 | 7 | 5 | 4.5 | 7.5 | 8 | 5 | 5 |
| May | 6 | 5 | 6 | 4 | 5 | 8 | 6 | 5 | 2 | 8 | 2 | 5 | 5 | 17 | 8 |
| Jun | 4.5 | 7.15 | 5 | 5 | 5 | 11 | 5 | 8 | 7.9 | 19.5 | 3 | 6.5 | 8 | 8 | 11 |
| Jul | 2 | 8 | 7.5 | 10.5 | 8 | 10.5 | 6 | 8 | 8 | 6.5 | 13 | 11 | 17 | 17 | 22 |
| Aug | 2 | 5 | 4.75 | 4.5 | 5.9 | 5 | 13 | 8 | 7 | 13 | 13 | 10.5 | 6 | 9.5 | 6.5 |
| Sep | 4.5 | 5 | 4 | 5 | 7 | 8 | 5 | 5 | 5 | 5 | 5 | 5.5 | 8 | 10.5 | 8 |
| Oct | 2 | 6 | 7 | 10.5 | 8 | 8 | 8 | 11 | 13.5 | 9.5 | 7 | 5 | 13 | 8 | 5 |
| Nov | 5 | 5 | 11 | 6.8 | 5 | 4 | 3 | 2 | 8 | 8 | 5 | 8 | 5 | 12 | 8 |
| Dec | 7.8 | 8 | 8 | 11 | 12 | 9.5 | 7.5 | 6 | 13 | 6 | 7 | 8 | 10.5 | 13 | 6.5 |

Table 4. Median monthly fecal coliform at each ODA shellfish sampling site in A. Coos Bay and B. South Slough from 1999-2014. Beige bars indicate relative fecal coliform concentration. Red values indicate exceedance of ODEQ standard of median 14 organisms/100mL. Data: ODA 2014

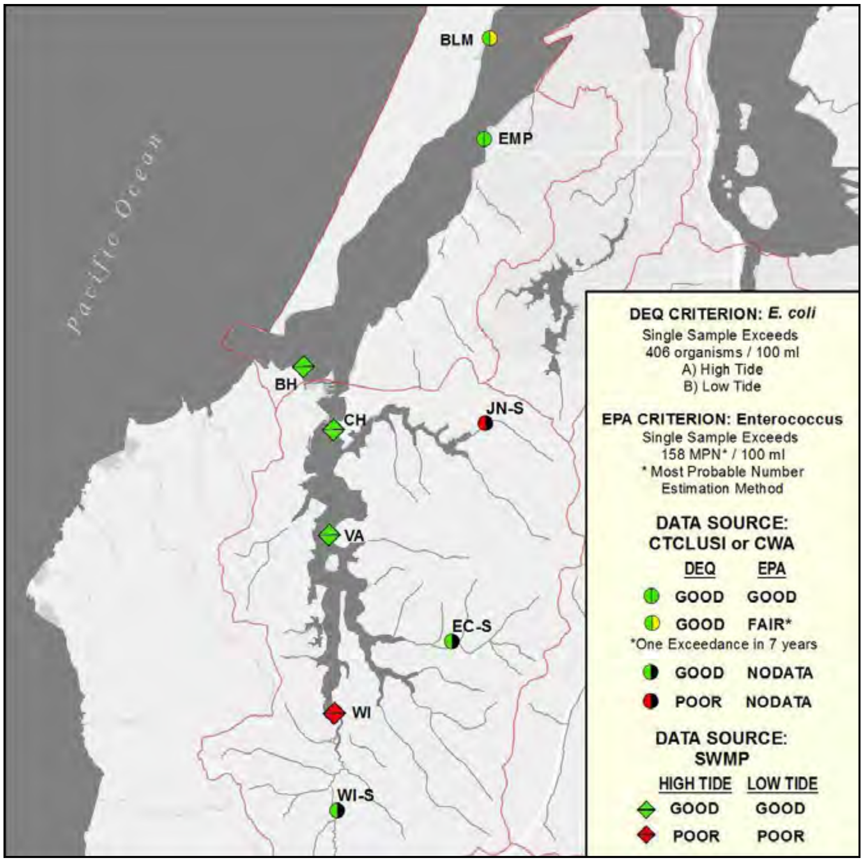



Figure 11. Bacteria concentrations at sites in the Lower Bay subsystem collected monthly by CTCLUSI (sites: BLM and EMP) and in South Slough by staff at SSNERR (sites: BH, CH, VA, WI). Three sites (JN-S, EC-S, WI-S) were stream sites sampled by CoosWA in 2010 as part of the State of the South Slough and Coastal Frontal Watersheds report. Sites were compared to ODEQ standards for *E. coli* or USEPA standards for *Enterococcus*. Site codes: BLM - BLM boat ramp, EMP: Empire Dock; BH: Boathouse, CH: Charleston, VA: Valino Island, WI: Winchester Creek; EC-S: Elliot Creek, JN-S: Joe Ney Slough; WI-S: Winchester Creek south.

ranged from 2-11%. The only site not meeting the percent samples standard when all years were combined was Sengstacken-Mid. Over the 15 year sampling period, bacteria concentrations remained relatively stable for all sites with linear regression slopes near zero (-0.0038 to 0.0056). Coos estuary sites with slightly positive slopes (bacteria levels slightly increasing) include Marker 7 and Willanch Inlet, and the majority of South Slough sites had slightly increasing slopes. The 16 remaining Coos Bay sites had slightly negative slopes, as did the following South Slough sites: Hanson's Landing, Valino SW, Valino NW, Joe Ney Mouth, Joe Ney Lwr, and Graveyard Hole.

When median monthly values were calculated for all years, no clear month or season emerged as having highest bacteria levels at all sites (Table 4). Higher winter month values occur at many Coos Bay sites (e.g., December and January at Marker 7 and Marker 11) while some of the highest medians overall were during summer months in South Slough (e.g., July at Sengstacken Mouth, Sengstacken Mid, and Winchester).

## Lower Bay Bacteria Monitoring

CTCLUSI began monitoring bacteria concentrations in the Coos estuary in 2006 at their water quality monitoring site near the U.S. Bureau of Land Management (BLM) boat ramp on North Spit, followed by their Empire

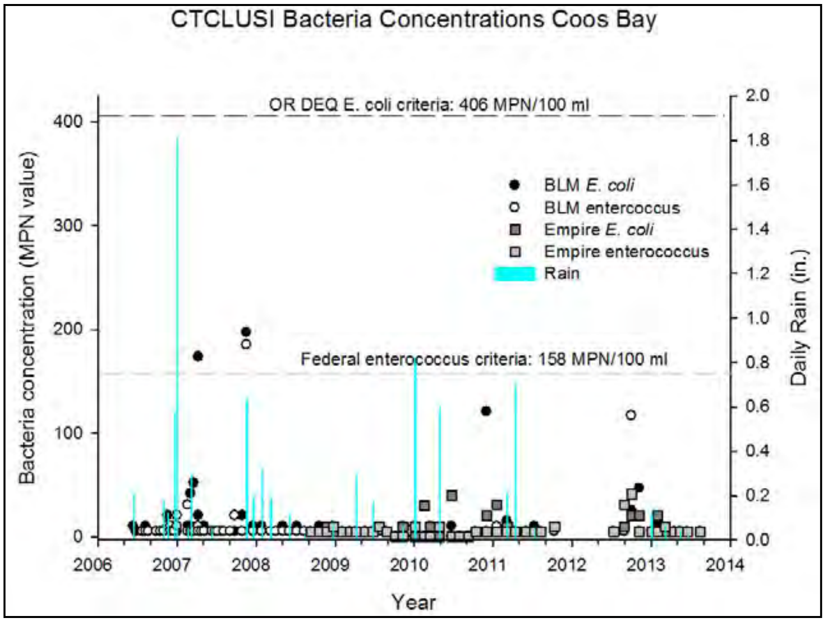



Figure 12. Monthly average *E. coli* and *Enterococcus* bacteria concentrations sampled at two sites in the Lower Bay subsystem by CTCLUSI. Gray dashed line is federal standard for *Enterococcus*; black dashed line is ODEQ *E. coli* standard for fresh and estuarine non-shellfish growing waters. Data: CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013

Dock site in 2008 (Figure 11). Both *E. coli* and *Enterococcus* concentrations were monitored monthly. Data reported here were derived from their annual reports (CTCLUSI 2007, 2008, 2009, 2010, 2011, 2012, 2013).

Average monthly *E. coli* bacteria concentrations at the BLM station ranged from 5 to 25 MPN/100 mL and median values were 5 to 15.3 MPN/100 mL. Average monthly *Enterococcus* concentrations at the BLM station ranged from 1.1 to 32.9 MPN/100 mL while median values were 0 to 5 MPN/100 mL) (Figure 12).

At the Empire Dock station, average monthly *E. coli* levels ranged from 5 to 13.9 MPN/100 mL while median values were 5 (< 10) to 15 MPN/100 mL. Average monthly *Enterococcus* values ranged from 3.3 to 20.5 MPN/100 mL; median values were 0 to 18 MPN/100 mL (Figure 12).

Overall, both *E. coli* and *Enterococcus* levels were higher at the BLM station (average 13.8 and 9.0 MPN/100 mL respectively) than at Empire Dock (average 8.9 and 6.4 MPN/100 mL respectively).

There was no direct correlation between rainfall events and high levels of bacteria at either site, although some rain events were associated with slightly higher bacteria concentrations (Figure 12).

All samples at both stations fell well below ODEQ single sample standard; maximum *E. coli* bacteria concentrations at the BLM station were 197 MPN/100 mL and were 40 MPN/100 mL at Empire Docks (Figure 12).

The federal standard of no single sample exceeding 158 *Enterococcus* organisms/100 mL for Moderate Use Coastal Recreation

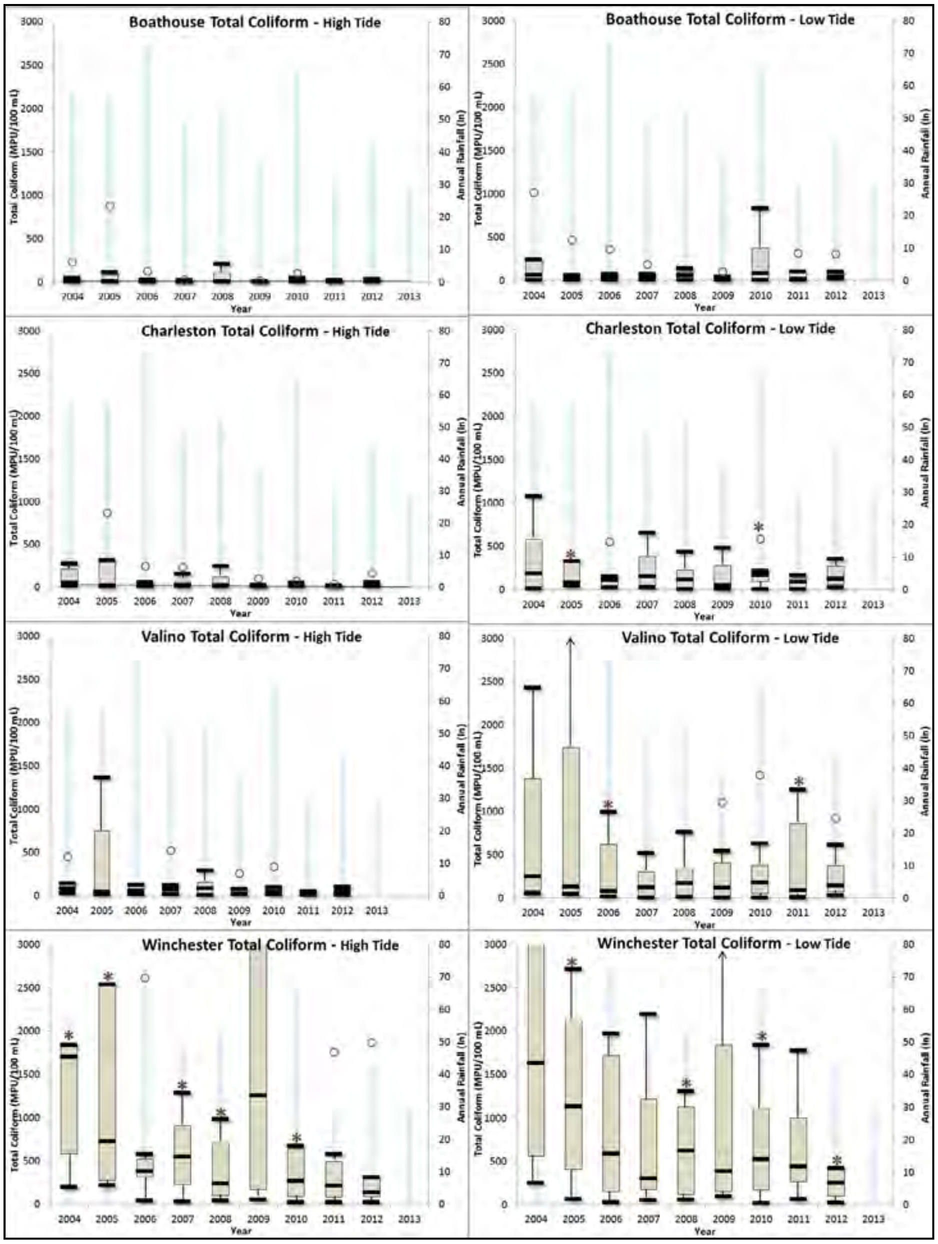



Figure 13. Tukey-style boxplots of average annual total coliform concentrations at high tide (left) and low tide (right) with daily rainfall at four South Slough sampling stations from 2004 to 2013. Shaded tan boxes represent middle 50% of the data. Black lines within tan boxes indicate median value. Upper and lower bars delineate normal distribution data. Outliers outside this coverage are shown as open red circles; red asterisks indicate outliers off the scale of the graphs. Rainfall is shown as blue bars behind the box plots. Bacteria data: SSNERR 2013; Precipitation data: NWS 2014

Waters was exceeded only once during the seven years of CTCLUSI sampling - at the BLM station in 2007 (184.9 MPN/100 mL). Generally concentrations were consistently low (e.g., the maximum level of *Enterococcus* at the Empire Dock station across all years was 41 MPN/100 mL).

South Slough Estuary Bacteria Monitoring

Staff at the SSNERR have conducted monthly bacteria concentration monitoring (total coliforms and *E. coli*) at four stations in the South Slough since 2004 as part of their long-term

System-Wide Monitoring Program (SWMP) (Figure 11). Reported here are data from 2004-2013.

Overall, the data were highly variable between sites, the most marine-dominated site (Boathouse) having lowest overall total coliform concentrations and lowest variability at both high and low tide. Bacteria concentrations increased up the estuary along the estuarine gradient peaking at the river-dominated Winchester station (Figure 13). All sites had higher total coliform levels and higher variability at low tide versus high tide.

Rainfall does not appear to have a strong relationship with bacteria levels; in fact, the years

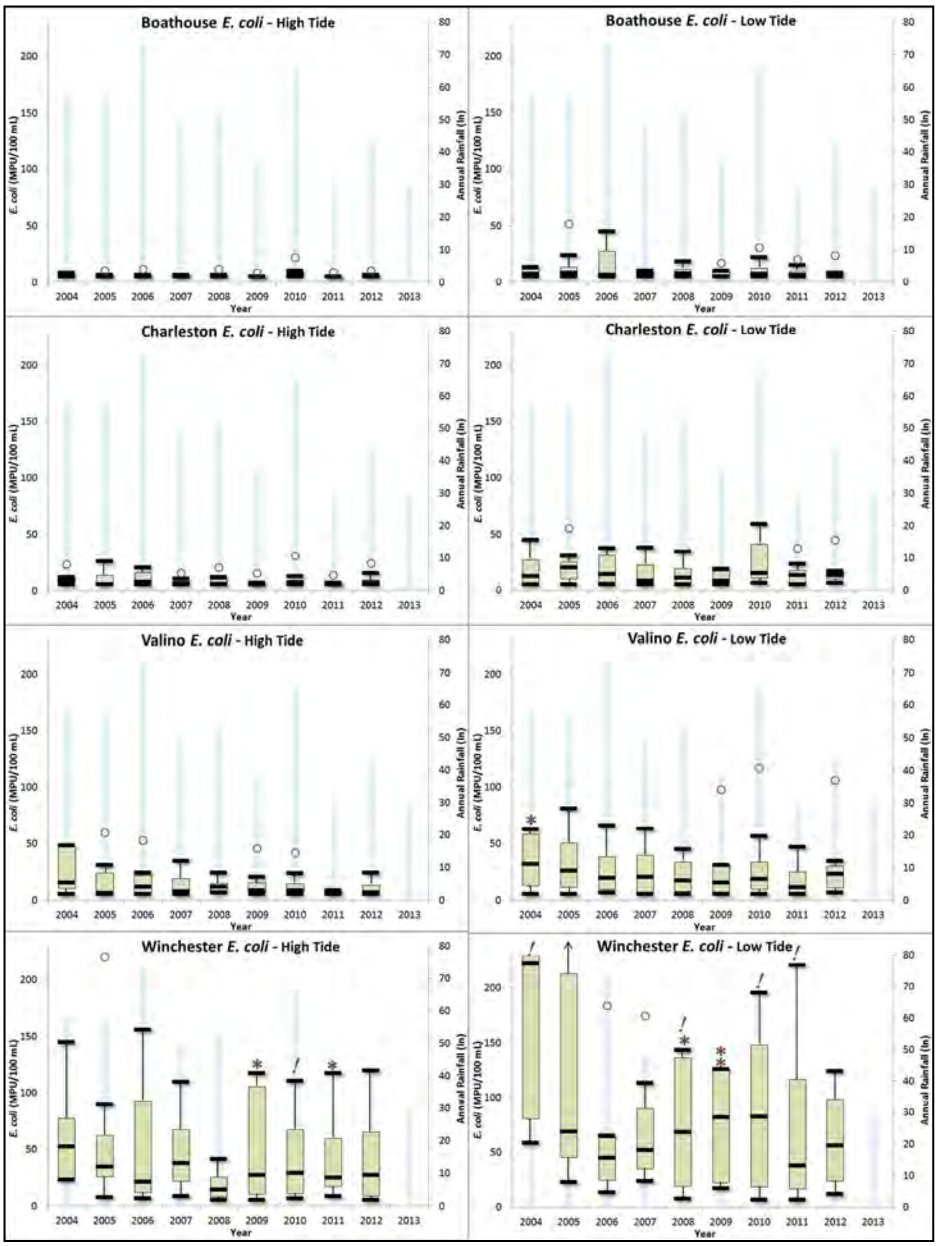



Figure 14. Tukey-style boxplots of average annual *E. coli* concentrations at high tide (left) and low tide (right) with daily rainfall at four South Slough sampling stations from 2004 to 2013. Shaded green boxes represent middle 50% of the data. Black line within green boxes indicates median values. Upper and lower bars delineate normal distribution data. Outliers outside this coverage are shown as open red circles; red asterisks indicate outliers off the scale of the figure; red exclamation points indicate outliers exceeding ODEQ's criterion of 406 organisms/100 mL. Rainfall is shown as blue bars behind the box plots. . Bacteria data: SSNERR 2013; Precipitation data: NWS 2014

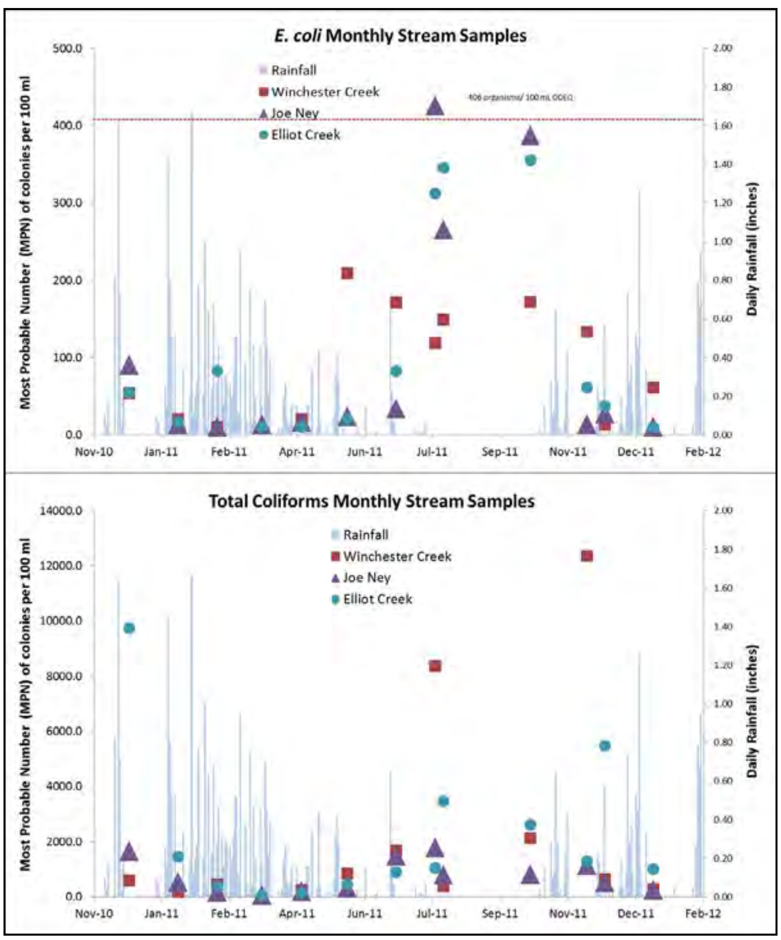
with the highest rainfall (2006 and 2010) had lower total coliform levels. Linear regressions of medians over the nine year period show a weak decreasing trend at all sites, all tides. Winchester station at low tide had the highest $R^2$ value at 0.61.

Similar findings were seen with *E. coli* data, with Boathouse station having the lowest levels and least variability while Winchester station had the highest (Figure 14). The Winchester station exceeded ODEQ's *E. coli* criterion (no single sample > 406 organisms/100 mL) on four occasions at low tide and once at high tide; it was the only station to do so. Higher *E. coli* concentrations and higher variability were found at low tide over high tide.

Again, there was no clear relationship between *E. coli* levels and annual rainfall, and linear regressions of *E. coli* medians had a weak decreasing trend at all sites, all tides. Valino at low tide showed the strongest correlation with an $R^2$ value of 0.42.

Bacteria Concentration in South Slough Streams

Stream bacteria concentrations at three streams collected by Cornu et al. (2012) are presented as the average MPN/100 mL of




Figures 15 (top) and 16 (bottom). Average monthly *E. coli* bacteria concentrations (top) and average monthly total coliform concentrations (bottom) with daily rainfall in South Slough streams. Only Winchester Creek, Elliot Creek and Joe Ney are discussed in this report – other streams are outside project boundaries. Dashed red line indicates the ODEQ standard for a single *E. coli* sample. Adapted from: Cornu et al. 2012 three replicate samples per month. They observed a general pattern of higher *E. coli* counts during the summer season (May-Oct) (Figure 15). Overall, most of the *E. coli* data fell below the single sample standard set by ODEQ for recreational freshwater and estuarine waters in non-shellfish growing areas, with Joe Ney being the single exception (425 MPN/100mLs)(Figure 14). Joe Ney had the highest *E. coli* maximums, followed by Elliot Creek.

Counts for total coliforms followed the same general pattern as the *E. coli* bacteria with higher counts occurring in summer months (Figure 16). Winchester Creek had the highest total coliform maximum, again followed by Elliot Creek.

**Why is it happening?**

Higher bacteria counts are common (if not expected) during times of higher stream flows and rainfall because increased runoff delivers more nutrients and bacteria to the estuary. While results from the above studies include sites where bacteria counts increased during high flows and precipitation events, not all sites followed this pattern (e.g., see South Slough Estuary Bacteria Monitoring section).

Higher summer counts possibly result from a combination of higher summertime water temperatures (which can increase bacteria counts) and summertime wildlife activity (typically more active than in other times of the year)(Tiefenthaler et al. 2008).

A more important factor to consider is the difference in landscape settings of the different water bodies.
Souder (2003) investigated bacteria sources in three water bodies in our project area that were representative of developed, rural residential, and undeveloped regions. He found multiple sources of bacteria contamination common to all three sample locations, but in different proportions, including wildlife (e.g., waterfowl), canines (e.g. domestic dogs), humans (e.g., septic failures), and livestock (e.g., cattle). Differences in sources at each of the sites was most likely linked to their associated land uses.

Pony Creek was characterized as an urban stream that receives input from three small tributary streams near residential and commercial areas. In addition, two sewage pump stations and numerous stormwater outfalls are located near Pony Creek. Pony Creek easily had the highest bacteria levels overall of the three sites, probably due to greater impervious surfaces leading to higher surface water runoff into the creek during the rainy season. Other studies have found fecal coliform concentrations increase with development and associated stormwater runoff (directly related to amount of impervious surfaces), which is the leading cause of nonpoint source bacteria pollution (Blair 2011).

In contrast, Coalbank Slough was characterized as a typical rural residential area. Livestock farms (horse, cattle) as well as hobby farms with cattle, horses, llamas, turkeys, sheep, and goats dominate the land use. The residential area ranges from ½ to 40 acres, all parcels of which are on septic systems or cesspools. In upper parts of the watershed, the land is forested and typical wildlife includes elk, deer, beaver, and bear.

Similar rural residential areas of the estuary discussed in other studies above consistently had high bacteria levels (e.g., Ross Slough and Stock Slough from the TMDL/storm bacteria section above), and are similarly likely tied to land use (e.g., agriculture or septic failure).

In contrast, in all studies South Slough sites had generally low bacteria levels. Souder (2003) described South Slough as relatively pristine with little residential or rural development surrounded by relatively undisturbed marshes and second-growth upland forests (which are industrially harvested in the upper portions of the watershed).

**References**

American Public Health Association (APHA). 1998. Standard Methods for the Examination of Water and Wastewater (20th ed.). Washington, DC.

Blair, A. 2011. Bacterial Contamination in the Context of Land Use, runoff and Climate [Powerpoint Slides]. National Oceanic and Atmospheric Administration, National Ocean Service office of National Centers for Coastal Ocean Science. Retrieved from : https://www.dnr.sc.gov/marine/NERR/present/contamination/Blair.pdf

Bohaboy, S. 2011. Oregon Bacteria Rule: Bacteria Criteria for Marine and Estuarine Waters. DEQ 10-WQ-0066-IMD. Version 1.1 State of Oregon Department of Environmental Quality. 15 pp.

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2007. Tribal Water Quality Assessment Report: October 2005-September 2006. CTCLUSI Department of Natural Resources, Coos Bay OR. 40 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2008. Tribal Water Quality Data Summary: October 2006-September 2007. CTCLUSI Department of Natural Resources, Coos Bay OR. 40 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2009. Confederate Tribes of the Coos, Lower Umpqua, and Siuslaw Indians Water Quality Data Summary: October 2007-September 2008. CTCLUSI Department of Natural Resources, Coos Bay OR. 33 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI). 2010. Intermediate Tribal Water Quality Assessment Report. CTCLUSI Department of Natural Resources, Coos Bay OR. 33 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2011. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 37 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2012. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI

Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians (CTCLUSI). 2013. Intermediate Tribal Water Quality Assessment Report for the Confederated Tribes of Coos, Lower Umpqua and Siuslaw Indians. CTCLUSI Department of Natural Resources, Coos Bay OR. 28 pp. Retrieved from: http://ctclusi.org/natural-resources/water-quality-program

Cornu, C.E., J. Souder, J. Hamilton, A. Helms, R. RimLer, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association 225 pp.

National Weather Service (NWS). 2014. [North Bend Airport (KOTH station) 24-Hour Precipitation Data 2004-2013]. Unpublished raw data. Retrieved from: http://mesowest.utah.edu/cgi-bin/droman/download_ndb.cgi?stn=KOTH&hour1=22&min1=56&time-type=LOCAL&unit=0&graph=0

Oregon Department of Agriculture (ODA). 2014. 1999-2014. [Coos Bay and South Slough Bacteria Sampling for Shellfish Growing Areas]. Unpublished raw data.

Oregon Department of Environmental Quality (ODEQ). 2006. 2001-2006. [Coos Bay Water Quality TMDL Development-Coos Bay Bacteria]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007. [Coos Bay Water Quality Storm Related Bacteria Sampling]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/.

Oregon Department of Environmental Quality (ODEQ). 2014. Oregon's Draft 2012 Integrated Report: Assessment Database and 303(d) List. Retrieved from: http://www.deq.state.or.us/wq/assessment/rpt2012/search.asp

Souder, J.A. 2003. Report on the Analyses of Bacteriological Contributions to Direct Bay Tributary Streams in the Coos Estuary Using Traditional Public Health Indicators and DNA Analyses of E. coli. Coos Watershed Association Assessment Reports. 9 pp.

South Slough National Estuarine Research Reserve (SSNERR). 2013. [System-Wide Monitoring Program Monthly *E. coli* and Total Coliform Bacteria Sampling - 2004-2013]. Unpublished raw data.

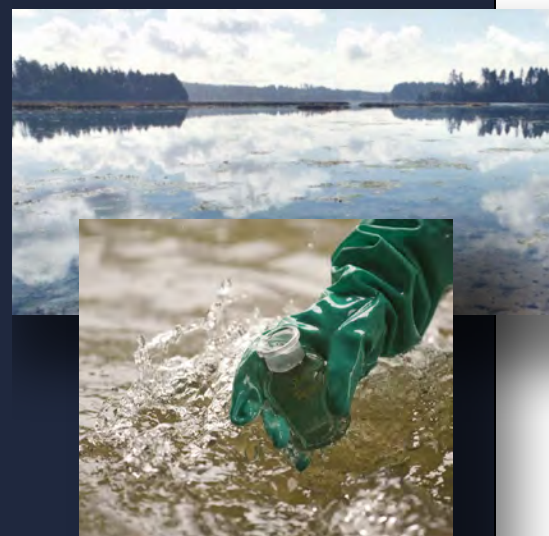
Tiefenthaler, LL, Stein, ED, and Lyon, GS. 2008. Fecal Indicator Bacteria (FIB) levels during dry weather from Southern California Reference Streams. Southern California Coastal Water Research Project Tech Report. 542 pp.

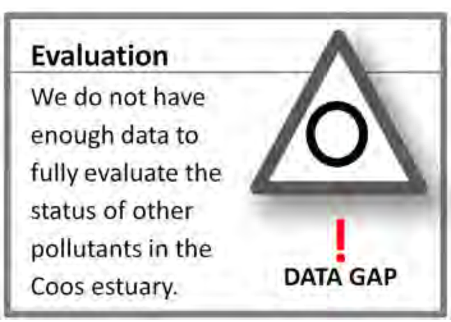
United States Environmental Protection Agency (USEPA). 2001. Protocol for Developing Pathogen TMDLs. EPA Office of Water, Washington, DC. 132 pp.

# Water Quality in the Coos Estuary and Lower Coos Watershed: Other Pollutants


*Summary:*

- *Previously problematic point sources of pollution may still pose threats to water quality.*
- *Outside of some known "pollution pockets" in the Coos estuary, it appears that concentrations of dissolved pollutants generally meet USEPA standards.*
- *Many streams in the study area are listed under Section 303d of the Clean Water Act for insufficient information.*
- *More comprehensive monitoring is needed to fully assess the status of other pollutants in the Coos estuary.*




**What's happening?**

<u>Organic Carbon in the Water Column</u>

*Total Organic Carbon*

Total organic carbon (TOC) is an indicator of the presence and abundance of organic compounds in the environment and is found naturally in estuary waters and sediments. High TOC levels are often associated with the presence of other pollutants, including the toxic by-products of organic decomposition (ammonia and sulfide)(Hyland et al. 2005). Additionally, dissolved organic matter binds with metals such as mercury (Swett 2010) and other pollutants, including pesticides and herbicides (Wijayaratne and Means 1984), as well as polychlorinated biphenyls (PCBs) (Brownawell and Farrington 1986). Consequently, TOC (more specifically the dissolved organic carbon (DOC) component of TOC - see below) may facilitate pollutant transport between sediments and the water column (Swett 2010). TOC may also result in harmful byproducts (i.e., trihalomethanes) during the water treatment process (Fleck et al. 2007). The presence and abundance of TOC is often used as an indirect measure of water quality and sediment contamination.

The Oregon Department of Environmental Quality (ODEQ) has monitored total organic carbon (TOC) in the South Slough, Isthmus Slough, and Coos River subsystems (Figure 1) (ODEQ 2001, 2007a, 2007b, 2009a, 2009b). TOC sampling is sporadic, with the most recent data coming from 2009 (Table 1). The highest TOC levels were recorded in the South Slough subsystem near the Joe Ney Landfill (closed in 2013 and most recently used exclusively for construction debris)(see sidebar).

The Coos Bay/North Bend Water board monitored TOC from 2010-2012 in the Pony Slough (Pony Creek and Merritt Lake) and Lower Bay (North Spit) Subsystems as part of their drinking water program (Water Board 2012). TOC levels in Pony Slough and the Lower Bay were 3-4 mg/L on average over these years (Table 2). These levels are similar to the mean observed concentrations at ODEQ sites at South Slough, Isthmus Slough, and Coos River.

***Joe Ney Landfill***

*The Joe Ney Construction and Demolition Landfill is located near Crown Point in the South Slough Subsystem (Figure 1). The facility is owned and was operated by Coos County from 1981 to 2013. Past landfill practices have likely contributed to groundwater contamination. For example, a complaint was filed in 1986 by a man who allegedly saw a “truck dumping 55-gallon drums” into the Joy Ney dump “which were immediately covered.” The Oregon Department of Environmental Quality (ODEQ) monitors groundwater at the site with semi-annual sampling/analyses using a network of 18 monitoring wells, and 4 residential wells. Surface water is also monitored on a semi-annual basis with samples collected from 5 locations. These monitoring points were established between 1989 through 1999 during the course of several environmental investigations conducted at this site. Based on groundwater monitoring results, landfill activities have affected groundwater, and for that reason, Coos County has prepared a remedial investigation work plan for this site which led to the County’s closure of the dump.*

*Source: ODEQ 2014b*

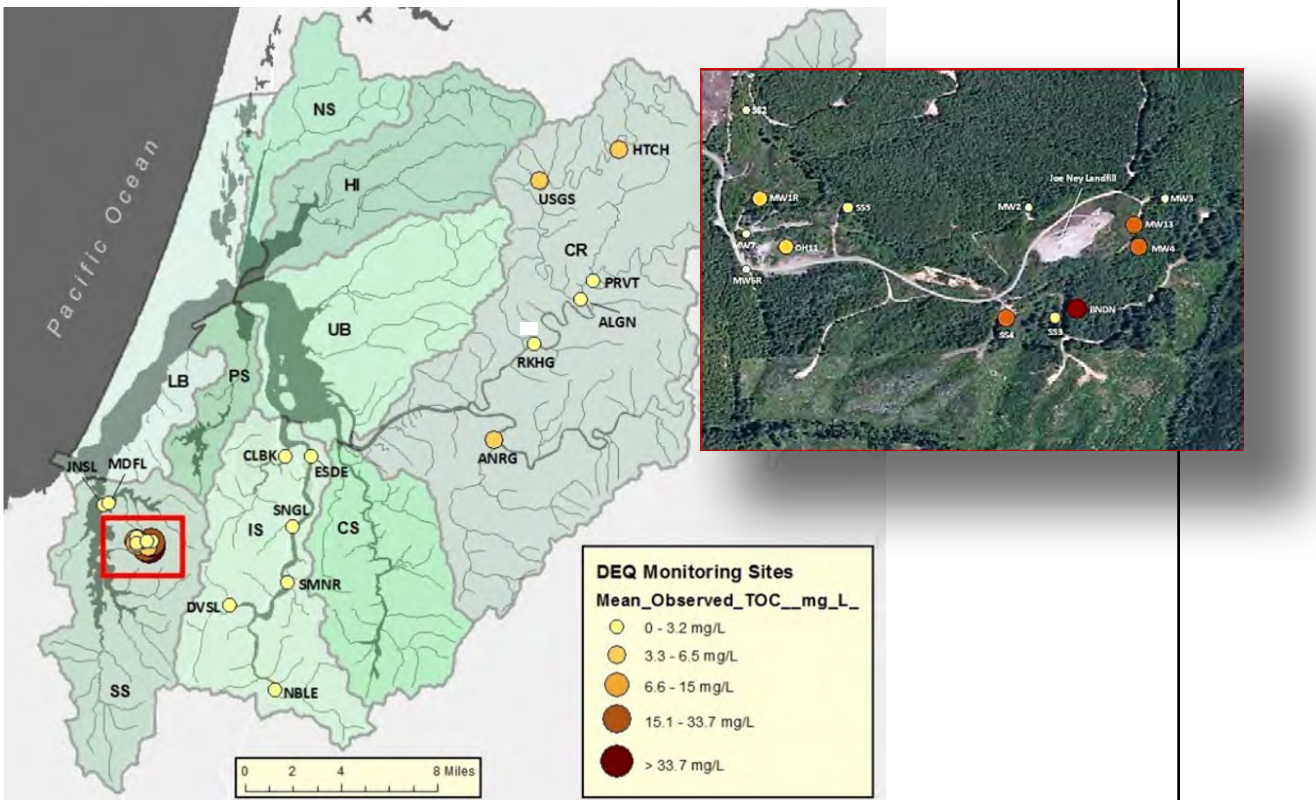



Figure 1. Location of ODEQ TOC monitoring sites and range of mean observed TOC concentrations at each site. Data: ODEQ 2001, 2007a, 2007b, 2009a, 2009b. Color aerial photo insert shows the number and location of TOC monitoring sites at or near the former Joy Ney dump site. Subsystem codes: SS-South Slough, LB-Lower Bay, PS-Pony Slough, IS-Isthmus Slough, UB-Upper Bay, NS-North Slough, HI-Haynes Inlet, CR-Coos River, CS-Catching Slough.

Table 1. Mean observed TOC and summary of all ODEQ observations (1995-2009). Data: ODEQ 2001, 2007a, 2007b, 2009a, 2009b

| Monitoring Site | Site Code | Subsystem | TOC (mg/L) | # Obs | Sampling Dates | Source |
|---|---|---|---|---|---|---|
| Bandon Landfill leachate drain | BNDN | SS | 60.0 | 1 | March 1995 | DEQ 2009b |
| SS-4 | SS4 | SS | 33.66* | 3 | April 1998, May 2009 | DEQ 2009b |
| Joe Ney Landfill Monitoring Well 4 | MW4 | SS | 30.3 | 3 | March 1995, April 2002, Oct. 2006 | DEQ 2009b |
| Joe Ney Landfill Monitoring Well 13 | MW13 | SS | 26.0 | 1 | April 2002 | DEQ 2009b |
| Joe Ney Landfill Monitoring Well MW-1R | MW1R | SS | 15.0 | 2 | March 1995, April 1998 | DEQ 2009b |
| Dh-11 | DH11 | SS | 11.3 | 4 | April 1998, April 2002, Oct. 2006, May 2009 | DEQ 2009b |
| Joe Ney Landfill Ss-3 surface site downstream of landfill | SS3 | SS | 6.5 | 2 | March 1995, Oct. 2006 | DEQ 2009b |
| South Fork Coos River at Anson Rogers Bridge | ANRG | CR | 6.0 | 2 | Sept. 2001, Nov. 2001 | DEQ 2001 |
| SS-5 | SS5 | SS | 5.0 | 1 | May 2009 | DEQ 2009b |
| Millicoma River at USGS Gaging Station (RM 6.6) | USGS | CR | 4.5 | 2 | Oct. 2009 | DEQ 2009a |
| West Fork Millicoma River 0.25 miles upstream of hatchery | HTCH | CR | 4.5 | 2 | Oct. 2009 | DEQ 2009a |
| Millicoma River at Rook-Higgins boat ramp | RKHG | CR | 3.2 | 5 | Sept. 2001, Nov. 2001, Oct. 2009, Oct. 2009 | DEQ 2001, DEQ 2009a |
| East Fork Millicoma River at Private Road | PRVT | CR | 3.0 | 2 | Oct. 2009 | DEQ 2009a |
| West Fork Millicoma River at Allegany | ALGN | CR | 3.0 | 2 | Oct. 2009 | DEQ 2009a |
| Davis Slough | DVSL | IS | 2.5 | 11 | April 2006, June 2006 - March 2007 | DEQ 2007 |
| Isthmus Slough at Sumner Bridge | SMNR | IS | 2.5 | 26 | April 2006 - March 2007 | DEQ 2007 |
| SS-2 Shana Creek upstream of Joe Ney Landfill north of SS-5 | SS2 | SS | 2.5 | 2 | March 1995, Oct. 2006 | DEQ 2009b |
| Noble Creek tidegate | NBLE | IS | 2.4 | 10 | April 2006, July 2006 - March 2007 | DEQ 2007 |
| Shinglehouse Slough mouth | SNGL | IS | 2.1 | 15 | April 2006, June 2006 - March 2007 | DEQ 2007 |
| Coalbank Slough mouth | CLBK | IS | 2.0 | 24 | April 2006 - March 2007 | DEQ 2007 |
| Coos Bay South Slough near Joe Ney Slough | JNSL | SS | 2.0 | 1 | April 1998 | DEQ 2009b |
| Isthmus Slough at Eastside Bridge | ESDE | IS | 1.8 | 26 | April 2006 - March 2007 | DEQ 2007 |
| Joe Ney Landfill Monitoring Well 3 | MW3 | SS | 1.75* | 2 | March 1995 | DEQ 2009b |
| Joey Ney Landfill Monitoring Well 6R | MW6R | SS | 0.875* | 4 | March 1995, April 1998, Oct. 2006, May 2009 | DEQ 2009b |
| Joe Ney Landfill Monitoring Well 7 | MW7 | SS | 0.5 | 1 | March 1995 | DEQ 2009b |
| Joe Ney Landfill Monitoring Well 2 | MW2 | SS | 0.5* | 1 | March 1995 | DEQ 2009b |
| Joey Ney Slough at mudflat east of boatyard (JNMFE) | MDFL | SS | 0.5* | 1 | April 1998 | DEQ 2009b |

* Mean was calculated by substituting a value of 0.5 mg/L for observations that were recorded as "< 1 mg/L."

Table 2. Mean observed TOC at three Pony Slough and Lower Bay sites. Data: Water Board 2012

| Year | Mean Annual TOC (mg/L) | Minimum TOC (mg/L) | Maximum TOC (mg/L) | Std. Error | Number of Observations |
|---|---|---|---|---|---|
| 2010 | 3.44 | 2.5 | 4.3 | 0.18 | 11 |
| 2011 | 3.05 | 1.12 | 4.75 | 0.28 | 19 |
| 2012 | 3.96 | 3.58 | 4.52 | 0.11 | 7 |

*Dissolved Organic Carbon*

Dissolved organic carbon (DOC) is a component of TOC, the measurement of which allows for particularly accurate TOC assessments in the water column. Unfortunately, little is known about the level of DOC in the Coos estuary.

What we do know comes from Pregnall (1983) who studied primary production in South Slough to help quantify DOC produced by Coos estuary biota. His findings suggest that photosynthesis of South Slough intertidal algae (*Enteromorpha prolifera*) releases 0.13-0.57 mg of DOC per gram of dry weight biomass per hour. This rate was shown to increase in response to changes commonly associated with estuarine environments such as daily salinity fluctuations.

More research is needed to fully understand estuarine DOC dynamics in the Coos estuary and how measuring DOC concentrations can be used to improve water quality assessments.

**Background**

TOC can be thought of as the sum of particulate organic carbon (POC) and dissolved organic carbon (DOC). While POC settles in the sediment (see Chapter 10: Sediment Contamination in the Coos Estuary), DOC is transported from the sediment to the water column by a variety of natural and human activity-related processes (e.g., diffusion, bioturbation, bioirrigation, pore water advection, sediment resuspension)(Burdige 2006). Swett (2010) explains that estuarine sediments release significant amounts of DOC due to highly active microbial communities. He adds that, due to its ability to bind to metals such as mercury, DOC is a water quality concern, because it can effectively transport pollutants into the water column. Research suggests that organic carbon may also transport pesticides and herbicides (Wijayaratne and Means 1984) as well as biphenyls (PCBs)(Brownawell and Farrington 1986) into the water column from contaminated sediments. Additionally, high TOC levels in source waters have been shown to result in harmful water treatment byproducts (e.g., trihalomethanes)(Fleck et al. 2007).

Bauer and Bianchi (2011) explain that estuaries are complex systems involving the exchange of carbon between terrestrial, marine, and atmospheric sources. They point out that the complexity of biogeochemical processes in estuaries is compounded by temporal variability. For example, estuarine biogeochemical processes respond to twice daily tidal flooding, daily or weekly storm events, seasonal or monthly changes in temperature and precipitation, and multi-year to decades-long changes in long term climatic regimes (e.g., El Niño Southern Oscillation and Pacific Decadal Oscillation). In addition to these natural processes, estuarine carbon cycling is carried out against a backdrop of human land use activities, which can further complicate an already intricate process (Bauer and Bianchi 2011). Consequently, we have a limited understanding of the role of DOC in governing the flux of organic matter and trace metals in coastal and estuarine systems (Martin et al. 1995).

Dissolved Metals

Metals can readily dissolve in water, and can find their way into estuarine waters from various sources including manufacturing, mining and farming activities (the latter featuring land-applied herbicides and pesticides), and air pollution from fossil fuel combustion (USEPA 2007a). Many metals (e.g., iron, copper ) are also naturally abundant elements found in coastal watersheds (Shacklette and Boerngen 1984; USEPA 2007b). Table 3 summarizes the dissolved metals discussed below.

Water quality criteria for dissolved metals have been developed for both aquatic life and human health (ODEQ 2014a; USEPA 1993, 2007a, 2007b, 2009). For aquatic life criteria, dissolved metal standards are evaluated using an acute criterion (CMC) and a chronic criterion (CCC)(see sidebar). For human health, standards are classified into categories for the safe consumption of 1) water and aquatic organisms, and 2) aquatic organisms only. Figure 2 summarizes the organizational structure of dissolved metal standards for each pollutant.

***Guideline Values for Assessing Aquatic Life Dissolved Metals Standards:***

***Acute Criterion (CMC) -*** *The highest concentration to which aquatic life may be exposed briefly without resulting in adverse effects.*

***Chronic Criterion (CCC) -*** *The highest concentration to which aquatic life may be exposed indefinitely without resulting in adverse effects.*

*Source: USEPA 2012*

Data describing dissolved metal concentrations are available in the Pony Slough, Sough Slough, Coos River, and Isthmus Slough subsystems (Figure 3 and Table 4)(ODEQ 1995, 1998a, 2002, 2006a, 2006b, 2006c, 2007a, 2007b, 2009a, 2009b; Water Board 2012).

From 1998 to 2012, 13 sites in the study area (including the subsystems listed above)(Figure 4 and Table 3) were listed under the Clean Water Act for insufficient data or as sites of “potential concern”. These listings reinforce the fact that we don’t yet have enough information to form a comprehensive understanding of the status of dissolved metals in the Coos estuary.

| Pollutant | What is it? | Industrial Uses and Sources | EPA National WQ Criteria Listing Aquatic Life | Human Health |
|---|---|---|---|---|
| Aluminum | Light-weight, mallable metal comprised of mostly bauxite | Transportation, construction, packaging, machinery | Not Listed | Not Listed |
| Antimony | Metalliod, toxic | Discharge from petroleum refineries, fire retardants, ceramics, electronics, solder | Not Listed | Priority |
| Arsenic | Metalloid, toxic | Marine building material, logging, erosion of natural deposits, runoff agriculture and glass/electronics | Priority | Priority |
| Barium | Alkaline metal | Discharge of drilling wastes, discharge from metal refineries, erosion of natural deposits | Not Listed | Not Listed |
| Beryllium | Alkaline metal | Discharge from metal refineries and coal-burning factories, discharge from electrical, aerospace, and defense industries | Not Listed | Priority |
| Boron | Metalloid | Heat resistant alloys | Non-Priority | Not Listed |
| Cadmium | Transitional metal, mallable, conductor | Corrosion of galvanized pipes, erosion of natural deposits, discharge from metal refineries, runoff from waste batteries and paints | Priority | Priority |
| Chromium | Transitional metal, mallable, conductor | Discharge from steel and pulp mills, erosion of natural deposits | Priority | Priority |
| Cobalt | Transitional metal, mallable, conductor, magnetic | Metal alloys, chemicals, colorant, nuclear power, radiactive waste | Not Listed | Not Listed |
| Copper | Transitional metal, mallable, condutor | Corrosion of household plubing systems, erosion of natural deposits | Priority | Priority |
| Iron | Transitional metal, mallable, conductor, magnetic | Component in steel, naturally abundant in geological materials | Non-Priority | Not Listed |
| Lanthanum | Lanthanide series, rare earth elements | LED and other lighting applications | Not Listed | Not Listed |
| Lead | Other metal, solid, dense | Corrosion of household plumbing systems, erosion of natural deposits, paints | Priority | Not Listed |
| Lithium | Alkali metal, soft, mallable, conductor | Ceramics and glass, batteries, lubricating greases, powders for molding/casting metal, dehumidifying | Not Listed | Not Listed |
| Magnesium | Alkaline metal | Component in titanium and other alloys, metal casting, wrought products | Not Listed | Not Listed |
| Manganese | Transitional metal, sulfur-fixing, deoxidizing, alloying for metal production | Metal production, gasoline additive, colorant, fertilizer | Not Listed | Priority |
| Mercury | Transitional metal, mallable, conductor | Erosion of natural deposits, discharge from refineries and factories, runoff from landfills and croplands | Priority | Priority |
| Molybdenum | Transitional metal, mallable, conductor | Metal alloys, steel, cast iron | Not Listed | Not Listed |
| Nickel | Transitional metal, mallable, conductor, magnetic | Metal alloys, steel, electroplating | Priority | Priority |
| Selenium | Non-metal | Petroleum refineries, erosion of natural deposits, discharge from mining lead, copper, and nickel | Priority | Priority |
| Silver | Transitional metal, mallable, conductor | Jewelry, photography and electronics, dental products, solder, brazing alloys, batteries | Priority | Not Listed |
| Thallium | Other metal, solid, dense, toxic | Leaching from ore-processing sites, discharge from electronics, glass, and drug factories | Not Listed | Priority |
| Vandium | Transitional metal, mallable, conductor | Metal alloys | Not Listed | Not Listed |
| Zinc | Transitional metal, mallable, conductor | Galvanizing, metal alloys | Priority | Priority |

Table 3. Dissolved metals found in aquatic systems.

Data sources: ODEQ 2014a, USEPA 1993;

Industrial Uses and Sources data: Buszka et al. 2007, CDC 2004, ODEQ 2008, RSC 2014, USEPA 2009, USGS 2014, Wilburn 2012, Winter 1993;

Water Quality Criteria Listing data sources: USEPA 1993

***Priority Pollutant Status***

*The USEPA has developed a list of 126 priority pollutants. Priority status is assessed based on the following criteria:*

*1. Must be included on USEPA's list of toxic pollutants*

*2. Must have chemical standards and published testing methods*

*3. Must be frequently found in water*

***4. Must have been produced domestically in substantial quantities***

***Source: USEPA 2014***

Of the 13 sites mentioned, only three were listed as potential water quality threats to both aquatic life and human health due to elevated concentrations of dissolved metals (Coos Bay in 1998 and Day and Storey Creeks in 2004). The remaining 10 sites were listed due to informational gaps (Table 3)(ODEQ 1998b, 2004, 2012).

The status of specific dissolved metals in the Coos estuary and surrounding area is detailed below. This inventory presents USEPA standards for both aquatic life and human health. However, the toxic effects of exposure focus on human health, because the effects on

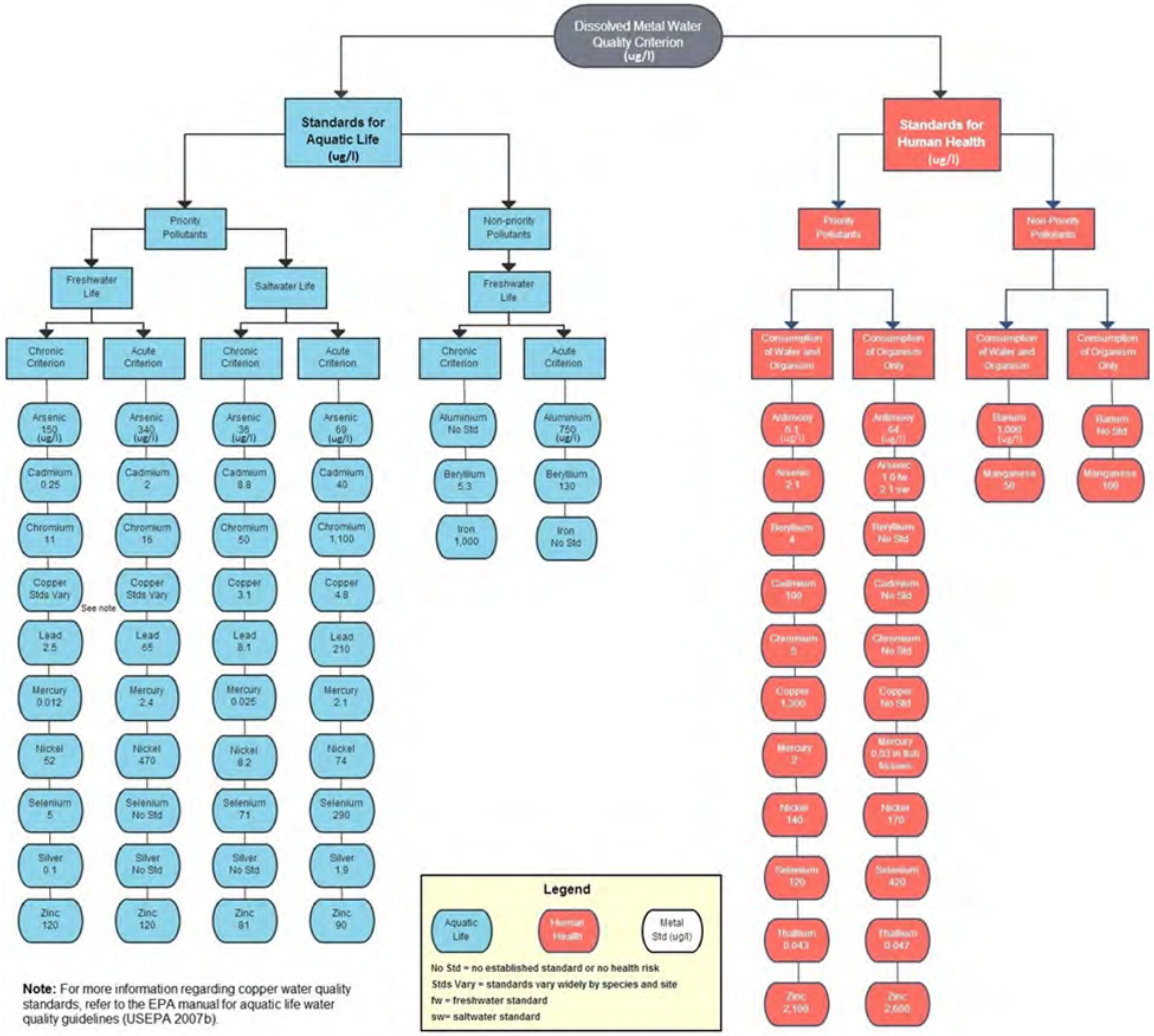



Figure 2. Dissolved metals standards in micrograms per liter (ug/l). Source: ODEQ 2014a; USEPA 1993, 2007a, 2007b, 2009

aquatic life can vary significantly by species and environmental conditions (e.g., pH, organic content, sediment characteristics, conductivity, etc.)(USEPA 1980; USEPA 2007b).

*Aluminum*

Dissolved aluminum (1995-2009) concentrations appear to be higher in Isthmus Slough than in South Slough or Pony Slough.

Aluminum is a non-priority pollutant for aquatic life standards (see sidebar)(USEPA 1993).

*Antimony*

Antimony concentrations (2005-2009) in South Slough at the former Joe Ney Landfill Disposal Site (JNDS) meet USEPA standards for human consumption of both water and aquatic organisms (Table 4).

| Subsystem | Number of Observations | Dectection Rate[A] (%) | Estimated Average[B] (µg/l) | Max Observed Value[C] (µg/L) | Data Source |
|---|---|---|---|---|---|
| | | | **Aluminium** | | |
| SS | 39 | 26 | 36 | 300 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| IS | 259 | 48 | 1,382 | 2,550 | ODEQ 2006b, 2006c, 2007a, 2007b |
| CR | 11 | 0 | 25 | 25 | ODEQ 2009b |
| | | | **Antimony** | | |
| SS | 31 | 3 | 2.2 | 3.4 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Arsenic** | | |
| SS | 39 | 15 | 38 | 21 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| PS | 10 | 30 | 1.97 | 4 | Water Board 2012 |
| | | | **Barium** | | |
| SS | 39 | 87 | 267 | 1,720 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Beryllium** | | |
| SS | 38 | 11 | 1.13 | 0.029 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Boron** | | |
| SS | 38 | 82 | 668 | 5,230 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| IS | 259 | 95 | 2,380 | 4,170 | ODEQ 2006b, 2006c, 2007a, 2007b |
| CR | 11 | 55 | 136 | 1,260 | ODEQ 2009b |
| | | | **Cadmium** | | |
| SS | 38 | 0 | 1.78 | N/A | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Chromium** | | |
| SS | 38 | 24 | 3.78 | 3.91 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Cobalt** | | |
| SS | 39 | 56 | 11 | 31 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Copper** | | |
| SS | 37 | 25 | 9.03 | 62 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| PS | 10 | 100 | 102.1 | 250 | Water Board 2012 |
| | | | **Iron** | | |
| SS | 38 | 74 | 5,026 | 41,900 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| IS | 259 | 51 | 1,398 | 2,680 | ODEQ 2006b, 2006c, 2007a, 2007b |
| CR | 11 | 45 | 54 | 178 | ODEQ 2009b |
| | | | **Lead** | | |
| SS | 12 | 0 | 0.37 | N/A | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| PS | 10 | 100 | 6.7 | 11 | Water Board 2012 |
| | | | **Lanthanum** | | |
| SS | 16 | 50 | 15 | 25 | ODEQ 1995, 1998 |
| | | | **Lithium** | | |
| SS | 38 | 26 | 11 | 22 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| IS | 259 | 47 | 428 | 750 | ODEQ 2006b, 2006c, 2007a, 2007b |
| CR | 11 | 18 | 14 | 50 | ODEQ 2009b |
| | | | **Magnesium** | | |
| SS | 39 | 100 | 23,663 | 61,900 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| IS | 259 | 47 | 698,268 | 1,210,000 | ODEQ 2006b, 2006c, 2007a, 2007b |
| CR | 11 | 100 | 62,427 | 384,000 | ODEQ 2009b |
| | | | **Manganese** | | |
| SS | 40 | 95 | 679 | 4,890 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| IS | 259 | 51 | 146 | 290 | ODEQ 2006b, 2006c, 2007a, 2007b |
| CR | 5 | 80 | 31 | 79 | ODEQ 2009b |
| | | | **Mercury** | | |
| SS | 26 | 19 | 0.63 | 0.01 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Molybdenum** | | |
| SS | 38 | 21 | 6 | 18 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Nickel** | | |
| SS | 38 | 42 | 6.1 | 10.3 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Selenium** | | |
| SS | 35 | 0 | 2.35 | — | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Silver** | | |
| SS | 39 | 3 | 1.34 | 0.26 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Thallium** | | |
| SS | 20 | 0 | 0.64 | N/A | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Vanadium** | | |
| SS | 39 | 8 | 4 | 0.66 | ODEQ 1995, 1998, 2002, 2006a, 2009a |
| | | | **Zinc** | | |
| SS | 11 | 27 | 1.74 | 4.8 | ODEQ 1995, 1998, 2002, 2006a, 2009a |

A- Percent of all observations above detectable limits.
B - In order to estimate the average concentration, observations that are below dectable limits take on an assumed value (see Chapter Summary).
C - Maximum observed value refers to the highest value in the subset of observations that are above dectectable limits.

Table 4. Summary of dissolved metal concentrations in the lower Coos Watershed. Data: ODEQ 1995, 1998a, 2002, 2006a, 2006b, 2006c, 2007a, 2007b, 2009a, 2009b; Water Board 2012

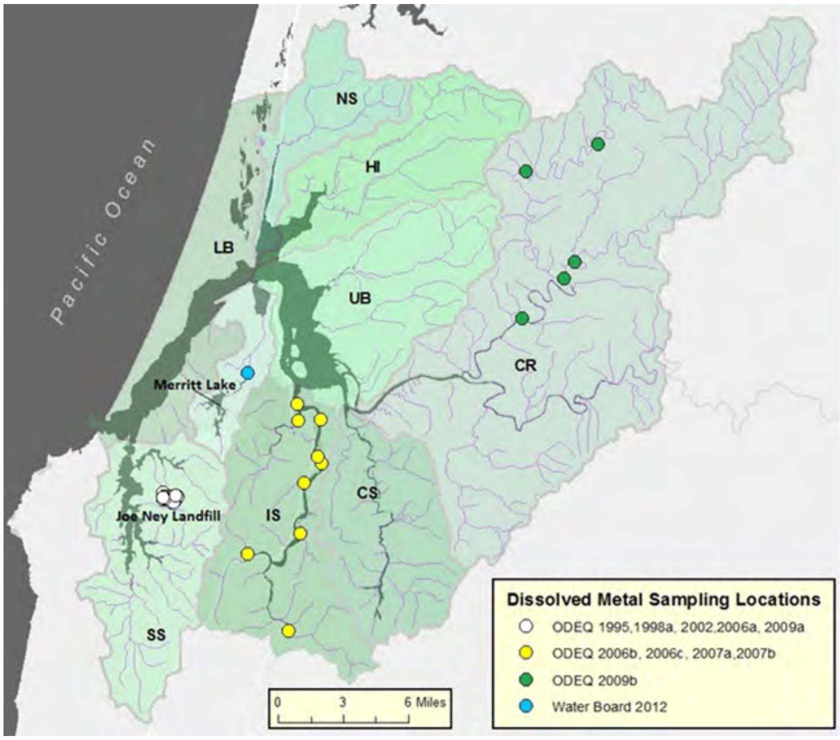



Figure 3. Sampling Locations of Dissolved Metals. Source: ODEQ 1995, 1998a, 2002, 2006a, 2006b, 2006c, 2007a, 2007b, 2009a, 2009b, Water Board 2012. Subsystem codes: SS-South Slough, LB-Lower Bay, PS-Pony Slough, IS-Isthmus Slough, UB-Upper Bay, NS-North Slough, HI-Haynes Inlet, CR-Coos River, CS-Catching Slough

In 2004, Day Creek (South Slough), Mettman Creek (Upper Bay), as well as Morgan Creek and the West Fork of the Millicoma River (Coos River) were all listed due to insufficient information (Table 3)(ODEQ 2004).

Antimony is a priority pollutant, meaning that it is a toxic pollutant with established chemical standards that is frequently found in water (USEPA 1993, 2014). Human exposure to antimony can affect the cardiovascular (heart and blood vessels) and respiratory (breathing) systems, but is not known to have any cancer effects (CDC 2014).

*Arsenic*

At South Slough's JNDS, arsenic concentrations (1995-2009) may be harmful to saltwater aquatic life. Elevated arsenic concentrations at South Slough's JNDS may not meet USEPA recommended concentrations for the safe human consumption of both water and aquatic organisms. In 2012, arsenic concentrations in the Pony Slough subsystem at Merritt Lake met USEPA guidelines (Table 4).

In 2004, arsenic was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004). Arsenic is a priority pollutant for both aquatic life and human health (USEPA 1993). Human exposure to arsenic can affect the dermal (skin), gastrointestinal (digestive), hepatic (liver), neurological (nervous system), and respiratory (breathing) systems. It is a known carcinogen (CDC 2014).

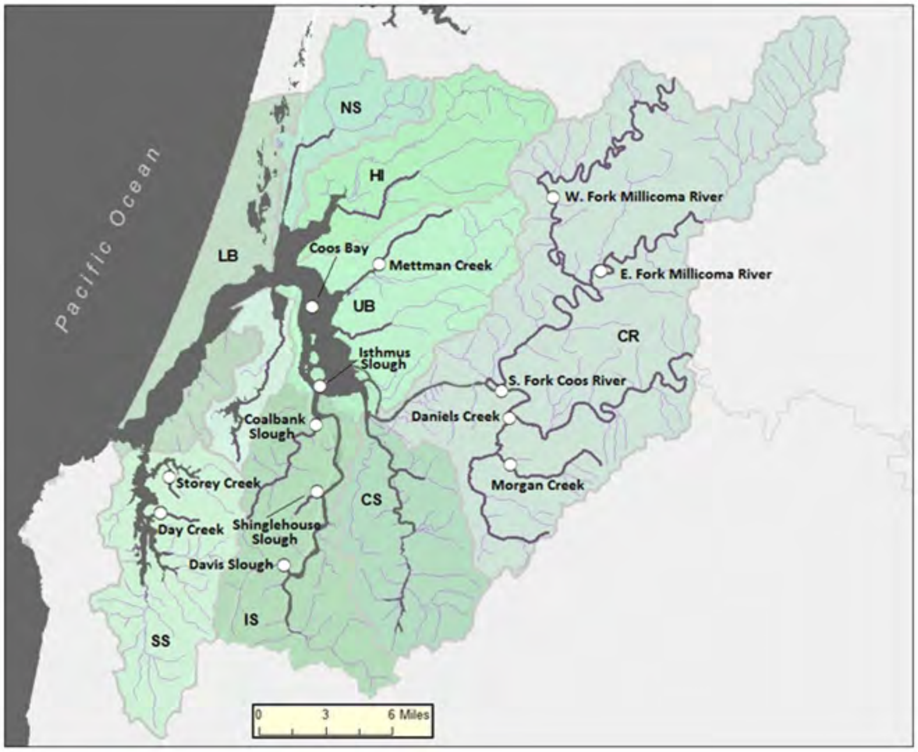



Figure 4. Location of 303d-listed sites (1998-2012). Source: ODEQ 1998, 2004, 2012.

Subsystem codes: SS-South Slough, LB-Lower Bay, PS-Pony Slough, IS-Isthmus Slough, UB-Upper Bay, NS-North Slough, HI-Haynes Inlet, CR-Coos River, CS-Catching Slough

*Barium*

In 2004, barium was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

The data that are available suggest that average barium concentrations (1995-2009) at South Slough's JNDS appear to meet the USEPA standards for safe human consumption of water and aquatic organisms, but maximum observed concentrations do not meet these standards (Table 4).

Barium is a non-priority pollutant (USEPA 1993). However, human exposure to barium may affect the cardiovascular (heart and blood vessels), gastrointestinal (digestive), and reproductive (producing children) systems. It does not have any cancer effects (CDC 2014).

*Beryllium*

In 2004, beryllium was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

However, the data that are available suggest that dissolved beryllium concentrations (1995-2009) in South Slough's JNDS meet USEPA standards for both aquatic life and human health (Table 4).

Beryllium is a priority pollutant for human health (USEPA 1993). Human exposure to beryllium may affect the gastrointestinal (digestive), immunological (immune system), and respiratory (breathing) systems. It is a known carcinogen (CDC 2014).

*Boron*

Average boron concentrations (1995-2009) are higher in Isthmus Slough than in either Sough Slough JNDS or Pony Slough at Merritt Lake. However, the highest maximum observed concentration occurred in South Slough at JNDS (Table 4).

The USEPA has not established water quality guidelines for boron.

*Cadmium*

In 2004, cadmium was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

The available data suggest that cadmium concentrations in the study are low. From 1995-2009, ODEQ made 38 cadmium observations at South Slough's JNDS. All of these observations were below detectable limits, indicating that cadmium concentrations at JNDS likely meet USEPA standards for human health. USEPA standards for freshwater aquatic life, however, are much closer to detectable limits. Therefore, it's difficult to know if the JNDS cadmium concentrations meet the freshwater aquatic life standard for indefinite exposure (Table 4).

Cadmium is a priority pollutant (USEPA 1993). Human exposure to cadmium may affect the cardiovascular (heart and blood vessels), gastrointestinal (digestive), neurological (nervous system), renal (urinary and kidneys), reproductive (producing children), and respiratory (breathing) systems. It is a known carcinogen (CDC 2014).

*Chromium*

Chromium concentrations (1995-2009) in South Slough's JNDS meet USEPA standards for both aquatic life and human health (Table 4).

In 1998, chromium was listed as a potential concern for aquatic life in Coos Bay (Upper Bay)(ODEQ 1998b). In 2004, it was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

Chromium is a priority pollutant (USEPA 1993). Human exposure to chromium may affect the immunological (immune system), renal (urinary and kidneys), and respiratory systems. It is a known carcinogen (CDC 2014).

*Cobalt*

About half of the cobalt observations (1995-2009) at South Slough's JNDS are below detectable limits, indicating that the accuracy of monitoring efforts could be improved by more complete information (Table 4). USEPA has not established water quality guidelines for cobalt (USEPA 1993).

*Copper*

Copper concentrations at South Slough's JDNS (1995-2009) as well as Pony Slough at Merritt Lake (2012) appear to meet the USEPA standard for safe human consumption. However, brief exposure to these sites may be harmful to saltwater aquatic life (Table 4).

In 1998, copper was listed as a potential concern for aquatic life in Coos Bay (Upper Bay) (ODEQ 1998b). In 2004, it was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

Copper is a priority pollutant (USEPA 1993). Human exposure to copper may affect the gastrointestinal (digestive), hematological (blood forming), and hepatic (liver) systems. It does not have any cancer effects (CDC 2014).

*Iron*

Iron concentrations in the Coos River subsystem (2009) as well as in Isthmus Slough (2006-2007) and South Slough's JNDS (1995-2009) may be harmful to freshwater aquatic life (Table 4).

In 2004, iron was listed as a potential concern for both aquatic life and human health at Day and Storey Creeks (South Slough). In 2012, it was listed for insufficient information at Mettman Creek (Upper Bay) as well as the following waters in the Coos River subsystem: Daniels Creek, East Fork Millicoma, West Fork Millicoma, Morgan Creek, and South Fork Coos (Table 3)(ODEQ 2004). Iron is a non-priority pollutant.

*Lead*

Lead observations at Pony Slough Merritt Lake (2012) and South Slough's JNDS (1995-2009) seem to meet USEPA standards for aquatic life (Table 4).

In 1998, lead was listed as a potential concern for aquatic life in Coos Bay (Upper Bay)(ODEQ 1998b). In 2004, it was listed for insufficient information in Day Creek (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

Lead is a priority pollutant for aquatic life (USEPA 1993). Although it is not listed as a priority pollutant for human health, lead exposure is associated with harmful health affects to the cardiovascular (heart and blood vessels), gastrointestinal (digestive), hematological (blood forming), musculoskeletal (muscles and skeleton), neurological (nervous system), ocular (eyes), renal (urinary and kidneys), and reproductive (producing children) systems. It is reasonably anticipated to be a carcinogen (CDC 2014)

*Lanthanum*

Only sixteen percent of lanthanum observations at South Slough's JNDS (1995-2009) are above detectable limits, indicating that accuracy of cobalt monitoring efforts could be improved by more complete information (Table 4). USEPA has not established water quality guidelines for lanthanum.

*Lithium*

Lithium concentrations appear to be an order of magnitude higher in Isthmus Slough (2006-2007) than at South Slough's JNDS (1995-2009) or in the Coos River (2009) subsystem (Table 4). USEPA has not established water quality guidelines for lithium.

*Magnesium*

Magnesium concentrations are much higher in Isthmus Slough (2006-2007) than at South Slough's JNDS (1995-2009) or in the Coos River (2009) subsystem (Table 4). USEPA has not established water quality guidelines for magnesium.

*Manganese*

In 2004, Manganese was listed as a potential concern for human health in both Day and Storey Creek (South Slough). It was also listed for insufficient information at Mettman Creek (Upper Bay) as well as Morgan Creek and the West Fork of the Millicoma River (Coos River) (Table 3)(ODEQ 2004). In 2012, Coalbank, Davis, Isthmus, and Shinglehouse Sloughs (Isthmus Slough subsystem) were all listed as informational gaps (Table 3)(ODEQ 2012).

The available data suggest that manganese concentrations may not meet USEPA standards. The estimated average manganese concentration does not meet the USEPA guideline for safe human consumption of either water or aquatic organisms in Isthmus slough (2006-2007); nor does it meet these standards at South Slough's JNDS (1995-2009). In the Coos River subsystem (2009), maximum observed concentrations do not meet USEPA standards for safe human consumption (Table 4).

Manganese is a non-priority pollutant (USEPA 1993). However, human exposure to manganese may affect the cardiovascular (heart and blood vessels), hepatic (liver), neurological (nervous system) and respiratory (breathing) systems. It does not have any cancer effects (CDC 2014).

*Mercury*

Indefinite exposure to mercury concentrations at South Slough's JNDS (1995-2009) may be harmful to both freshwater and saltwater aquatic life. However, mercury concentrations appear to meet the USEPA recommended standard for safe human consumption of water (Table 4). For a discussion of mercury in fish tissues, see Chapter 10: Sediments in the Coos Estuary and Lower Coos Watershed.

In 2004, mercury was listed for insufficient information at Day Creek (South Slough)(Table 3)(ODEQ 2004).

Mercury is a priority pollutant for both aquatic life and human health (USEPA 1993). Human exposure to mercury may affect the gastrointestinal (digestive), neurological (nervous system), ocular (eyes), and renal (urinary and kidneys) systems. It does not have any cancer effects (CDC 2014).

*Molybdenum*

Only 21% of molybdenum observations at South Slough's JNDS (1995-2009) were above detectable limits, indicating that the accuracy of monitoring efforts could be improved by more complete information (Table 4). USEPA has not established water quality guidelines for molybdenum.

*Nickel*

Dissolved nickel concentrations at South Slough's JNDS (1995-2009) easily meet USEPA standards for safe human consumption of both water and aquatic organisms (Table 4).

In 2004, nickel was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

Nickel is a priority pollutant for both aquatic life and human health (USEPA 1993). Human exposure to nickel may affect the cardiovascular (heart and blood vessels), dermal (skin), immunological (immune system), and respiratory (breathing) systems. It is a known carcinogen (CDC 2014).

*Selenium*

In 2004, selenium was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

However, the available data suggest that selenium concentrations at South Slough's JNDS (1995-2009) meet USEPA standards for both aquatic life and human health.

Selenium is a priority pollutant for both aquatic life and human health (USEPA 1993). Human exposure to selenium may affect the dermal (skin), and reproductive (producing children) systems. It is reasonably anticipated to be a carcinogen (CDC 2014).

*Silver*

Indefinite exposure to dissolved silver at South Slough's JNDS (1995-2009) may be harmful to freshwater aquatic life (Table 4).

In 2004, silver was listed for insufficient information in Storey and Day Creeks (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

Silver is a priority pollutant for aquatic life (USEPA 1993). Although it is not listed as a priority pollutant for human health, exposure to silver is associated with harmful health effects to the renal (urinary and kidneys) and reproductive (producing children) systems. It does not have any cancer effects (CDC 2014).

*Thallium*

All twenty thallium observation at South Slough's JNDS (1995-2009) are below detectable limits. However, the estimated average concentration indicates that thallium concentrations at JNDS may not meet USEPA standards for safe human consumption of either water or aquatic life (Table 4).

In 2004, thallium was listed for insufficient information in Day Creek (South Slough), Mettman Creek (Upper Bay), and Morgan Creek and the West Fork of the Millicoma River (Coos River)(Table 3)(ODEQ 2004).

Thallium is a priority pollutant for human health (USEPA 1993). Human exposure to thallium may affect the gastrointestinal (digestive), hepatic (liver), neurological (nervous system), and renal (urinary or kidneys) systems. It does not have any cancer effects (CDC 2014).

*Vanadium*

Only 8% of all vanadium observations at South Slough's JNDS (1995-2009) are above detectable limits, indicating that the accuracy of monitoring efforts could be improved by more complete information.

USEPA has not established water quality guidelines for vanadium. Human exposure to vanadium may affect the cardiovascular (heart and blood vessels), gastrointestinal (digestive), renal (urinary and kidneys), reproductive (producing children), and respiratory (breathing) systems. It does not have any cancer effects (CDC 2014).

*Zinc*

Dissolved zinc concentrations at South Slough's JNDS (1995-2009) easily meet USEPA standards for both aquatic life and human health (Table 4).

Zinc is a priority pollutant for both aquatic life and human health (USEPA 1993). Human exposure to zinc may affect the gastrointestinal (digestive), hematological (blood forming), and respiratory (breathing) systems. It does not have any cancer effects (CDC 2014).

<u>Persistent Organic Pollutants, Biocides, and Other Contaminants</u>

"Persistent organic pollutants" (POPs) are widely distributed herbicides, pesticides, insecticides, and other biocides that are internationally recognized for their potential to cause environmental damage (see "Stockholm Convention" sidebar). In addition to POPs, tributyltin (TBT), an anti-fouling chemical found in boat bottom paints, has historically been a concern in the Coos estuary (Wolniakowski et al. 1987). Table 5 details the properties of the most common POPs and provides their associated water quality standards.

Although little is known about dissolved POPs and TBT in the Coos estuary, what we do know comes from the Coos Bay/North Bend Water Board, which monitors Merritt Lake (Pony Slough Subsystem) for eight POPs including aldrin and dieldrin, chordane, DDT, endrin, heptachlor, HCB, PCBs, and toxaphene. Since the monitoring program began in 1985, the Water Board has not recorded any POPs observations above detectable limits (Water Board 2012).

Cornu et al. (2012) note that a wide range of pesticides, including POPs such as DDT, have been detected by ODEQ in low ("unquantifiable") amounts at 29 sites in the Coos Basin. Although the location of many these sites is undisclosed, it is clear that sampling occurred at no fewer than three Sough Slough locations, including Joe Ney Slough, Collver Point, and Brown's Cove (ODEQ 2014b).

| Persistent Organic Pollutant (POP) | What is it? | Environmental and Human Health Effects | Human Health Water Quality Standard (mg/L) |
|---|---|---|---|
| Aldrin and Dieldrin | Agricultural insecticide; terminte control | Fatal to birds. Harmful to aquatic life, especially frogs and fish. Known to be fatal to humans. | No standard |
| Chlordane | Agric. insecticide; terminte control; home lawn and garden pesticide | Persistant in soil. Fatal to ducks, quail, and shrimp. May affect the human immune system, liver, or nervous system. Possible human carcinogen. | 0.002 |
| Chlordecone | Agric. pesticide | Highly persistant. High potential for transport over long distances and bioaccumulation/biomagnification in ecosystems. Very toxic to aquatic life. Possible human carcinogen. | No standard |
| 1,1,1- Trichloroethane and 1,1,2-Trichloroethane (DDT) | Agric. insecticide | Egg shell thinning among birds, especially raptors. Long-term exposure associated with chronic health effects in humans including liver, kidney, immunse system, and neurological problems. | 0.005-0.2 depending on properties |
| Endosulfan and related isomers | Agric. pesticide | Persistent in the atmosphere, sediments, and water. Toxic effects in animals. Linked with congential physical disorders, mental retardations, and death in humans. | No standard |
| Endrin | Agric. insecticide, rodent control | Persistant in soils. Highly toxic to fish. Associated with liver problems in humans. | 0.002 |
| Heptachlor | Agric.insecticide | Fatal to birds. Harmful to small mammals. Linked to liver damage in humans. Possible human carcinogen. | 0.0004 |
| Hexabromobiphenyl | Industrial chem.; fire retardant | Highly persistant. Bioaccumulation in ecosystems. Possible human carcinogen. | No standard |
| Hexabromobiphenyl ether and heptabromodiphenyl ether | Chem. manufacturing | Persistant with high likelihood of long-rang transport and bioaccumulation. Possible human carcinogen. | No standard |
| Hexachlorobenzene (HCB) | Fungicide; Industrial chem. in fireworks, ammunition, and synthetic rubber. Byproduct of chem. manufacturing. | Lethal to some animals. Associated with limited reproductive success in wildlife. Human effects include liver or kidney problems, reproductive difficulties, increased risk of cancer, and death. | 0.001 |
| Hexachlorocyclohexane and related isomers | Byproduct of Lindane | Highly persistant. May bioaccumulate. Possible human carcinogen. | No standard |
| Lindane | Agric. insecticide; human health pharmeceutical | Bioaccumulates rapidly. Toxic effects in aquatic wildlife and humans. | 0.0002 |
| Mirex | Insecticide; Industrial chem.; fire retardant. | Extremely persistant. Toxic to fish and plants. Possible human carcinogen. | No standard |
| Tetrabromodiphenyl ether and pentabromodiphenyl ether | Industrial chem.; fire retardant | Persistent. High potential for long-range transport and bioaccumulation. Toxic effects in widlife. Adverse human health effects. | No standard |
| Toxaphene | Agric. pesticide. | Extremely persistent. Toxic to fish. Related to kidney, liver, or thyroid problems in humans. Possible human carcinogen. | 0.003 |
| Pentachlorobenzene | Fungicide and industrial chem. Byproduct of combustion. | Persistant with potential for bioaccumulation and long-range transport. Moderately toxic to humans and very toxic to aquatic organisms. | No standard |
| Perfluorooctane sulfonic acid, its salts, and perfluorooctane sulfonyl fluoride | Industrial chem. Byproduct of chem. degradation. | Extremely persistent. Bioaccumulates rapidly. Binds to the blood and liver tissues rather than fat. | No standard |
| Polychlorinated biphenyls (PCB) | Industrial chem. Byproduct of combustion. | Persistance depends on chem. properties. Toxic to fish. Harmful to mammals. Severe human ealth effects to nervious and immune systems. Probable human carcinogen. | 0.0005 |
| Polychlorinated dibenzo-p-dioxins and Polychlorinated dibenzofurans (PCDD and PCDF) | Byproduct of combustion. Comtaminant in herbicides, wood preservatives, and PCBs | Persistant. Lethal to fish. Immune and enzyme disorders in humans. Possible human carcinogen. | No standard |

Table 5. Properties of the most common POPs. Source: Stockholm Convention 2008.

For additional information about POPs, TBT, biocides, and other contaminants, refer to Chapter 10: Sediment Contamination in the Coos Estuary.

## References

Bauer J. E. and T. S. Bianchi. 2011. Dissolved Organic Carbon Cycling and Transformation. In: Wolanski E. and McLusky D.S. (eds.) Treatise on Estuarine and Coastal Science, Vol 5, pp. 7–67. Waltham: Academic Press. Accessed from http://aquaticbiogeochem.osu.edu/sites/aquaticbiogeochem.osu.edu/files/Bauer%20and%20Bianchi%20(2012)%20TECS-DOC%20Cycling.pdf

***Stockholm Convention***

*The Stockholm Convention on Persistent Organic Pollutants is a multinational agreement intended to eliminate or mitigate the production/use of harmful Persistent organic pollutants (POPs). POPs are "organic" (i.e., carbon-based) pollutants with high potential for environmental damage.*

*In 2001, the Convention identified 12 priority POPs, and an additional nine POPs were added in 2009. These POPs were selected based on the following properties:*

- *Persistence: The ability to remain intact in the environment for many years*
- *Long-range distribution: Widely distributed throughout the environment as a result of natural processes*
- *Bioaccumulation and Biomagnification: Accumulation in fatty tissues of living organisms, with higher concentrations occurring at higher levels in the food chain*
- *Toxicity: Associated with harmful health affects in humans and wildlife*

*Long-range transport of POPs is often facilitated by the migration of animals that have been exposed to them. Due to the characteristics of POPs, predatory animals that are high up the food chain, such as fish, raptors, mammals, and humans, are at elevated risk for absorbing high POP concentrations.*

*Source: Stockholm Convention 2008*

Brownawell, B. J. and J. W. Farrington. 1986. Biogeochemistry of PCBs in Interstitial Waters of a Coastal Marine Sediment. Geochimica et Cosmochimica Acta. 50: 157-169.

Burdige, D. J. 2006. Geochemistry of marine sediments (Vol. 398). Princeton: Princeton University Press.

Buszka, P. M., J. Fitzpatrick, L. R. Watson, and R. T. Kay. 2007. Evaluation of ground-water and boron sources by use of boron stable-isotope ratios, tritium, and selected water-chemistry constituents near Beverly Shores, northwestern Indiana, 2004: U.S. Geological Survey Scientific Investigations Report 2007–5166, 46 p.

Centers for Disease Control and Prevention Agency for Toxic Substances and Disease Registry (CDC). 2004. Public Health Statement for Cobalt CAS# 7440-48-4. Accessed 28, May, 2014. Available http://www.atsdr.cdc.gov/ToxProfiles/tp33-c1-b.pdf

Centers for Disease Control and Prevention Agency for Toxic Substances and Disease Registry (CDC). 2014. Agency for Toxic Substances and Disease Registry: Toxic Substance Portal. Accessed 11 June, 2014. Available http://www.atsdr.cdc.gov/substances/index.asp

Coos Bay/North Bend Water Board (Water Board). 2012. [Drinking Water Program Data]. Unpublished raw data. Accessed 22 May 2014 from the Estuarine and Coastal Sciences Laboratory of the South Slough National Estuarine Research Reserve.

Cornu, C.E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 93 pp.

Fleck, J.A., M.S. Fram, and R. Fujii. 2007. Organic Carbon and Disinfection Byproduct Precursor Loads from a Constructed, Non-Tidal Wetland in California's Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. 5: 24 pp.

Hyland, J., L. Balthis, I. Karakassis, P. Magni, A. Petrov, J. Shine, and R. Warwick. 2005. Organic carbon content of sediments as an indicator of stress in the marine benthos. Marine Ecology Progress Series, 295(9).

Martin, Jean-Marie, Min-Han Dai, and Gustave Cauwet. 1995. Significance of Colloids in the Biogeochemical Cycling of Organic Carbon and Trace Metals in the Venice Lagoon (Italy). Limnology and Oceanography. 40 (1), 119-131.

Oregon Department of Environmental Quality (ODEQ). 1995. [Joe Ney Monitoring Well Data 1995]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 1998a. [Joe Ney Monitoring Well Data 1998]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 1998b. [303d-listed sites 1998]. Unpublished raw data. Accessed 30 May 2014 from the Estuarine and Coastal Sciences Laboratory of SSNERR.

Oregon Department of Environmental Quality (ODEQ). 2001. [Coos and Millicoma River]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2002. [Joe Ney Monitoring Well Data 2002]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2004. [303d-listed sites 2004]. Unpublished raw data. Accessed 30 May 2014 from the Estuarine and Coastal Sciences Laboratory of SSNERR.

Oregon Department of Environmental Quality (ODEQ). 2006a. [Joe Ney Monitoring Well Data 2006]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006b. [South Fork Coos River Summer Synoptic 2006b]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006c. [South Fork Coos River Summer Synoptic 2006]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007a. [Isthmus Slough/South Fork Coos DO Study]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007b. [South Fork Coos River Summer Synoptic 2007b]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2008. Molalla-Pudding Subbasin TMDL Chapter 6: Iron, Manganese, Arsenic. Accessed 28 May 2014. Available http://www.deq.state.or.us/wq/tmdls/docs/willamettebasin/MolallaPudding/MoPudChapter6Metals.pdf

Oregon Department of Environmental Quality (ODEQ). 2009a. [Joe Ney Monitoring Well Data 2009]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009b. [Millicoma River TMDL DO Study 2009]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2012. [303d-listed sites 2012]. Unpublished raw data. Accessed 30 May 2014 from the Estuarine and Coastal Sciences Laboratory of SSNERR.

Oregon Department of Environmental Quality (ODEQ). 2014a. Water Quality Standards: Beneficial Uses, Policies, and Criteria for Oregon, Toxic Substances. [Table 30 and 40 of Division 41 Report 340-041-0033].

Oregon Department of Environmental Quality (ODEQ). 2014b. Solid Waste Information and Facility Tracking: Facility Detail Report for Facility #104382. [Available through ODEQ Site Profiler tool]. Accessed 11 June 2014. Avilable http://deq12.deq.state.or.us/fp20/StartPage.aspx

Pregnall, A.M. 1983. Release of Dissolved Organic Carbon from the Estuarine Intertidal Macroalga *Enteromorpha prolifera*. Marine Biology, 73, 37-42.

Royal Society of Chemistry (RSC). 2014. Periodic Table: Lanthanum. Accessed 28 May 28, 2014. Available http://www.rsc.org/periodic-table/element/57/lanthanum

Shacklette, Hansford T. and Josephine G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. [U.S. Geological Survey Professional Paper 1270]. Accessed 29 May 2014. Available http://pubs.usgs.gov/pp/1270/pdf/PP1270_508.pdf

Stockholm Convention. 2008. What are POPs. Retrieved 24 July, 2014, from http://chm.pops.int/TheConvention/ThePOPs/tabid/673/Default.aspx

Swett, Micaeal P., 2010. Assessment of Benthic Flux of Dissolved Organic Carbon in Estuaries Using the Eddy Correlation Technique. Master's Thesis, University of Maine.

United States Environmental Protection Agency (USEPA). 1980. Ambient Water Quality Criteria for Arsenic. Accessed 12 June 2014. Available http://water.epa.gov/scitech/swguidance/standards/upload/2001_10_12_criteria_ambientwqc_arsenic80.pdf

United States Environmental Protection Agency (USEPA). 1993. Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria. [online via USEPA National Recommended Water Quality Criteria Tables]. Accessed 20 May 2014. Available http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm#gold

United States Environmental Protection Agency (USEPA). 2007a. Framework for Metals Risk Assessment. Accessed 29 May 29, 2014. Available http://www.epa.gov/raf/metalsframework/pdfs/metals-risk-assessment-final.pdf

United States Environmental Protection Agency (USEPA). 2007b. Aquatic Life Ambient Freshwater Quality Criteria- Copper. Accessed 20 May 2014. Available http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/copper/upload/2009_04_27_criteria_copper_2007_criteria-full.pdf

United States Environmental Protection Agency (USEPA). 2009. National Primary Drinking Water Regulations. Accessed 20 May 2014. Available http://water.epa.gov/drink/contaminants/index.cfm#two

United States Environmental Protection Agency (USEPA). 2012. Water: Water Quality Standards Academy. [Introduction: Two Criteria Specifying Concentration-Related Thresholds]. Accessed 11 June 2014 from http://water.epa.gov/learn/training/standardsacademy/aquatic_page3.cfm

United States Environmental Protection Agency (USEPA). 2014. Toxic and Priority Pollutants. Accessed 11 June 2014. Available http://water.epa.gov/scitech/methods/cwa/pollutants-background.cfm

United States Geological Survey (USGS). 2014. Mineral Commodity Summaries 2014. 196 p. Accessed 28 May 2014. Available http://minerals.usgs.gov/minerals/pubs/mcs/2014/mcs2014.pdf

Wijayarantne, R. D. and J. C. Means. 1984. Affinity of Hydrophobic Pollutants for Natural Estuarine Colloids in Aquatic Environments. Environmental Science and Technology. 18(2): 121-123.

Wilburn, D. R. 2012. Byproduct metals and rare-earth elements used in the production of light-emitting diodes—Overview of principal sources of supply and material requirements for selected markets: U.S. Geological Survey Scientific Investigations Report 2012–5215, 15 p., Accessed 28 May 2014. Available http://pubs.usgs.gov/sir/2012/5215/

Winter, Mark. 1993. “Web Elements.” [online periodic table of elements]. Accessed 28 May 2014. Available http://www.webelements.com/

Wolniakowski, K. U., M. D. Stephenson, and G. S. Ichikawa. 1987. Tributyltin concentrations and pacific oyster deformations in Coos Bay, Oregon. Proceedings International Organotin Symposium. Marine Technology Society, Washington, DC. pp. 1438-1442.

# **Chapter 10:** Sediment Quality in the Coos Estuary and Lower Coos Watershed

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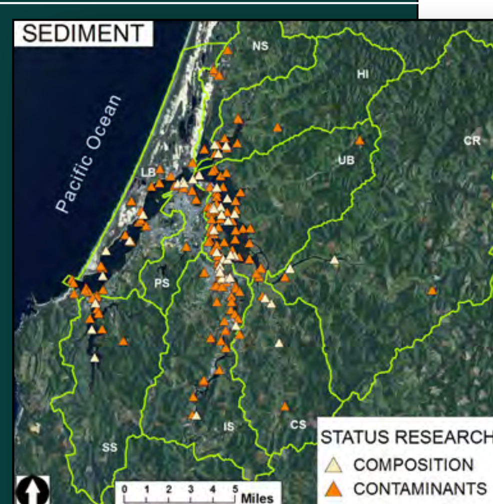
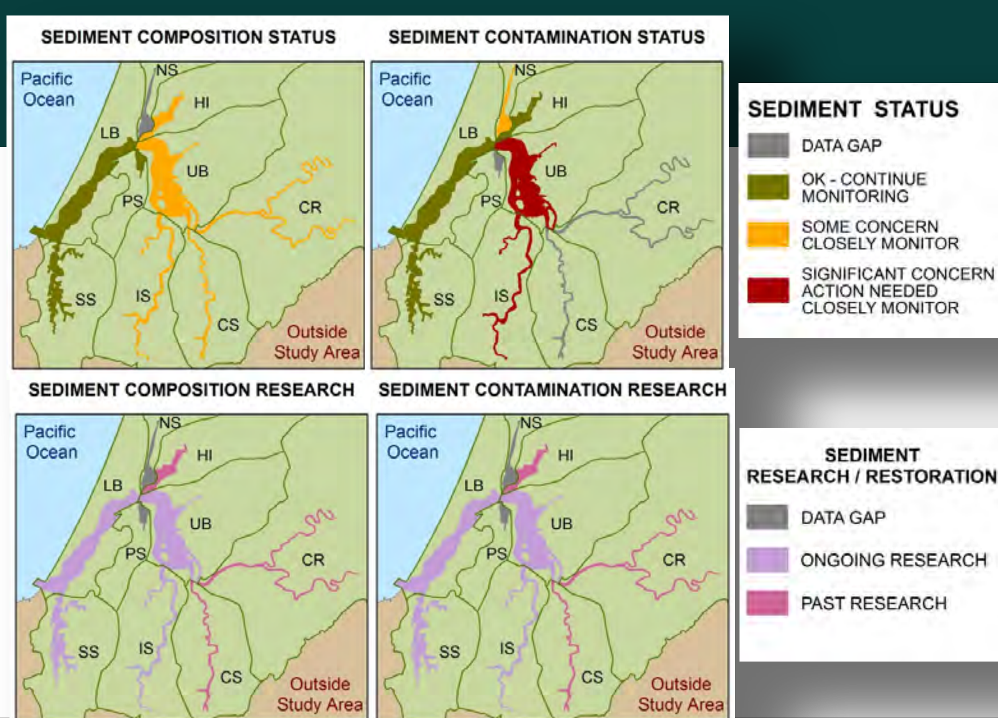



Subsystems: CR- Coos River, CS- Catching Slough, HI- Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay

***<u>Sediment Composition</u>:*** *Compared with other Oregon estuaries, Coos estuary sediments contain a high percentage of "fines" (i.e., clay and silt), which tend to be concentrated in the upper estuary near tributary mouths (e.g., Coos River, Isthmus Slough, Haynes Inlet).*

***<u>Sediment Contamination</u>:*** *Sediment quality in the upper estuary may be contaminated with metals, synthetic organic compounds, and other industrial chemicals. There are several instances of confirmed releases of these chemicals, which have primarily occurred in Isthmus Slough and the Upper Bay subsystems.*



## Chapter 10: Sediment Quality in the Coos Estuary and Lower Coos Watershed

*This section includes the following data summaries: **Sediment Composition**, and **Sediment Contamination**— which describe the condition of Coos estuary sediment in the lower Coos watershed.*

Sediment Composition: Data summarizing sediment composition in the Coos system came primarily from two sources. The Oregon Department of Environmental Quality (ODEQ) monitored sediment composition in the Coos estuary from 1999 to 2006 as part of their Coastal Environmental Monitoring and Assessment Program (CEMAP)(ODEQ 1999, 2001, 2004, 2006). The United States Army Corps of Engineers (USACE) also assessed sediment composition in a series of sediment quality evaluation reports (USACE 1980, 1989, 1994, 1998, 2004, 2009).

These data sources are supplemented by two additional reports: 1) Lee II and Brown (2009) provide a regional perspective by characterizing sediment composition of seven Oregon estuaries; and 2) Hubler (2008) describes the macroinvertrate response to fine sediment stress in the Coos River subsystem.

In addition to these studies, the Coastal and Marine Ecological Classification Standard (CMECS), a NOAA-developed habitat classification scheme currently being applied to Oregon's estuaries by the Oregon Department of Land Conservation and Development, was used to generate maps of generalized areas with fine sediments (CMECS 2014). It's important to note that CMECS is currently in the developmental stages; its data layers are subject to refinement.

Sediment Contamination: Similar to sediment composition, sediment contamination data came primarily from the CEMAP program as well as the USACE sediment quality evaluation reports (ODEQ 1999, 2001, 2004, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009). Sediment contamination is assessed using a set of sediment quality guidelines (SQGs) that were established by Long et al. (1995). These data quantify a suite of metals, synthetic organic pollutants, industrial chemicals, and total organic carbon (TOC) in Coos sediments.

These data were also supplemented by additional studies. From 1986 to 2006, NOAA's Mussel Watch Contaminant Monitoring Program monitored sediment contamination at two Coos estuary sites every ten years (NOAA 1986, 1996, 2006). In 2007 and 2009, TOC was measured by ODEQ in the Isthmus Slough and Coos River Subsystems as part of a dissolved oxygen study (ODEQ 2007, 2009).

Where possible, regional data (i.e., Washington, Oregon, and California) are presented to provide context for interpretation (Hayslip et al. 2006, Nelson et al. 2007).

A review of the potential and confirmed toxic release sites within the study area is also provided. This information came from several

ODEQ and USEPA sources, including the Toxics Release Inventory (TRI), Brownfield listings, the Environmental and Cleanup Site Information Program (ECSI), and the Confirmed Release List (CRL)(ODEQ n.d., USEPA 2014).

In addition to sediment contamination, this chapter summarizes data useful as indicators of sediment quality, such as fish tissue contamination data from the CEMAP program (ODEQ 1999, 2001, 2004, 2006). Dissolved contaminants are also briefly discussed here but refer to the Chapter 9: Water Quality for a more complete discussion.

<u>Data Gaps and Limitations</u>

Collectively, the CEMAP program and the USACE sediment quality reports represent observations in all nine subsystems (see maps above)(ODEQ 1999, 2001, 2004, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009). The majority of these data come from the Lower Bay and Upper Bay Subsystems. In some subsystems, the data may be sparse. For example, the only metals sampling in the North Slough subsystem occurred in 2002 (ODEQ 2002). As a result, there are only three observations for metals in this subsystem.

The accuracy of a data set is a function of its size or “robustness,” because larger samples more accurately estimate the population mean. For this reason, the number of observations in each subsystem is provided when contaminant data are presented.

In many cases, the data may be outdated. The most recent data for both sediment contamination and composition come from 2009 (USACE 2009).

An all-inclusive evaluation of sediment quality is made difficult by the limitations of the SQGs. Although Long et al. (1995) developed SQGs for nine metals and 19 synthetic organic pollutants, none have been established for some commonly occurring contaminants (e.g., petroleum hydrocarbons such as diesel and hydraulic fluid).

The guidelines for evaluating fish tissue contaminants are also subject to some limitations. Developing human health standards for safe fish consumption requires making numerous assumptions about dietary preferences, characteristics of the consumer (e.g., body weight and age), level of risk aversion, and other variables (USEPA 2000). To avoid making overly broad generalizations, the contaminants data summary refers curious readers to the appropriate online tools (USEPA 2007a; OR Health Division, n.d).

Interpretation of sediment quality data is further complicated by the intricacies of environmental systems. The mobility and availability of contaminants in estuaries is influenced by many factors, including chemical, geological and physical processes such as oxidation, precipitation, sedimentation, tidal inundation, etc. (Carroll et al. 2002, Bauer and Bianchi 2011, Williams et al. 1994). In addition to natural processes, pollutant cycling is carried out against a backdrop of human land use activities, which can further complicate an already intricate process (Bauer and Bianchi 2011).

The sediment contaminants data summary applies Long et al. (1995) methods to analyze sediment quality in the study area to provide consistency for evaluating sediment contamination within and among estuaries. However, the approach does not account for the interaction of multiple chemicals or environmental conditions that may affect the toxicity of contaminants (USEPA 2002). It should be noted that the environmental impacts of sediment contaminants is subject to change as the surrounding conditions in the estuary evolve.

In many cases, the toxicity of sediment contaminants in aquatic organisms is dependent on species-specific physiology. Toxic responses in plants and animals require the transfer of chemicals from the environment to biochemical receptors on or in an organism (USEPA 2007b). Therefore, the ecological response to changes in sediment contamination may vary depending on individual species tolerances for a given contaminant.

Due to the complexity of these systems, the status of sediment contaminants in the study area should be interpreted along with the data presented in the contaminants data summary of "Chapter 9: Water Quality in the Coos Estuary and the Lower Coos Watershed". Interpreting both together offers a more comprehensive understanding of the overall status of contamination in the Coos estuary.

**References**

Bauer J.E. and Bianchi T.S. 2011. Dissolved Organic Carbon Cycling and Transformation. In: Wolanski E. and McLusky D.S. (eds.) Treatise on Estuarine and Coastal Science, Vol 5, pp. 7–67. Waltham: Academic Press. Retrieved from: http://aquaticbiogeochem.osu.edu/sites/aquaticbiogeochem.osu.edu/files/Bauer%20and%20Bianchi%20(2012)%20TECS-DOC%20Cycling.pdf

Carroll, Susan, Peggy A. O'Day, Brad Esser, and Simon Randal. 2002. Speciation and Fate of Trace Metals in Estuarine Sediments under Reduced and Oxidized Conditions, Seaplane Lagoon, Alameda Naval Air Station (USA). Geochemical Translations (3): 81.

Coastal and Marine Ecological Classification Standard (CMECS). 2014. [Unpublished shapefiles for ArcGIS from the National Oceanographic and Atmospheric Association (NOAA)]. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve.

Hayslip, G., L. Edmond, V. Partridge, W. Nelson, H. Lee, F. Cole, J. Lamberson , and L. Caton. 2006. Ecological Condition of the Estuaries of Oregon and Washington. EPA 910-R-06-001. U.S. Environmental Protection Agency, Office of Environmental Assessment, Region 10, Seattle, Washington.

Hubler, Shannon. 2008. Macroinvertebrate Report: Oregon Coast Coho Evolutionarily Significant Unit (2006-2007). [Reported prepared by the Oregon Department of Environmental Quality]. Accessed 25 August 2014. Available http://www.oregon.gov/OWEB/MONITOR/docs/mr_odfwbugreport.pdf

Lee II, H. and Brown, C.A. (eds.) 2009. Classification of Regional Patterns of Environmental Drivers and Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA. Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. EPA/600/R-09-140. Retrieved from: http://www.epa.gov/wed/pages/publications/authored.htm

Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder, 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19(1): 81-97.

National Oceanic and Atmospheric Administration (NOAA). 1986. [National Center for Coastal Monitoring and Assessment, Mussel Watch Contamination Monitoring Program]. Raw data. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve on 7 August, 2014.

National Oceanic and Atmospheric Administration (NOAA). 1996. [National Center for Coastal Monitoring and Assessment, Mussel Watch Contamination Monitoring Program]. Raw data. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve on 7 August, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2006. [National Center for Coastal Monitoring and Assessment, Mussel Watch Contamination Monitoring Program]. Raw data. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve on 7 August, 2014.

Nelson, Walter G, Henry Lee II, Janet O. Lamberson, Faith A. Cole, Christine L. Weilhoefer, and Patrick J. Clinton. 2007. The Condition of Tidal Wetlands of Washington, Oregon, and California – 2002. Office of Research and Development. National Health and Environmental Effects Research Laboratory, EPA/620/R-07/002.

Oregon Department of Environmental Quality (ODEQ). 1999. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2001. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2002. [CEMAP 2002 Sediment]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2004. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007. [Isthmus Slough/South Fork Coos DO Study]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009. [Joe Ney Landfill Subproject-Groundwater Monitoring Data]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). n.d. Land Quality: Environmental Cleanup. [ECSI online database tool]. Accessed 11 September 2014 from http://www.deq.state.or.us/lq/ecsi/ecsi.htm

Oregon Division of Public Health (OR Health Division). n.d. Fish Consumption: Advisories and Guidelines. Accessed 2 September, 2014. Available from http://public.health.oregon.gov/HealthyEnvironments/Recreation/FishConsumption/Pages/fishadvisories.aspx

United States Army Corps of Engineers (USACE). 1980. Factual Determinations of Dredged Material Disposal Operations Coos River Federal Navigation Project [Coos Bay Sediment Sampling Evaluation Report 1980].

United States Army Corps of Engineers (USACE). 1989. Results of 1989 Coos Bay Empire Turning Basin Sediment Quality Evaluation [Coos Bay Sediment Sampling Evaluation Report 1989].

United States Army Corps of Engineers (USACE). 1994. Supplemental TBT Data for the Coos Bay Channel Deepening Project [Coos Bay Sediment Sampling Evaluation Report 1994].

United States Army Corps of Engineers (USACE). 1998. Coos Bay Sediment Sampling Evaluation Report 1998.

United States Army Corps of Engineers (USACE). 2004. Coos Bay Sediment Quality Evaluation Report 2004.

United States Army Corps of Engineers (USACE). 2009. Coos Bay Sediment Quality Evaluation Report. [report prepared by Wendy Briner and Mark Siipola of the Portland District USACE].

United States Environmental Protection Agency (USEPA). 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Vol. 2: Risk Assessment and Fish Consumption Limits 3rd ed. Accessed 2 September, 2014. Available http://water.epa.gov/scitech/swguidance/fishshellfish/techguidance/risk/upload/2009_04_23_fish_advice_volume2_v2cover.pdf

United States Environmental Protection Agency (USEPA). 2002. Mid-Atlantic Integrated Assessment (MAIA) Estuaries 1997-98 Summary Report. Chapter 5: Sediment Contamination. Accessed 9 September 2014. Available http://www.epa.gov/emap2/maia/html/docs/Est5.pdf

United States Environmental Protection Agency (USEPA). 2007a. Framework for Metals Risk Assessment. Accessed 29 May 29, 2014. Available http://www.epa.gov/raf/metalsframework/pdfs/metals-risk-assessment-final.pdf

United States Environmental Protection Agency (USEPA). 2007b. Aquatic Life Ambient Freshwater Quality Criteria- Copper. Accessed 20 May 2014. Available http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/copper/upload/2009_04_27_criteria_copper_2007_criteria-full.pdf

United States Environmental Protection Agency (USEPA). 2014. Toxic Release Inventory (TRI) Program. [TRI Explorer: Online Interactive Tool, Coos County, OR, data]. Accessed 11 September 2014 from http://iaspub.epa.gov/triexplorer/tri_release.chemical

Williams, T.P., J.M. Bubbs, and J.N. Lester. 1994. Metal Accumulation within Salt Marsh Environments: A Review. Marine Pollution Bulletin. 28(5): 277-290.

# How the Local Effects of Climate Change Could Affect Sediments in the Coos Estuary and Lower Coos Watershed

CLW DATA SOURCE

*Several climate-related changes expected on the Oregon coast could affect sediments in the Coos estuary and lower Coos watershed:*

- *Stronger, more frequent ocean storms, and "flashier" river flows may change sediment delivery and distribution patterns in the Coos estuary.*
- *Changes in the distribution of estuarine sediment may affect plant and animal communities throughout the estuary.*
- *Increases in sediments delivered to the Coos estuary may help local tidal marshes keep pace with sea level rise.*
- *Areas of increased sedimentation may affect developed areas in the estuary, potentially resulting in, greater demand for commercial shipping channel dredging.*

Top Photo: A Pacific Northwest headland
Photo: Ruggeira et al. 2013

Above: Erosion of coastal headlands
Photo: OCCRI 2010

Climate change is expected to effect sediment dynamics in the Coos estuary and lower Coos watershed waterways mainly though: 1) potential shifts in the timing and intensity of ocean storms; 2) the related timing and intensity of fresh water delivery to the system; and 3) sea level rise. These changes along with human-induced changes to local hydrology and bathymetry are likely to change the way sediment is deposited and eroded in the estuary (Scavia et al. 2002). The complex relationships between the abiotic (e.g., sediments) and

*Changes in Precipitation Timing, Frequency and Intensity*

*In the future, precipitation in coastal Oregon is expected to remain a predominately wintertime phenomenon (i.e., most precipitation will continue to occur in the winter). However, the extent to which precipitation timing, frequency and intensity on the Oregon coast may change remains uncertain. There is evidence that high-intensity storms are becoming more frequent, and that the frequency of weak to moderate-strength storms is declining.*

*Sources: Sharp 2012; OCCRI 2010; OSU 2005*

biotic (i.e., plants and animals) components of estuaries are likely to compound the local effects of climate change as estuarine plant and animal communities respond sometimes unpredictably to changing sediment conditions (Day et al. 2008).

**Geomorphology, Hydrology, and Sediment Transport**

Distribution of sediments is largely determined by tidal and non-tidal hydrologic mechanisms that transport materials to the estuary from the ocean or watershed (Day et al. 2008). Climate-related hydrologic shifts (i.e., changes to water movement, such as river discharge, ocean inundation, storm surges, estuary flushing, etc.) will likely result in some variations in sediment distribution in the estuary. While we cannot conclusively forecast changes in sediment distribution in the Coos estuary, we can develop some reasonable sediment change scenarios based on likely climate-related changes in local tidal and non-tidal hydrology.

Climate change is expected to affect precipitation patterns that control the timing and intensity (and perhaps the quantity) of freshwater contributions to estuaries from coastal rivers and streams. For example, a climate model of a coastal watershed in British Columbia (where the wintertime rainy season is expected to shorten and intensify, extending summertime drought conditions) predicted increases in fall/winter surface water runoff (frequently to flood levels) coupled with increased dependency on groundwater during dryer spring and summer seasons (Loukas et al. 2002). Similar trends are anticipated in Oregon, where climate change may result in decreased summer precipitation and more intense rain events in the winter (Mielbrecht et al. 2014, Oregon Climate Change Research Institute [OCCRI] 2010). Higher peak flows in streams and rivers during the winter season are likely to increase sediment input to the lower watershed from terrestrial sources (Defenders of Wildlife and ODFW 2008, OCCRI 2010, Scavia et al. 2002, Cannon et al. 2010, Goode et al. 2012). The opposite is true of low river and stream flows during anticipated extended drought periods of the summer months.

Sediment transfer to and from estuaries is also facilitated by natural processes in the ocean. On the Oregon coast, sediment is transferred within “littoral cells,” which are stretches of beach bounded by rocky headlands (Ruggiero et al. 2013, OCCRI 2010, Revell 2001)(Figure 1). There are 18 littoral cells along the Oregon coast (Ruggiero et al. 2013). The characteristics of these cells vary widely in along-shore length, geometry, and capacity to act as a buffer between storm waves and the backing dunes or sea cliffs along which infrastructure may be located (OCCRI 2010).

The Coos estuary is near the boundary of the Coos littoral cell (bounded by Heceta Head to the north and Cape Arago to the south) and the Bandon littoral cell (bounded by Cape Arago in the north and Blacklock Point in the south)(Revell 2001)(Figure 2). The Coos littoral cell contains the Coos Bay dune sheet. Stretching approximately 150 miles across the Oregon coast, the Coos Bay dune sheet is the largest coastal dune accumulation in the United States and represents a substantial source of sediment (Ruggeirro et al. 2013, Revell 2001). Since the construction of the Coos Bay jetty in the beginning of the 20th century, coastal sediments have generally accumulated on the south side of the estuary mouth and erosion has occurred to the north (Ruggeiro et al. 2013).

The longshore transport of coastal sediments in Oregon follows a seasonal pattern. Rugeiro et al. (2013) explain that waves approach the shore from the southwest in the winter, pushing sediment northward within the littoral cell. The pattern reverses in the summer,

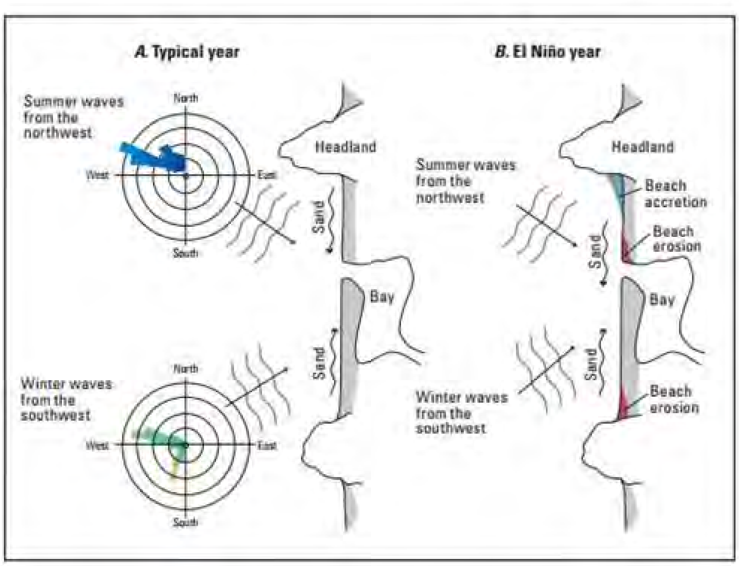



Figure 1. Comparing sand movements due to seasonal wave directions along the beaches between rocky headlands of Oregon’s littoral cells. During typical years (A) seasonal sand movements are approximately balanced in both directions (equilibrium) whereas during major El Niño events(B), the waves transport greater volumes of sand northward, resulting in zones of accumulation (blue shading) and hotspot erosion (red shading). Figure: Rugeiro et al. 2013.

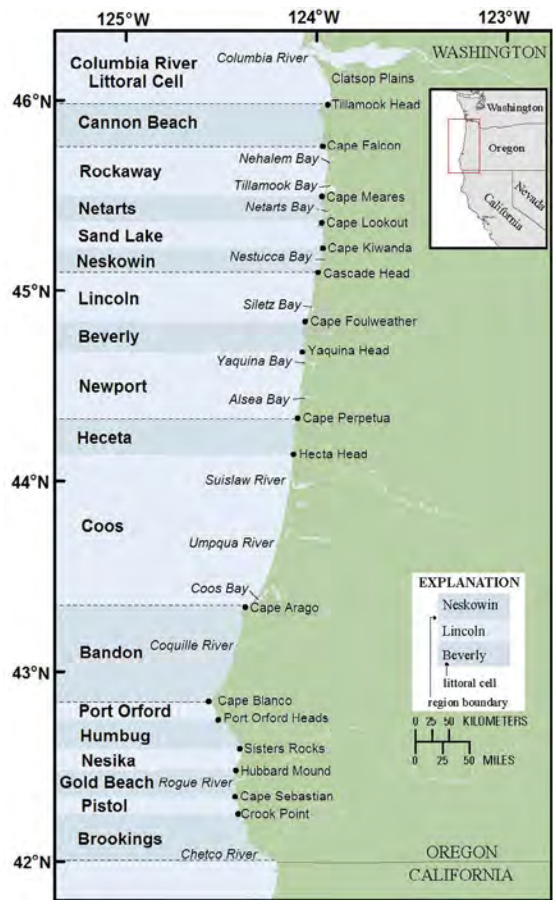



Figure 2. Littoral cells on the Oregon coast (bold text). Cells are stretches of beach bounded by rocky headlands (black dots). Waves transport coastal sediment within each cell.

when waves arrive primarily from the northwest and push sediment to the southern end of the littoral cell. In normal years, an approximately equal volume of coastal sediment is transported during each season so that the shoreline maintains a nearly balanced equilibrium as sediment oscillates within each littoral cell (OCCRI 2010).

In years with particularly intense winter storms (e.g., El Niño years), the northward displacement of sediment within each cell may result in beach accretion (i.e., sand accumulation) at the northern headland of the cell and the creation of erosion “hot spots” at the southern headland (Rugeiro et al. 2013) (Figure 1).

Ruggeiro et al. (2013) further explain that intense winter storms crossing the Northern Pacific ocean typically make landfall in the Pacific Northwest latitudes (i.e., 42°N to > 48°N) and sometimes achieve hurricane force wind speeds, spanning areas large enough to affect the entire length of the Pacific Northwest shoreline. Climate change experts report these storms may have become stronger since the 1970s, suggested by statistically significant increases in both wind speeds and average wave height on the Oregon coast (OCCRI 2010, Ruggeiro et al. 2013).

More intense winter storms may favor the southward displacement of coastal sediment within littoral cells (Ruggeiro et al. 2013). As a consequence, the headlands at the northern ends of these cells (e.g., Cape Arago) may become erosion “hot-spots” (OCCRI 2010, Ruggeir et al. 2013). In addition, portions of the lower Coos estuary that are currently protected from wave erosion may become increasingly affected by ocean storms (winds and associated waves), causing shifts in sediment distribution in the lower estuary. These changes may be compounded by tidal current-generated modifications to estuarine bathymetry, which can work to focus or spread wave energy and further modify local and regional coastal sediment transport regimes (Scavia et al. 2002).

Increased intensity of winter storms may also produce more turbid water (i.e., more suspended fine sediments). In the lower estuary, seasonally higher waves and wind speeds will re-suspend estuarine sediment, while in the upper estuary, increased river flows during intense winter precipitation events will have the same effects.

Contaminants that enter estuaries are often adsorbed onto suspended particles that eventually settle into estuarine depositional basins (USEPA 2002). Since suspended sediment fines (i.e., silt and clay) can act as "ligands" for contamination, climate change may facilitate more contaminant transferals between sediments and the estuarine water column, ultimately facilitating contaminant transport into other parts of the estuary.

**Sea Level Rise**

Sea level rise (SLR) has the potential to result in the loss of wetland habitat and associated ecosystem services (e.g., flood control, maintenance of estuarine water quality, and carbon sequestration)(OCCRI 2010, Zedler and Kercher 2005). Experts anticipate that continued SLR may cause substantial wetland loss on the southern Oregon coast. Forecasting tools suggest that the Bandon Marsh National Wildlife Reserve (NWR), for example, may lose between 19-92% of its wetland habitat by 2100, depending on the SLR scenario used (Clough and Larson 2010 as cited from OCCRI 2010).

*Sea Level Rise*

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, the National Research Council (NRC), predicted SLR rates as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100 for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary).*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

Coastal wetlands can persist if the rate of vertical growth or "accretion" keeps pace with SLR (Cahoon et al. 1995, Day et al. 1995, Pont et al. 2002). Experts forecast that in Oregon the rate of SLR will increase over the next 100 years, suggesting that SLR may threaten tidal wetlands unless accretion rates grow as a result of climate-related changes including SLR (OCCRI 2010)(see local sea level rise rates in sidebar).

Sediment accretion rates are determined by coastal watershed and estuary sediment transport processes (see Geomorphology, Hydrology, and Sediment Transport)(Cahoon et al. 1995; Day et al. 2000, 2003). Climate change may increase accretion rates in some parts of the estuary (e.g., those projected to receive more sediment from potentially higher wintertime peak flows). Conversely, rates may decrease in other areas (e.g., in the lower bay where higher waves and more intense marine storms may cause more erosion).

Rates of sediment accretion may also be affected by coastal development. Scavia et al. (2002) explain that coastal wetlands are able to "retreat" from SLR in undeveloped low-lying areas by migrating inland (also known as "landward migration of tidal wetlands"). They also note that wetlands could be lost in cases where landward migration is prevented by development such as constructed levees, seawalls, bulkheads, etc.

**Effect of Sediment-Related Changes on Estuarine Biota**

Climate-driven changes are expected to alter sediment deposition and erosion patterns, resulting in complex biotic responses that are "mediated by a network of biological interactions" (Day et al. 2008). Although the exact biotic response to changing sediment conditions is unknown, previously conducted research provides some clues.

In the upper estuary, increased sedimentation from intense winter precipitation events and higher peak flows is likely to further limit the suitability of fish spawning habitat (ODFW 2014, USEPA 2012). Sediment conditions often associated with climate change may also favor parasitic hosts of harmful bacterial diseases in native salmon species (e.g., *Ceratomyxa shasta* in the ploychaete worm host, *Manayunkia speciosa*)(OCCRI 2010).

Alterations to estuarine habitat may also affect plant communities that facilitate critical ecosystem functions. For example, excessive sediment in the water (e.g., from intense winter storms) combined with rising sea levels may block sunlight from reaching eelgrass beds which function as forage and refuge habitat for many commercial and recreationally important fish and shellfish species, particularly in their juvenile stages (USEPA 2012).

Changes to estuarine sediment may also affect human infrastructure. For example, increased sediment in storm run-off may affect water treatment facilities (Miller and Yates 2007 as cited from OCCRI 2010). Port facilities including Coos Bay's commercial shipping channel may be subject to alterations by more frequent and stronger winter storms, allowing for more sediment to enter the estuary from the ocean. They could also be affected by greater sediment delivery from the Coos river, which would result in the need for more frequent shipping channel and boat basin dredging (OCCRI 2010).

**References**


Cahoon, D., D. Reed, and J. Day. 1995. Estimating shallow subsidence in microtidal salt marshes of the southeastern United States: Kaye and Barghoorn revisited. Marine Geology 128: 1–9

Cannon, S. H., J. E. Gartner, M. G. Rupert, J. A. Michael, A. H. Rea, and C. Parrett. 2010. "Predicting the Probability and Volume of Post Wildfire Debris Flows in the Intermountain Western United States." Geological Society of America Bulletin 122: 127–144. doi: 10.1130 /B26459.1

Clough, J. S., and E. C. Larson. 2010. Application of the Sea-Level Affecting Marshes Model (SLAMM 6) to Bandon Marsh NWR. Warren Pinnacle Consulting, Inc. Report to U.S. Fish and Wildlife Service, National Wildlife Refuge System, Division of Natural Resources and Conservation Planning Conservation Biology Program

Day, J. W. Jr., D. Pont, P.F. Hensel, and C. Ibañez. 1995. Impacts of sea-level rise on deltas in the Gulf of Mexico and the Mediterranean: the importance of pulsing events to sustainability. Estuaries 18: 636–647.

Day, J., N. Psuty, and B. Perez. 2000. The role of pulsing events in the functioning of coastal barriers and wetlands: Implications for human impact, management and the response to sea level rise. In Concepts and Controversies in Salt Marsh Ecology, eds. M. Weinstein, and D. Dreeger, 633–660. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Day, J.W., A. Yáñez-Arancibia, W.J. Mitsch, A.L. Lara-Dominguez, J.N. Day, J.Y. Ko, R. lane, J. Lindsey, and D. Zárate-Lomelí. 2003. Using ecotechnology to address water quality and wetland habitat loss problems in the Mississippi basin: a hierarchical approach. Biotechnology Advances 22: 135–159.

Day, John W., Robert R. Christian, Donald M. Boesch, Alejandro Yáñnz-Arancibia, James Morris, Robert R. Twilley, Larissa Naylor, Linda Schaffner, and Court Stevenson. 2008. Consequences of climate change on the ecogeomorphology of coastal wetlands. Estuaries and Coasts, 31(3), 477-491.

Defenders of Wildlife and Oregon Department of Fish and Wildlife (ODFW). 2008. Preparing Oregon's Fish, Wildlife, and Habitats for Future Climate Change: A Guide for State Adaption Efforts. Accessed 15 January, 2014. Available online http://www.oregon.gov/ENERGY/GBLWRM/docs/f-w_adaptation_guide.pdf

Goode, J. R., C. H. Luce, and J. M. Buffington. 2012. Enhanced Sediment Delivery in a Changing Climate in Semi-Arid Mountain Basins: Implications for Water Resource Management and Aquatic Habitat in the Northern Rocky Mountains. Geomorphology 139-140: 1-15. doi: 10.1016/j.geomorph.2011.06.021.

Loukas, A., L. Vasiliades, and N. R. Dalezios. 2002. Potential climate change impacts on flood producing mechanisms in southern British Columbia, Canada using the CGCMA1 simulation results. Journal of Hydrology, 259(1), 163-188.

Mielbrecht, E., J Weber, C. Swenson, D. Patte, and S. Denney. 2014. Coquille Estuary Climate Change Vulnerability Assessment. EcoAdapt/ US Fish and Wildlife Service report. 79 pp.

Miller, K. and D. Yates. 2007. Climate change and water resources: a primer for municipal water providers. 92pp. ISBN - 9781843399667

NOAA Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Retrieved from: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council. 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Washington, DC: The National Academies Press. 201 pp.

Oregon Climate Change Research Institute (OCCRI). 2010. “Chapter 6. Impacts of Climate Change on Oregon’s Coasts and Estuaries”, in Oregon Climate Assessment Report. K.D. Dello and P.W. Mote (eds). College of Ocean¬ic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Oregon Department of Fish and Wildlife (ODFW). 2014. Coastal Multi-Species Conservation and Management Plan. Unpublished Manuscript.

Oregon State University (OSU). 2005. Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest. Unpublished report no. 2004-3. Corvallis OR. Retrieved from: http://ir.library.oregonstate.edu/jspui/handle/1957/113

Pont, D., J. Day, P. Hensel, E. Franquet, F. Torre, P. Rioual, C. Ibañez, and E. Coulet. 2002. Response scenarios for the deltaic plain of the Rhône in the face of an acceleration in the rate of sea level rise, with a special attention for Salicornia-type environments. Estuaries 25: 337–358.

Revell, David L. 2001. Littoral Cell Management Planning: A Case Study in Bandon, Oregon. [Proceedings of the 12th Biennial Coastal Zone Conference]. Accessed 26 September 2014 from http://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/4916229/FID3790/pdf_files/posters/revelld.pdf

Ruggiero, Peter, Kratzmann, M.G., Himmel stoss, E.A., Reid, David, Allan, John, and Kaminsky, George. 2013. National assessment of shoreline change—Historical shoreline change along the Pacific Northwest coast: U.S. Geological Survey Open-File Report 2012–1007, 62 p., http://dx.doi.org/10.3133/ofr20121007

Scavia, D., J. C. Field, D. F. Boesch, R. W. Buddemeier, V. Burkett, D. R. Cayan, M. Fogarty, et al. 2002. Climate Change Impacts on U.S. Coastal and Marine Ecosystems. Estuaries. 25 (2): 149-164.

Sharp, D. 2012. Climate Change and the Lower Coquille Watershed. Unpublished report. Oregon Climate Change Research Institute/EcoAdapt. Retrieved from: http://ecoadapt.org/data/documents/CoquilleClimate_02nov2012_FINAL.pdf

United State Environmental Protection Agency (USEPA). 2002. Mid-Atlantic Integrated Assessment (MAIA) Estuaries 1997-98 Summary Report. Chapter 5: Sediment Contamination. Accessed 9 September 2014. Available http://www.epa.gov/emap2/maia/html/docs/Est5.pdf

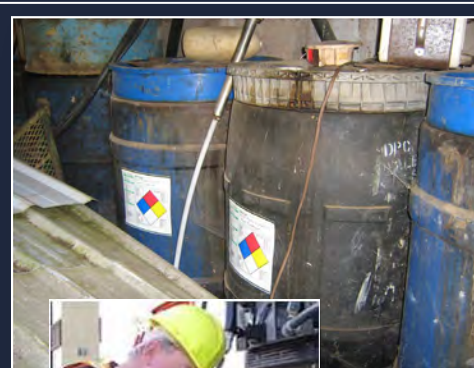
United States Environmental Protection Agency (USEPA). 2012. Water: Estuaries and Coastal Watersheds, Challenges and Approaches. Accessed 24 September 2014 from http://water.epa.gov/type/oceb/nep/challenges.cfm

Zedler, J. B. and S. Kercher, (2005), Wetland resources: Status, trends, ecosystem services, and restorability, Annual Review of Environment and Resources, 30, 39-74.

# Sediment Contaminants in the Coos Estuary


*Summary:*

- *Elevated arsenic, chromium, mercury, and nickel levels may diminish sediment quality in parts of Isthmus Slough, the Upper Bay, and North Slough.*
- *Documented releases of metals, tributyltin, petroleum, and other industrial chemicals have occurred primarily in Isthmus Slough and the Upper Bay; toxicity risk is compounded by elevated levels of organic carbon and fine-grained sediment.*
- *Historically, sediment in the Coos Estuary has been relatively uncontaminated by pesticides.*

**Evaluation**

Areas of elevated metals and industrial pollutants in North Slough, Upper Bay, and Isthmus Slough.

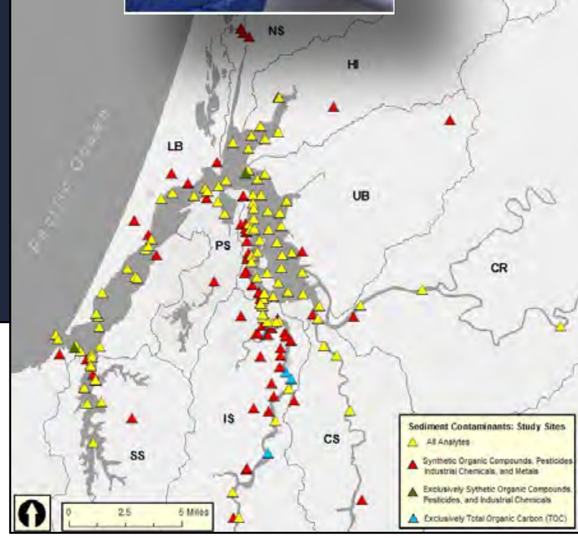



Figure 1. Study sites for sediment contaminants including metals, total organic carbon, synthetic organic compounds, pesticides, and industrial chemicals. CR= Coos River, CS= Catching Slough, HI= Haynes Inlet, IS= Isthmus Slough, LB=Lower Bay, NS= North Slough, PS= Pony Slough , SS= South Slough, UB= Upper Bay. Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006, 2007, n.d; USACE 1980, 1989, 1994, 1998, 2004, 2009; NOAA 1986,1996, 2006; USEPA 2014b

**What's happening?**

A variety of contaminants generated from urban, agricultural, and industrial activities in the Coos estuary and surrounding lands can find their way into coastal waters, where they can accumulate in sediments, posing threats to organisms throughout the estuarine food web, including humans (USEPA 2012).

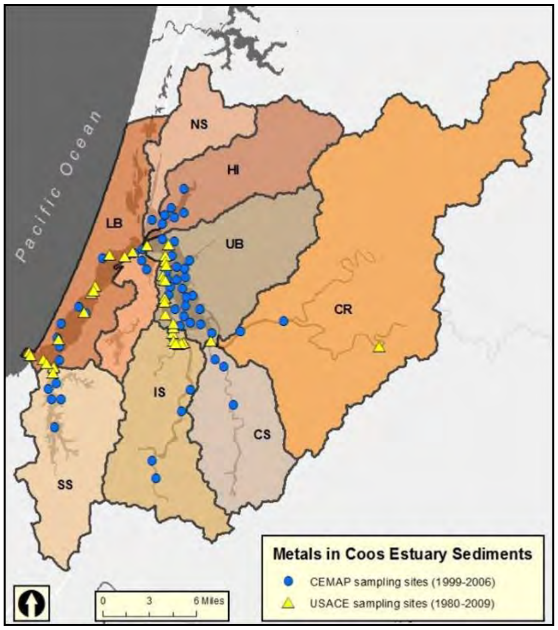


Figure 2. Metals in Coos Sediment Sampling Sites (1980 – 2009)
Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009

This data summary describes the status and trends of those contaminants and is organized by three main pollutant categories:

1. **Metals**
2. **Synthetic Organic Contaminants** (e.g., chlorinated pesticides, polynuclear aromatic hydrocarbons (PAHs), total petrolium hydrocarbons (TPH), and polychlorinated biphenyls(PCBs))
3. **Total Organic Carbon** (TOC)

The status of these sediment contaminants is evaluated using two metrics: Effects Range Low (ERL) and Effects Range Median (ERM) (Table 1)(see sidebar).

*Guideline Values for Assessing Sediment Quality*

*Long et al. (1995) developed a set of guidelines to help "relate ambient sediment chemistry data to the potential for adverse biological effects." Their method establishes reference points based on the observed biological effects of common sediment contaminants:*

*Effects Range Low (ERL) - lowest 10th percentile of concentrations associated with harmful biological effects.*

*Effects Range Median (ERM) - 50th percentile of concentrations associated with harmful biological effects.*

*ERL and ERM are commonly used by public agencies to evaluate the health of estuarine sediment.*

*Source: Long et al. 1995*

**ERL and ERM Values**

| Analyte | ERL | ERM |
|---|---|---|
| **Metals (µg/g dry sediment = ppm)** | | |
| Arsenic | 8.2 | 70 |
| Cadmium | 1.2 | 9.6 |
| Chromium | 81 | 370 |
| Copper | 34 | 270 |
| Lead | 46.7 | 218 |
| Mercury | 0.15 | 0.71 |
| Nickel | 20.9 | 51.6 |
| Silver | 1 | 3.7 |
| Zinc | 150 | 410 |
| **Synthetic Organic Pollutants (ng/g dry sediment, equivalent to ppb)** | | |
| Acenaphthene | 16 | 500 |
| Acenaphthylene | 44 | 640 |
| Anthracene | 85.3 | 1100 |
| Flourene | 19 | 540 |
| 2-Methylnaphthalene | 70 | 670 |
| Naphthalene | 160 | 2100 |
| Penhahthrene | 240 | 1500 |
| Benz(a)anthracene | 261 | 1600 |
| Benzo(a)pyrene | 430 | 1600 |
| Chrysene | 384 | 2800 |
| Dibenzo(a,h)anthracene | 63.4 | 260 |
| Fluoranthene | 600 | 5100 |
| Pyrene | 665 | 2600 |
| Low molecular-weight PAH | 552 | 3160 |
| High molecular-weight PAH | 1700 | 9600 |
| Total PAHs | 4020 | 44800 |
| 4,4-DDE | 2.2 | 27 |
| Total DDT | 1.6 | 46.1 |
| Total PCB | 22.7 | 180 |

Table 1. Wentworth Scale for Sediment Classification
Source: Bartram and Balance 1996

### Metals

The Oregon Department of Environmental Quality (ODEQ) has monitored the metal content of sediments in the Coos Estuary since 1999 as part of their Coastal Environmental Monitoring and Assessment Program (CEMAP)(ODEQ 1999, 2001, 2002, 2004, 2005, 2006). Additionally, the United States Army Corps of Engineers (USACE) has recorded the status of metals in local sediments since 1980 in a series of sediment quality evaluation reports (USACE 1980, 1989, 1994, 1998, 2004, 2009). Figure 2 shows the spatial distribution of the sampling sites associated with those two programs.

Collectively, the CEMAP data and the USACE reports represent over 1,000 “true detects” (i.e., observations above the minimum detection limit) for arsenic, cadmium, chromium, copper, mercury, nickel, silver, and zinc. Generally, these observations indicate good to fair sediment quality, with 74% of all CEMAP true detects and 87% of all USACE true detects meeting the ERL criteria. However, slightly elevated levels of arsenic, chromium, mercury, and nickel may be of concern (Figure 3).

Below are detailed descriptions of metal concentrations in Coos estuary sediments:

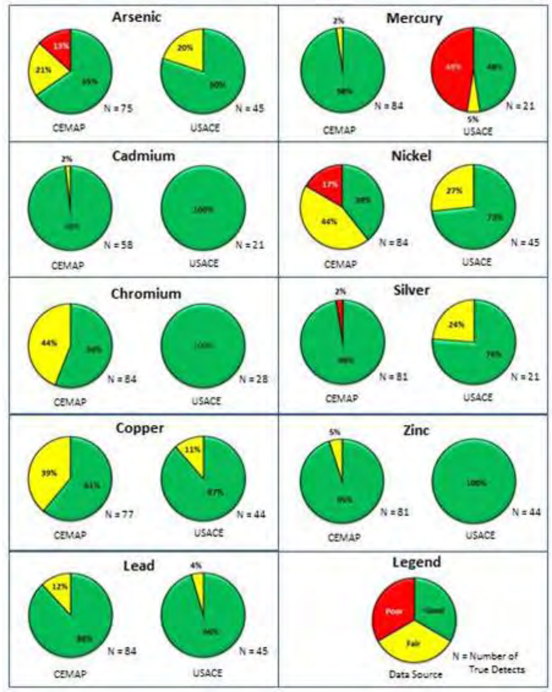



Figure 3. . Percentage of all CEMAP and USACE observations true detects that meet the ERL criteria (good quality), fail to meet the ERL criteria (fair quality), and fail to meet the ERM criteria (poor quality). Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009

<u>Arsenic (ERL=8.2 ppm, ERM=70 ppm)</u>

Arsenic concentrations in Coos Estuary sediment suggest good to fair sediment quality (Table 2). USACE data show that the mean arsenic level (7.5 ppm) meets the ERL criteria (USACE 1980, 1989, 1994, 1998, 2004, 2009). However, the CEMAP data indicate a mean arsenic level (18.4 ppm) that fails to meet the ERL criteria (ODEQ 1999, 2001, 2002, 2004, 2005, 2006). Maximum mean arsenic concentrations occurred in the North Slough subsystem (CEMAP, 66.4 ppm) and Isthmus Slough (USACE, 16.7 ppm). Although these maxima failed to meet the ERL standard, both met the ERM criteria.

<u>Cadmium (ERL=1.2 ppm, ERM=9.6 ppm)</u>

Cadmium data suggest good sediment quality throughout the study area (Table 3). Mean cadmium concentrations for all subsystems easily meet the ERL criteria for both CEMAP (0.26 ppm) and USACE (0.4 ppm) data (ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009).

| Arsenic (CEMAP) | | | | | |
|---|---|---|---|---|---|
| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
| Catching Slough | 4 | 7.1 | 5.5 | 8.4 | 0.7 |
| Coos River | 2 | 51.5 | 1.0 | 102.0 | 50.5 |
| Haynes Inlet | 10 | 8.4 | 3.9 | 12.8 | 1.0 |
| Isthmus Slough | 5 | 9.7 | 6.5 | 12.6 | 1.0 |
| Lower Bay | 12 | 20.9 | 3.5 | 98.2 | 10.3 |
| North Slough | 3 | 66.4 | 4.6 | 97.3 | 30.9 |
| Pony Slough | 2 | 6.1 | 5.6 | 6.5 | 0.5 |
| South Slough | 7 | 4.5 | 3.1 | 5.6 | 0.4 |
| Upper Bay | 30 | 20.7 | 2.2 | 101.6 | 6.4 |
| **All Subsystems** | **75** | **18.4** | **1.0** | **102.0** | **3.6** |
| **Arsenic (USACE)** | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | 1 | 1.0 | 1.0 | 1.0 | ---- |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 9 | 16.7 | 7.5 | 57.0 | 5.4 |
| Lower Bay | 16 | 4.6 | 2.2 | 12.1 | 0.5 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 3 | 4.5 | 3.8 | 5.0 | 0.4 |
| Upper Bay | 15 | 5.6 | 3.0 | 11.3 | 0.7 |
| **All Subsystems** | **44** | **7.5** | **1.0** | **57.0** | **1.3** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)
Poor sediment quality (avg. observation fails to meet ERM)

Table 2. Summary of all CEMAP and USACE arsenic observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

| Cadmium (CEMAP) | | | | | |
|---|---|---|---|---|---|
| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
| Catching Slough | 3 | 0.16 | 0.10 | 0.20 | 0.03 |
| Coos River | 1 | 0.32 | 0.32 | 0.32 | N/A |
| Haynes Inlet | 10 | 0.16 | 0.09 | 0.20 | 0.01 |
| Isthmus Slough | 6 | 0.20 | 0.16 | 0.25 | 0.02 |
| Lower Bay | 5 | 0.38 | 0.10 | 0.65 | 0.12 |
| North Slough | 3 | 0.52 | 0.21 | 0.68 | 0.16 |
| Pony Slough | 2 | 0.23 | 0.17 | 0.28 | 0.05 |
| South Slough | 5 | 0.14 | 0.07 | 0.28 | 0.04 |
| Upper Bay | 23 | 0.31 | 0.07 | 2.31 | 0.10 |
| **All Subsystems** | **58** | **0.26** | **0.07** | **2.31** | **0.04** |
| **Cadmium (USACE)** | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | | No Data | | | |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 6 | 0.7 | 0.2 | 1.3 | 0.2 |
| Lower Bay | 5 | 0.1 | 0.1 | 0.2 | 0.01 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 3 | 0.1 | 0.1 | 0.2 | 0.03 |
| Upper Bay | 9 | 0.4 | 0.1 | 1.5 | 0.2 |
| **All Subsystems** | **23** | **0.4** | **0.1** | **1.5** | **0.1** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)
Poor sediment quality (avg. observation fails to meet ERM)

Table 3. Summary of all CEMAP and USACE cadmium observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

| Chromium (CEMAP) | | | | | |
|---|---|---|---|---|---|
| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
| Catching Slough | 4 | 78.5 | 74.7 | 82.4 | 2.1 |
| Coos River | 3 | 68.7 | 27.2 | 148.8 | 40.1 |
| Haynes Inlet | 10 | 90.9 | 77.4 | 119.0 | 4.5 |
| Isthmus Slough | 6 | 86.0 | 59.4 | 102.0 | 6.1 |
| Lower Bay | 13 | 66.0 | 6.8 | 234.0 | 22.9 |
| North Slough | 3 | 200.7 | 107.0 | 250.0 | 46.9 |
| Pony Slough | 2 | 92.1 | 77.2 | 107.0 | 14.9 |
| South Slough | 7 | 50.5 | 14.9 | 131.0 | 17.0 |
| Upper Bay | 36 | 93.4 | 24.6 | 346.0 | 14.2 |
| **All Subsystems** | **84** | **87.0** | **6.8** | **346.0** | **7.9** |
| **Chromium (USACE)** | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | | No Data | | | |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 6 | 22.2 | 0.3 | 46.2 | 9.7 |
| Lower Bay | 9 | 7.4 | 0.1 | 12.0 | 1.2 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 1 | 10.1 | 10.1 | 10.1 | ---- |
| Upper Bay | 11 | 17.6 | 0.03 | 38.7 | 5.4 |
| **All Subsystems** | **27** | **14.9** | **0.03** | **46.2** | **3.2** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)
Poor sediment quality (avg. observation fails to meet ERM)

Table 4. Summary of all CEMAP and USACE chromium observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

Chromium (ERL=81 ppm, ERM=370 ppm)

Average chromium levels indicate good to fair sediment quality (Table 4). USACE (1980, 1989, 1994, 1998, 2004, 2009) data indicate that average chromium concentrations for all subsystems (14.9 ppm) easily meet the ERL criteria. However, the CEMAP data show that average chromium levels (87 ppm) fail to meet the same criteria (ODEQ 1999, 2001, 2002, 2004, 2005, 2006). Elevated mean chromium levels are primarily due to high chromium concentrations in the North Slough subsystem, which were recorded during the 2002 CEMAP monitoring effort (ODEQ 2002). The 2002 CEMAP data are the most current data for North Slough. No CEMAP sampling has occurred in North Slough since 2002; the USACE has not collected data in North Slough.

Four sites in the Isthmus Slough, Lower Bay, and South Slough subsystems are listed on ODEQ's Confirmed Release List (CRL) for the documented release of chromium (see Why is it happening?)(ODEQ n.d.).

Copper (ERL=34 ppm, ERM=270 ppm)

Copper concentrations indicate good to fair sediment quality throughout the study area (Table 5). Mean copper concentrations for all subsystems meet the ERL criteria for both CEMAP (26.8 ppm) and USACE (20.1 ppm) data (ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009). Average concentrations for individual subsystems were highest in the North Slough (81 ppm) and Isthmus Slough (58.6 ppm), where mean concentrations failed to meet the ERL criteria (CEMAP 2002; USACE 1994,

| Copper (CEMAP) | | | | | |
|---|---|---|---|---|---|
| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
| Catching Slough | 4 | 18.7 | 16.4 | 22.9 | 1.5 |
| Coos River | 3 | 36.1 | 3.5 | 100.5 | 32.2 |
| Haynes Inlet | 10 | 13.7 | 11.4 | 17.8 | 0.8 |
| Isthmus Slough | 6 | 20.5 | 9.0 | 26.3 | 2.6 |
| Lower Bay | 8 | 38.1 | 2.1 | 119.0 | 17.9 |
| North Slough | 3 | 81.0 | 13.1 | 115.0 | 34.0 |
| Pony Slough | 2 | 17.8 | 14.5 | 21.1 | 3.3 |
| South Slough | 6 | 9.8 | 2.2 | 23.6 | 3.3 |
| Upper Bay | 35 | 28.0 | 4.5 | 117.0 | 6.2 |
| **All Subsystems** | **77** | **26.8** | **2.1** | **119.0** | **4.0** |
| Copper (USACE) | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | 1 | 22 | 22 | 22 | ---- |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 9 | 58.6 | 20.3 | 180.0 | 18.9 |
| Lower Bay | 15 | 2.7 | 0.9 | 9.1 | 0.5 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 3 | 2.9 | 2.6 | 3.1 | 0.2 |
| Upper Bay | 16 | 17.9 | 1.80 | 55.8 | 4.0 |
| **All Subsystems** | **44** | **20.1** | **0.86** | **180.0** | **5.1** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)
Poor sediment quality (avg. observation fails to meet ERM)

Table 5. Summary of all CEMAP and USACE copper observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

| Lead (CEMAP) | | | | | |
|---|---|---|---|---|---|
| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
| Catching Slough | 4 | 14.2 | 13.9 | 14.6 | 0.2 |
| Coos River | 3 | 54.3 | 10.1 | 141.9 | 43.8 |
| Haynes Inlet | 10 | 12.4 | 10.2 | 14.9 | 0.5 |
| Isthmus Slough | 6 | 15.7 | 12.5 | 20.3 | 1.2 |
| Lower Bay | 13 | 24.1 | 9.3 | 98.8 | 9.1 |
| North Slough | 3 | 66.2 | 11.8 | 93.5 | 27.2 |
| Pony Slough | 2 | 14.0 | 13.2 | 14.8 | 0.8 |
| South Slough | 7 | 11.0 | 8.8 | 13.7 | 0.6 |
| Upper Bay | 36 | 25.6 | 7.7 | 147.4 | 5.6 |
| **All Subsystems** | **84** | **23.5** | **7.7** | **147.4** | **3.4** |
| Lead (USACE) | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | 1 | 7 | 7 | 7 | ---- |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 9 | 26.9 | 10.1 | 81.0 | 8.7 |
| Lower Bay | 16 | 2.0 | 1.3 | 3.1 | 0.1 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 3 | 2.0 | 1.8 | 2.5 | 0.2 |
| Upper Bay | 16 | 7.9 | 1.9 | 23.8 | 1.7 |
| **All Subsystems** | **45** | **9.2** | **1.3** | **81.0** | **2.2** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)
Poor sediment quality (avg. observation fails to meet ERM)

Table 6. Summary of all CEMAP and USACE lead observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

| Mercury (CEMAP) | | | | | |
|---|---|---|---|---|---|
| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
| Catching Slough | 4 | 0.07 | 0.05 | 0.12 | 0.02 |
| Coos River | 3 | 0.14 | 0.06 | 0.29 | 0.08 |
| Haynes Inlet | 10 | 0.04 | 0.03 | 0.06 | < 0.01 |
| Isthmus Slough | 6 | 0.06 | 0.03 | 0.09 | 0.01 |
| Lower Bay | 14 | 0.05 | 0.01 | 0.29 | 0.02 |
| North Slough | 3 | 0.06 | 0.04 | 0.07 | 0.01 |
| Pony Slough | 2 | 0.06 | 0.06 | 0.06 | < 0.01 |
| South Slough | 7 | 0.03 | 0.01 | 0.05 | 0.01 |
| Upper Bay | 35 | 0.04 | 0.01 | 0.10 | < 0.01 |
| **All Subsystems** | **84** | **0.05** | **0.01** | **0.29** | **0.01** |
| Mercury (USACE) | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | 1 | 10 | 10 | 10 | ---- |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 8 | 12.6 | 0.1 | 66.0 | 8.1 |
| Lower Bay | 1 | 1.3 | 1.3 | 1.3 | ---- |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 1 | 0.01 | 0.01 | 0.01 | ---- |
| Upper Bay | 10 | 3.7 | 0.02 | 10.6 | 1.5 |
| **All Subsystems** | **21** | **7.1** | **0.01** | **66.0** | **3.2** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)
Poor sediment quality (avg. observation fails to meet ERM)

Table 7. Summary of all CEMAP and USACE mercury observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

2004, 2009). Four sites in the Isthmus Slough, Lower Bay, and South Slough subsystems are listed on ODEQ's CRL for the document release of copper (see Why is it happening?) (ODEQ n.d.).

Lead (ERL= 46.7 ppm, ERM= 218 ppm)

Lead concentrations averaged across all subsystems met the ERL criteria (Table 6)(ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009). The CEMAP data show that average lead concentrations exceed the ERL criteria in the North Slough (66.2 ppm) and Coos River (54.3 ppm) subsystems (ODEQ 1999, 2001, 2002, 2004, 2005, 2006).

There is one site in the Upper Bay Subsystem that is listed on ODEQ's CRL for the document release of lead (see Why is it happening?) (ODEQ n.d.).

Mercury (ERL=0.15 ppm, ERM=0.71 ppm)

Mercury levels generally indicate good sediment quality; however, elevated levels in Isthmus Slough suggest localized areas of poor quality sediment (Table 7)(ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009). There is one site in the South Slough Subsystem that is listed on ODEQ's CRL for the document release of mercury (see Why is it happening?)(ODEQ n.d.).

Nickel (ERL=20.9 ppm, ERM=51.6 ppm)

Although data sources are somewhat conflicting, elevated nickel concentrations in Coos sediments may represent fair to poor sediment quality (Table 8).

| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
|---|---|---|---|---|---|
| **Nickel (CEMAP)** | | | | | |
| Catching Slough | 4 | 36.23 | 31.80 | 40.90 | 2.45 |
| Coos River | 3 | 42.43 | 12.90 | 100.10 | 28.84 |
| Haynes Inlet | 10 | 35.02 | 30.30 | 43.30 | 1.65 |
| Isthmus Slough | 6 | 33.82 | 20.90 | 44.10 | 3.17 |
| Lower Bay | 13 | 35.68 | 3.70 | 136.00 | 13.26 |
| North Slough | 3 | 94.93 | 35.80 | 125.00 | 29.57 |
| Pony Slough | 2 | 38.15 | 33.90 | 42.40 | 4.25 |
| South Slough | 7 | 18.16 | 5.20 | 44.20 | 5.76 |
| Upper Bay | 36 | 55.44 | 7.50 | 326.00 | 13.38 |
| **All Subsystems** | **84** | **44.92** | **3.70** | **326.00** | **6.39** |
| **Nickel (USACE)** | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | 1 | 0.01 | 0.01 | 0.01 | ---- |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 9 | 23.3 | 0.06 | 37.9 | 5.8 |
| Lower Bay | 15 | 4.7 | 3.1 | 7.4 | 0.3 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 3 | 5.7 | 4.7 | 7.7 | 1.0 |
| Upper Bay | 16 | 13.7 | 0.02 | 31.4 | 3.3 |
| **All Subsystems** | **44** | **11.8** | **0.01** | **37.9** | **2.0** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)

Poor sediment quality (avg. observation fails to meet ERM)

Table 8. Summary of all CEMAP and USACE nickel observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
|---|---|---|---|---|---|
| **Silver (CEMAP)** | | | | | |
| Catching Slough | 4 | 0.08 | 0.07 | 0.09 | < 0.01 |
| Coos River | 3 | 3.68 | 0.03 | 10.96 | 3.64 |
| Haynes Inlet | 10 | 0.06 | 0.05 | 0.07 | < 0.01 |
| Isthmus Slough | 6 | 0.08 | 0.07 | 0.09 | < 0.01 |
| Lower Bay | 12 | 0.13 | 0.03 | 0.54 | 0.06 |
| North Slough | 3 | 0.39 | 0.07 | 0.56 | 0.16 |
| Pony Slough | 2 | 0.09 | 0.07 | 0.10 | 0.02 |
| South Slough | 7 | 0.04 | 0.03 | 0.06 | < 0.01 |
| Upper Bay | 34 | 0.40 | 0.03 | 9.65 | 0.28 |
| **All Subsystems** | **81** | **0.36** | **0.03** | **10.96** | **0.18** |
| **Silver (USACE)** | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | | | | | |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 7 | 0.8 | 0.11 | 1.7 | 0.3 |
| Lower Bay | 2 | 0.3 | 0.2 | 0.4 | 0.1 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 1 | 0.03 | 0.03 | 0.03 | ---- |
| Upper Bay | 11 | 0.4 | 0.01 | 2.1 | 0.2 |
| **All Subsystems** | **21** | **0.5** | **0.01** | **2.1** | **0.1** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)

Poor sediment quality (avg. observation fails to meet ERM)

Table 9. Summary of all CEMAP and USACE silver observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

| Subsystem | Number of Observations | Average (ppm) | Min (ppm) | Max (ppm) | Std. error |
|---|---|---|---|---|---|
| **Zinc (CEMAP)** | | | | | |
| Catching Slough | 4 | 75.8 | 70.4 | 85.8 | 3.4 |
| Coos River | 3 | 54.3 | 29.9 | 101.6 | 23.7 |
| Haynes Inlet | 10 | 63.6 | 52.3 | 79.9 | 3.2 |
| Isthmus Slough | 6 | 81.1 | 54.3 | 95.9 | 6.3 |
| Lower Bay | 11 | 32.2 | 9.7 | 93.6 | 9.7 |
| North Slough | 3 | 125.7 | 62.0 | 158.0 | 31.8 |
| Pony Slough | 2 | 66.1 | 58.1 | 74.1 | 8.0 |
| South Slough | 7 | 28.5 | 11.8 | 55.5 | 6.6 |
| Upper Bay | 35 | 64.1 | 24.6 | 155.0 | 6.1 |
| **All Subsystems** | 81 | 60.4 | 9.7 | 158.0 | 3.9 |
| **Zinc (USACE)** | | | | | |
| Catching Slough | | No Data | | | |
| Coos River | 1 | 10.0 | 10.0 | 10.0 | ---- |
| Haynes Inlet | | No Data | | | |
| Isthmus Slough | 9 | 83.2 | 43.7 | 140.0 | 8.6 |
| Lower Bay | 15 | 10.4 | 7.8 | 13.0 | 0.4 |
| North Slough | | No Data | | | |
| Pony Slough | | No Data | | | |
| South Slough | 3 | 14.2 | 11.8 | 17.6 | 1.7 |
| Upper Bay | 16 | 36.8 | 7.6 | 74.3 | 6.1 |
| **All Subsystems** | **44** | **35.1** | **7.6** | **140.0** | **4.9** |

Good sediment quality (avg. observation meets ERL) Fair sediment quality (avg. observation fails to meet ERL)

Poor sediment quality (avg. observation fails to meet ERM)

Table 10. . Summary of all CEMAP and USACE zinc observations Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009. Sediment quality guidelines: Long et al. 1995

CEMAP data show that the mean nickel concentration, averaged across all subsystems, fails to meet the ERL criteria (ODEQ 1999, 2001, 2002, 2004, 2005, 2006). This is primarily due to elevated nickel concentrations in North Slough (94.9 ppm) and Upper Bay (55.44 ppm), both of which failed to meet the ERM criteria (ODEQ 1999, 2002, 2004, 2005, 2006). CEMAP data also indicate that six of the remaining seven subsystems fail to meet the ERL criteria, with the exception of South Slough (18.2 ppm).

Contrary to CEMAP, USACE (1980, 1989, 1994, 1998, 2004, 2009) data suggest that mean nickel concentrations easily meet the ERL critieria in most subsystems. However, elevated nickel levels in the Isthmus Slough subsystem (23.3 ppm) failed to meet the ERL criteria.

Five sites in the Isthmus Slough, Lower Bay, and South Slough Subsystems are listed on ODEQ's CRL for the document release of nickel (see Why is it happening?)(ODEQ n.d.).

<u>Silver (ERL=1 ppm, ERM= 3.7 ppm)</u>

Silver concentrations indicate generally good sediment quality throughout the study area (Table 9). However, CEMAP data suggest that silver concentrations in Coos River sediments (3.68 ppm) failed to meet the ERL criteria (ODEQ 1999). It should be noted that these are 1999-era data, and the Coos River subsystem has not been monitored by CEMAP since.

<u>Zinc (ERL= 150 ppm, ERM=410 ppm)</u>

Zinc concentrations suggest good sediment quality throughout the study area (Table 10)

(ODEQ 1999, 2001, 2002, 2004, 2005, 2006; USACE 1980, 1989, 1994, 1998, 2004, 2009). Three sites in the Isthmus Slough and Lower Bay Subsystems are listed on ODEQ's CRL for the documented release of zinc (see Why is it happening?)(ODEQ n.d.).

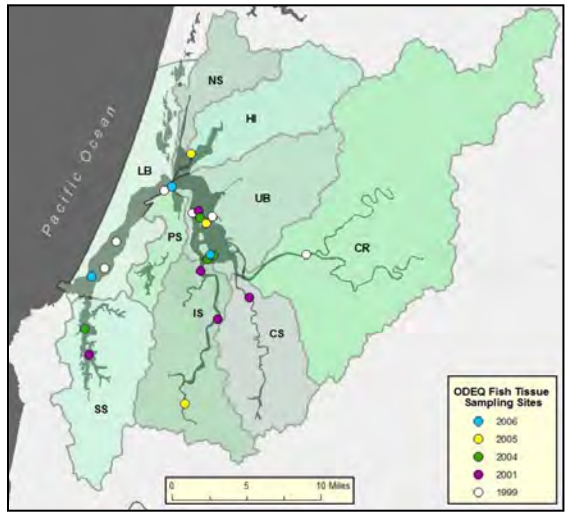



Figure 4. Fish Tissue Sampling Locations. Data ODEQ 1999, 2001, 2004, 2005, 2006

## Metals in Fish Tissues

Contaminants may accumulate in the fatty or muscle tissue of fish and shellfish. Even low levels of contaminants in the water column or sediment may result the contamination of recreationally or commercially harvested fish and shellfish that can result in serious human health risks (USEPA 2000).

ODEQ (1999, 2001, 2004, 2005, 2006) collected data detailing tissue contamination in bottom dwelling fish from sites in the Lower Bay, Upper Bay, South Slough, and Coos River subsystems as part of their CEMAP monitoring program (Figure 4). These data are summarized in Table 11.

| Metal | Number of Observations | Average (ppm wet weight) | Maximum (ppm wet weight) |
|---|---|---|---|
| Aluminum | 12 | 144.2 | 376.5 |
| Arsenic | 11 | 0.51 | 1.14 |
| Cadmium | 74 | 0.04 | 0.05 |
| Chromium | 12 | 0.31 | 0.83 |
| Copper | 11 | 1.06 | 2.06 |
| Iron | 12 | 38.78 | 190.76 |
| Lead | 4 | 0.13 | 0.26 |
| Mercury | 9 | 0.03 | 0.05 |
| Nickel | 8 | 0.27 | 0.61 |
| Selenium | 12 | 0.29 | 0.42 |
| Silver | 4 | 0.01 | 0.01 |
| Tin | 1 | 2.8 | 2.8 |
| Zinc | 12 | 16.08 | 24.08 |

Table 11. Metal concentrations in fishes of Coos Estuary. Data ODEQ 1999, 2002, 2004, 2005, 2006; USEPA 2000

The ODEQ data are difficult to interpret because the development of human health standards for safe fish consumption requires making numerous assumptions about people's dietary preferences, body type (e.g., body weight, age), level of risk aversion, and other variables (USEPA 2000).

However, some indication about the overall suitability of fish for human consumption in the Coos Estuary is provided by the National Listing of Fish Advisories, a compendium created by the United States Environmental Protection Agency (USEPA) to alert the public of any potential health hazards. Similarly, the Oregon Division of Public Health maintains a listing of active fish advisories and consumption guidelines in Oregon (OR Health Division n.d.).

For additional information regarding nationally recommended safe consumption limits, refer to Volume 2 of USEPA's "Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories" (USEPA 2000).

## Synthetic Organic Contaminants, Chlorinated Pesticides, and Other Contaminants

Long et al. (1995) established sediment quality guidelines (SQG) for a series of commonly occurring synthetic organic contaminants, including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dichlorodiphenyltrichloroethane (DDT)(Table 1). These SQGs use the ERL and ERM evaluation criteria (see Guidelines for Assessing Sediment Quality sidebar).

With respect to synthetic organic contaminants and pesticides, sediment quality in Pacific Northwest estuarine sediments has historically been relatively good. In 1999 and 2000, the USEPA sampled 8,670 square kilometers (3,348 square miles) of estuarine sediment in Oregon and Washington as part of their Environmental Monitoring and Assessment Program (EMAP)(Hayslip et al. 2006). Their data suggest limited exposure to pesticides and other synthetic organic contaminants (Figure 5).

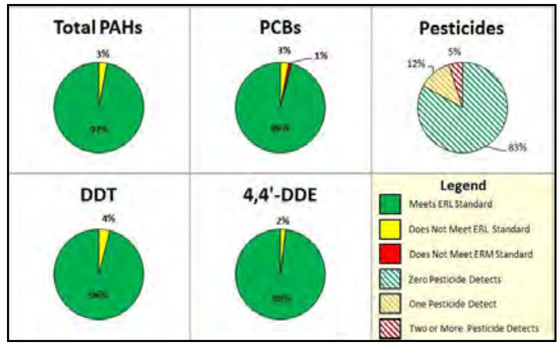



Figure 5. EMAP data (1999-2000) showing sediment contamination by percent of total study area (3,348 square miles) in Washington and Oregon estuaries. Data: Hayslip et al. 2006

The Coos Estuary is typical of a regional pattern of relatively low sediment contamination. In 2002, the USEPA conducted a survey of soft sediment habitat in the estuaries of Washington, Oregon, and California (Nelson et al. 2007). They examined sediment toxicity by calculating the Effects Range Median Quotient (ERM-Q), which is intended to be an indicator of overall sediment contamination.

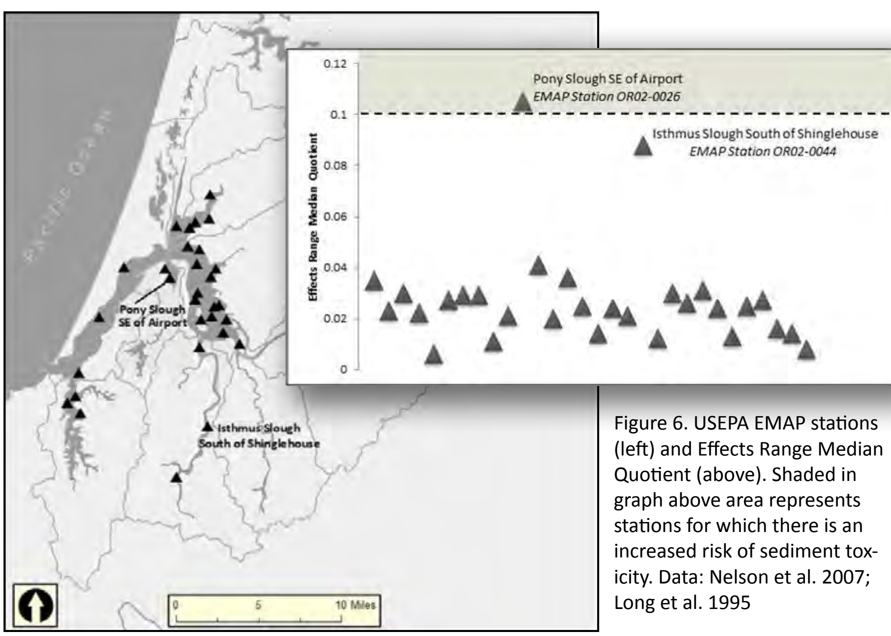



Figure 6. USEPA EMAP stations (left) and Effects Range Median Quotient (above). Shaded in graph above area represents stations for which there is an increased risk of sediment toxicity. Data: Nelson et al. 2007; Long et al. 1995

An ERM-Q < 0.1 corresponds to low probability (11.6%) of sediment toxicity (Long et al. 1995). Most Coos estuary stations easily met the low toxicity risk benchmark. Only one station (Pony Slough subsystem) failed to meet the benchmark (Figure 6).

ODEQ monitors pesticides, tributyltin (TBT), and PCBs in the Coos estuary as part of their Coastal Environmental Monitoring and Assessment Program (CEMAP). CEMAP monitoring was conducted in 1999, 2001, 2002, 2004, 2005, and 2006 at 60 Coos estuary sites (Figure 7).

The CEMAP data indicate little exposure to pesticides, PCBs, or TBT in the Coos estuary. Between 1999 and 2006, CEMAP recorded nearly 2,500 observations in the study area. Just over 1 percent of all CEMAP observations were “true detects” (40 observations)(i.e., above reporting limits)(Table 12).

USACE also evaluates sediment quality by comparing sediment contaminant levels to a “screening level,” which is used to determine the acceptability of management alternatives for dredged materials (Sediment Evaluation Framework for the Pacific Northwest 2009).

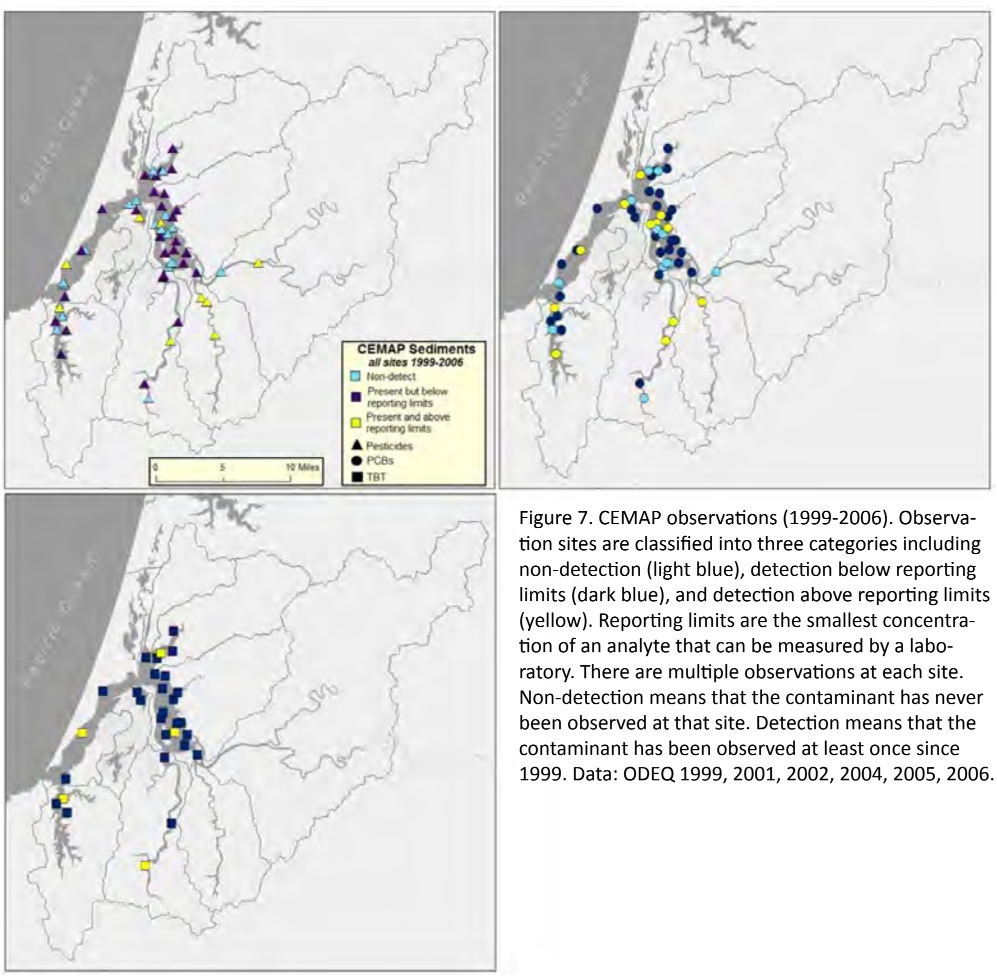



Figure 7. CEMAP observations (1999-2006). Observation sites are classified into three categories including non-detection (light blue), detection below reporting limits (dark blue), and detection above reporting limits (yellow). Reporting limits are the smallest concentration of an analyte that can be measured by a laboratory. There are multiple observations at each site. Non-detection means that the contaminant has never been observed at that site. Detection means that the contaminant has been observed at least once since 1999. Data: ODEQ 1999, 2001, 2002, 2004, 2005, 2006.

| Contaminant | Observations | True Detects |
|---|---|---|
| Aldrin | 65 | 5 |
| Alpha-Chlordane | 65 | 0 |
| Dieldrin | 66 | 0 |
| Endosulfan I | 66 | 0 |
| Endosulfan II | 66 | 0 |
| Endosulfan Sulfate | 66 | 0 |
| Endrin | 66 | 0 |
| Endrin Aldehyde | 77 | 0 |
| Endrin Ketone | 77 | 0 |
| Heptachlor | 66 | 6 |
| Heptachlor epoxide | 66 | 1 |
| Lindane (gamma-BHC) | 66 | 1 |
| Mirex | 66 | 0 |
| Toxaphene | 66 | 0 |
| Trans-Nonachlor | 65 | 0 |
| Total DDT | 1,272 | 2 |
| Total PCBs | 1,440 | 22 |
| Total TBTs | 132 | 3 |
| **All Contaminants** | **3,853** | **40** |

Table 12. CEMAP Sediment Contaminants Observations (1999-2006)

From 1989 to 2009, the USACE evaluated Coos sediments for several contaminants including pesticides and PCBs, TBT and other butyltin compounds, PAHs, total petrolium hydrocarbons (TPH), chlorinated hydrocarbons, phenols, phthalates, and "miscellaneous extractables" (see Figure 2)(USACE 1980, 1989, 1994, 1998, 1999, 2004, 2009).

Generally, chemical analyses indicated very little sediment contamination. Many of the USACE observations were below reporting limits (Table 13). However, in 1994, testing at Mid-coast Marine and Hilsrom Marine (two formerly operational shipbuilding sites in Isthmus Slough) revealed elevated TBT levels (USACE 1994).

Since 1986, the National Oceanic and Atmospheric Administration (NOAA) has monitored sediment contamination at two Coos estuary sites for their Mussel Watch Contaminant Monitoring Program (Figure 8)(NOAA 1986, 1996, 2006). The NOAA data set includes 216 observations for contaminants with established SQGs (See Table 1 for SQGs). All of these observations met the SQGs (Table 14).

**Total Organic Carbon**

Total Organic Carbon (TOC) occurs naturally in estuarine sediments, but elevated TOC can change the "benthic" (i.e., sea floor) environments, deplete oxygen levels (ODEQ 2014, Pearson and Rosenberg 1978), and can be associated with the presence of other pollutants (Hyland et al. 2005). In the 2012 National Coastal Condition Report, USEPA outlines sediment quality standards for TOC (Table 15).

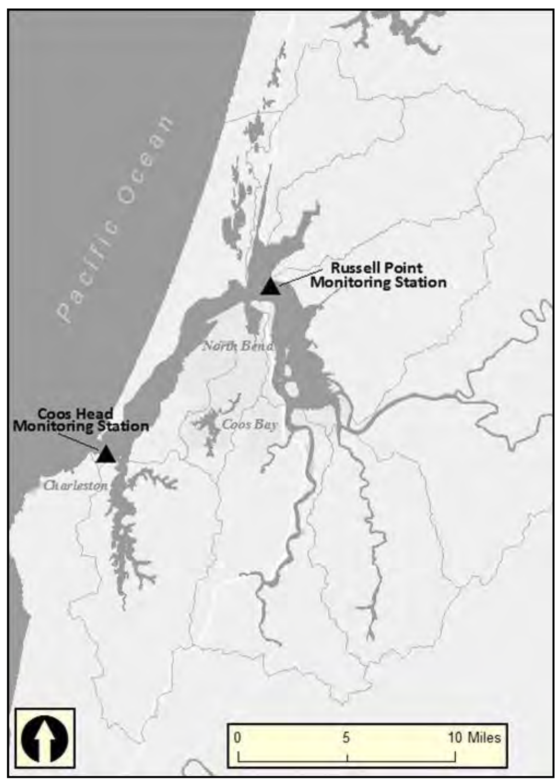



Figure 8. NOAA Mussel Watch Contaminant Monitoring Program site locations Data: NOAA 1986, 1996, 2006.

Table 13. Summary of USACE Sediment Quality Evaluation Report Conclusions (1989-2009)

| Year | Pesticides and PCBs | Chlorinated hydrocarbons, phenols, phthalates, and misc extractables | TBT and butyltin compounds | Polynuclear Aromatic Hydrocarbons (PAHs) | Total Petroleum Hydrocarbons (TPH) |
|---|---|---|---|---|---|
| 2009 | No pests or PCBs detected above reporting limits | No chlorinated hydrocarbons were above reporting limits. Phenols, phthalates, benzoic acid, and dibenzofuran were detected in several samples, but did not approach screening levels. | | PAHs were detected in some samples, but levels were well below screening levels. | Diesel detected at an estimated 6 ppm in one sample and 40 ppm in another. Residual range organics (i.e. lubricating oils from motor oil, hyrdolic fluid, etc) detected in two samples at 59 ppm and 330 ppm. |
| 2004 | No PCB or DDT detected. Some elevated Chlordane levels. Historically Chrlodance has not been detected in Coos sediments. | Two phenol and three phtalate compounds detected in fine-grained sediments from Isthmus samples, but these observations did not approach screening levels. | No butylin compounds present at detection limits | Several PAHs were detected within Isthmus Slough. However, these observations did not approach screening levels. | |
| 1999 | | | | | Testing conducted to evaluate the acceptability of dredge spoils disposal after the New Carrissa spill event. Did not detect petrolium hydrocarbons at levels exceeding recommended screening level. |
| 1998 | No pesticides, PCBs, or chlorinated organic compounds were above method detection limits | Several phenol, phtalates, and dibenzofuran detections, but all of them were below the screening level | Evaluated Isthmus Slough sediment at sites of concern, including Mid-Coast Marine and Hilstrom Marine. Only 2 stations (both at Hilstrom) indicated the presence of a butyltin compous (monobutyltin). The highest concentration exceeded screening levels by 43%. | | |
| 1994 | | | Sediment contained elevated levels of TBT near Hilstrom and Mid-coast Marine. Evidence of toxic effects to oysters in some areas. Refuse appears to settle quickly near the edges of the channel in sediment that is not frequently dredged. | | |
| 1989 | | The concentration of dioxin/furans in sediment samples were very low, with only 3 of the 17 dioxin/furan congeners tested detected. | | | |

| Year | Analyte | Observed Value (ng/ g dry sediment) | ERL (ng/ g dry sediment) | ERM (ng/ g dry sediment) |
|---|---|---|---|---|
| Coos Head Monitoring Station | | | | |
| 1996 | Total DDT | 0.09 | 1.58 | 46.1 |
| 1996 | Total PAH | 2.23 | 4,022 | 44,792 |
| 1996 | Total PCB | 0.26 | 22.7 | 180 |
| 2006 | Total DDT | 0.02 | 1.58 | 46.1 |
| 2006 | Total PAH | 6 | 4,022 | 44,792 |
| 2006 | Total PCB | 0.13 | 22.7 | 180 |
| Russell Point Monitoring Station | | | | |
| 1986 | Total DDT | 0.45 | 1.58 | 46.1 |
| 1987 | Total DDT | 0.57 | 1.58 | 46.1 |
| 1996 | Total DDT | 0.19 | 1.58 | 46.1 |
| 1996 | Total PAHs | 50.43 | 4,022 | 44,792 |
| 1996 | Total PCB | 0.95 | 22.7 | 180 |
| 2006 | Total DDT | 0.67 | 1.58 | 46.1 |
| 2006 | Total PAHs | 130.27 | 4,022 | 44,792 |
| 2006 | Total PCB | 2.09 | 22.7 | 180 |

Table 14. Summary of NOAA Mussel Watch Contaminant Monitoring Program (1986-2006) Data: NOAA 1986, 1996, 2006.

| Rating | Cutpoints |
|---|---|
| Good | The TOC concentration is less than 2% of sediment composition |
| Fair | The TOC concentration is between 2% and 5% of sediment composition |
| Poor | The TOC concentration is greater than 5% of sediment composition |

Table 15. Sediment quality standards. Data: USEPA 2012

According the USEPA, TOC levels in Oregon coast sediments generally meet the criteria for good sediment quality (Figure 9)(Nelson et al. 2007). In 2002, less than 2% of estuarine sediment on the Oregon coast had TOC levels associated with poor quality sediment ( > 5% TOC)(Nelson et al. 2007).

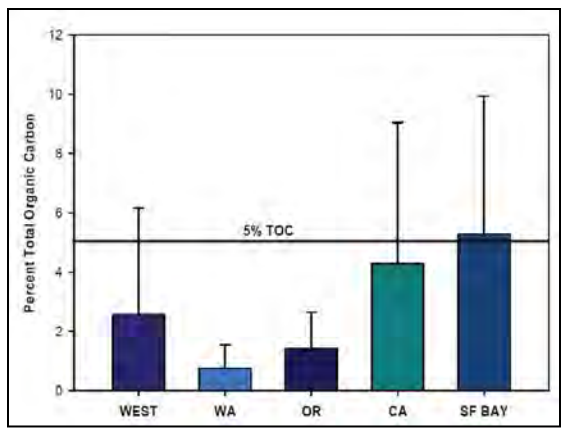



Figure 9. TOC levels in west coast estuarine sediment (mean ± 1 sd). Data: Nelson et al. 2007

The regional trend for low TOC is reflected in Coos Estuary sediments. Lee II and Brown (2009)(Western Ecology Division of the USEPA) reported that median Coos estuary TOC levels were the second highest in the state, but overall sediment quality was still high (TOC < 1% of sed. composition)(Table 16).

The USACE has maintained records of TOC in Coos Bay sediments since 1980 for the the Lower and Upper Bay subsystems (USACE 1980, 1989, 1994, 1998, 2004, 2009). A few samples were also collected in the South Slough (1998 and 2004), Pony Slough (1998), Isthmus Slough (1898, 1994, 2004, and 2009), and Coos River (1980)(see Figure 2).

USACE records indicate that the organic content of Coos River sediments has historically been low, and, in the Upper Bay Subsystem, "TOC [concentrations]… were typical of uncontaminated coastal and estuarine sediment" (USACE 1980, 1989).

| Estuary | Median TOC (% Sediment Composition) | Percent of Area with fair quality sediment (2-5% TOC) | Percent of Area with poor quality sediment (> 5% TOC) |
|---|---|---|---|
| **Coos** | **0.90** | **17** | **< 1** |
| Alsea | 0.69 | 2.5 | 0 |
| Nestucca | 0.16 | 7.1 | 0 |
| Salmon | 0.34 | 7.3 | < 1 |
| Tilamook | 0.41 | 2.6 | 0 |
| Umpqua | 0.51 | 9.6 | 0 |
| Yaquina | 1.30 | 21.4 | 0 |

Table 16. TOC sediment composition of Oregon estuaries. Data: Lee II and Brown 2009

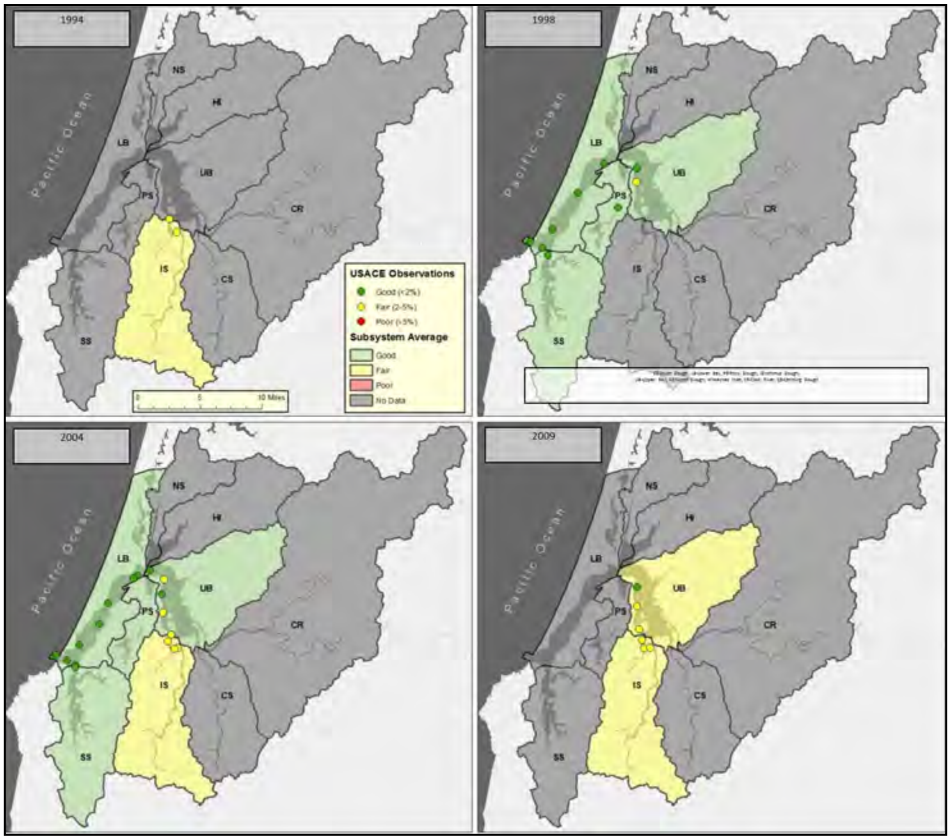



Figure 10. USACE TOC observations (1994-2009) and subsystem averages. Data: USACE 1994, 1998, 2004, 2009 Sediment quality standards: USEPA 2012

In 1994, the USACE evaluated sediment quality near Hilstrom Marine and Mid Coast Marine, two formerly operational boat repair sites in Isthmus Slough (USACE 1994). By current standards, the average sediment quality at both Hilstrom (2.85% TOC) and Mid Coast Marine (4.87 % TOC) was fair, but Mid Coast Marine sediment tended towards poor quality, with four of the five samples exceeding 5% TOC.

In more recent years, USACE data have indicated good sediment quality on average in some subsystems (e.g., South Slough and Lower Bay) and fair sediment quality in others (e.g., Upper Bay and Isthmus Slough)(Figure 10).

TOC was monitored in all nine project area subsystems (see Figure 2) as part of the Coastal Environmental Monitoring and Assessment Program (CEMAP) in 1999, 2002, and 2004 (ODEQ 1999, 2002, 2004).

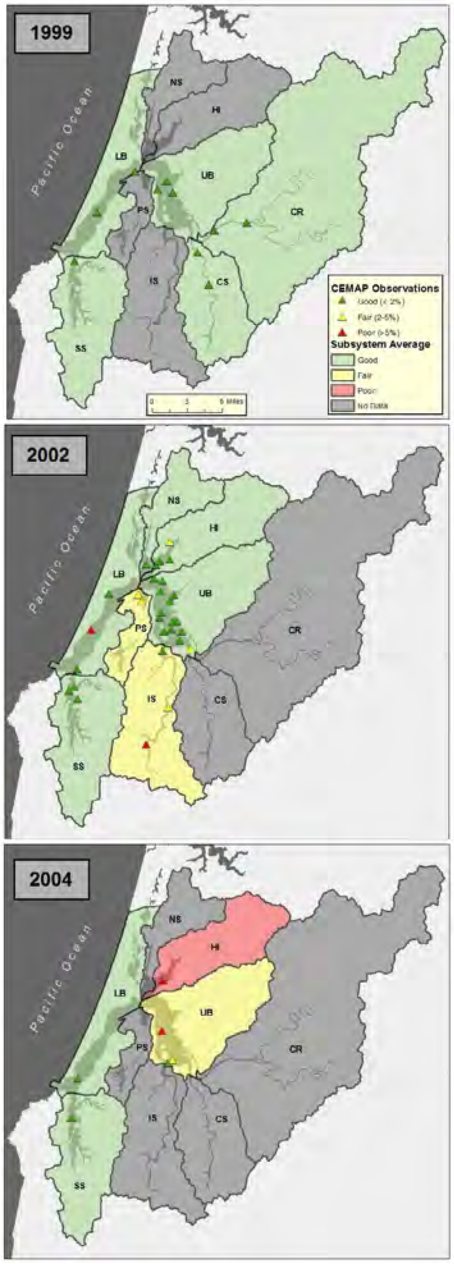



Figure 11. CEMAP TOC observations and subsystem averages. Data: ODEQ 1999, 2002, 2004. Sediment quality standards: USEPA 2012

In 1999, TOC levels easily met the USEPA recommended water quality criteria (ODEQ 1999). Observations in 2002 generally met USEPA guidelines. However, there were instances of fair to poor sediment quality (2-5% TOC) in Haynes Inlet, Pony Slough, Isthmus Slough, and the Upper and Lower Bay subsystems (ODEQ 2002). In 2004, CEMAP observations suggested good sediment quality in the Lower Bay and South Slough subsystems and fair to poor sediment quality in the Upper Bay and Haynes Inlet. TOC levels in Haynes Inlet were more than double USEPA's recommended values (Figure 11 and Table 17)(ODEQ 2004).

| Subsystem | Number of Sites | Number of Observations | Average TOC (% Sediment Composition) | Minimum | Maximum |
|---|---|---|---|---|---|
| **1999 CEMAP DATA** | | | | | |
| Catching Slough | 2 | 4 | 0.73 | 0.03 | 1.48 |
| Coos River | 2 | 4 | 0.1 | 0.06 | 0.15 |
| Lower Bay | 2 | 4 | 0.41 | 0.05 | 0.47 |
| South Slough | 1 | 2 | 0.11 | 0.1 | 0.11 |
| Upper Bay | 3 | 6 | 0.46 | 0.2 | 0.93 |
| **ALL SUBSYSTEMS** | **10** | **20** | **0.41** | **0.03** | **1.48** |
| **2002 CEMAP DATA** | | | | | |
| Haynes Inlet | 4 | 5 | 1.49 | 1.15 | 2.01* |
| Isthmus Slough | 3 | 3 | 3.43* | 1.17 | 5.13** |
| Lower Bay | 4 | 6 | 1.13 | 0.07 | 5.41** |
| North Slough | 1 | 1 | 1.47 | 1.47 | 1.47 |
| Pony Slough | 2 | 2 | 2.36* | 2.07* | 2.65* |
| South Slough | 3 | 3 | 1.03 | 0.4 | 1.45 |
| Upper Bay | 13 | 13 | 0.99 | 0.29 | 2.41* |
| **ALL SUBSYSTEMS** | **30** | **33** | **1.41** | **0.07** | **5.41**** |
| **2004 CEMAP DATA** | | | | | |
| Haynes Inlet | 1 | 1 | 12** | 12** | 12** |
| Lower Bay | 1 | 1 | 0.8 | 0.8 | 0.8 |
| South Slough | 1 | 1 | 1.4 | 1.4 | 1.4 |
| Upper Bay | 3 | 3 | 3.87* | 1.3 | 5.4** |
| **ALL SUBSYSTEMS** | **6** | **6** | **4.3** | **0.8** | **12** |

* Exceeds EPA guidelines for fair water quality ( >2%) ** Exceeds EPA guidelines for poor water quality (>5%)

Table 17. CEMAP observations and subsystem averages (1999-2004). Data: ODEQ 1999, 2002, 2004. Sediment quality standards: USEPA 2012

In 2006, ODEQ measured TOC in Isthmus Slough (ODEQ 2007). Sediment quality was fair to poor, with only one measurement indicating good sediment quality (Figure 12).

TOC in suspension has been measured sporadically from 1995-2012 in the South Slough, Isthmus Slough, Coos River, Pony Slough, and Lower Bay subsystems (ODEQ 2001, 2007, 2009a, 2009b, Water Board 2012). Generally, TOC concentrations in these subsystems range between 3-4 mg/L. However, anomalously high TOC levels were measured near the Joe Ney Construction Debris Landfill in South Slough, with several instances of

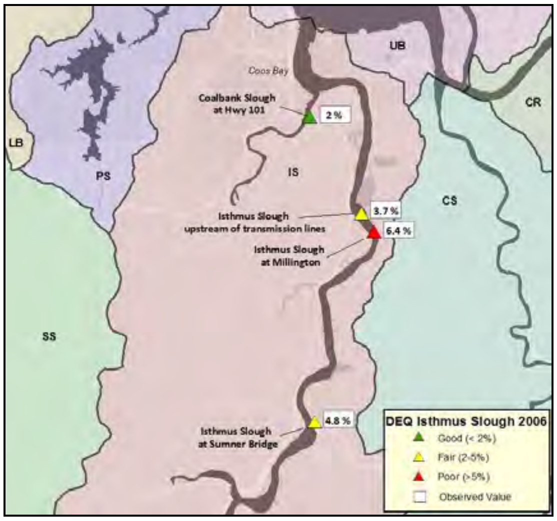


Figure 12. Isthmus Slough TOC observations 2006. Data: ODEQ 2007. Sediment quality standards: USEPA 2012. SS-South Slough, LB-Lower Bay, PS-Pony Slough, IS-Isthmus Slough, UB-Upper Bay, NS-North Slough, HI-Haynes Inlet, CR-Coos River, CS-Catching Slough

concentrations ranging from 20-42 mg/L and once instance of 60 mg/L (ODEQ 2009a). For more detail, refer to the Organic Carbon section of the Water Quality Chapter.

**Why is it happening?**

There are many potential sources of metals, synthetic organic pollutants, chlorinated pesticides, petroleum hydrocarbons, and other pollutants in estuarine sediment (USEPA 2002). The toxicity of these chemicals in estuarine sediment depends on several factors (Bauer and Bianchi 2011; USEPA 2002, 2007a; Bentivegna et al. 2004; Flemming and Trevors 1989). As a result, it can be difficult to determine sediment contaminant sources.
Despite these difficulties, several tools have been developed to track potential contaminant sources, including USEPA's Toxic Release Inventory (TRI) and "Brownfield" site listings as well as ODEQ's Environmental Cleanup Site Information (ECSI) program.

It's important to note that these programs often list sites as "potential" or "suspected" sources of pollution. Therefore, registry with these programs does not necessarily mean that a facility is responsible for the release of pollutants into the environment. Supplemental details about the sites that are enrolled in these programs can be found in the online databases (ODEQ n.d., USEPA 2014b).

In addition to ECSI, ODEQ also manages a confirmed release list (CRL). Registry with the CRL means that the release of pollutants has been confirmed and documented at that site (ODEQ n.d.).

There are 3 TRI sites, 4 Brownfield sites, and sixty ECSI sites in the study area (ODEQ n.d., USEPA 2014a)(Figure 13). Although there are sites in all 9 subsystems, the majority (61%) of these sites are located in the Isthmus Slough and Upper Bay Subsystems (ODEQ n.d., USEPA 2014a).

These sites represent a potential source of contamination to the soil, groundwater, surface water, and sediment. They're listed for a variety of reasons, including but not limited to mismanagement of hazardous wastes, accidental spills, and historic practices that are presently ill-advised. The suspected pollutants include metals, PCBs, PAHs, TPH, TBT, dioxins, and other industrial chemicals (e.g., wood preservation chemicals).

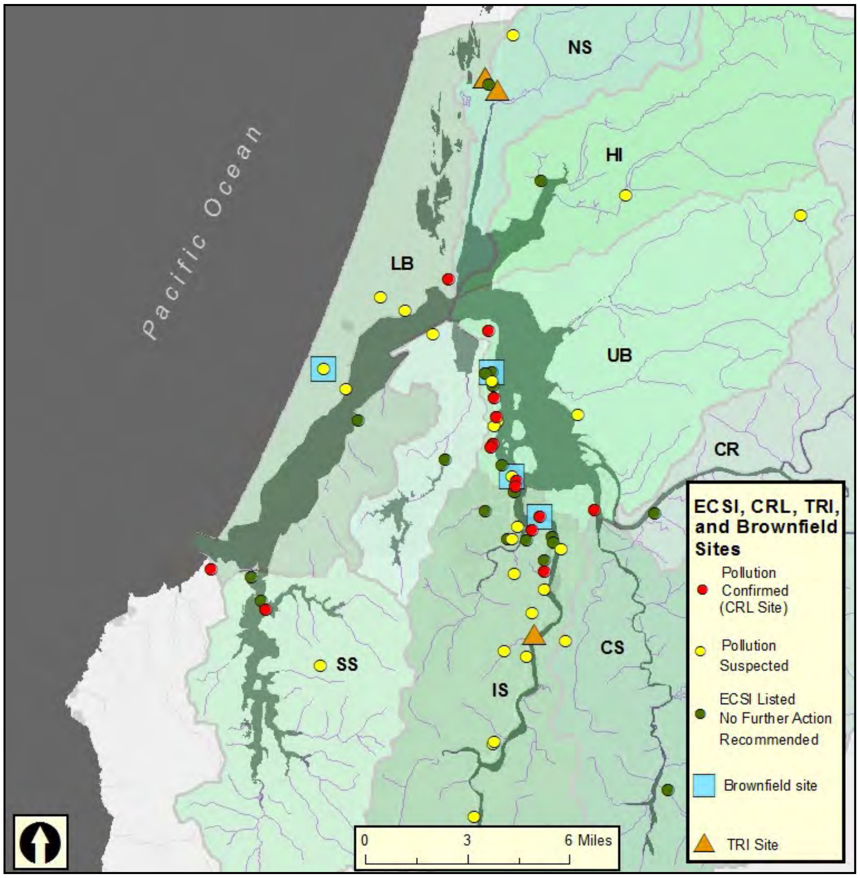



Figure 13. Location of potential sediment pollution sources (green, yellow, blue) and documented pollution sources (red) Source: ODEQ n.d., USEPA 2014a

Fourteen of the 60 ECSI sites in the study area are CRL sites, meaning that the release of pollutants has been documented in nearly a quarter (23%) of all ECSI sites (ODEQ n.d.). Similar to all ECSI, the majority (78%) of these CRL sites are in the Upper Bay and Isthmus Slough Subsystems (Figure 13). These CRL sites are industrial properties, including boat building, metal works, lumber mills, and fueling stations. They are listed for mismanagement and improper disposal of pollutants resulting in the confirmed release of metals, PCBs, PAHs, TPH, TBT, and other industrial chemicals into the soil, groundwater, surface water, or sediment.

**Background**

Metals, synthetic organic contaminants, chlorinated pesticides, and other pollutants can enter estuaries from a variety of sources, including effluent from nearby industry or agriculture activities (USEPA 2002). Many metals (e.g., iron, copper) are also naturally abundant elements found in coastal watersheds (Shacklette and Boerngen 1984; USEPA 2007b). Contaminants that enter estuaries are often adsorbed onto suspended particles that eventually settle into depositional basins, where they enter the sediment (USEPA 2002). Some metals (e.g., copper and zinc) are a necessary part of a healthy estuarine environment, because they facilitate important metabolic functions (USEPA 2002, USEPA 2006). Other metals (e.g., mercury, lead, chromium, and cadmium) have no known metabolic function (USEPA 2006).

The toxicity of contaminants in sediment is determined by several factors, including the physical characteristics of the sediment (e.g., grain size and organic content) as well as other chemical and environmental factors such as pH, redox potential (i.e., the tendency of a contaminant to acquire electrons), water hardness, organic content, and the availability of other pollutants or binding agents (Bentivegna et al. 2004; USEPA 2002, 2007a; Flemming and Trevors 1989). Since toxic responses in plants and animals require the transfer of chemicals from the environment to biochemical receptors on or in an organism, the toxicity of these pollutants may also depend on species-specific physiology (USEPA 2007b). Estuaries are complex interfaces between terrestrial, marine, and atmospheric organic carbon (OC) sources, both naturally occurring and human-generated (Bauer and Bianchi 2011)(Figure 14). Estuarine OC may be lost through naturally occurring geological mechanisms (e.g., sedimentation and remineralization) as well as chemical processes (e.g., flocculation and precipitation)(Bauer and Bianchi 2011).

Estuarine carbon cycling is influenced by human activities (e.g., wetland drainage, damming and diversion of waterways, and other land use changes, as well as aerosol sources such as fossil fuel combustion and biomass burning). These activities have the potential to rapidly change and further complicate an already intricate process (Bauer and Bianchi 2011).

Organic matter (OM), such as TOC, is an important source of food for benthic fauna. However, an overabundance of OM in the sediment may reduce biodiversity, because the decomposition of excess OM is associated with oxygen depletion and the accumulation of toxic by-products (e.g., ammonia and sulphide)(Hyland et al. 2005, Diaz and Rosenberg 2008). Excess OM may also be accom-

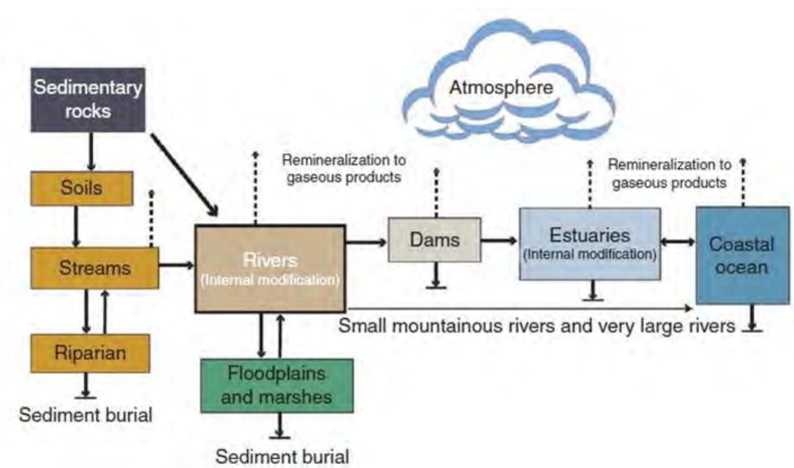



Figure 14. Potential sources and pathways of introduction of terrestrial dissolved organic carbon (DOC) and particulate organic carbon (POC) to the coastal ocean via watersheds, rivers, and estuaries. DOC and POC are the components of TOC. Also shown are the potential losses from natural (e.g. remineralization and sedimentation) and anthropogenic (e.g., damming and watershed modification) factors. Figure and caption: Bauer and Bianchi 2011

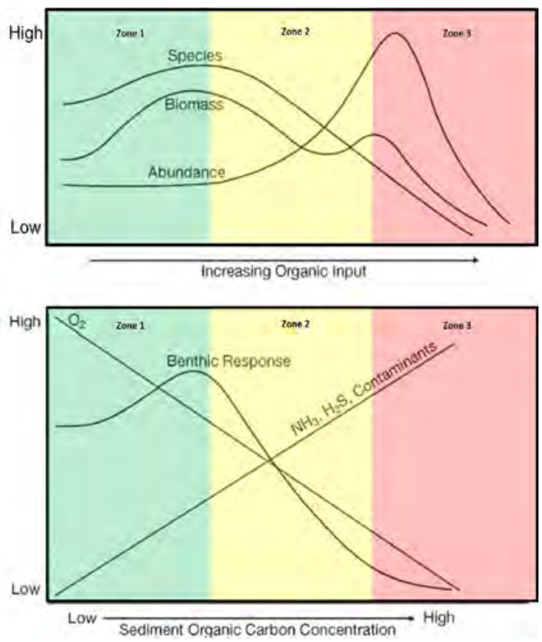



Figure 15. Species richness, biomass, and abundance in response to increasing organic input (top) and the benthic response to organic carbon in the sediment and co-varying stressors (bottom). Responses have been divided into three conceptual "zones," representing low organic carbon (green), intermediate levels (yellow), and high levels (red). Source: Pearson and Rosenberg 1978; Hyland et al. 2005

panied by increases in chemical pollutants, because high OM levels require some of the same environmental factors that facilitate increases in other contaminants (e.g., increase in finer-grained sediments that allow a greater surface area for adsorption)(Hyland et al. 2005). Pearson and Rosenberg (1978) have modeled of benthic response to increasing OM levels (Figure 15).

In their model, low OM levels (Figure 15, Zone 1) result in high species richness due to the combined effects of the sufficient food availability and few environmental stressors. Over the intermediate OM range (Zone 2), species richness declines, because sensitive organisms are unable to withstand increasing exposure to environmental stressors (e.g., depleted oxygen, toxic by-products of OM decomposition, and increased chemical contaminants). However, hardier/opportunistic species may be tolerant of increased OM levels, resulting in a net increase in species abundance and a secondary peak in biomass. At high OM levels (Zone 3), environmental stressors exceed most tolerance levels; consequently, there is a precipitous loss of biodiversity.

**References**

Bauer J.E. and Bianchi T.S. 2011. Dissolved Organic Carbon Cycling and Transformation. In: Wolanski E. and McLusky D.S. (eds.) Treatise on Estuarine and Coastal Science, Vol 5, pp. 7–67. Waltham: Academic Press. Accessed from http://aquaticbiogeochem.osu.edu/sites/aquaticbiogeochem.osu.edu/files/Bauer%20and%20Bianchi%20(2012)%20TECS-DOC%20Cycling.pdf

Bentivegna, Carolyn S., Joy-Elaine Alfano, Sean M. Bugel, and Katarzyna Czechowicz. 2004. Influence of Sediment Characteristics on Heavy Metal Toxicity in an Urban Marsh. Urban Habitats. Vol. 2 (1) pp. 91-111.
Burdige, D.J. 2006. Geochemistry of Marine Sediments. Princeton University Press: Princeton, NJ, 609 pp.

Coos Bay/North Bend Water Board (Water Board). 2012. [Drinking Water Program Data]. Unpublished raw data. Accessed 15 April 2014 from the Estuarine and Coastal Sciences Laboratory of the South Slough National Estuarine Research Reserve.

Diaz, R.J. and R. Rosenberg. 2008. Spreading dead zones and consequences for marineecosystems. Science 321: 926-929.

Flemming, C.A. and J.T. Trevors. 1989. Copper Toxicity and Chemistry in the Environment: A Review. Water, Air, and Soil Pollution 44: 145-158.

Hayslip, G., L. Edmond, V. Partridge, W. Nelson, H. Lee, F. Cole, J. Lamberson , and L. Caton. 2006. Ecological Condition of the Estuaries of Oregon and Washington. EPA 910-R-06-001. U.S. Environmental Protection Agency, Office of Environmental Assessment, Region 10, Seattle, Washington.

Hyland, J., L. Balthis, I. Karakassis, P. Magni, A. Petrov, J. Shine, and R. Warwick. 2005. Organic carbon content of sediments as an indicator of stress in the marine benthos. Marine Ecology Progress Series, 295(9).

Lee II, H. and Brown, C.A. (eds.) 2009. Classification of Regional Patterns of Environmental Drivers and Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA. Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. EPA/600/R-09-140. Retrieved from: http://www.epa.gov/wed/pages/publications/authored.htm

Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder, 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19(1): 81-97.

National Oceanic and Atmospheric Administration (NOAA). 1986. [National Center for Coastal Monitoring and Assessment, Mussel Watch Contamination Monitoring Program]. Raw data. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve on 7 August, 2014.

National Oceanic and Atmospheric Administration (NOAA). 1996. [National Center for Coastal Monitoring and Assessment, Mussel Watch Contamination Monitoring Program]. Raw data. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve on 7 August, 2014.

National Oceanic and Atmospheric Administration (NOAA). 2006. [National Center for Coastal Monitoring and Assessment, Mussel Watch Contamination Monitoring Program]. Raw data. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve on 7 August, 2014.

Nelson, Walter G, Henry Lee II, Janet O. Lamberson, Faith A. Cole, Christine L. Weilhoefer, and Patrick J. Clinton. 2007. The Condition of Tidal Wetlands of Washington, Oregon, and California – 2002. Office of Research and Development. National Health and Environmental Effects Research Laboratory, EPA/620/R-07/002.

Oregon Department of Environmental Quality (ODEQ). 1999. [CEMAP 1999 Sediment]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2001. [Coos and Millicoma River Data]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2002. [CEMAP 2002 Sediment]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2004. [CEMAP 2004 Sediment]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2005. [CEMAP 2005 Sediment]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006. [CEMAP 2006 Sediment]. Raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2007. [Isthmus Slough/South Fork Coos DO Study]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009a. [Joe Ney Landfill Subproject-Groundwater Monitoring Data]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2009b. [Millicoma DO Study]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2014. Basin Status Report and Action Plan South Coast Baisin –December 2013. [Unpublished draft].

Oregon Department of Environmental Quality (ODEQ). n.d. Land Quality: Environmental Cleanup. [ECSI online database tool]. Accessed 11 September 2014 from http://www.deq.state.or.us/lq/ecsi/ecsi.htm

Oregon Division of Public Health (OR Health Division). n.d. Fish Consumption: Advisories and Guidelines. Accessed 2 September, 2014. Available from http://public.health.oregon.gov/HealthyEnvironments/Recreation/FishConsumption/Pages/fishadvisories.aspx

Pearson T.H. and R. Rosenberg. 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceanography and Marine Biology Annual Review. 16:229–311

Sediment Evaluation Framework for the Pacific Northwest. 2009. Table 6-3: Bulk Sediment Screening Levels for Chemicals of Concern.

Shacklette, Hansford T. and Josephine G. Boerngen. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. [U.S. Geological Survey Professional Paper 1270]. Accessed 29 May 2014. Available http://pubs.usgs.gov/pp/1270/pdf/PP1270_508.pdf

United States Army Corps of Engineers (USACE). 1980. Factual Determinations of Dredged Material Disposal Operations Coos River Federal Navigation Project [Coos Bay Sediment Sampling Evaluation Report 1980].

United States Army Corps of Engineers (USACE). 1989. Results of 1989 Coos Bay Empire Turning Basin Sediment Quality Evaluation [Coos Bay Sediment Sampling Evaluation Report 1989].

United States Army Corps of Engineers (USACE). 1994. Supplemental TBT Data for the Coos Bay Channel Deepening Project [Coos Bay Sediment Sampling Evaluation Report 1994].

United States Army Corps of Engineers (USACE). 1998. Coos Bay Sediment Sampling Evaluation Report 1998.

United States Army Corps of Engineers (USACE). 2004. Coos Bay Sediment Quality Evaluation Report 2004.

United States Army Corps of Engineers (USACE). 2009. Coos Bay Sediment Quality Evaluation Report. [report prepared by Wendy Briner and Mark Siipola of the Portland District USACE].

United States Environmental Protection Agency (USEPA). 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories Vol. 2: Risk Assessment and Fish Consumption Limits 3rd ed. Accessed 2 September, 2014. Available http://water.epa.gov/scitech/swguidance/fishshellfish/techguidance/risk/upload/2009_04_23_fish_advice_volume2_v2cover.pdf

United States Environmental Protection Agency (USEPA). 2002. Mid-Atlantic Integrated Assessment (MAIA) Estuaries 1997-98 Summary Report. Chapter 5: Sediment Contamination. Accessed 9 September 2014. Available http://www.epa.gov/emap2/maia/html/docs/Est5.pdf

United States Environmental Protection Agency (USEPA). 2006. Voluntary Estuary Monitoring Manual. Chapter 12: Contaminants and Toxic Chemicals: Heavy Metals, Pesticides, PCBs, and PAHs. Accessed 9 September 2014. Available http://water.epa.gov/type/oceb/nep/upload/2009_03_13_estuaries_monitor_chap12.pdf

United States Environmental Protection Agency (USEPA). 2007a. Framework for Metals Risk Assessment. Accessed 29 May 29, 2014. Available http://www.epa.gov/raf/metalsframework/pdfs/metals-risk-assessment-final.pdf

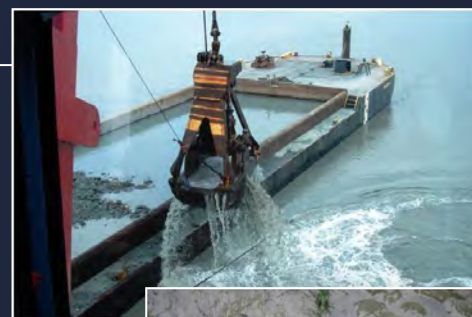
United States Environmental Protection Agency (USEPA). 2007b. Aquatic Life Ambient Freshwater Quality Criteria- Copper. Accessed 20 May 2014. Available http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/copper/upload/2009_04_27_criteria_copper_2007_criteria-full.pdf

United States Environmental Protection Agency (USEPA). 2012. National Coastal Condition Report IV. US EPA Office of Wetlands, Oceans and Watersheds, Washington DC. 334p. Accessed 30 April, 2014. Retrieved from: http://water.epa.gov/type/oceb/assessmonitor/nccr/upload/NCCR4-Report-Part1.pdf

United States Environmental Protection Agency (USEPA). 2014a. Toxic Release Inventory (TRI) Program. [TRI Explorer: Online Interactive Tool, Coos County, OR, data]. Accessed 11 September 2014 from http://iaspub.epa.gov/triexplorer/tri_release.chemical

United States Environmental Protection Agency (USEPA). 2014b. Learn about the Toxics Release Inventory. Accessed 11 September 2014 from http://www2.epa.gov/toxics-release-inventory-tri-program/learn-about-toxics-release-inventory

# Sediment Composition in the Coos Estuary




*Summary:*

- *Coos estuary sediment contains a high percentage of fine-grained silt and clay.*
- *Sediment in the upper estuary contains more silt and clay than the sandier sediments located closer to the mouth of the estuary.*
- *The coastal rivers of southern Oregon contain more fine-grained sediments than Oregon's north coast rivers*
- *The composition of Coos River sediments may be moderately stressful to macroinvertebrates, key biological community.*

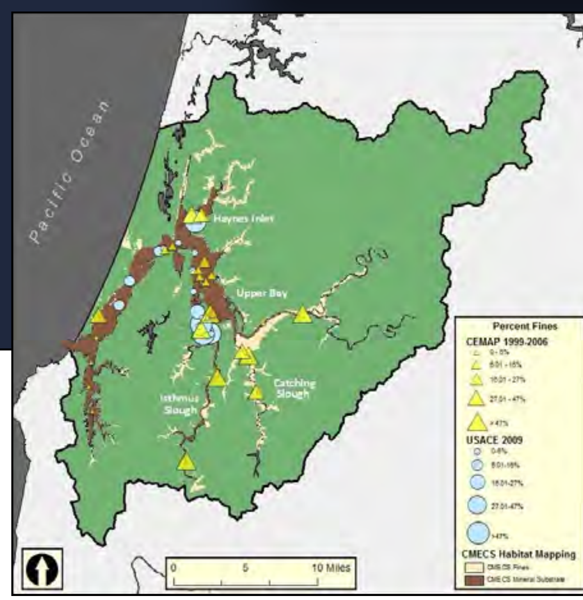




Figure 1. Sediment composition in the Coos Estuary. Larger symbolize represent "muddier" sediment (i.e., greater percentage of fines). Generalized areas of fine-grained sediment (tan) were created from the CMECS habitat classification scheme for the Coos estuary. Data: ODEQ 1999, 2001, 2004, 2005, 2006; USACE 2009; CMECS 2014

**Evaluation**

Fine-grain sediment may elevate the risk for pollutant transport and excessive sedimentation.

**What's happening?**

The Coos estuary has been classified as one of the muddiest estuaries in Oregon (Lee II and Brown 2009) due to the relatively high percentage of "fines" (i.e., silt and clay) (Figures 1 and 2), a classification particularly applicable to the upper estuary. Data from the Oregon Department of Environmental

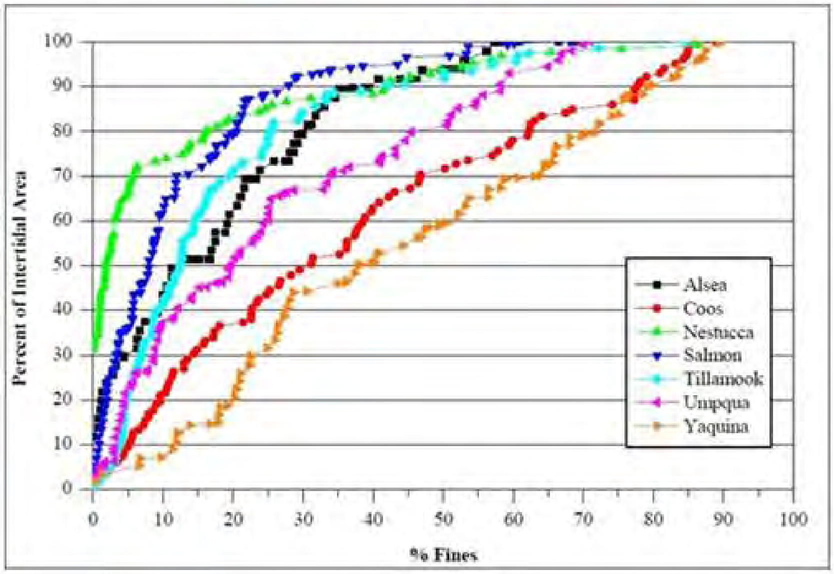



Figure 2. Cumulative distribution functions (CDFs) show the percentage of fine sediment versus the total area of seven Oregon estuaries. Relatively steep CDFs represent sandy estuaries (e.g., Nestucca and Salmon). CDFs with shallow gradients indicate "silty" estuaries (e.g., Yaquina and Coos). Source: Lee II and Brown 2009

Quality (ODEQ 1999, 2001, 2004, 2005, 2006) and the United States Army Corps of Engineers (USACE 2009) confirm that sediment in the estuary's upper reaches (e.g., Haynes Inlet, Upper Bay, Isthmus Slough, and Catching Slough) is muddier than sediment near the mouth of the estuary (e.g., lower South Slough and Lower Bay Subsystems). Sediment composition is commonly classified using the Wenthworth Grade Scale, based on the particle size and cohesive properties of a material (Wenthworth 1922)(Table 1).

| Material | Particle Size (mm) | Cohesive Properties |
|---|---|---|
| Cobble | 256 - 64 | Non-Cohesive |
| Gravel | 64 - 2 | " |
| Very Coarse Sand | 2 - 1 | Non-Cohesive Sediment |
| Coarse Sand | 1 - 0.5 | " |
| Medium Sand | 0.5 - 0.25 | " |
| Fine Sand | 0.125 - 0.063 | " |
| Silt | 0.062 - 0.004 | Cohesive Sediment |
| Clay | 0.004 - 0.00024 | " |

Table 1. Wentworth Scale for Sediment Classification
Source: Bartram and Balance 1996

These conclusions are generally supported by Oregon's newly developed estuary habitat classification maps using NOAA's Coastal and Marine Ecological Classification Standard (CMECS) applied to Oregon estuaries by the Oregon Department of Land Conservation and Development (Figure 1).

Coos River Sediment

Hubler (2008) suggests that elevated levels of fine sediments in some rivers and streams on the southern Oregon coast may be stressful to aquatic biota. In her report, fine sediment stress is categorized into four categories (Figure 3). Fines in the Coos River subsystem sampling sites exceeded Hubler's lowest/least stress sediment category (0-10% fines) considered to be stressful to macroinvertebrate communities. However, the median sediment score in the Coos river did meet the moderate stress benchmark (11-20% fines). Thus, sediment stress in the Coos river is higher than the smaller estuaries (e.g., Necanicum,

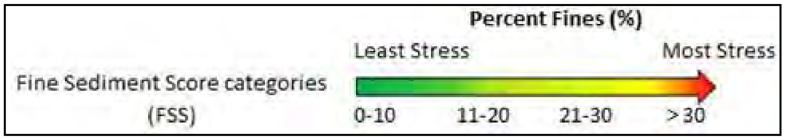



Figure 3. Fine Sediment Stressor categories. Source: Hubler 2008

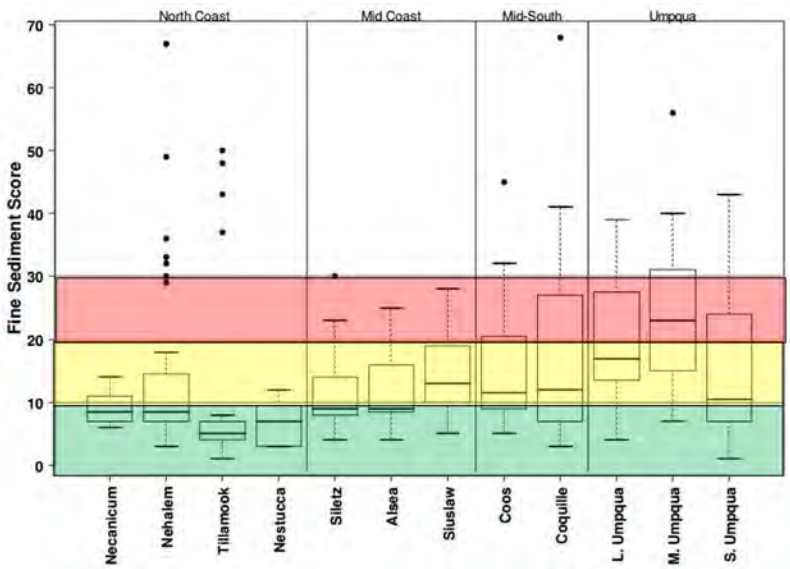



Figure 4. The Fine Sediment Score indicates the amount of sediment-related stress on macroinvertebrates in coastal streams and rivers. Low stress environments (green) are generally found on the north coast, while southern Oregon streams tend to be moderately stressful (yellow) or highly stressful (red) environments. Source: Hubler 2008

Nehalem) but lower than, or similar to, the estuaries associated with major coastal rivers (e.g., Coquille, Umpqua rivers)(Figure 4).

**Background**

Sediment distribution in estuaries is determined by dynamic hydrologic processes that control sediment inputs and outflows (Thrush et al. 2004; Bell et. al 2000). Sediment distribution and estuarine residence time depends on many factors including: a) particle density, size, and shape; b) flow conditions; c) tidal and wave motion; d) vegetation; and e) precipitation (Bell et al. 2000; Stevenson et al. 1988; Wright 1977; Bartram and Balance 1996). Many determinants of estuarine sediment dynamics are naturally occurring, but human activities (e.g., shellfish culture, land use changes, dredging) can also change the way sediments are distributed (Bell et al. 2000; Pregnall 1993).

Sediments provide vital estuarine habitat for many organisms such as bivalves, snails, worms, echinoderms, crustaceans, etc. These organisms live in the sediment and often facilitate important ecological and geochemical processes in the estuary (Thrush et al. 2004). Sediments also facilitate the transport of nutrients and contaminants within aquatic ecosystems (Bartram and Ballance 1996; Swett 2010). This is particularly true of fine sediments (i.e., silt and clay), which are “responsible for a significant proportion of the annual transport of metals, phosphorus, chlorinated pesticides, and many industrial compounds such as polynuclear aromatic hydrocarbons, polychlorinated biphenyls, dioxins and furans” (Bartram and Ballance 1996).

Although sediments are a fundamental part of a fully functioning estuary, excessive sediment loading is increasingly recognized as a threat to the quality of coastal and estuarine environments (Thrush et al. 2004). Bell et al. (2000), explain that rapid changes to sediment patterns can harm many of the animals that live in aquatic systems. Fine sediments, in particular, "can easily push the sedimentation balance towards irreversible infilling."

**References**

Bartram, J. and R. Ballance [Eds]. 1996. Water Quality Monitoring. A Practical Guide to the Design and Implementation of Fresh Water Quality Studies and Monitoring Programmes. Chapman & Hall, London.

Bell, Rob, Mal Green, Terry Hume, and Richard Gorman. 2000. Estuaries: What Regulates Sedimentation in Estuaries? Water and Atmosphere 8 (4): 13-16.

Coastal and Marine Ecological Classification Standard (CMECS). 2014. [Unpublished shapefiles for ArcGIS from the National Oceanographic and Atmospheric Association (NOAA)]. Accessed from the Estuarine and Coastal Sciences Laboratory of South Slough National Estuarine Research Reserve.

Hubler, Shannon. 2008. Macroinvertebrate Report: Oregon Coast Coho Evolutionarily Significant Unit (2006-2007). [Reported prepared by the Oregon Department of Environmental Quality]. Accessed 25 August 2014. Available http://www.oregon.gov/OWEB/MONITOR/docs/mr_odfwbugreport.pdf

Lee II, H. and Brown, C.A. (eds.) 2009. Classification of Regional Patterns of Environmental Drivers and Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA. Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. EPA/600/R-09-140. Retrieved from: http://www.epa.gov/wed/pages/publications/authored.htm

Oregon Department of Environmental Quality (ODEQ). 1999. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2001. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2004. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2005. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Oregon Department of Environmental Quality (ODEQ). 2006. [CEMAP Sediments]. Unpublished raw data. Retrieved from: http://deq12.deq.state.or.us/lasar2/

Pregnall, Maribel Marcy. 1993. Regrowth and Recruitment of Eel Grass (*Zostera marina*) and Recovery of Benthic Community Structure in Areas Disturbed by Commercial Oyster Culture in the South Slough National Estuarine Research Reserve, Oregon. [Master's thesis]. Department of Environmental Sciences, Bard College, Annandale-On-Hudson, New York.

Stevenson, J., L. G. Ward, and M. S. Kearney. 1988. Sediment transport and trapping in marsh systems: implications of tidal flux studies. Marine Geology,80(1), 37-59.

Swett, Michael P. 2010. Assessment of Benthic Flux of Dissolved Organic Carbon in Estuaries Using the Eddy Correlation Technique. Master's Thesis, University of Maine.

Thrush, S. F., J. E. Hewitt, V. J. Cummings, J. I. Ellis, C. Hatton, A. Lohrer, and A. Norkko. 2004. Muddy waters: elevating sediment input to coastal and estuarine habitats. Frontiers in Ecology and the Environment, 2(6), 299-306.

United States Army Corps of Engineers (USACE). 2009. Coos Bay Sediment Quality Evaluation Report. [report prepared by Wendy Briner and Mark Siipola of the Portland District USACE].

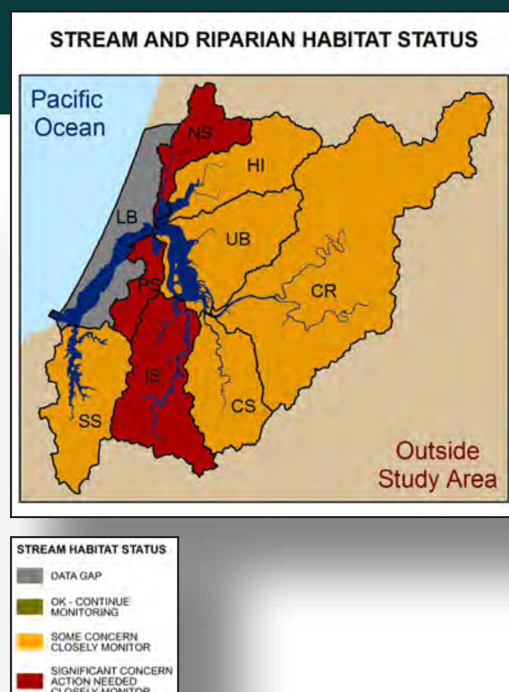
Wentworth, C. K. 1922. A scale of grade and class terms for clastic sediments. The Journal of Geology, 377-392.

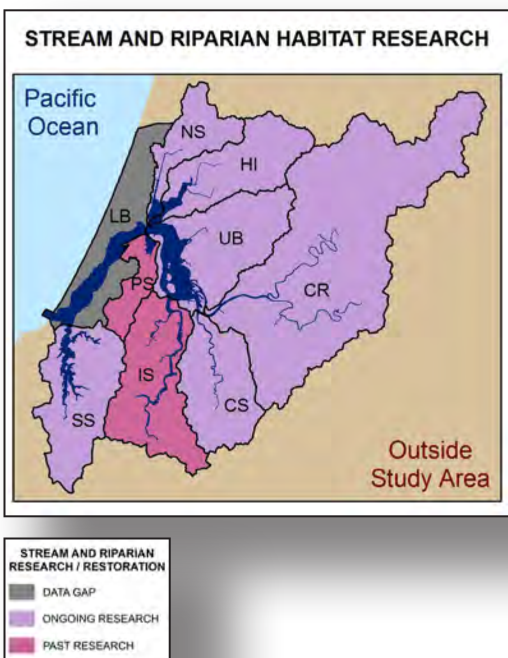
Wright, L. D. 1977. Sediment transport and deposition at river mouths: a synthesis. Geological Society of America Bulletin, 88(6), 857-868.

# **Chapter 11:** Stream and Riparian Habitat in the Lower Coos Watershed

*Colin Duncan, Jenni Schmitt, Rose Rimler, Colleen Burch Johnson - South Slough NERR*

***Stream and Riparian Habitat:***
*All evaluated reaches suffer from a lack of large woody debris, and sediment levels in essential riffle habitat regularly exceed ODFW benchmarks. Pool area is good, and may become a vital habitat resource in the face of advancing climate change.*



# Chapter 11: Stream and Riparian Habitat in the Lower Coos Watershed

*This Chapter includes a single data summary: **Stream and Riparian Habitat in the Lower Coos Watershed**– which describes the most current status and trends of important stream and riparian habitat attributes including pool area and residual pool depth, large woody debris (pieces, volume, and key pieces), gravel and sediment in riffles, road-related sediment and bank stability, and riparian cover type and percent shade.*

### Data Sources

Data used in this chapter came primarily from Coos Watershed Association (CoosWA) reports (CoosWA 2006, 2008, 2011) and survey work (Cornu et al. 2012), and from Oregon Department of Fish and Wildlife (ODFW) surveys conducted between 1998 and 2013. Each of these sources addresses a different part of the lower Coos watershed, and they bear enough similarity in methods and analyses to be largely comparable. The CoosWA surveys took place on selected reaches in various Coos watershed sub-basins and were intended to be indicative of the status of entire sub-basins. The ODFW surveys were disbursed throughout the Coos watershed.

### Data Gaps and Limitations

The stream and riparian habitat summary relies heavily on data gathered from Coho habitat surveys. Due to the species-specific nature of the surveys, data gathered may be less applicable to other species of concern, such as lamprey or sturgeon, which may thrive in conditions different from those beneficial to salmonids.

Studies summarized in this document are not necessarily evenly distributed through time and space. This reflects the limited resources of researchers and occasionally limited access to various areas of the Coos watershed (especially private property). Additionally, the units of study employed in these reports are stream “reaches” which vary in length, making comparisons difficult. Surveys also do not comprehensively cover the entire watershed; the area west of the North Slough sub-basin and the upper reaches of the watershed, in particular, are not addressed in the CoosWA surveys. Finally, the ODFW summer habitat surveys go back to 1998, and it is possible that conditions in the reaches surveyed have changed over the duration of the study and that these changes were not taken into account.

There are factors that should be taken into account when using the Habitat Limiting Factors Model (HLFM) to evaluate the condition of a watershed (Nickelson 1998). In the first place, the HLFM relies on data from both summer and winter habitat surveys. As stream habitats are typically surveyed during the summer, Nickelson was forced to develop a multiple regression model to predict winter habitat capacity from summer habitat data. HLFM estimates of winter habitat, while statistically robust, may therefore not be based on actual winter survey observations.

The HLFM also implicitly assumes that winter habitat is the primary bottleneck to salmonid smolt production, and assumes that salmonid survival rates from Coho egg deposition to summer parr (large juvenile salmonid, between a fry and a smolt) is 7.2% for all reaches at full seeding (the number of wild Coho in a spawning population that produces the most juveniles a habitat will support). Furthermore, the model designer notes that during 1990-95, the correlation between estimated habitat quality and observed salmon in the Coos basin was not as good as in other Oregon coast basins. Nickelson (1998) attributed this phenomenon to lower exploitation rates and better marine survival conditions during this period. These factors should be taken into account when considering the results of HFLM in the Coos watershed.

Finally, not all of the assessments evaluate the same factors which can hinder comparisons. Of particular note, only 9 of the 15 evaluated sub-basins addressed in this assessment were subject to the HLFM, and only 7 had their potential and actual shade modeled using the SHADOW model. This means that while common sense might suggest that conditions similar to those portrayed by the models are prevalent to some degree throughout the watershed, there is not necessarily either documentary or model evidence to support such an assertion. What is more, the observable variation in conditions between individual reaches means that while models and averages may reflect large patterns in habitat quality, any given reach may be very different from its neighbors, and from model results.

**References:**

Coos Watershed Association (CoosWA). 2006. *Coos Bay Lowland Assessment and Restoration Plan*. Coos watershed Association, Charleston, Oregon. pp. 268. http://www.cooswatershed.org/Publications/Coos%20Bay%20Lowland%20Assessment%20and%20Restoration%20Plan01-07.pdf

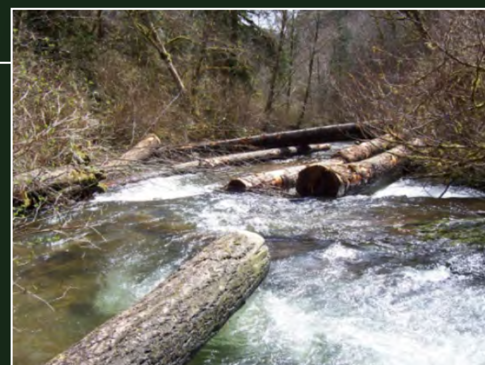
Coos Watershed Association (CoosWA). 2008. *Catching Slough, Daniel's Creek and Heads of Tide Sub-basin Assessment and Restoration Opportunities.* Coos watershed Association, Charleston, Oregon. pp. 144. http://www.cooswatershed.org/Publications/Assessment%20Body-%20Catching%20Daniels%20HoT%2003-2009.pdf

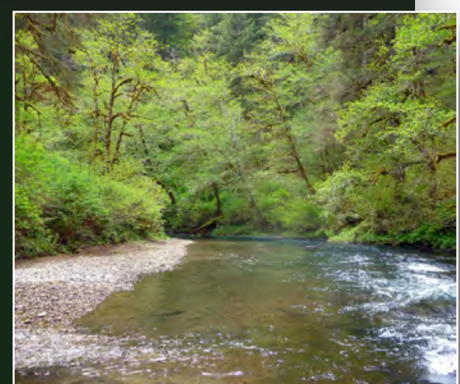
Coos Watershed Association (CoosWA). 2011. *Isthmus and Coalbank Slough Sub-basin Assessment and Restoration Opportunities.* Coos watershed Association, Charleston, Oregon. pp. 95. http://www.cooswatershed.org/Publications/Isthmus%20Assessment%20Final%20Draft%206-2011red.pdf

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. *Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds.* Report prepared for the Partnership for Coastal Watersheds Steering Committee, South Slough National Estuarine Research Reserve, and Coos watershed Association. pp. 225.

Nickelson, T. E. 1998. *A habitat-based assessment of coho salmon production potential and spawner escapement needs for Oregon coastal streams.* No. 98. Portland: Oregon Department of Fish and Wildlife.

# How Local Effects of Climate Change Could Affect Stream and Riparian Habitat in the Lower Coos Watershed





Photos: The West Fork Millicoma River habitat logs in the Elliot State Forest (Top) and springtime flows (Bottom). Credits: Department of State Lands and Francis Eatherington


*Summary:*

- *Reduced summer stream flows may result in higher summer water temperatures, increasing reliance on deep pools as cool water refuge for aquatic organisms, and restricting salmonid habitat, especially in the watershed's lower reaches.*
- *Increased winter flows may result in fish habitat erosion and scouring, increasing reliance on deep pools as refuge from strong currents for aquatic organisms.*
- *Changes in habitat availability and the timing of resource availability may affect aquatic species' abundance and distribution.*
- *Changes in vegetation may affect bank stability and shade potential.*


**Summer and Winter Flows**

The local effects of climate change may affect stream habitat in the project area through periodic wintertime increases in stream flows (from more frequent and intense storms), and summertime reductions in stream flows (from longer, dryer summers)(OCCRI 2010) (see sidebar). Recent observations in Idaho have documented rising water temperatures in lakes and streams, affecting the quality of salmonid habitat (Isaak et al. 2010). The Coos watershed may be spared the most dramatic reductions in summer stream flows, as these are expected to take place in areas dependent on snow pack (Dalton et al. 2013, Ashfaq et al. 2013); stream flows in coastal Oregon are affected almost entirely by rainfall (OCCRI

*Changes in Precipitation Timing, Frequency, Abundance, and Intensity*

*In the future, precipitation in coastal Oregon is expected to remain a predominately wintertime phenomenon (i.e., most precipitation will continue to occur in the winter). However, the extent to which precipitation timing, frequency, abundance, and intensity on the Oregon coast may change in the future remains uncertain. There is evidence that high-intensity storms are becoming more frequent, and that the frequency of weak to moderate-strength storms is declining. Climate models suggest that summers in the Pacific Northwest will become warmer and drier; a 14% decrease in summertime precipitation by the 2080's is predicted.*

*Sources: Sharp 2012; OCCRI 2010; OSU 2005*

2010). Regardless, some summertime stream flow reductions are still expected, which may reduce the range of summer habitat in the Coos watershed for temperature-sensitive fish, like juvenile Coho salmon.

Also, while snow pack does not affect stream flows in the project area, the lack of snow melt may render the watershed more susceptible to temperature changes than streams fed from snow pack (Mohseni et al. 1998). Such temperature changes may be particularly severe in the lower watershed, where wider, shallower waterways and lack of shade can increase stream temperatures to levels higher than salmonids can tolerate. Weybright (2011) has already documented juvenile Coho migrating upstream in the Coos watershed, concurrent with a rise in summer temperatures. The contraction of summer salmonid habitat may occur earlier and end later each year in lower watershed stream reaches. This change could result in prolonged summer crowding and associated competition for resources in middle and upper stream reaches.

The multi-model mean value of water temperature rise is 7˚ F (4˚ C) by 2100 in the Pacific Northwest (Figure 1). As temperatures rise, deep pools may play a larger role in maintaining summer habitat potential than they have in the past. Goniea et al. (2006) found upstream Chinook salmon migration slowed during seasonal high temperatures (above 20˚ C) and in warmer years, as the returning salmon made temporary use of cooler tributaries as thermal refugia. Pools also provide thermal refuge during low flow events, as well as permitting fish to hide from predators (Foster et al. 2001). As low flow events become more frequent, however, average pool depth may decrease, intensifying competition for remaining deep pool habitat. The availability of pool habitat may thus become a limiting factor for Coho and other salmonid species in more reaches of the Coos watershed.

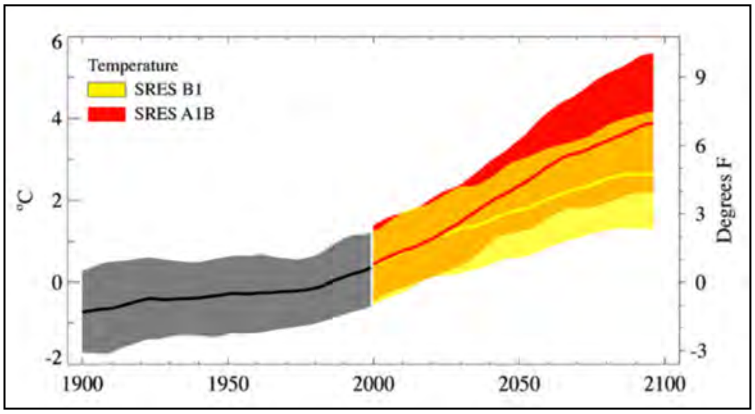



Figure 1. Smoothed curves and bounds for 20th and 21st century Pacific Northwest water temperature model simulations, relative to the 1970 - 99 mean. The heavy smooth curve (black and red line) for each scenario is the weighted multi-model mean value. The top and bottom bounds of the shaded areas are the 5th and 95th percentiles of annual values (in a running 10-year window) from ~20 simulations, smoothed in the same manner as the mean value. Mean warming rates for the 21st century differ substantially between the two scenarios here presented after 2020. From Mote and Salathé (2010).

Battin et al. (2007) identified minimum flow during the pre-spawning period (during which salmon return to freshwater but before they spawn) as a limiting factor for Chinook salmon in the Pacific Northwest. This may be due to a number of factors, such as temperature-related stress, increased vulnerability of returning adults to predation (due to lack of cover), and reduced access to gravel beds suitable for redd creation.

Battin et al. noted, however, that the worst effects tended to be at high elevation, as climate impacts on hydrology were predicted to be greatest in these areas. This may paint a slightly rosier picture in the lower Coos watershed than that predicted by Battin, whose study area (the Snohomish Basin) received water that drained from mountainous areas well over 1,000 meters of elevation.

Battin et al. (2007) also predicted that increased high flow events during the winter had the potential to scour out redds, killing incubating salmon eggs. While winter high flows may present a similar threat to Coho eggs, it is also possible that the Coos watershed may be spared the worst of this prediction, again due to the watershed's relatively low elevation and reliance on rainfall more than snow pack (Mantua et al. 2009). The predictions in Battin et al. (2007) were based in an increase in winter high flow events in the Cascades, due to warmer air temperatures preventing snow pack and sending water downstream during the winter that would normally have melted gradually during the summer. The streams of the Coos watershed are not so dependent on snow pack due to their low elevation, meaning that the modeled impact of winter high flows may not be as severe locally. However, given the complexity and uncertainty associated with climate change (see sidebar), and given that winter high flow events already have an impact on fish survival in the Coos watershed (Weybright 2011), it may be prudent to prepare for future storm-driven changes to stream habitats in the Coos watershed.

**Changes in Habitat Use**

Climate-induced habitat changes may also affect the manner in which aquatic species

*Uncertainty in Predicting Local Effects of Climate Change*

*There is inherent uncertainty in predicting what the local effects of climate change are likely to be. The uncertainties generally fall into three categories: 1) Natural variability of the earth's climate; 2) Climate sensitivity (how the earth's climate system responds to increases in future greenhouse gas levels); and 3) Future greenhouse gas emissions.*

*To manage for these uncertainties, climate scientists use multiple models ("multi-model ensembles") that incorporate the estimated range of possible natural variability, climate sensitivity, and future greenhouse gas emission values when investigating climate-related change. The models typically generate a range of values for potential future air temperatures, ocean surface temperatures, sea level rise, etc., which naturally become increasingly variable the longer into the future the model predicts. This approach gives communities a range of projections to consider when developing climate change vulnerability assessments and adaptation plans.*

*Sources: Sharp 2012; Hawkins and Sutton 2009*

use their habitat. For example, Crozier et al. (2011) determined that sockeye salmon migration on the Columbia River now takes place approximately 10.3 days earlier than it did in the 1940s, corresponding with a 2.6˚ C (4.7˚ F) increase in average water temperatures.

In the Coos watershed, Weybright (2011) documented juvenile Coho engaging in different habitat use strategies, which he identified as summer mobile, winter mobile, summer sedentary, and winter sedentary. Sedentary fish tended to attach themselves to one particular area of a stream, usually a pool, while mobile fish moved frequently from place to place and habitat to habitat. Further, Weybright noted differences in survival rates among fish adopting these different strategies: in particular, he documented higher survival rates among winter sedentary fish compared with winter mobile fish.

Given the likelihood that pool habitat will increase in importance as refuge from both summer low flows and winter high flows, the difference in survival rates between mobile and sedentary fish in the Coos watershed may increase, as sedentary fish prove more resilient in the face of habitat change. In the long run, this may result in Coos watershed Coho populations becoming more sedentary and pool-loving in their habitat use, further increasing the importance of pools and pool-supporting habitat resources.
It's also possible that concerns noted by Dalton et al. (2013) may affect the viability of aquatic species in the Coos watershed. If the

timing of local salmonid life cycles and the availability of critical resources become misaligned (e.g., the timing of salmonid fry emergence and aquatic insect hatches), it could create a timing mismatch between resource availability and species' needs, and the ability of the local habitat to support salmonids and other species may be greatly reduced. The exact responses of different habitat resources and different species life cycles to changes in climate are a source of uncertainty. It may be difficult to predict such mismatches in advance.

**Changes in Riparian Vegetation**

The watershed's proximity to the ocean may provide its riparian forests with some temperature relief compared with more extreme temperature increases likely to occur further inland. Considering the current scarcity of large, old riparian conifers in the Coos watershed (see Terrestrial Vegetation summary in Chapter 12: Vegetation), any climactic shift that might result in a change in conifer distribution could affect local aquatic habitats. The range redistribution of important conifers like the Douglas fir, cedar, and spruce are particularly worrisome, as these are the sort of large trees commonly found in high quality riparian habitat. Should a change in their distribution affect the Coos watershed, it could have important implications for key habitat resources like large woody debris in streams, and perhaps bank stability and riparian shade. However, it should also be noted like conifer species that are currently distributed south of the project area may also expand their ranges northward due to climate change, which could fill the gap created by local species retreating north.

While the gradual shift of tree species northward may move at a relatively sedate pace, pathogens that can decimate tree communities in short order are capable of much faster movement, as they can be transported by organisms, vehicles, and even people. This range allows pathogens to adapt to changes in climate far more rapidly than tree communities, with possibly devastating results for trees.

The most iconic case of such movement may be that of Sudden Oak Death. A mere six years after the first symptomatic tanoaks (Notholithocarpus densiflorus) were observed in Marin County, California, the pathogen responsible (*Phytophthora ramorum*) was detected by aerial survey in Curry County, OR (Kliejunas 2010).

Although *P. ramorum* is cause for concern in itself, it also acts as an example of what may be expected from other pathogens and parasites as their range changes in response to climate change. Compared to trees, pathogens and parasites have rapid life cycles. They can also travel quickly, often with unwitting human assistance. It is instructive to examine how in a mere two decades since the first infection, *P. ramorum* has traveled hundreds of miles, cost millions of dollars in damages and control actions, and altered the species balance of trees in northern California, and soon, possibly, in southern Oregon.

*Phytophthora ramorum* does not act alone.


Figure 2: Douglas fir infected with *Phaeocryptopus gaeumannii*
USDA Forest Service – North Central Research Station
Source: www.forestryimages.org

Across the planet, forest communities have changed in response to changes in pathogen ranges facilitated by climate change. On the eastern seaboard, the hemlock woolly adelgid (*Adelges tsugae*) is currently decimating hemlock forests (Thompson et al. 2013). This parasite has moved steadily northward from its initial observation point in Richmond, VA in 1952, and is currently changing the species mix of forests as far north as Massachusetts. The parasite's spread seems limited by cold temperatures at higher latitudes, but as warming continues, the quiet epidemic seems likely to spread.

Closer to home, Douglas fir in the Coos watershed already suffers from *Phaeocryptopus gaeumannii*, a fungus that causes Swiss needle cast (Figure 2)(Robinson 2009). This pathogen causes fir needles to turn yellow and fall off the tree, ultimately retarding growth by reducing the tree's ability to photosynthesize. Research by Watt et al. (2010) has established that this pathogen, like *P. ramorum*, is temperature-controlled, and warmer winters may facilitate its spread to higher latitudes and increase its impact in areas where it is already present. In addition to impacting the local economy, which relies heavily on Douglas fir as a commercial product, Swiss needle cast has the potential to negatively impact the growth of a key riparian conifers, affecting stream habitat quality throughout the watershed.

## References


Ashfaq, M., S. Ghosh, S. C. Kao, and N. S. Diffenbaugh. 2013. Near-term acceleration of hydroclimatic change in the western U.S. Journal of Geophysical Research: Atmospheres. 118(19): 10,676-10,693.

Battin, J., M. W. Wiley, M. H. Ruckelshaus, R. N. Palmer, E. Korb, K. K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences 104 (16): 6720-6725.

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee, South Slough National Estuarine Research Reserve, and Coos watershed Association. pp. 225.

Crozier, L. G., M. Scheuerell, and R. Zabel. 2011. Using time series analysis to characterize evolutionary and plastic responses to environmental change: a case study of a shift toward earlier migration date in sockeye salmon. American Naturalist 178:755-773

Dalton, M.M., P. W. Mote, and A. K. Snover [Eds.]. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press.

Foster, S. C., C. H. Stein, and K. K. Jones. 2001.

Oregon Department of Fish and Wildlife, A Guide to Interpreting Stream Survey Reports. P.A. Bowers [Ed.]. Information Reports 2001-06. Portland, OR.

Goniea, T. M., M. L. Keefer, T. C. Bjornn, C. A. Peery, and D. H. Bennett. 2006. Behavioral thermoregulation and slowed migration by adult fall Chinook salmon in response to high Columbia River water temperatures. Transactions of the American Fisheries Society 135:408–419

Hawkins, E. and R. Sutton. 2009. The potential to narrow uncertainty in regional climate predictions, Bulletin of the American Meteorological Society (BAMS) 90, 1095-1107, doi:10.1175/2009BAMS2607.1

Isaak, D. J., C. H. Luce, B. E. Rieman, D. E. Nagel, E. E. Peterson, D. L. Horan, S. Parkes, and G. L. Chandler. 2010. Effects of climate change and wildfire on stream temperatures and salmonid thermal habitat in a mountain river network. Ecological Applications 20(5): 1350-1371.

Kliejunas, J. T. 2010. Sudden oak death and *Phytophthora ramorum:* a summary of the literature. 2010 edition. Gen. Tech. Rep. PSW-GTR-234. Albany, CA:. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 181 pages.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. In The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, M. M. Elsner, J. Littell, L. Whitely Binder [Eds.], 217-253. The Climate Impacts Group, University of Washington, Seattle, WA.

Mohseni, O., H. G. Stefan, and T. R. Erickson. 1998. A Nonlinear Regression Model for Weekly Stream Temperatures. Water Resources Research 34: 2685-2692.

Mote, P. W. and E. P. Salathé. 2010. Future climate in the Pacific Northwest. Climatic Change 102(1-2): 29-50, doi: 10.1007/s10584-010-9848-z.

Oregon Climate Change Research Institute (OCCRI). 2010. Oregon Climate Assessment Report, K. D. Dello and P. W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Oregon State University (OSU). 2005. Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest. Unpublished report no. 2004-3. Corvallis OR. Retrieved from: http://ir.library.oregonstate.edu/jspui/handle/1957/113

Robinson, J. 2009. Upper watershed restoration action plan. South Slough National Estuarine Research Reserve, Charleston, OR. 107pp

Sharp, D. 2012. Climate Change and the Lower Coquille Watershed. Unpublished report. Oregon Climate Change Research Institute/ EcoAdapt. Retrieved from: http://ecoadapt.org/data/documents/CoquilleClimate_02nov2012_FINAL.pdf

Thompson J. R., D. N. Carpenter, C. V. Cogbill, and D. R. Foster. 2013. Four Centuries of Change in Northeastern United States Forests. PLoS ONE 8(9): e72540. doi:10.1371/journal.pone.0072540

Watt, M. S., J. K. Stone, I. A. Hood, and D. J. Palmer. 2010. Predicting the severity of Swiss needle cast on Douglas fir under current and future climate in New Zealand. Forest Ecology and Management 260 (12): 2232–2240. doi:10.1016/j.foreco.2010.09.034.

Weybright, A. D. 2011. Juvenile Coho Salmon Movement, Growth and Survival in a Coastal Basin of Southern Oregon. Thesis (M.S.) -- Oregon State University.

# Stream and Riparian Habitat in the Lower Coos Watershed


*Summary:*

- *Almost all stream reaches surveyed lacked large woody debris, particularly key pieces that perform essential ecosystem functions.*
- *Fine sediment loads documented in key stream riffle habitats may limit the ability of salmonids to successfully reproduce.*
- *Streams in the lower watershed were largely unshaded, which may contribute to high summer temperatures that restrict summer rearing habitat for juvenile salmonids.*
- *Stream surveys in the project area focused mostly on salmonid habitat needs (particularly for Coho salmon). More broadly focused stream habitat evaluations are needed to investigate the status of habitat for other aquatic organisms (e.g., lamprey and sturgeon).*

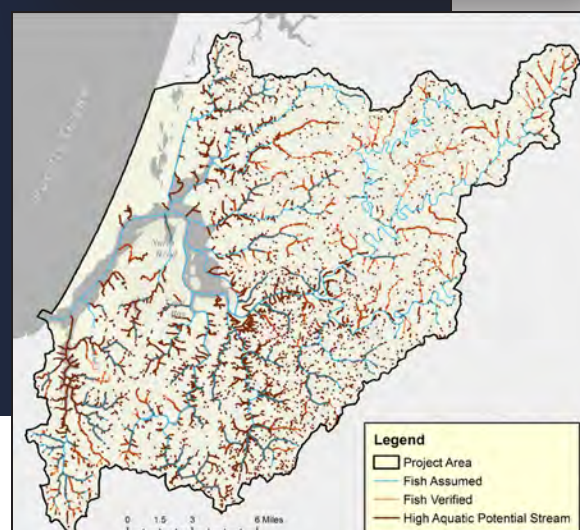




Figure 1: "High Aquatic Potential" streams in the project area in combination with streams where fish presence is known or assumed. Project area shaded in yellow and outlined in black. Data: ODF n.d.

**Evaluation**

Pool content of streams in the project area regularly meets ODFW standards; gravel content of key riffle habitat is high.

**Evaluation**

Bank stability in the Coos watershed is mixed.

**Evaluation**

Additional information is needed to evaluate stream habitat for non-salmonid fishes in the project area.

**DATA GAP**

**Evaluation**

Large woody debris in stream habitat is consistently low, as is riparian shade. Fine sediments in riffles is high.

**What's happening?**

This data summary describes the status of key stream habitat resources in the lower Coos watershed, especially as they relate to the habitat needs of Coho salmon (*Oncorhynchus kisutch*).

Figure 1 shows the distribution of streams in the project area with high potential for supporting runs of Coho salmon, as well as streams in which the presence of Coho has been verified or assumed. Developed by the Oregon Department of Forestry (ODF), High Aquatic Potential (HAP) streams are small (annual average flow ≤2 cubic feet per second [cfs]) and medium (2-8 cfs) streams with significant potential to provide high quality fish habitat – specifically for Coho salmon production (Oregon Plan 2012). HAP streams have a gradient ≤6% and a valley width index (the ratio of active channel width to valley width) of ≥2.5, which allows the stream to migrate and meander. Designated HAP streams do not necessarily indicate the presence of high quality Coho salmon habitat (e.g., it could be lacking large wood or have little shade and high stream temperatures), only the presence of favorable habitat potential. These data can nonetheless help land managers prioritize stream reaches for enhancing habitat, especially when used with additional data.

Another way to identify limiting habitat features, and target potential restoration sites, is with the use of a Habitat Limiting Factors Model (HLFM), described by Nickelson (1998) and modified by Rodgers et al. (2005)(see also Background section below). The HLFM model was used in two Coos Watershed Association (CoosWA) assessments (2006, 2008) to identify Coho salmon habitat limitations in the lower Coos watershed (Figure 2); it was also used in a similar assessment of the Elliott State Forest (ODF 2003). The HLFM

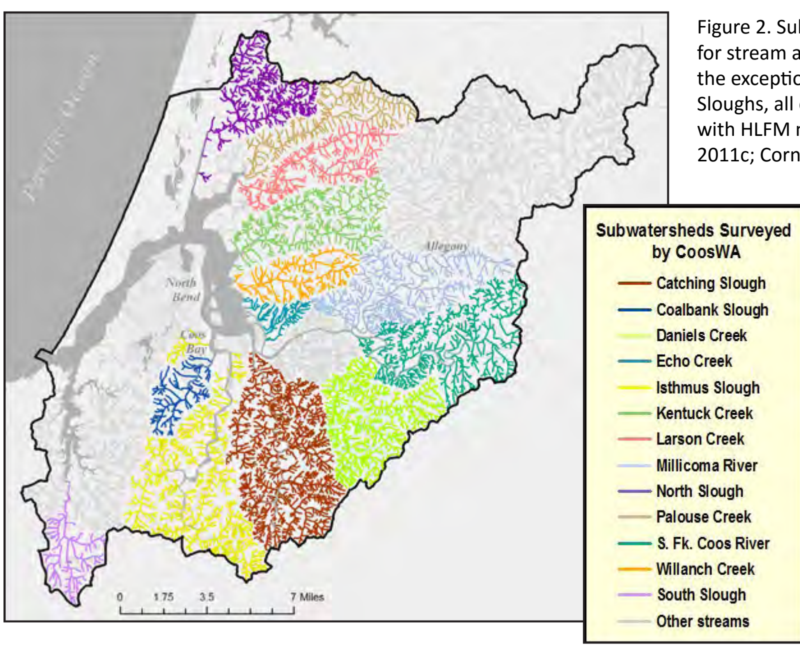



Figure 2. Subwatersheds evaluated by CoosWA for stream and riparian habitat surveys. With the exception of South, Isthmus, and Coalbank Sloughs, all drainage basins were also evaluated with HLFM modeling. Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

model identifies which habitat resource (e.g., summer or winter habitat) is least available. If these resources were made more available, it could allow Coho salmon populations to grow until they're constrained by the next most limiting habitat factor.

For example, ODF (2003) found that the most limiting factor for Coho salmon migration to and from the Elliot State Forest was human barriers (e.g., inadequate culverts and tide gates), particularly for juvenile Coho salmon. Winter habitats, such as off channel habitats that protect juvenile fish during high winter flows, were also found to limit Coho salmon production.

Of the nine subwatersheds modeled by CoosWA, winter habitat was described as the major seasonal habitat limiting factor to Coho smolt production in five: Larson Creek, Willanch Creek, Catching Slough, Daniels Creek, and Millicoma and lower South Fork Coos Rivers. Winter Coho habitat generally includes adequate pools (especially secondary, off-channel pools) and beaver ponds (CoosWA 2008). This trend suggests that habitat enhancement focusing on such pools might have a greater potential to improve Coho smolt production in these watersheds than other conservation measures.

Subwatersheds that identified summer habitat as the primary limiting factor to Coho salmon production were North Slough, Palouse Creek, Kentuck Creek, and Echo Creek. In these subwatersheds, summer temperatures were regularly cited as restricting Coho habitat and constraining the population level (CoosWA 2006). High temperatures in lower tidal reaches were noted as particularly important factors, and are consistent with ob-

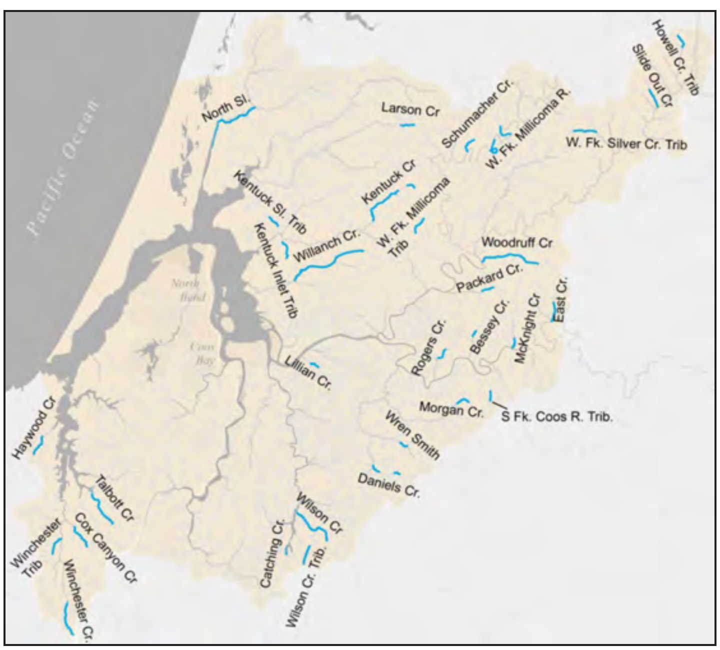



Figure 3. General locations of stream reaches surveyed by ODFW 1998-2013 (in blue) within the project area. Location of reach within the stream and reach lengths are approximate. Orange shading indicates the project area. Data: ODFW 2013

servational evidence of Coho salmon migrating upstream ahead of temperature spikes in the lower reaches (Weybright 2011).

Status of Stream and Riparian Habitat

The status of features associated with key summer and winter Coho salmon stream habitats is examined in more detail below. These features include: Pool Habitat (pool area, residual pool depth), Large Woody Debris (pieces [abundance], volume, key pieces), Riffle Substrate (gravel, silt/sand/fine organics), Road-related Sediment (road structures, bank stability), and Riparian Habitat (cover type, shade). These evaluations come primarily from CoosWA survey work (Cornu et al. 2012) and reports (CoosWA 2006, 2008, 2011c)(Figure 2). Oregon Department of Fish and Wildlife (ODFW 2013) habitat surveys within the project area from 1998 to 2013 are included for comparison (Figure 3). Where data from other sources are used, it is noted in the text. Key ODFW and United States Environmental Protection Agency (USEPA) stream habitat benchmarks are listed in the sidebar (next page). The Background section provides additional information about the habitat features discussed in this section.

Pool Habitat

*Pool Area*

The ODFW benchmark for minimum pool area is 10% of total stream area; 35% is the preferred pool area benchmark (OCSRI 1997).

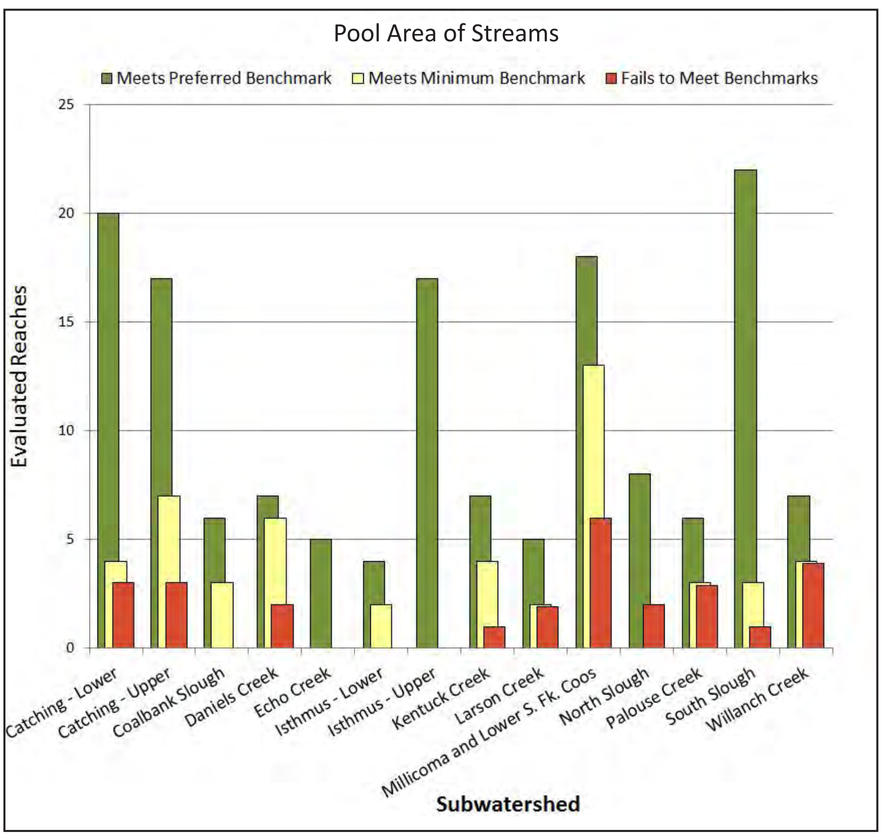



Figure 4. Distribution of evaluated stream reaches in the project area that met, exceeded, or did not meet ODFW habitat benchmarks for pool area of streams.
Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

*Stream Habitat Benchmarks*

*Pool area*
*Minimum: 10%; Preferred: 35%*
*(% total stream area)*

*Residual pool depth*
*Small stream minimum: 0.2m;*
*Preferred: 0.5m*
*Medium stream minimum: 0.3m;*
*Preferred: 0.6m*

*Large wood pieces*
*Minimum: 10pieces/100m of stream*
*Preferred: 20 pieces/100m of stream*

*Large wood volume*
*Minimum: 20m³/100m*
*Preferred: 30m³/100m*

*Large wood key pieces*
*Minimum: 1 piece/100m of stream*
*Preferred: 3 pieces/100m of stream*

*Gravel in riffles*
*Minimum: 15%; Preferred: 35%*

*Sediment in riffles*
*Streams with sedimentary parent material*
*Maximum: 20%; Preferred: 10%*
*Streams with low (<1.5%) gradients*
*Maximum: 25%; Preferred: 12%*

*Bank stability**
*Minimum: 90%*

*Shade*
*Small stream (<12m) minimum: 60%;*
*Preferred: 70%*
*Large stream (>12m) minimum: 50%;*
*Preferred: 60%*

*Source: Foster et al. 2001, CoosWA 2011c*
** USEPA benchmark; all others are ODFW*

Of 227 project area stream reaches evaluated by CoosWA, nearly 66% (149) met or exceeded the ODFW preferred benchmark, 22% (51) met the minimum benchmark, and 12% (27) failed to meet any benchmark (Figure 4).
By contrast, of nearly 40 reaches evaluated by ODFW during 1998-2013 summer surveys in the project area (Figure 3), 28% (11) exceeded the preferred benchmark, 51% (20) met the minimum benchmark, and 21% (8) failed to meet either benchmark. ODFW data indicate an average pool area per reach of nearly 29%, but as Figure 5 indicates, the average conceals a wide variation range, from 0% pool area to nearly 100%. If anything, the average may be slightly biased in favor of high pool content by a few reaches with exceptionally high content (the median, by contrast, is a somewhat more modest 23%).

It is important to note that greater numbers of pools tended to be found in the lower reaches of the subwatersheds examined, where human use generally intensifies. Dredging, channelization, and diking can alter water flow; tide gates at the bases of subwatersheds can generate a reservoir effect, backing up water and creating artificial pool environments. These artificial pools may skew the average pool area of streams, hiding a scarcity of pools in the mid-or upper reaches of a watershed (CoosWA 2009).

*Residual Pool Depth*
The ODFW minimum benchmark for residual pool depth in small streams is 0.2 m (0.67 ft); 0.5 m (1.6 ft) or deeper is the preferred depth. In mid-sized streams, the minimum

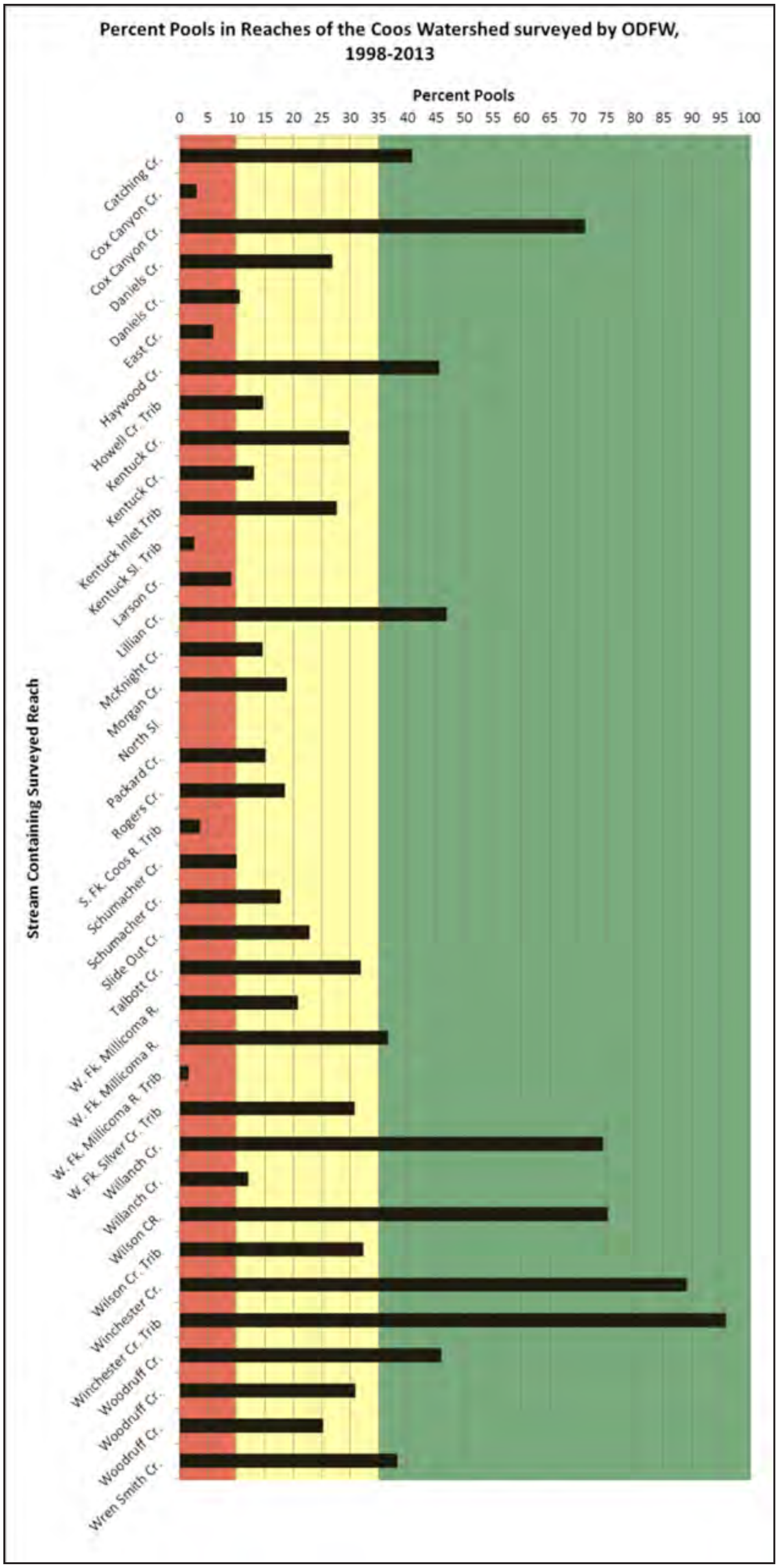



Figure 5. Percentage of pools in surveyed stream reaches of the lower Coos watershed during summers 1998-2003. Stream reaches surveyed across multiple years were averaged. Repeat stream reach names indicates more than one distinct reach on that named stream was surveyed. Graph background colors: Red zone- reach did not meet the 10% minimum benchmark; Yellow zone- reach met the minimum benchmark but did no meet >35% preferred benchmark; Green zone- reach met or exceeded the preferred benchmark of >35% . Data: ODFW 2013.

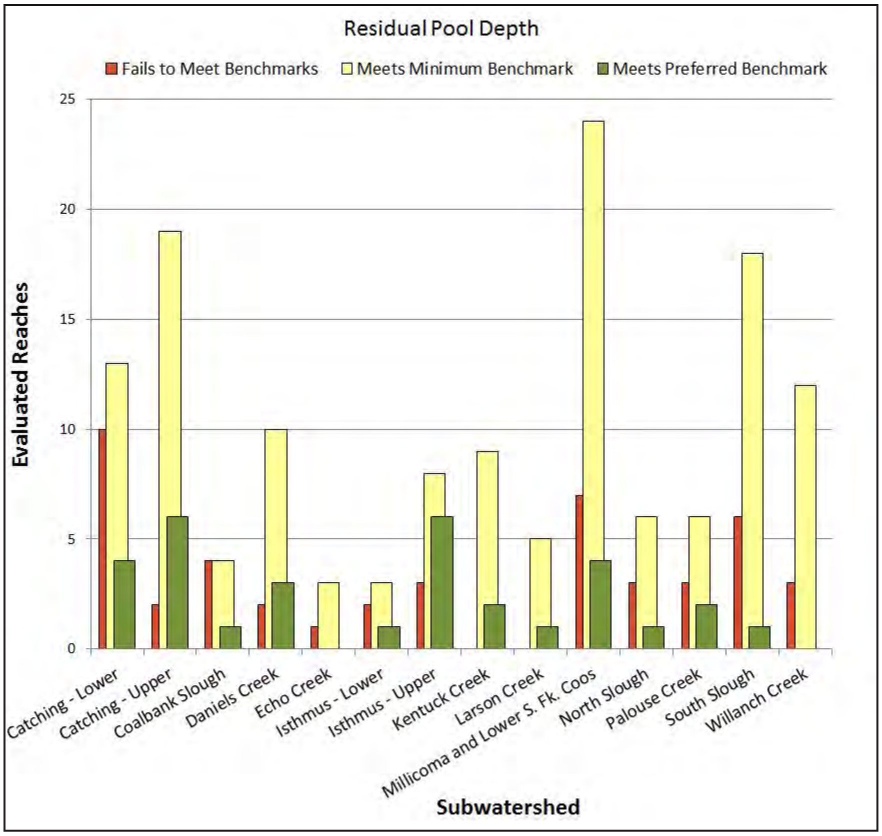



Figure 6. Distribution of evaluated stream reaches in the project area that met, exceeded, or did not meet ODFW habitat benchmarks for residual pool depth. Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

benchmark is 0.3 m (1 ft), while 0.6 m (2 ft) or deeper is the preferred depth (OCSRI 1997). While a sizable majority of stream reaches evaluated by the CoosWA met or exceeded the minimum and preferred pool area benchmarks, residual pool depth in those same reaches was not as impressive (Figure 6). Of 218 reaches analyzed, 64% (140) met the minimum residual pool depth benchmark; 21% (46) failed to meet the minimum benchmark. Only 15% (32) of the reaches met the preferred benchmark. The Lower Catching Slough, in particular, had the most pools fail to meet any benchmarks for residual pool depth.

Summer rearing habitats have been identified as a limiting factor for Coho salmon populations in at least four subwatersheds (North Slough, Palouse Creek, Kentuck Creek, and Echo Creek), which suggests that residual pool depth might be a particularly important factor for Coho salmon and other temperature-sensitive species.

***Residual Pool Depth***

*The term "residual pool depth" refers to the depth of a pool assumed to remain during low-flow periods such as the summer.*

While it’s encouraging that the majority of stream reaches in the project area meet or exceed residual pool depth benchmarks, the fact that only 14% of reaches met the preferred benchmarks raises questions about how well-prepared the watershed may be to withstand extreme low-flow events such as droughts. Droughts may limit the availability of pools as a habitat resource, putting pressure on pool-dependent species like Coho salmon. This may be a particularly serious concern in the context of a changing climate. In the future, the project area may experience longer and dryer summers, increasing the frequency and severity of low stream flow events (see Stream Habitat Climate Change Summary).

<u>Large Woody Debris (LWD)</u>

*Large Wood Pieces*

The ODFW minimum benchmark level of LWD in riparian habitat is 10 pieces per 100 meters of stream, with 20 pieces per 100 meters of stream being preferred (OCSRI 1997).

As shown in Figure 7, of 226 stream reaches evaluated by the CoosWA, 8% (18) met the preferred benchmark, 15% (34) met the minimum benchmark, and 77% (174) did not meet either benchmark. Of particular note is the North Slough watershed, which did not have a single surveyed reach that met the minimum benchmark for large wood pieces. In every subwatershed, reaches not meeting either benchmark outnumbered those that did.

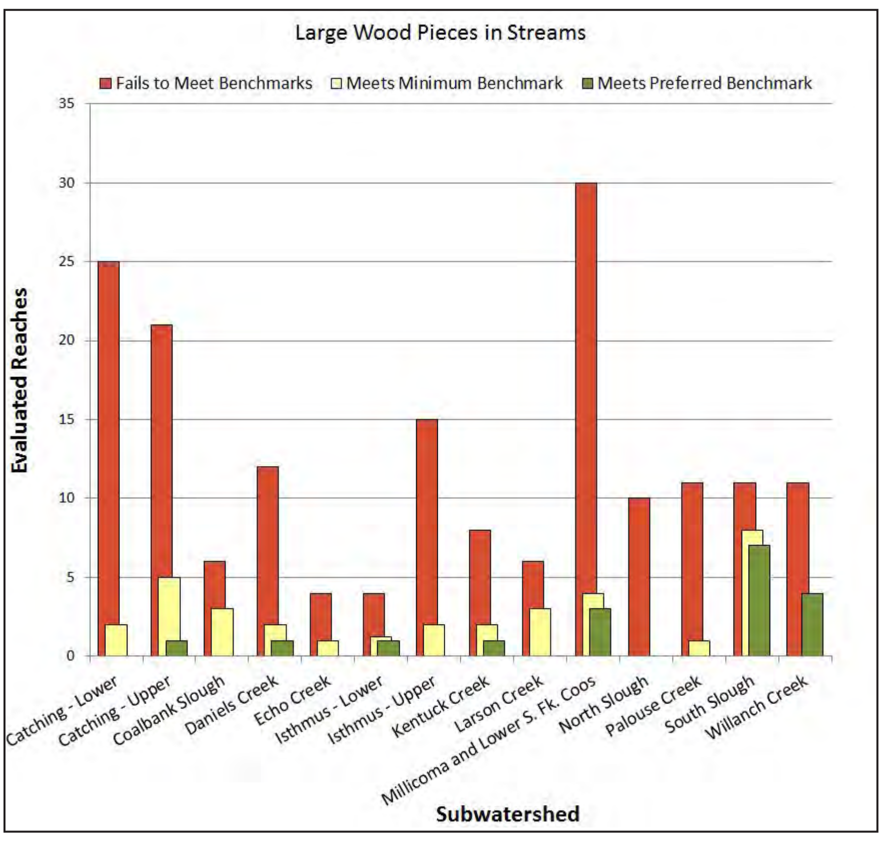



Figure 7. Distribution of evaluated stream reaches in the project area that met, exceeded, or did not meet ODFW habitat benchmarks for LWD pieces in streams. Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

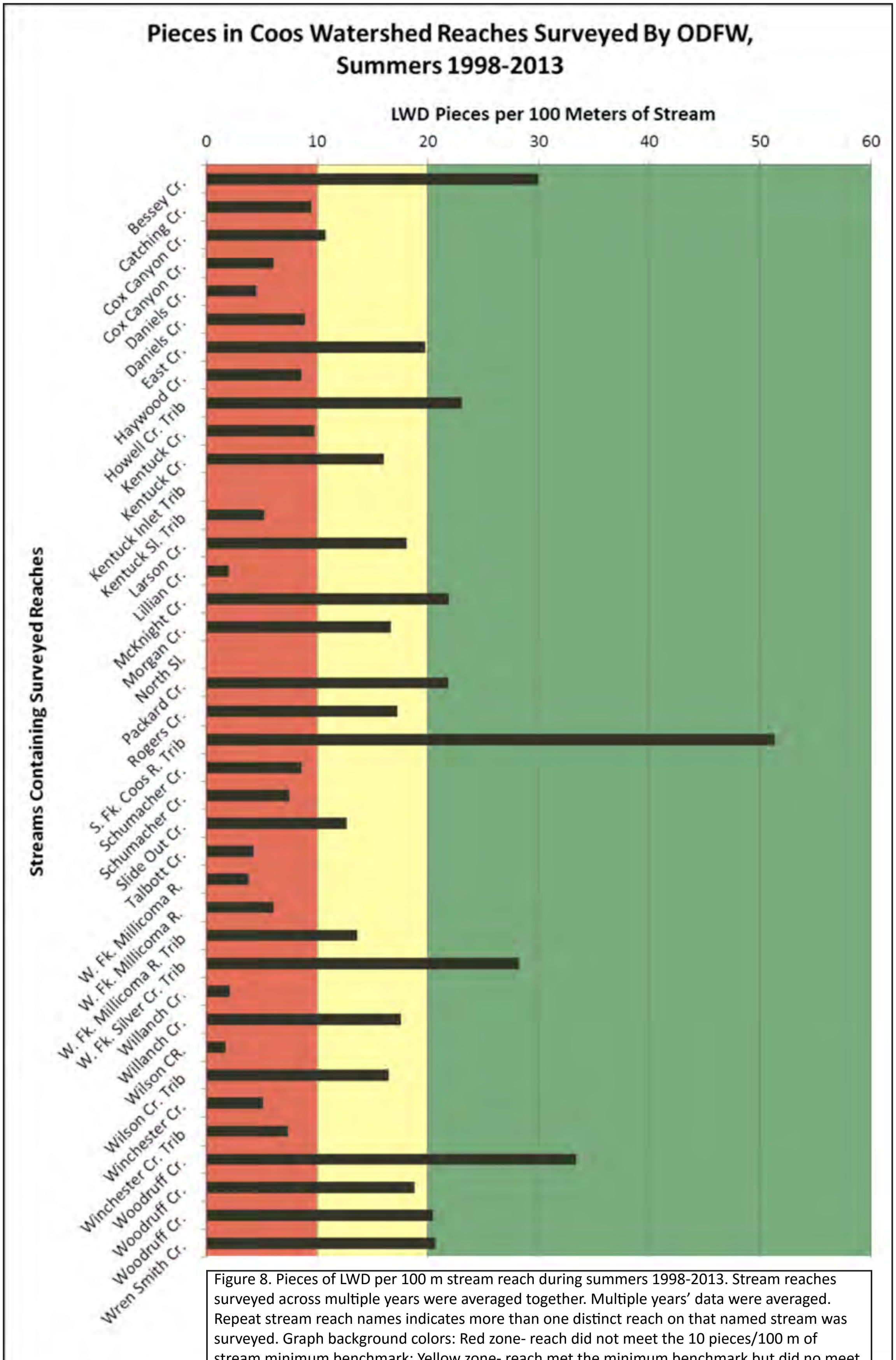



Figure 8. Pieces of LWD per 100 m stream reach during summers 1998-2013. Stream reaches surveyed across multiple years were averaged together. Multiple years' data were averaged. Repeat stream reach names indicates more than one distinct reach on that named stream was surveyed. Graph background colors: Red zone- reach did not meet the 10 pieces/100 m of stream minimum benchmark; Yellow zone- reach met the minimum benchmark but did no meet >20 pieces preferred benchmark; Green zone- reach met or exceeded the preferred benchmark of >20 pieces /100 m of stream. Data: ODFW 2013.

Summer surveys conducted by ODFW (Figure 3) paint a slightly different picture, as shown in Figure 8. In these surveys, 23% of surveyed reaches (9 of 39) met the preferred benchmark, 28% (11) met the minimum benchmark, and 49% (19) failed to meet the minimum benchmark. This difference may reflect minimal overlap between the reaches surveyed by ODFW and those surveyed by the CoosWA since CoosWA's surveys were focused on lower watershed tributaries only. Even so, nearly half the ODFW surveyed reaches do not meet the minimum standard for pieces of LWD per 100 meters of stream. Additionally, both surveys document a distinct lack of LWD in project area streams.

Figure 8 also demonstrates the high level of variability and therefore the high level of uncertainty associated with evaluating LWD in streams. Values in the ODFW surveys range from 0 to 51 pieces of LWD per 100 meters of stream.

*Large Wood Volume*

As shown in Figure 9, of 226 reaches evaluated by the CoosWA for wood volume in streams, 4% (10) met the 30 $m^3$ per 100 m stream reach preferred benchmark, 12% (26) met the 20 $m^3$ per 100 m stream reach minimum benchmark, and 84% (190) failed to meet either benchmark. Of particular note are Coalbank, Lower Catching, and Upper and

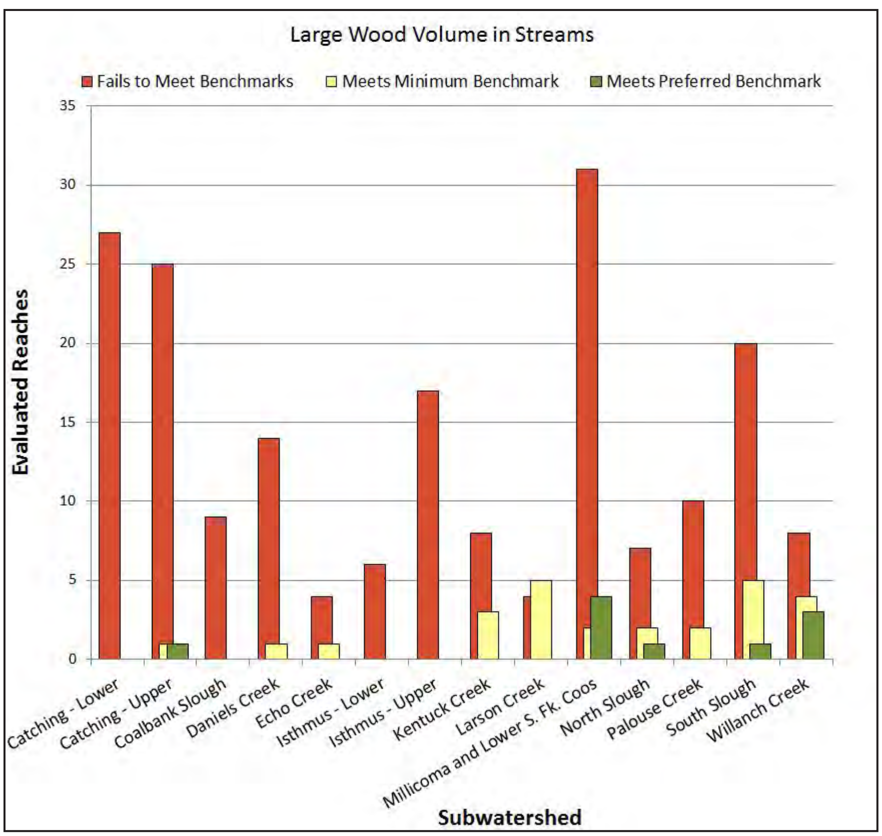



Figure 9. Distribution of evaluated stream reaches in the project area that met, exceeded, or did not meet ODFW habitat benchmarks for volume of LWD in streams. Data: CoosWA 2006, 2008, 2011c, Cornu et al. 2012

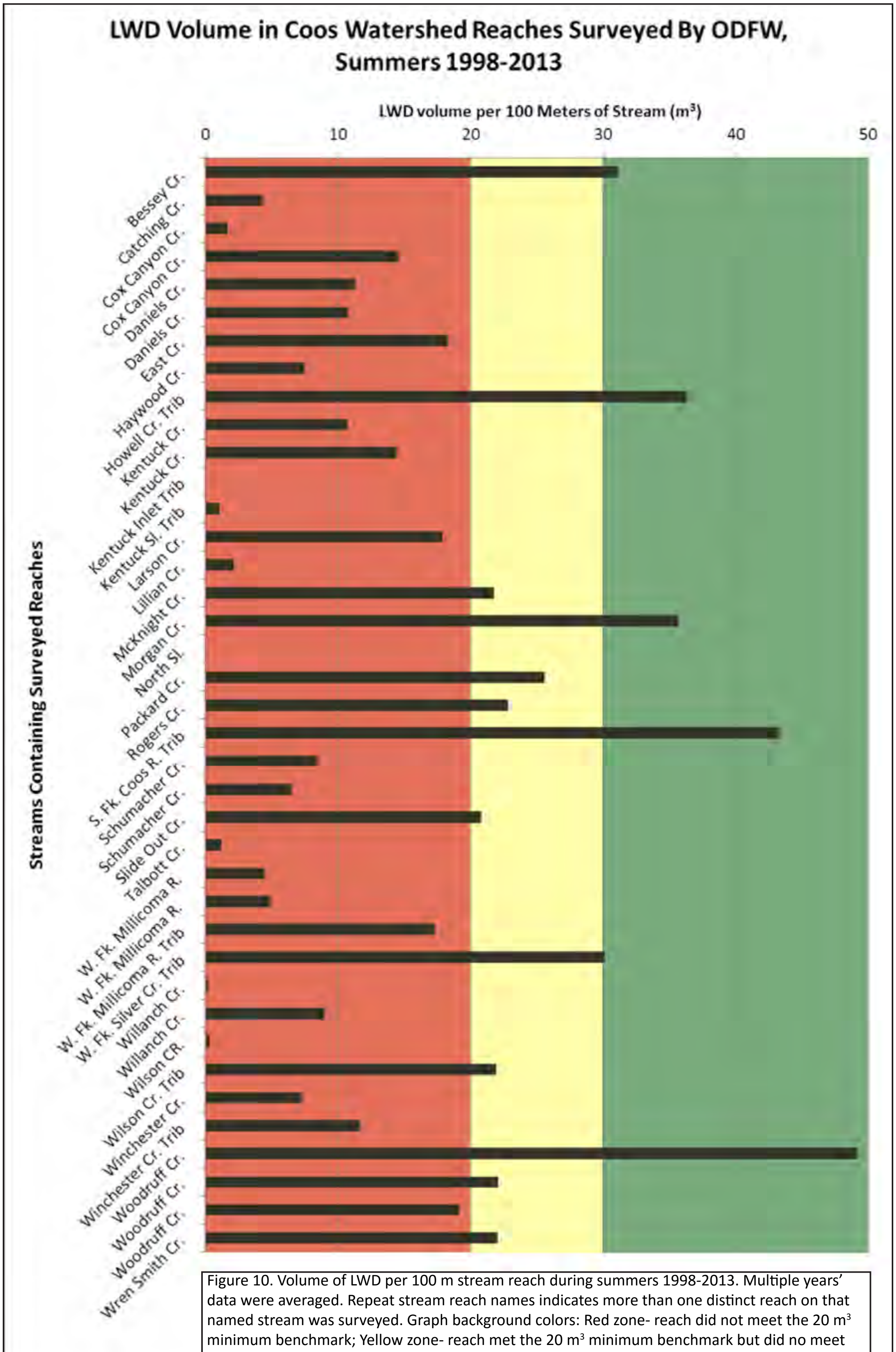



Figure 10. Volume of LWD per 100 m stream reach during summers 1998-2013. Multiple years' data were averaged. Repeat stream reach names indicates more than one distinct reach on that named stream was surveyed. Graph background colors: Red zone- reach did not meet the 20 $m^3$ minimum benchmark; Yellow zone- reach met the 20 $m^3$ minimum benchmark but did no meet >30 $m^3$ preferred benchmark; Green zone- reach met or exceeded the >30 $m^3$ benchmark. Data: ODFW 2013.

Lower Isthmus subwatersheds, within which not a single evaluated reach met the minimum benchmark.

ODFW 1998-2013 survey results indicate more wood volume than CoosWA surveys with 15% (6 of 39) of surveyed stream reaches meeting the preferred benchmark, 18% (7) of reaches meeting the minimum benchmark, and 67% (26) of reaches failing to meet either benchmark (Figure 10). Both CoosWA and ODFW surveys further highlight the alarming lack of wood volume in project area streams.

ODFW's LWD volume results averaged 15 $m^3$/100 m stream reach (median: nearly 12 $m^3$/100 m). But these data are highly variable, ranging from 0 to 49 $m^3$/100 m. No LWD was found in Kentuck Inlet tributary or North Slough. The highest volume was found in Woodruff Cr, where it easily exceeded ODFW's preferred LWD volume benchmark.

*Large Wood Key Pieces*

As shown in Figure 11, of 226 stream reaches evaluated by the CoosWA, an astonishing 94% (214) of the reaches did not meet either ODFW LWD key pieces benchmark. Only 4% (10 reaches) met the 1 key piece per 100 m stream reach minimum benchmark, and <1% (2 reaches) met the 3 per 100 m stream reach preferred benchmark. Four stream reaches in South Slough and one in the North Slough met ODFW LWD key piece benchmarks. The Millicoma and lower South Fork Coos Rivers performed best, with six stream reaches that exceeded ODFW's preferred benchmark; this was also the only subwatershed in which the preferred benchmark was met. Of all the variables considered in this data summary, it is LWD key pieces that most consistently fails to meet benchmarks.

CoosWA stream survey results suggest slightly better overall conditions compared with ODFW's summer surveys. As shown in Figure 12, the overwhelming majority of surveyed reaches (34 of 39, or 87%) failed to meet either ODFW benchmarks for LWD key pieces, 10% (4 reaches) met the minimum benchmark, and <3% (1 reach) met the preferred benchmark. Ten reaches had no key LWD pieces and only Woodruff Cr met the preferred criteria.

Although the general picture for all three LWD metrics (based on CoosWA or ODFW data) is that LWD is lacking in project area streams, there was again great variability in these results. Some stream reaches are well stocked with LWD while others aren't.

<u>Riffle Substrate</u>

*Gravel in Riffles*

As shown in Figure 13, of 195 reaches evaluated by the CoosWA for gravel in riffles, 18% (36) met the 15% gravel minimum benchmark, 76% (149) met the 35% gravel preferred benchmark, and 5% (10) failed to meet either benchmark. It should be noted that the majority of the reaches that failed to meet the minimum benchmark were located in the South Slough watershed. All stream reaches surveyed in seven subwatersheds (Daniel's Creek, Echo Creek, Upper and Lower Isthmus Slough, Kentuck Creek, Larson Creek, Wil-

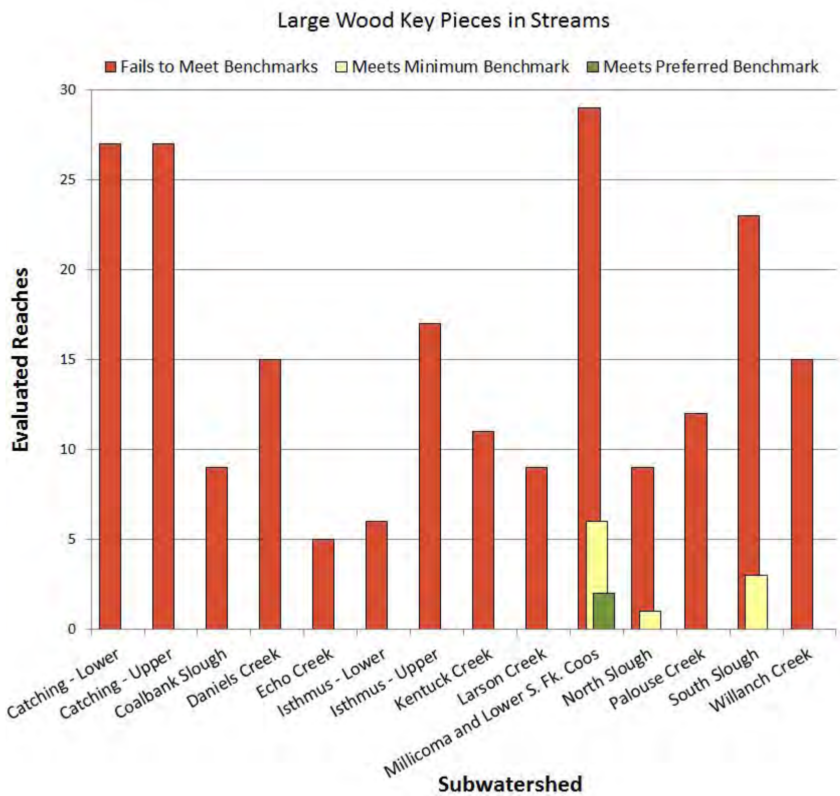



Figure 11. Distribution of evaluated stream reaches in the project area that met, exceeded, or did not meet ODFW habitat benchmarks for LWD key pieces in streams. Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

lanch Creek, and Coalbank Slough) met either of ODFW's riffle gravel benchmarks. Kentuck Creek, Echo Creek, and Coalbank subwatersheds particularly stand out in that all of their evaluated reaches met or exceeded the ODFW preferred benchmarks.

*Silt/Sand/Fine Organics in Riffles*

ODFW uses two sets of benchmarks for evaluating the levels of silt, sand, and fine organics in riffles. The first is for streams with sedimentary parent material, with a maximum benchmark of 20% silt, sand, and fine organics, though 10% or lower is preferred. By contrast, low gradient (<1.5%) streams have a maximum benchmark of 25%, with a preferred level of less than 12% (OCSRI 1997).

As shown in Figure 14, of 193 reaches evaluated by the CoosWA for silt, sand, and fine organics, 11% (21) met preferred benchmark levels, 32% (62) met the minimum benchmark, and 57% (110) failed to meet either benchmark. This suggests consistent problems with sedimentation in the project area, possibly stemming from erosion from unstable stream banks, especially those lacking a mature riparian plant community. Upstream, sedimentation may originate from access roads and steep slopes subject to episodic industrial timber production. The Daniels and Millicoma and lower South Fork Coos Rivers subwatersheds stand out as exceptions by consistently meeting preferred ODFW sedimentation benchmarks.

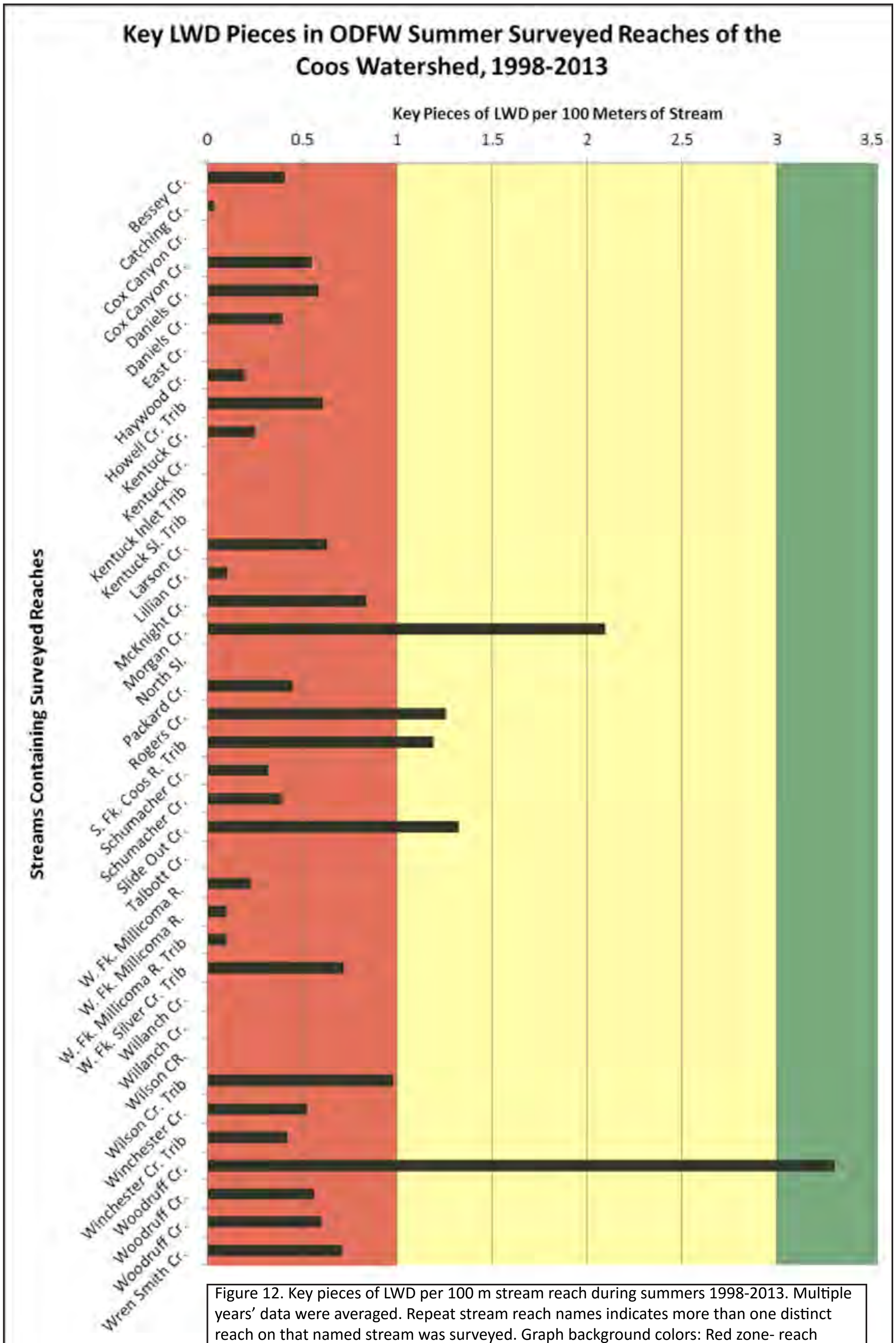



Figure 12. Key pieces of LWD per 100 m stream reach during summers 1998-2013. Multiple years' data were averaged. Repeat stream reach names indicates more than one distinct reach on that named stream was surveyed. Graph background colors: Red zone- reach did not meet the 1 key piece/100 m minimum benchmark; Yellow zone- reach met the 1 key piece/100 m minimum benchmark but did no meet >3 key pieces/100 m preferred benchmark; Green zone- reach met or exceeded the >3 key pieces/100 m benchmark. Data: ODFW 2013.

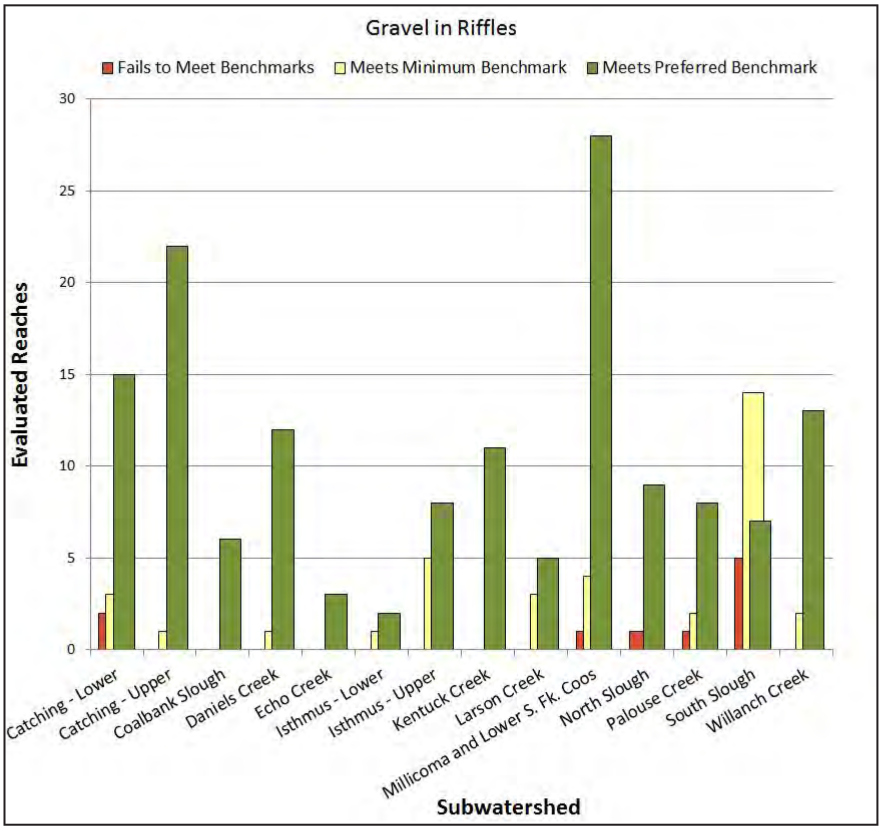



Figure 13. Distribution of evaluated stream reaches in the project area that met, exceeded, or did not meet ODFW habitat benchmarks for gravel content of riffles. Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

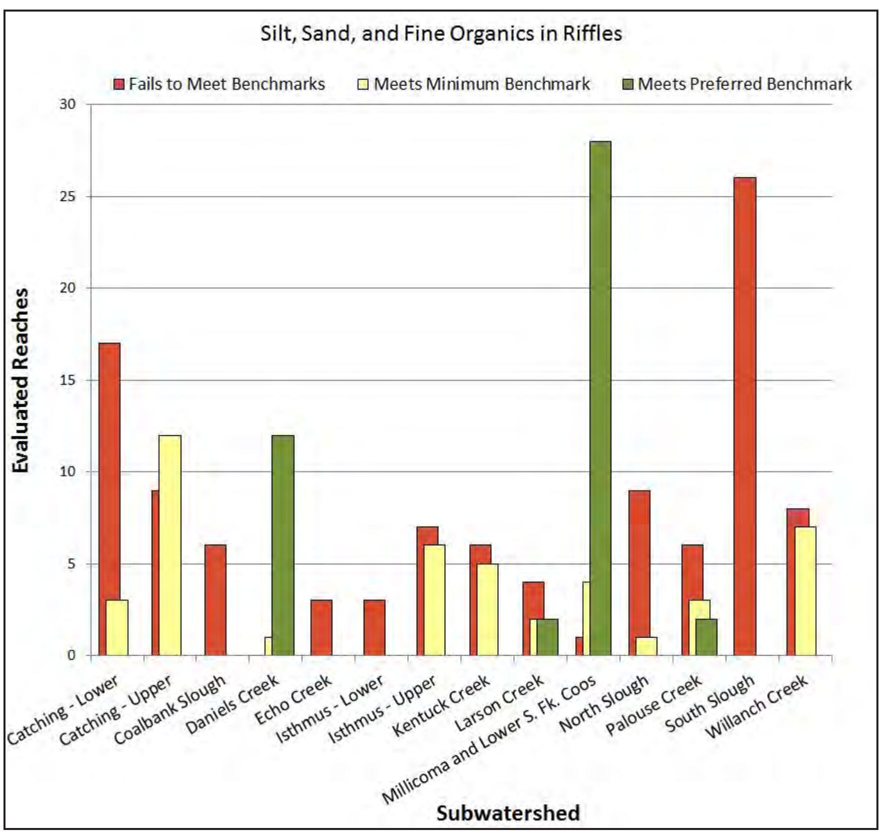



Figure 14. Distribution of evaluated stream reaches in the project area that met, exceeded, or did not meet ODFW habitat benchmarks for silt, sand, fines, and organic content of riffles. Data Source: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

Road-related Sediment

CoosWA (2006, 2008, 2011c; Cornu et al. 2012) and ODF (2003) have conducted surveys of roads (county-owned and private) and stream-crossing structures (including culverts) in the lower Coos watershed for the past 10-20 years; their efforts cover over 550 road miles and over 3,700 structures (Figure 15, Table 1).

*Road Structures*

CoosWA and ODF determined that many of the roads and stream-crossing structures they surveyed were potential sediment sources for project area streams, resulting from both chronic erosion and sudden structure failures. To reduce these risks, they recommended nearly 350 road or structure upgrades (e.g., ditch relief or stream crossing) and nearly 1,650 new road improvements or structures, the designs of which would be guided by ODF regulations (ODF 2003). Of the existing structures, those with highest risk of failure could result in the delivery of nearly 27,000 yds$^3$ of sediment; those with moderate risk have the potential to input over 7,400 yds$^3$ (CoosWA 2006, 2008, 2011c; Cornu et al. 2012).

Nearly 90 road-related sediment and fish passage improvement projects have been completed in the project area from 1995-2013 (OWRI 2015)(Table 2, Figure 16). These projects have made over 41 miles of upstream habitat once again accessible to fish (Figure 17).


Figure 15. Subwatersheds evaluated by Coos Watershed Association for road-related sediments (shaded yellow) within the project boundaries (outlined in black). Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

*Bank Stability*

Researchers also documented unstable banks and landslide-prone slopes adjacent to streams. An unstable bank is one that is actively eroding, due to its underlying geology, plant cover, gradient, or proximity to flowing water (USEPA 2012). According to USEPA, no more than 10% of the stream banks in a watershed with fully functioning streams should be considered “unstable”.

As shown in Figure 18, of 217 reaches evaluated for bank stability by the CoosWA, 51% (110) met the benchmark and 49% (107) did not.

Areas of particular concern include the Upper Catching and Millicoma and lower South Fork Coos Rivers subwatersheds, which feature the highest number of reaches that fail to meet benchmarks.

| Location | Dates of Assessment | Miles of Roads Surveyed | Structures Assessed* | Recommended New Structures* | Recommended Replacement Structures* | Potential Sediment Input ($yd^3$)/ # Culverts High - Very High Risk Failure | Potential Sediment Input ($yd^3$)/ # Culverts Moderate Risk Failure | Source |
|---|---|---|---|---|---|---|---|---|
| **Catching Slough** | April 2006-Jan 2007; May 2001-August 2001 | 72 | 525 | 131 | 42 | 10,763 / 44 | 2,486 / 10 | CoosWA 2008 |
| **Coos River** | | | | | | | | |
| Daniel's Creek | Apr 2006 - Jan 2007; June-July 1999; Oct 2004 | 40 | 368 | 56 | 11 | 1,158 / 13 | 1,912 / 13 | CoosWA 2008 |
| Elliot State Forest | 1997-1998; 2003 | N/A | 309** | 7 | N/A | N/A | N/A | ODF 2003 |
| Lower Millicoma and S. Fk. Coos Rivers | Jun 2004-Nov 2005 | 101.7 | 618 | 344 | 42 | 1,570 / 22 | 984 / 7 | CoosWA 2008 |
| **Haynes Inlet** | | | | | | | | |
| Palouse | Feb 2001 - Oct 2004 | 23.5 | 208 | 76 | 10 | 1,139 / 29 | 252 / 2 | CoosWA 2006 |
| Larson | Feb 2001 - Oct 2004 | 29.4 | 186 | 94 | 29 | 1,104 / 12 | 201 / 2 | CoosWA 2006 |
| **Isthmus Slough** | Jun 2008 - Aug 2010 | 81.3 | 430 | 248 | 40 | 2,796 / 31 | 438 / 6 | CoosWA 2011c |
| **North Slough** | Jan 2001; Aug 2004 | 32 | 240 | 86 | 14 | 3,303 / 15 | 179 / 3 | CoosWA 2006 |
| **South Slough ***** | Jun 2010 - Aug 2011 | 81.3 | 589 | 358 | 83 | 598 / 8 | 174 / 2 | Cornu et. al. 2012 |
| **Upper Bay** | | | | | | | | |
| Kentuck | Mar 2001 - Mar 2005 | 47.9 | 330 | 139 | 33 | 2,849 / 26 | 762 / 6 | CoosWA 2006 |
| Willanch | Apr 2001 - Jul 2004 | 25 | 162 | 64 | 30 | 947 / 21 | 48 / 1 | CoosWA 2006 |
| Echo Creek | Jun-July 2004 | 17.2 | 63 | 42 | 12 | 763 / 7 | 0 / 0 | CoosWA 2006 |
| **Total** | | **551.3** | **3719** | **1645** | **346** | **26,990 / 228** | **7,436 / 52** | |

Table 1. Summary of road-related sediment assessment data for most subsystems in the project area.

* Structures include stream crossings, ditch relief, ditch out, road ponding
** Stream crossings and ditch reliefs only
*** Over-representation, since report includes coastal frontal watersheds

| Sub-basin | # of Projects | Stream Habitat Made Accessible (mi) | Road/Stream Crossing Improvements for Fish Passage | Road/Stream Crossing Improvements for Peak Flow | Road Flow Improvements (non-stream crossings) | Road Rocking Improvements (mi) | Landowner (s) |
|---|---|---|---|---|---|---|---|
| **Catching Slough** | 9 | 6.3 | 6 | 0 | 2 | 0 | Private timber companies; private landowners; Coos County |
| **Coos River** | 2 | 0.5 | 2 | 1 | 6 | 0 | Private landowner; ODOT |
| **E. Fk. Millicoma River** | 15 | 2.25 | 7 | 7 | 5 | 1.09 | Private timber companies; ODF |
| **Isthmus Slough** | 6 | 7.5 | 6 | 2 | 1 | 0 | Private timber companies; private landowners; drainage district |
| **Kentuck Cr** | 4 | 2.4 | 2 | 5 | 0 | 0 | Private timber companies; private landowners |
| **Larson Cr** | 3 | 0.25 | 1 | 4 | 14 | 0.38 | Private landowner; ODF |
| **North Slough** | 1 | 0.7 | 3 | 0 | 0 | 0 | Private timber companies |
| **Palouse Cr** | 7 | 4.68 | 10 | 4 | 5 | 0 | Coos County; ODF |
| **S. Fk. Coos River** | 13 | 4.89 | 9 | 6 | 125 | 0.45 | Coos County; private timber companies |
| **S. Fk. Coos River & Millicoma River** | 1 | 0 | 0 | 3 | 42 | 0 | Private timber companies |
| **South Slough** | 4 | 0.7 | 2 | 0 | 2 | 0.38 | Coos County; private timber companies |
| **W. Fk. Millicoma River** | 13 | 2.14 | 4 | 1 | 39 | 9.58 | ODF |
| **Willanch Cr** | 5 | 8.8 | 4 | 2 | 0 | 0 | Coos County; private timber companies |
| **Other** | 3 | 0.03 | 1 | 0 | 1 | 1.84 | ODF; sanitary district |
| **TOTAL** | **86** | **41.14** | **57** | **35** | **242** | **13.72** | |

Table 2. Summary of road-related restoration projects that occurred between 1995 and 2013 in the project area. Some road restoration activities (e.g., road closures) were not included in this table. Data: OWRI 2015

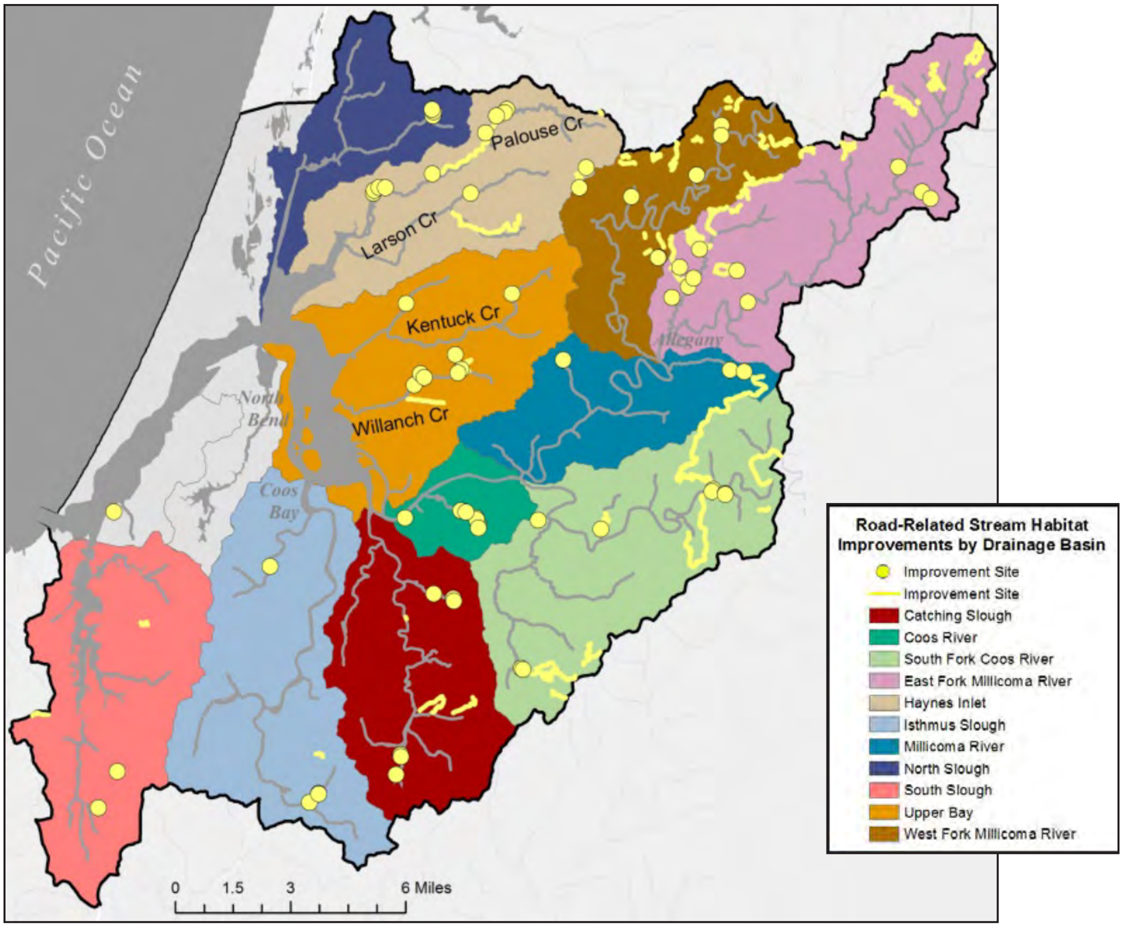



Figure 16. Road-related stream habitat improvements in the project area by drainage basin. Improvement site points include such things as new or replaced culverts , fords replaced with bridges, etc. Improvement site lines include surface drainage improvements along a road; erosion control; and other along-road improvements. Data: OWRI 2013

Figure 17. Undersized culvert with step blocked movement of Coho and Chinook to high quality upstream habitat (left). Culvert was removed and replaced with 26' wide arched steel set onto concrete footings (right), allowing natural stream habitat to be maintained through the 126' long passage. Source: CoosWA 2013

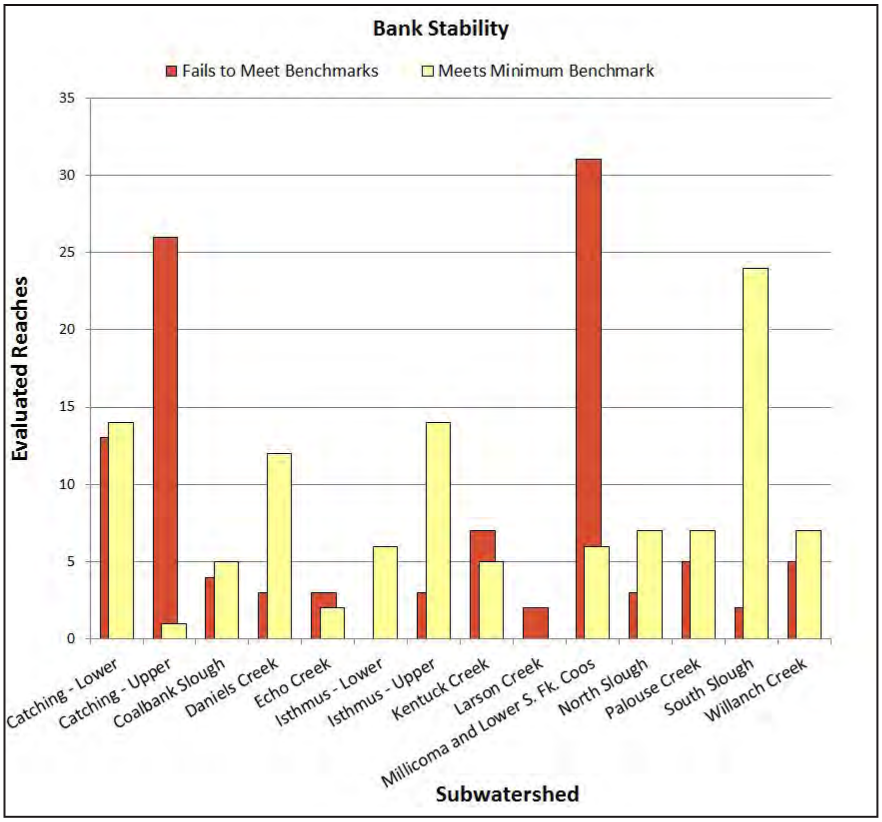



Figure 18. Distribution of evaluated reaches in the Coos watershed that met or did not meet USEPA habitat benchmarks for riparian bank stability. Note, there is no "Preferred benchmark" for bank stability, USEPA uses a pass/fail standard. Data: CoosWA 2006, 2008, 2011c; Cornu et al. 2012

A landslide-prone slope is, as one might expect, typically steep, although even a gently sloping hill can lead to deep-seated, slower-moving landslides (CoosWA 2011c). Landslide hazard assessment in the project area is included in Table 1. Risk varies by subwatershed. High to very high landslide risk is insignificant in some basins (e.g., North Slough was only 1.5% of the subwatershed area), while in others, it is substantial (e.g., 33.5% of Daniel's Creek area)(CoosWA 2006, 2008, 2011c; Cornu et al. 2012). For more detailed information on landslides and debris flows in the project area see the Geology Data Summary in Chapter 8: Physical Description.

Riparian Habitat

*Riparian Cover Type*

No applicable benchmarks to evaluate riparian cover type are currently in use in Oregon, but a diversity of conifer and deciduous trees, shrubs, and herbaceous cover is considered desirable. Conifers are particularly valuable, as their large size makes them well-suited to contribute LWD to stream channels and provide shade. Herbaceous cover ("grass") alone is possibly the least preferred vegetative cover as it has limited potential to shade streams and its relatively shallow roots cannot hold soil together very effectively (CoosWA 2008). Riparian habitat parameters were assessed in CoosWA (2008, 2011c) and in Cornu et al. (2012).

As may be seen in Figure 19, grass is the predominant cover type throughout the evaluated drainage basins, with an average of 40% cover. In the subwatersheds' lower reaches, this is likely due to agricultural and other human activities. The second most widespread cover type is shrubs, averaging 28% of cover throughout the evaluated areas. Deciduous tree cover averages 23% of the evaluated areas, and conifers, the least widespread of the cover types, average 6% cover. In some subwatersheds, such as Daniel's Creek and Millicoma and lower South Fork Coos Rivers, average riparian conifer cover is only 2%.

In addition to evaluating riparian cover type, Robinson (2009) addressed the age of stands in the South Slough National Estuarine Research Reserve (a 6,000 acre natural area located in the Coos estuary and managed for long-term research, education, and coastal stewardship). They found that roughly 21% of the Reserve's timber stands in the area were young (20-30 years old) and were regenerating from past harvests or other disturbances. By contrast, mature stands, defined as trees that are approximately 80-150 years old, comprise only about 3% of the Reserve. The majority of stands (76%) in the Reserve were between 40 and 80 years old in the competitive exclusion phase of forest development, meaning that these are high density stands dominated by similarly aged trees limiting the growth of understory vegetation.
The distribution of land use between forestry, agriculture, and rural residential uses (excluding the South Slough Reserve) is shown in Figure 20 and demonstrates how much of the watershed is managed for young forests, rather than the mature forests that would be

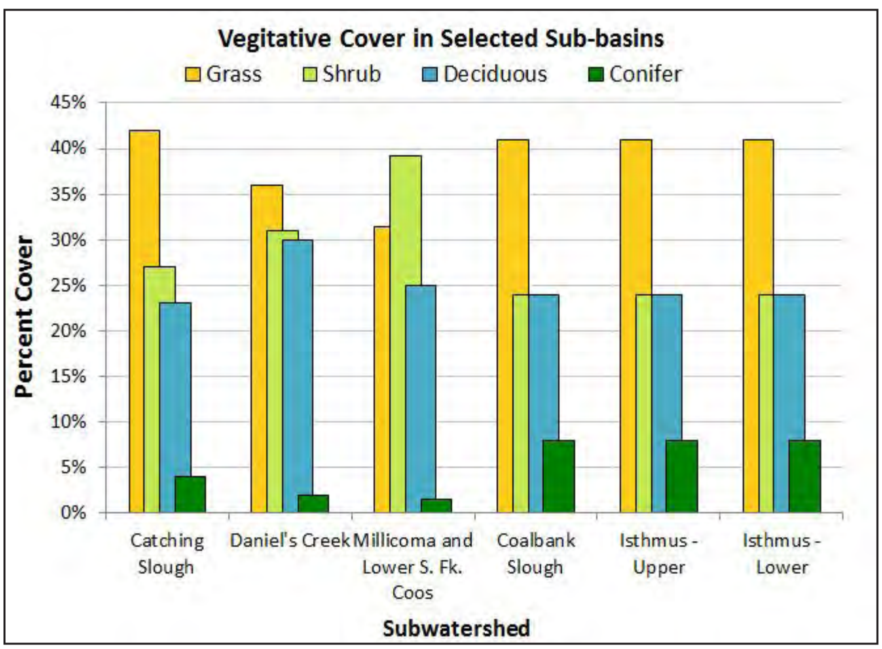



Figure 19. Distribution of riparian cover in evaluated stream reaches of the lower Coos watershed. Data: CoosWA 2008, 2011b

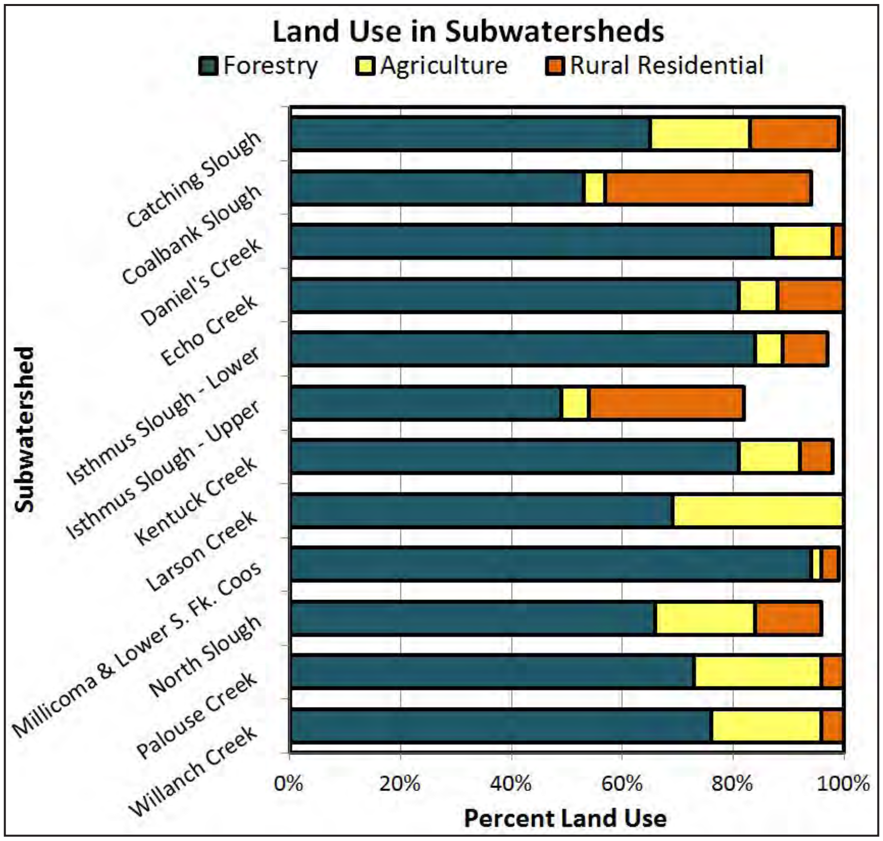



Figure 20. Proportions of the three dominant land use types identified in several project area subwatersheds. The totals do not add up to 100%, as there are other uses in the watershed, such as urban development. Data: CoosWA 2006, 2008, 2011c

more beneficial to riparian habitat. However, alternate uses of watershed area (agriculture, residential) may be even less amenable to vegetative cover, so the high percentage of the Coos watershed which is forested may actually represent an opportunity to improve riparian habitat more effectively than in other, more urbanized or agricultural watersheds.

*Shade*

The CoosWA's 2006 assessment used photographs from 2002 U.S. Bureau of Land Management (BLM) aerial surveys to run a SHADOW model that estimated both potential and actual shading of subwatersheds on the north side of the Coos estuary. The model was used to examine three types of stream reach: upper stream reaches (steep gradient, forested narrow canyons), upper valleys (well-drained valleys with some elevation change), and lower valleys (poorly-drained, with very little elevation change). Shade data were collected in the field to check the model's accuracy.

SHADOW model results indicated that while shade in the steep canyons of subwatersheds' upper stream reaches was relatively close to reaching its potential, shade values dropped dramatically in both upper and lower valley areas. This likely reflects the contrasting vegetation cover associated with industrial forestry and agricultural land uses in local subwatersheds. Figures 21, 22 and 23 illustrate the disparity between potential and actual values of riparian shade in different reaches of the subwatersheds to which the SHADOW model was applied.

ODFW benchmarks for shade cover are for streams with an active channel width <12m, less than 60% shade cover is undesirable and more than 70% is desirable, and for streams >12m wide, less than 50% shade cover is undesirable and more than 60% is desirable (Foster et al. 2001).

The CoosWA and Cornu et al. assessments did not compare riparian shade analyses using ODFW benchmarks. Though we do not know the size of reaches from their shade analyses, ODFW's benchmarks can still be generally applied. All of the upper reaches met both the <12m and >12m benchmarks for desirable shade cover. The upper valley reaches were more mixed; Willanch Creek failed to meet any benchmark while Daniel's Creek, Echo Creek, and Kentuck Creek exceeded the most stringent benchmark (streams <12m (70%)). The reaches in the lower valleys were the least able to offer shade cover. Larson Creek and Echo Creek were the only streams to meet or exceed the minimum benchmark for streams >12m (50%). All other lower valley reaches failed to meet any benchmarks.

By reducing riparian shade on a stream, solar load is increased, raising stream temperatures, which in turn lowers dissolved oxygen (DO). There are 19 streams in the project area listed as water quality impaired for temperature and four water bodies are listed as water quality impaired for DO under USEPA's Clean

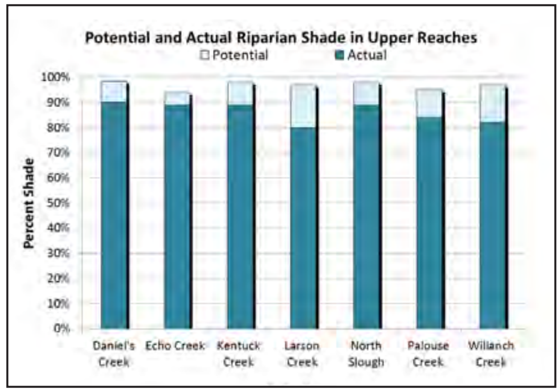


Figure 21. Actual and potential riparian shade cover of upper stream reaches in the lower Coos watershed. Data: CoosWA 2006, 2008

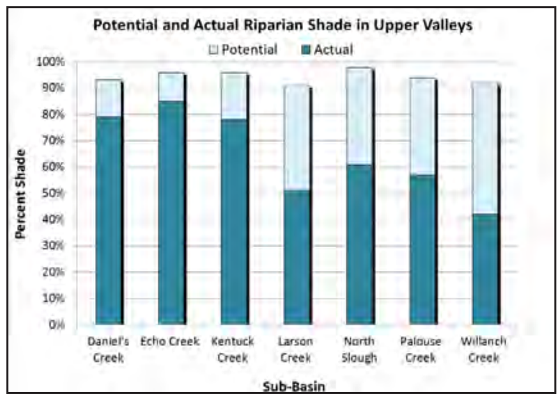


Figure 22. Actual and potential riparian shade cover of upper valleys in the lower Coos watershed. Data: CoosWA 2006, 2008

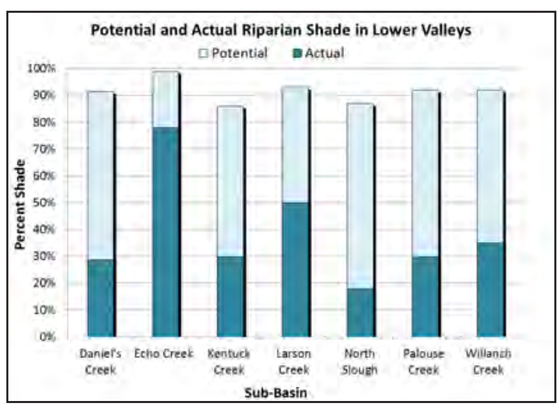


Figure 23. Actual and potential riparian shade cover of lower valleys in the lower Coos watershed. Data: CoosWA 2006, 2008

Water Act (section 303(d))(Figures 24 and 25). Many of these streams are considered limited for salmon rearing due to year-round high temperatures. DO is the oxygen available for aquatic fauna and is directly related to water temperature; slow moving, high temperature waters contain less DO than cool, fast flowing waters. Low dissolved oxygen levels affect resident fish, juvenile salmon rearing and aquatic life in general. For more information on temperatures and dissolved oxygen levels of water bodies in the project area, see the Physical Factors summary in Chapter 9: Water Quality.

**Background**

<u>Habitat Limiting Factors Model (HLFM)</u>
The HLFM, used in some of the CoosWA assessments (2006, 2008), was designed to identify those habitat factors that limit Coho salmon populations and smolt production capacity in coastal Oregon watersheds (Nickelson 1998). In effect, the model identifies resource "bottlenecks," which resource managers can address to help improve Coho salmon populations. The HLFM focuses on the amount of pool habitat in stream reaches, particularly beaver ponds and off-channel pool habitat. The model evaluates winter habitat capacity by total beaver and off-channel pool habitat, and summer habitat capacity by quantifying total pool habitat (which includes beaver, off-channel, and main channel pools) (ODF 2003).

The HLFM bottleneck illustrated in Figure 26 is a habitat limitation that occurs (A) during winter juvenile Coho salmon migration; and (B) during summertime juvenile Coho salmon migration. A manager facing scenario A might consider devoting resources to off-channel

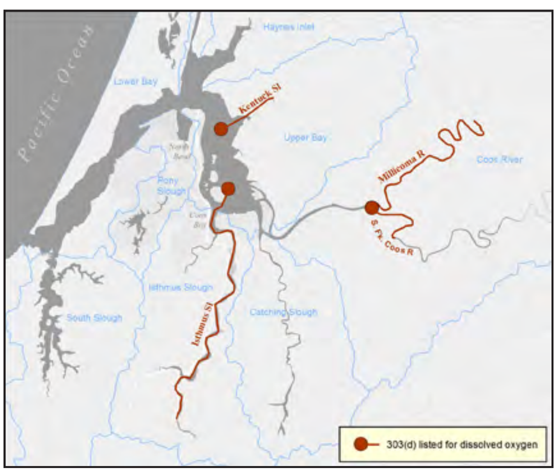



Figure 24. Streams listed as impaired for dissolved oxygen (303 (d) listed) under USEPA's Clean Water Act. Red dot signifies the start of the stream segment that is listed. Report subsystems delineated and labeled in blue.  Data: ODEQ 2014


Figure 25. Streams listed as impaired for water temperature (303(d) listed) under USEPA's Clean Water Act. Red dot signifies the start of the stream segment that is listed. Report subsystems delineated and labeled in blue. Data: ODEQ 2014

pools that give Coho salmon refuge from high stream flow events. Faced with scenario B, managers might place a higher priority on improving total pool area and on strategies for maintaining or improving cold water refugia in Coho streams.

<u>Pools</u>

Pools in streams provide important habitat for juvenile and adult fish; the deeper and more abundant the pools, the greater the benefits are to fish. Pools can provide fish with refuge from both high-flow events (hydrologic refugia), when water velocity could damage fish, and low-flow events (cold water refugia), when high water temperatures could prove harmful. Furthermore, pool depths can provide refuge to fish from surface predators (Foster et al. 2001). Pools can also act as sediment traps, allowing silt, sand, and fine organics to settle out of the water column and leaving downstream reaches free of these fine particles, which might otherwise clog valuable gravel beds that salmonids use for spawning (Swales and Levings 1989).

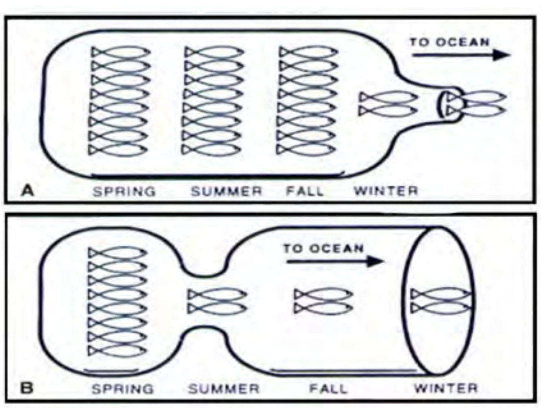



Figure 26. Bottlenecks identified by the HLFM model, and their potential affects on Coho populations. A: Winter habitat bottleneck; B: Summer habitat bottleneck. Source: Reeves et al. 1991

In British Columbia, Swales and Levings (1989) observed age 1+ Coho expressing a decided preference for pools as rearing habitat. They also found that the growth rates on Coho salmon in pools were greater than the growth rates of those in mainstem river reaches. In the project area, Weybright (2011) found that juvenile Coho that remained in pools during winter had a significantly higher survival rate than those that exhibited more mobile behavior. It's likely that the pools provided juvenile fish with refuge from wintertime high-flow events, allowing calories that might otherwise have been expended fighting strong currents to be devoted to growth. Given that salmon are powerful and efficient swimmers compared to other species such as sturgeon or lamprey (Verhille et al. 2014; Lampman 2011), it's possible that pools may prove to be even more important refuge for non-salmonid fish species.

During warm and dry summer months, residual pool depth may serve as essential habitat for fishes by providing concealment and the cooler water temperatures necessary for their health and survival (Foster et al. 2001). In the Oregon Coast Range, May and Lee (2004) found that limited residual pool habitat resulted in severe crowding of fish seeking refuge during summer low flows, and was associated with population decreases over the course of the summer. In streams subject to high temperatures and low summer flows (likely to exacerbated in the future by the local effects of climate change), deep pools are critical to the survival of temperature-sensitive species like salmon.

Large Woody Debris (LWD)

LWD provides fish with cover in streams, helps create pools through hydraulic scouring of stream beds, and enhances the quality of pool habitat for fish. LWD in streams also provides the substrate for the growth of microorganisms, which are the foundation of stream and riparian zone food webs (Cornu et al. 2012).

This data summary describes LWD conditions in project area streams in terms of LWD "pieces", "volume", and "key pieces." LWD pieces measures the frequency with which LWD is encountered in streams, and LWD volume measures amount of LWD present. Large volumes suggest a more persistent LWD presence and higher levels of habitat complexity while lower volumes suggest relatively diffuse and transient wood presence (as smaller wood is more likely to decompose relatively quickly or be moved downstream during high-flow events)(Foster et al. 2001).

Key LWD pieces, by contrast, are more likely to have an intense, sustained impact on stream ecology. Key LWD pieces are defined as those greater than 60 cm (24 in) in diameter and over 10 m (33 ft) long (OCSRI 1997). Larger LWD pieces are less likely to decompose quickly or to be moved during high-flow events. Key LWD pieces also anchor and retain other pieces of wood around which other material is deposited and trapped (Foster et al. 2001). Murphy and Koski (1989) found that key LWD pieces remained in streams significantly longer than smaller LWD, and their natural rates of replenishment was significantly slower than those of smaller pieces. Their research indicated that clear-cut timber harvesting without a stream side buffer could impair the ability of streams to replenish their stores of LWD for up to 250 years.

Alarmingly, a distinct lack of LWD was a defining feature of all evaluated subwatersheds of the project area. While certain individual reaches displayed adequate or occasionally even preferred levels of LWD, the overwhelming majority failed to meet even the minimum benchmark. This suggests that the introduction of LWD (especially key pieces) into stream habitats might be one of the most immediately effective ways to enhance stream habitat in the project area (Figure 27). Another way to encourage the future recruitment of LWD into project area streams is the management of riparian vegetation (see below) for the production of LWD. The simultaneous implementation of both strategies would generate immediate and long term benefits for project area streams and associated fish populations.

Gravel and Sediment in Riffles

Riffles are fast-water stream sections with surface turbulence, shallow, uniform cross-sections, gravel or cobble substrate and gradients of 1% to 4% (Foster et al. 2001). Riffles tend to occur more frequently in tributaries and higher mainstem stream reaches (CoosWA 2006). All salmonid species spawn in gravels associated with riffles, using the gravel to construct redds (depressions into which

Figure 27. Tributary of the West Fork Millicoma River before (left) and after (right) intentional placement of large wood pieces. Source: CoosWA 2009

salmon eggs are deposited and fertilized)(Figure 28). Each salmon species prefers gravel of different sizes, allowing multiple species to reproduce in the same stream reach (Foster et al. 2001). It is therefore important that riffles contain sufficient amounts of gravel to support salmonid reproduction. Koski (1966) conducted studies in three Oregon streams which indicated that the composition of gravel within a redd was the single most important factor affecting the emergence of newly hatched Coho salmon.

Gravel in riffles is most useful when it coincides with low levels of fine sediments such as silt, sand, and fine organics (SSFO). Sediment is a natural component of stream beds, but excessive fine sediment can fill the space between gravel pieces, restricting oxygen flow to fish eggs and the macroinvertebrate communities which are the prey resources for juvenile fish. Koski (1966) also found that sedimentation negatively affected the survival of emerging salmon in Oregon streams, a phenomenon partially attributed to "entombment", as newly hatched salmon starved to death while struggling to emerge from the stream bed.

Sedimentation of streams results from the chronic erosion of stream banks or other erodible watershed feature, or from sudden sediment depositions from episodic events such as landslides or culvert failures. A great deal of sedimentation, however, simply comes from unstable banks, often lacking vegetative cover and easily worn away by stream action.

Road-related Sediment and Bank Stability

Improperly designed or maintained roads and culverts are major sources of excess sediment loading in streams. Sedimentation can occur gradually, as road sediments are washed from road surfaces with traffic and heavy rain. Many factors contribute to sediment-filled runoff from roads, including road surface composition, distance between culverts or ditch reliefs, road slope, nearby forest and plant cover, road age, and road traffic volume (ODF 2003). This sedimentation can also be sudden and disastrous, as when a road fill

Figure 28. Coho building redds in gravel in a coastal Oregon stream. Source: CoosWA 2011a

slumps, a cut bank collapses, or a culvert washes out.

Even the best-constructed roads can pose a sediment hazard when located on high gradients near streams. In 2003, ODF released the Forest Practices Act, which included regulations on forest road construction (see sidebar) (ODF 2003c). ODF recommends maintaining existing roads as one of the best strategies for keeping road-related sediment out of watershed streams (ODF 2003).

A study conducted by CoosWA (2011b) found that ditch-relief culverts (structures designed to divert runoff from ditches to stable areas below roads) are very effective for reducing runoff and sediment delivery to streams. Many of the surveys discussed above recommended ditch-relief culverts.

Unstable banks contribute sediment to streams through collapse, slumping, chronic deterioration, landslides, and earth flows. Although a degree of erosion and occasional landslides occur naturally in healthy, dynamic stream systems, an excess of bank erosion or failure can lead to excessive sediment loading in streams.

The causes of bank instability can be natural or the result of human activity (particularly the clearing of stream side vegetation)(Figure 29). When riparian areas undergo human disturbances like development, agriculture, timber harvest, and fires, they often lack the plant cover necessary to stabilize stream banks. In fact, plant cover is so important to bank stabilization that 99% of uncovered banks in the Catching Slough and Daniels Creek assessments were considered unstable (CoosWA 2008). To become stable, a harvested riparian area must be replanted. In coastal Oregon, replanted stream banks will be considered stable after about 30 years of riparian vegetation regrowth (CoosWA 2008). According to USEPA, healthy watersheds cannot have more than more than 10% unstable (typically uncovered) banks; in some of our watersheds, unstable banks make up twice that percentage (USEPA 2012; CoosWA 2006, 2008, 2011c; Cornu et al. 2012).

<u>Riparian Cover Type and Shade</u>

Riparian vegetation provides a range of functions for steam habitat and water quality: it's the major source of stream LWD, it helps keep stream banks stable (Foster et al. 2001), and it provides important nutrients and habitat for macroinvertebrates and other wildlife (Romero 2003). Vegetation shades streams and pools, moderating temperatures, especially during the summer (Foster et al. 2001).

### *ODF Best Management Practices for Road Construction*

*In order of priority:*

1. *Do not divert surface runoff onto steep slopes, headwalls, or active or recently active landslide areas, since additional water can trigger landslides.*
2. *Always place adequately sized and positioned culverts at stream crossing locations.*
3. *Provide a cross drainage structure immediately upstream from stream crossings to allow muddy, sediment-laden runoff to seep into the forest floor. Cross drains need to be installed as close to stream crossings as possible; allow 15 - 200 ft of ground filtering between the outlet of the cross drain and the high water level of the stream.*
4. *When wet areas are crossed, provide drainage to keep water from affecting the road surface.*
5. *Slope roads so the need for cross drains is minimized; space essential cross drains at intervals to prevent gully formation.*

*Source: ODF 2003*

Figure 29. An eroding stream bank on the Oregon coast, which has been facilitated by the removal of stream bank vegetation. Source: Clackamas County Soil and Water Conservation District 2015

The provision of stream shade is one of the most important functions provided by riparian vegetation, which plays a critical role in maintaining cold water refugia for salmonid and other fishes. Salmonids become stressed above 18˚ C (64˚ F), and the incipient lethal temperature for many salmonids occurs around 24˚ C (75˚ F). Particularly during the summer, intense sunlight combined with relatively low stream flows can make exposed stream reaches uninhabitable for fish. Shade keeps riparian habitats relatively cool and habitable (Foster et al. 2001).

Shrubs and trees in riparian zones provide food and dam building materials for beavers. Beaver activities provide pool complexes used as rearing habitat by juvenile salmonids which also function as sediment traps in stream systems.

Riparian vegetation also enriches local stream system food webs. Red alder (*Alnus rubra*), a common riparian zone tree in coastal Oregon, is notable for fixing nitrogen from the atmosphere which is then contributed to stream systems through extensive leaf litter and woody material (Compton et al. 2003). Large conifers, by contrast, provide the key LWD pieces that act as shelter for salmonids and create essential scour pool habitat (ODF 2003).

The relative scarcity of large conifers in reaches evaluated by CoosWA may be due in part to riparian vegetation clearing for residences and agriculture activities (particularly in the lower reaches), in addition to legacy timber harvests. In large portions of the project area, legacy forestry practices and current timber harvest rules determine the species composition and density of the riparian forests that border project area streams.

**References**

Clackamas County Soil and Water Conservation District. 2015. Is your stream bank heading downstream? Accessed 21 July 2015: https://conservationdistrict.org/2014/is-your-stream-bank-heading-downstream.html

Compton, J. E., M. R. Church, S. T. Larned, and W. E. Hogsett. 2003. Nitrogen Export from Forested Watersheds in the Oregon Coast Range: The Role of $N^2$-fixing Red Alder. *Ecosystems* Vol. 6, Is. 8, pp. 773-785

Coos Watershed Association (CoosWA). 2006. *Coos Bay Lowland Assessment and Restoration Plan.* Coos watershed Association, Charleston, Oregon, pp. 268. http://www.cooswatershed.org/Publications/Coos%20Bay%20Lowland%20Assessment%20and%20Restoration%20Plan01-07.pdf

Coos Watershed Association (CoosWA). 2008. *Catching Slough, Daniel's Creek and Heads of Tide Sub-basin Assessment and Restoration Opportunities.* Coos watershed Association, Charleston, Oregon. pp. 144. http://www.cooswatershed.org/Publications/Assessment%20Body-%20Catching%20Daniels%20HoT%2003-2009.pdf

Coos Watershed Association (CoosWA). 2009. Elk Creek Wood Placement Phase II. Final Grant Report to Oregon Watershed Enhancement Board. Accessed 21 July 2015: http://www.oregon.gov/OWEB/MONITOR/docs/mr_cooswa206-292_finalreport.pdf

Coos Watershed Association (CoosWA). 2011a. Coos Watershed Association Annual Report 2011. Accessed 21 July 2015: http://www.cooswatershed.org/Publications/Annual%20Reports/AnnualReport-11%20Reduced%20File.pdf

Coos Watershed Association (CoosWA). 2011b. *Dellwood Mainline Road Sediment Monitoring Study.* Final Grant Report to Oregon Watershed Enhancement Board. 25 pp. Accessed 3 June 2015: http://www.cooswatershed.org/Publications/Dellwood%20Mainline%20Sediment%20Report%2011-2011.pdf

Coos Watershed Association (CoosWA). 2011c. *Isthmus and Coalbank Slough Sub-basin Assessment and Restoration Opportunities.* Coos watershed Association, Charleston, Oregon. pp. 95. http://www.cooswatershed.org/Publications/Isthmus%20Assessment%20Final%20Draft%206-2011red.pdf

Coos Watershed Association (CoosWA). 2013. CoosWA 2012 Restoration Summary. CoosWA Annual Meeting. Retrieved from: http://www.cooswatershed.org/Publications/Watershed%20Restoration%20Highlights.pdf

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. *Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds.* Report prepared for the Partnership for Coastal Watersheds Steering Committee, South Slough National Estuarine Research Reserve, and Coos watershed Association. pp. 225.

Foster, S. C., C. H. Stein, and K. K. Jones. 2001. Oregon Department of Fish and Wildlife, *A Guide to Interpreting Stream Survey Reports.* Edited by P. A. Bowers. Information Reports 2001-06. Portland.

Koski, K. V. 1966. *The Survival of Coho Salmon (Oncorhynchus Kisutch) from Egg Deposition to Emergence in Three Oregon Coastal Streams.* Thesis (M.S.) – Oregon State University.

Lampman, R. T. 2011. *Passage, Migration Behavior, and Autoecology of Adult Pacific Lamprey at Winchester Dam and within the North Umpqua River Basin, Oregon, USA.* Thesis (M.S.) – Oregon State University.

May, C. L. and D. C. Lee. 2004. "The relationships among in-channel sediment storage, pool depth, and summer survival of juvenile salmonids in Oregon Coast Range streams." North American Journal of Fisheries Management Vol.24, Is. 3, pp. 761-774.

Moore, K. K. Jones, and J. Dambacher. 2006. Oregon Department of Fish and Wildlife, *Methods for Stream Habitat Surveys Aquatic Inventories Project,* Conservation and Recovery Program, Version 15.1 Corvallis, OR. pp. 58.

Murphy, M. L. and K. V. Koski. 1989. "Input and Depletion of Woody Debris in Alaska Streams and Implications for Stream side Management." *North American Journal of Fisheries Management*, Vol. 9, Is. 4, pp. 427-436.

Nickelson, T. E. 1998. *A habitat-based assessment of coho salmon production potential and spawner escapement needs for Oregon coastal streams.* No. 98. Portland: Oregon Department of Fish and Wildlife.

Oregon Coastal Salmon Restoration Initiative (OCSRI). 1997. *The Oregon Plan.* United States National Marine Fisheries Service.

Oregon Department of Environmental Quality (ODEQ). 2014. Oregon's Draft 2012 Integrated Report: Assessment Database and 303(d) List. Retrieved from: http://www.deq.state.or.us/wq/assessment/rpt2012/search.asp

Oregon Department of Fish and Wildlife (ODFW). 2013. Oregon Plan Habitat Reach Summary Data Attributes - Summer Habitat Surveys 1998-2013 [Data set]. Accessed 15 June 2015: http://oregonstate.edu/dept/ODFW/freshwater/inventory/orplan/orpln-hab.htm

Oregon Department of Forestry (ODF). 2003. *Elliot State Forest Watershed Analysis.* pp. 288. http://www.oregon.gov/ODF/Documents/WorkingForests/ElliottStateForestWatershedAnalysis.pdf

Oregon Department of Forestry (ODF). n.d. GIS Data Export, accessed 11 May 2015: http://www.oregon.gov/ODF/AboutODF/Pages/ExtractData.aspx

The Oregon Plan for Salmon and Watersheds (Oregon Plan). 2012. Private Forest Landowners and the Oregon Plan: Oregon Plan Actions for Landowners, By Landowners. 24pp. Accessed 21 July 2015: http://www.oregon.gov/ODF/Documents/WorkingForests/Oregon_Plan_PFguide.pdf

Oregon Watershed Restoration Inventory (OWRI). 2013. Oregon Watershed Resoration Inventory. Accessed 10 June 2015: http://www.oregon.gov/oweb/monitor/pages/owri.aspx#Get_Data_from_OWRI

Oregon Watershed Restoration Inventory (OWRI). 2015. Projects with Road and Fish Passage Crossing Improvements. Unpublished data prepared by OWRI coordinator.

Robinson, J. 2009. Upper Watershed Restoration Action Plan. South Slough National Estuarine Research Reserve, Charleston, OR. 107pp.

Rodgers, J. D., K. K. Jones, A. G. Talabere, C. H. Stein, and E. H. Gilbert. 2005. *Oregon Coast Coho Assessment: Habitat.* Oregon Plan for Salmon and Watersheds, Oregon Department of Fish and Wildlife, Salem.

Romero, N. 2003. *Seasonal Influences on Food Availability and Diet of Coastal Cutthroat*

*Trout in Relation to Riparian Vegetation.* Thesis (M.S.) – Oregon State University.

Swales, S. and C. D. Levings. 1989. “Role of off-channel ponds in the life cycle of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Coldwater River, British Columbia.” *Canadian Journal of Fisheries and Aquatic Sciences* 46, 232–242.

U.S. Environmental Protection Agency (USEPA). 2012. Channel Processes: Streambank Erosion. Viewed 29 May 2015: http://water.epa.gov/scitech/datait/tools/warsss/streamero.cfm

Verhille C. E., J. B. Poletto, D. E. Cocherell, B. DeCourten, S. Baird, J. J. Jr. Cech, and N. A. Fangue. 2014. “Larval green and white sturgeon swimming performance in relation to water-diversion flows.” *Conservation Physiology*, Vol. 2.

Weybright, A. D. 2011. *Juvenile Coho Salmon Movement, Growth and Survival in a Coastal Basin of Southern Oregon.* Thesis (M.S.) -- Oregon State University.

# **Chapter 12:** Vegetation in the Lower Coos Watershed

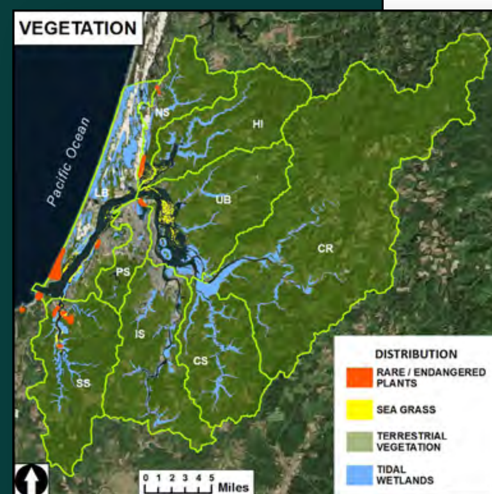
*Erik Larsen, Jenni Schmitt, Craig Cornu, Hannah McDonald, Colleen Burch Johnson - South Slough NERR*

***Rare and Endangered Plants:*** *Three local plant species are listed as threatened or endangered. Two additional listed species occur south of the project area; suitable habitats for these species occur within the project boundary.*

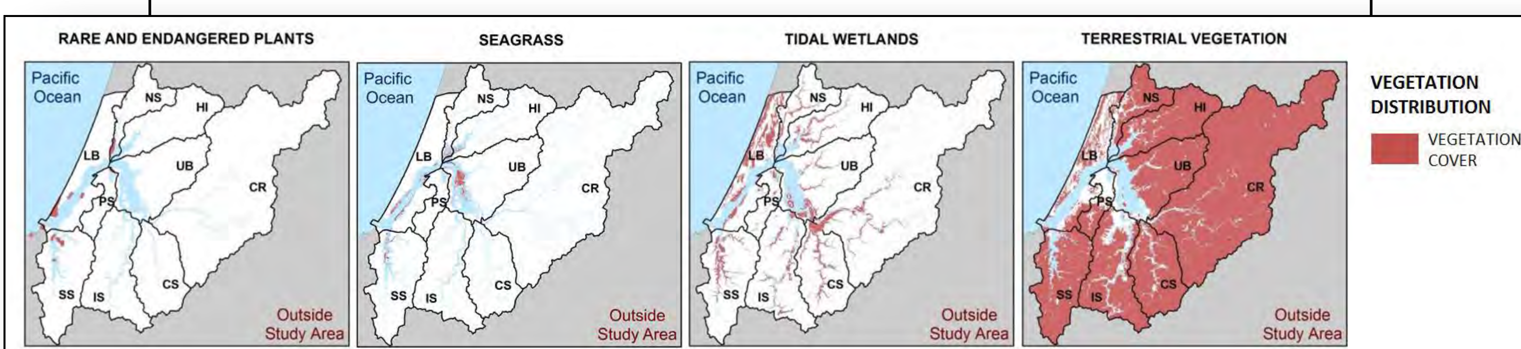
***Seagrasses and Algae:*** *Where data are available, eelgrass meadows appear stable and becoming denser; more data are needed. Algae are abundant, not necessarily indicating poor water quality.*

***Tidal Wetland Vegetation:*** *Much of the historic wetland area in the Coos estuary has been permanently converted for human uses. Surviving wetlands host diverse and relatively stable plant communities.*

***Terrestrial Vegetation:*** *The spatial extent of* ***m****ature forests continues to decline, becoming more fragmented; diseases (e.g., Swiss needle cast) limit production and cause high tree mortality.*




Subsystems: CR- Coos River, CS- Catching Slough, HI- Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay



## Chapter 12: Vegetation in the Lower Coos Watershed

*This chapter includes four data summaries:* ***Rare and Endangered Plants, Seagrasses and Algae, Tidal Wetland Vegetation,*** *and* ***Terrestrial Vegetation—*** *which describe the status and trends (where data allow) of tidal wetland and upland vegetation in the lower Coos watershed.*

Rare and Endangered Species: This data summary compiles information on five threatened or endangered plant species that occur within or near the project area (pink sand verbena, salt marsh bird's beak, silvery phacelia, Western lily, and wolf's evening primrose).

Information used to compile this summary came primarily from agency reports. The majority of information for the only federally listed species (Western lily – *Lilum occidentale*) came from the most current United States Fish and Wildlife (USFWS) Western lily management report (USFWS 2009). Information for the remaining four species were compiled from a variety of agency reports (Rittenhouse 1999, BLM 2006, Brown et al. 2013, ORBIC 2013), including agency reports prepared by the Institute for Applied Ecology (Giles-Johnson et al. 2013; Giles-Johnson and Kaye 2012; Giles-Johnson et al. 2011; Kaye et al. 2006) and by Currin and Meinke (2004). Other sources included peer-reviewed literature (Chuang and Heckard 1971, Rittenhouse 1996), book sections (Imper 1997a, 1997b; Kaye 2004), and a graduate student thesis (Julian 2012).

Seagrasses and Algae: The spatial extent of eelgrass in the Coos estuary has been mapped by the United States Environmental Protection Agency (USEPA)(Clinton et al. 2007). Eelgrass monitoring data are available through the South Slough National Estuarine Research Reserve (SSNERR), which has participated in SeagrassNet (a global eelgrass monitoring program) since 2004 (SSNERR 2015). The SeagrassNet monitoring data have supported a number of publications and unpublished technical reports (Rumrill 2006; Rumrill and Sowers 2008; Cornu et al. 2012). Historic information about algae in the Coos estuary was provided by a 1944 publication and dissertations from the 1980s (Sandborn and Doty 1944; Pregnall 1983; Hodder 1986). More current algae data were provided by the SSNERR Site Profile (Rumrill 2006) as well as a report from the Western Ecology Division of USEPA (Nelson et al. 2007).

Tidal Wetland Vegetation: The most comprehensive collection of tidal wetland vegetation data came from a report compiled by SSNERR and the Confederated Tribes of Coos, Lower Umpqua, and Siuslaw Indians (CTCLUSI)(Laferriere et al. 2010). This report was supplemented by other SSNERR publications and technical reports (Cornu 2005a, 2005b, 2005c, 2005d; Hamilton 2011). Additional data are available from Coos Watershed Association publications (CoosWA 2006, 2010).

USFWS provided information about the spatial extent of wetlands in the project area (USFWS 1979, 2003). Estimates of historical wetland loss (within the project area, state-wide, and regionally) were provided by peer reviewed literature and technical reports (Hofnagle et al. 1976, NRC 1996, Good 2000, Borde et al. 2003, CoosWA 2006).

Terrestrial Vegetation: This data summary discusses available information on forest structure, forest fragmentation, vegetation type, species and common associates, and the status and causes of damaged and diseased forests.

The National Oceanic and Atmospheric Administration's (NOAA's) Coastal Change and Analysis Program (C-CAP) provided land cover data (raster-based maps) from remote sensing imagery. These data, collected at five year intervals, are intended to identify changes to landscape patterns and habitats on large scales (e.g., watershed or county scales). Overall the raster data have an 85% accuracy, but this varies by location and date. Horizontal accuracy of the 1996 and 2010 land cover datasets was 2 pixels or less. Horizontal accuracy of the 1996 and 2010 forest fragmentation datasets was 1 pixel or less.

Oregon State University's Department of Forest Ecosystems and Society in collaboration with the United States Forest Service's Pacific Northwest Research Station model forest species coverage for western Oregon as part of the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) program (http://lemma.forestry.oregonstate.edu/). LEMMA's models characterize a wide variety of species attributes for the region's terrestrial habitats including conifer richness, hardwood richness, trees species percent coverage, shrub coverage, forb coverage, and forest type.

The LEMMA program also provided spatial forest structure data, which were analyzed using GIS methods. Structure information, including mature forests cover, late successional/old growth forest cover, and non-forest land, was compared to ownership (county lands were moved from Private to Local Government).

The Oregon Department of Forestry (ODF) flew Swiss needle cast (SNC) aerial surveys using two mile transects across Oregon and northern California (Kanaskie and Norlander 2014). Observers approximated coverage of yellowed foliage onto maps based on the aircraft's position. They also classified the disease as either moderate or severe. A random sample of 14 mapped polygons was ground-checked – all contained Swiss needle cast disease.

The United States Department of Agriculture (USDA) and ODF make forest disease aerial survey data (1980-2013) available online (USFS 2014). Aerial digital mapping methods were the same as described above from 2003-13. Prior to 2003, data were collected manually by two aerial observers sketching diseased areas on paper, then later combining their observations into one map. Because of the discrepancy in the two methods, only 2003-13 data were used in the Terrestrial Vegetation data summary.

**Data Gaps and Limitations**

Rare and Endangered Species: Local rare and endangered species population data were compiled from surveys completed as long ago as the early 1990s and as recently as 2013, depending on species and location. Identifying status and trends for many of these species was challenging. For example, of the multiple known populations of salt marsh bird's beak (*Chloropyron maritimum ssp. palustre*), only one population is regularly surveyed, and most populations have not been surveyed since 1999.

Another major limitation is lack of known extent of these plant populations, especially on private land. This is particularly important as newly discovered populations are most likely to occur on private lands, since most habitats have already been extensively surveyed on public lands (USFWS 2009).

Aquatic Vegetation: The data describing the spatial extent of seagrasses are outdated. The most current characterization of the distribution of seagrasses in the project area came from an analysis of 2005 aerial photos (Clinton et al. 2007). It won't be until another eelgrass mapping effort is completed for the Coos estuary (local agencies are currently working to secure funding) that researchers will be able to characterize trends in the spatial distribution and relative density of eelgrass beds.

SeagrassNet data from a single site in South Slough (SSNERR 2015) are the only long-term time-series data available that characterize eelgrass meadows in the Coos estuary. As a result, the scope of long-term eelgrass trends assessments are limited exclusively to the South Slough Subsystem (Rumrill 2006; Rumril and Sowers 2008; Cornu et al. 2012; SSNERR 2015). Since habitat conditions in South Slough are not necessarily representative of the whole system, eelgrass trends may be distinct in different parts of the estuary. More information is needed to determine the status of eelgrass in the estuary as a whole.

Historic information about the production of algae in the lower Coos estuary is available from the 1940s and the 1980s (Sandborn and Doty 1944; Pregnall 1983; Hodder 1986). More recently, Hessing-Lewis et al. (2011) have studied algae-eelgrass interactions. However, no recently collected information describing the extent or production of algae in the Coos estuary is currently available.

Tidal Wetland Vegetation: Analysis of the National Wetlands Inventory (NWI) habitat classification shapefiles is limited by uncertainties in potential differences in how wetlands were classified in 1979 and in 2003. For example, the amount of "unclassified" land increased by more than 150,000 acres from 1979-2003 (USFWS 1979, 2003). Due to this sizable change, it's difficult to tell if analytical results indicating apparent losses of any wetland class between 1979 and 2003 represent actual trends or simply a reclassification from a formerly classified habitat to an "unclassified" habitat. Similarly, reclassification from one habitat class to another may appear as an apparent gain or loss, but could reflect a simple reclassification without any net change in wetland area. Additional work, beyond the scope of this project, needs to be undertaken to clarify the NWI classifications for the Coos estuary.

Similarly, for Hamilton's (2011) evaluation of tidal wetland plant community diversity trends in South Slough sites, important methodological differences between survey years complicated her analyses. Specifically, she noted that plot size bias may have influenced estimates of diversity indices. She adds that the effects of marsh surface elevation/inundation period were not controlled for during data collection.

It should be noted that the Laferriere et al. (2010) study was designed primarily to assess the status of *Assiminea parasitologica* (AP), a small, invasive snail native to Japan. Although vegetation sampling occurred in a variety of habitats, including both low and high marshes across a wide salinity range, data collection was limited by design to areas that are most likely inhabited by AP. For more information about AP, refer to Chapter 18: Non-Indigenous/Invasive Species.

Unfortunately, there is no written historic record of marsh vegetation in the lower Coos estuary. Consequently, it is difficult to determine the precise amount of wetland within the project area that has been lost to other uses since the early 19th century. Analyses of sediment and plant material and other analytical techniques indicate that marshes within the lower Coos watershed have been severely disturbed by human activities (Hofnagle et al. 1976, Good 2000, CoosWA 2006). Arriving at an exact estimate of wetland acres converted has proven to be difficult in the absence of a comprehensive historical reconstruction of the original extent of tidal wetlands in the Coos estuary (e.g., Benner 1992).

In particular, there is little information available about the historic extent of scrub-shrub and forested tidal wetlands in the Coos estuary, which would have been almost entirely converted prior to NWI wetland mapping in 1979. The Tidal Wetland Vegetation data summary does not reflect the true loss of those habitats and recognizes the omission as a critical data gap.

Finally, it is important to note that the studies used in this data summary do not all make use of the same standardized sampling or analysis method. Care should be taken when comparing the results and conclusions of one study against another.

<u>Terrestrial Vegetation</u>: LEMMA models are most useful (and accurate) at landscape or regional scales, and are considered much less useful at the stand scale (LEMMA 2014a, 2014b). The project area boundaries are slightly smaller than a landscape scale so there will be some discrepancies between the modeled attributes reported and those observed on the ground. In addition, the models only apply to lands that currently support at least 10% tree cover. The purpose of using the LEMMA data was to compile a picture of species distributions for the project area as a whole.

Aerial surveys of SNC disease are a conservative estimate since only those diseased trees visible from the air are counted. The same holds true for aerial surveys conducted for other damaged trees (e.g., bears damage is an underestimate). In addition, accuracy of aerial surveys depends on surveyor experience (sketch-mapping is highly subjective), weather, time of day, time of year and visibility. Observers evaluate and record forest health at a rate of 30 seconds/mile. Accuracy assessments have not been completed for the USFS 2014 annual surveys. However, the data are ground-checked to ensure appropriate coding on the maps. The map information should only be used as an indicator of insect and disease activity and need to be ground verified for other uses.

<u>Old Growth Forests</u>: The old growth forest dataset (LEMMA 2014b) was developed for regional monitoring of old growth forest status and trends. Spatial accuracy is based on a regional scale and may be suitable for use at 5th or 6th field watershed scales. The entire project area is slightly larger that a 5th field watershed, so fits within that criteria, though the subsystems we consider are often times smaller (e.g. Pony subsystem is a 7th field watershed) and so accuracy becomes questionable at that scale.

**References**

Benner, P. A. 1992. Historical reconstruction of the Coquille river and surrounding landscape. Sections 3.2 and 3.3 in: Oregon Department of Environmental Quality (ed.). Near coastal waters national pilot project: The Coquille river, Oregon. Action plan for Oregon coastal watersheds, estuary, and ocean waters, 1988-1991. Oregon Department of Environmental Quality, Portland.

Borde, A. B., R. M. Thom, S. Rumrill, and L. M. Miller. 2003. Geospatial Habitat Change Analysis in Pacific Northwest Coastal Estuaries. Estuaries 26 (4B): 1104-1116.

Brown, J., K. Amsberry and R. J. Meinke. 2013. Recovery-Based Propagation and Outplanting of *Lilium occidentale*: Preparation for Outplanting Year 3 (2011). Oregon Department of Agriculture, Corvallis. 21 pp.

Bureau of Land Management (BLM). 2006. Final North Spit Plan: An Update to the Coos Bay Shorelands Plan of 1995. Coos Bay District Office, North Bend, Oregon . 104 pp.

Chuang, T. I. and L. R. Heckard. 1971. Observations on Root-Parasitism in *Cordylanthus* (Scrophulariaceae). American Journal of Botany. 58: 218-228.

Clinton, P. J., D. R. Young, D. T. Specht, and H. Lee. 2007. A Guide to Mapping Intertidal Eelgrass and Nonvegetated Habitats in Estuaries of the Pacific Northwest USA, U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-07/062, 2007

Coos Watershed Association (CoosWA). 2006. Coos Bay Lowland Assessment and Restoration Plan. March, 2006, Charleston, OR: Coos Watershed Association. Accessed 07 April 2015 from http://www.cooswatershed.org/publications.html

Coos Watershed Association (CoosWA). 2010. Coos Bay Tidal Wetlands Assesment: Isthmus Slough, Coalbank Slough, Catching Slough, and Echo Creek Sub-basins. [Draft of a technical report]. May, 2010, Charleston, OR: Coos Watershed Association. Accessed 07 April 2015 from http://www.cooswatershed.org/publications.html

Cornu, C. E. 2005a. Restoring Kunz Marsh. South Slough NERR Coastal Resource Management Series. CRMS-2005-1. Coos Bay, Oregon.

Cornu, C. E. 2005b. Restoring Anderson Creek Marsh. South Slough NERR Coastal Resource Management Series. CRMS-2005-3. Coos Bay, Oregon.

Cornu, C. E. 2005c. Restoring Cox, Dalton, and Fredrickson Creek Marshes. South Slough NERR Coastal Resource Management Series. CRMS-2005-2. Coos Bay, Oregon.

Cornu, C. E. 2005d. Winchester Tidlands Restoration Project: Introduction. South Slough NERR Coastal Resource Management Series. Accessed 8 April 2015 from http://www.oregon.gov/dsl/SSNERR/Pages/CRMSmain.aspx

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watershed. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Associations. 225 pp.

Currin, R. and R. Meinke. 2004. Establishment of Two Experimental Populations of Wolf's Evening Primrose (*Oenothera wolfii*). Final Report for U.S. Fish and Wildlife Service. 32 pp.

Giles-Johnson, D. E. L., A. S. Thorpe, and E. C. Gray. 2011. Habitat Monitoring and Improvement for *Cordylanthus maritimus ssp*. palustrs: 2011 Progress Report. Progress Report. Prepared by Institute for Applied Ecology for Bureau of Land Management; Corvallis, Oregon. 29 pp.

Giles-Johnson, D. E. L. and T. N. Kaye. 2012. *Abronia umbellata* var. *breviflora* on the Oregon Coast: Reintroduction and Population Monitoring. Prepared by the Institute for Applied Ecology for Bureau of Land Management, US Fish and Wildlife Service, USDA Forest Service and Oregon Department of Parks and Recreation. 74 pp.

Giles-Johnson, D. E. L., E. C. Gray, and T. N. Kaye. 2013. Habitat Monitoring and Improvement for *Cordylanthus maritimus ssp*. palustris: 2012 Progress Report. Prepared by Institute for Applied Ecology for Bureau of Land Management; Corvallis, Oregon. 48 pp.

Good, J. W. 2000. Summary and current status of Oregon's estuarine ecosystems. Pp. 33-44 in: The Oregon State of the Environment Report 2000. 214 pp. Oregon Progress Board, Salem.

Hamilton, Judy. 2011. SWMP Bio-monitoring: Final Report. [Un-published report from South Slough National Estuarine Research Reserve]. Accessed at the Estuarine and Coastal Sciences Laboratory of SSNERR. 10 March, 2015.

Hessing-Lewis, Margot L., Sally D. Hacker, Bruce A. Menge, and Steve S. Rumrill. 2011. Context-Dependent Eelgrass-Macroalgae Interactions Along an Estuarine Gradient in the Pacific Northwest, USA. Estuaries and Coasts 34:1169-1181.

Hodder, J. 1986. Production biology of an estuarine population of the green alga, Ulva spp. in Coos Bay, Oregon. Ph.D. thesis, University of Oregon. 106 pp.

Hofnagle, J., R. Ashley, B. Cherrick, M. Gant, R. Hall, C. Magwire, M. Martin, J. Schrag, L. Stuntz, K. Vanderzanden, and B. Van Ness. 1976. A comparative study of salt marshes in the Coos Bay Estuary. National Science Foundation Student Originated Project. Summer, 1976. University of Oregon, Oregon Institute of Marine Biology, Charleston, Oregon.

Imper, D. K. 1997a. 'Ecology and Conservation of Wolf's Evening Primrose in Northwestern California', in Kaye, T.N., A. Liston, R.M. Love, D.L. Luoma, R.J. Meinke, and M.V. Wilson (eds.), Conservation and Management of Native Plants and Fungi. Native Plant Society of Oregon, Corvallis. 296 pp.

Imper, D. K. 1997b. 'Ecology and Management of the Endangered Western Lily (*Lilium occidentale*) in Northwestern California', in Kaye, T.N., A. Liston, R.M. Love, D.L. Luoma, R.J. Meinke, and M.V. Wilson (eds.), Conservation and Management of Native Plants and Fungi. Native Plant Society of Oregon, Corvallis. 296 pp.

Julian, L. S. 2012. A Comparison of Bee Fauna in Two Northern California Coastal Dune Systems. Thesis (M.S.)--Humboldt State University.

Kanaskie, A. and D. Norlander. 2014. 2014 Swiss Needle Cast Aerial Survey. Oregon Department of Forestry, Salem. 5 pp.

Kaye, T. N. 2004. 'Reintroducing the Endangered Pink Sand-Verbena to Pacific Coast Beaches: Direct Seeding and Out-Planting', in Brooks, M.B., S.K. Carothers, and T. LaBanca (eds.), The Ecology and Management of Rare Plants of Northwestern California: Proceedings from a 2002 Symposium of the North Coast Chapter of the California Native Plant Society, California Native Plant Society, Sacramento, CA, p131-139.

Kaye, T., N. Brian, D. Segotta, and N. Bacheller. 2006. Conservation Stgrategy for Pink Sand-Verbana (*Abronia umbellata ssp. breviflora*). Prepared by the Institute for Applied Ecology for Bureau of Land Management, USFS Siuslaw National Forest, and Oregon Department of Parks and Recreation. 44 pp.

Laferriere, Alix M., Heidi Harris, and John Schaefer. 2010. Early detection of a new invasive mesogastropod, *Assiminea parasitological*, in Pacific Northwest estuaries. [Unpublished technical report from South Slough National Estuarine Research Reserve and Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians]. Accessed 23 March 2015 from https://scholarsbank.uoregon.edu/xmlui/handle/1794/10146

Landscape Ecology, Modeling, Mapping and Analysis (LEMMA). 2014a. GNN Species Maps, GIS data files, viewed 4 December 2014: http://lemma.forestry.oregonstate.edu/data/species-maps

Landscape Ecology, Modeling, Mapping and Analysis (LEMMA). 2014b. GNN Structure (Species-Size) Maps, GIS data files, viewed 4 December 2014: http://lemma.forestry.oregonstate.edu/data/structure-maps

National Research Councile (NRC). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

Nelson, Walter G., Henry Lee II, Janet O. Lamberson, Faith A. Cole, Christine L. Weiloefer, and Patrick J. Clinton. 2007. The Condition of Tidal Wetlands of Wasthington, Oregon, and California – 2002. Office of Research and Development, National Health and Environmental Effects Research Laboratory, EPA/620/R-07/002.

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Institute for Natural Resources, Portland State University, Portland, OR. 111 pp.

Pregnall, A. M. 1983. Production ecology of green macroalgal mats (*Enteromorpha spp.*) in the Coos Bay, Oregon estuary. Ph.D. thesis, University of Oregon. 145 p.

Rittenhouse, B. 1996. Botanizing the Southern Oregon Coast (Coos Bay to Port Orford). Kalmiopsis. 6:1-8.

Rittenhouse, B. 1999. Status of Salt Marsh Bird's Beak (*Cordylanthus maritimus ssp. palustris*) in the Coos Bay Estuary. Status Report by Bureau of Land Management, Coos Bay office. 10 pp.

Rumrill, S. S. 2006. The Ecology of the South Slough Estuary: Site Profile of the South Slough National Estuarine Research Reserve. Salem, Oregon: NOAA, Oregon Department of State Lands Technical Report, 238p.

Rumrill, Steven S. and Derek C. Sowers. 2008. Concurrent Assessment of Eelgrass Beds (*Zostera marina*) and Salt Marsh Communities along the Estuarine Gradient of the South Slough, Oregon. Journal of Coastal Research. 55: 121-134.

Sanborn, E. I. and M. S. Doty. 1944. The marine algae of the Coos Bay – Cape Arago region of Oregon. Corvallis, OR: Oregon State University (Collection Records). 23 pp

South Slough National Estuarine Research Reserve (SSNERR). 2015. SeagrassNet eelgrass Monitoring Raw Data. [Unpublished data]. Accessed at the Estuarine and Coastal Sciences Laboratory of SSNERR 15 April 2015.

United States Fish and Wildlife Service (USFWS). 1979. National Wetlands Inventory Shapefiles. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

United States Fish and Wildlife Service (USFWS). 2003. National Wetlands Inventory Shapefiles. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

United States Fish and Wildlife Service (USFWS). 2009. *Lilium occidentale* (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Arcata, CA. 48 pp.

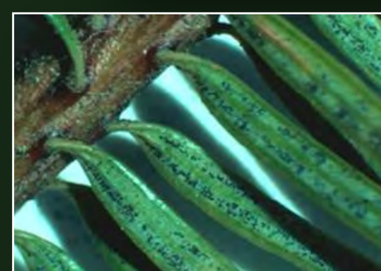
United States Forest Service (USFS). 2014. Aerial Survey Detection Data, GIS shapefiles, viewed 24 November 2014: http://www.fs.usda.gov/detail/r6/forest-grasslandhealth/insects-diseases/?cid=stelprdb5448186

# How Local Effects of Climate Change Could Affect Vegetation in the Lower Coos Watershed

*Several anticipated climate-related changes will potentially affect vegetation in the lower Coos watershed:*

- *Climate change will likely alter seasonal air temperatures and watershed hydrology, which will affect the presence, distribution, and health of local plant species.*
- *Tidal wetland habitats are particularly vulnerable to sea level rise. However, the fate of the plant communities associated with those habitats has not yet been determined.*
- *Elevated atmospheric carbon dioxide, a greenhouse gas that contributes to climate change, may encourage plant growth if other changing conditions do not limit plant production.*
- *Climate change may result in additional stressors for already endangered plant species (e.g., Western lily).*

Tidal marsh elevation data collection. SSNERR Photo.



Swiss needle cast pathogen on Douglas fir needles. Photo: OR Dept of Forestry.

Climate change has the distinct potential to affect local vegetation communities through changing weather patterns and watershed hydrology, increased air temperatures, and rising sea level. Some of these changes are likely to be exacerbated by human activities (Erwin 2009, Scavia et al. 2002). However, determining the specific effects of climate change on local tidal vegetation will be difficult since climate change models are designed to pre-

*Uncertainty in Predicting Local Effects of Climate Change*

*There is inherent uncertainty in predicting what the local effects of climate change are likely to be. The uncertainties generally fall into three categories: 1) Natural variability of the earth's climate; 2) Climate sensitivity (how the earth's climate system responds to increases in future greenhouse gas levels); and 3) Future greenhouse gas emissions.*

*To manage for these uncertainties, climate scientists use multiple models ("multi-model ensembles") that incorporate the estimated range of possible natural variability, climate sensitivity, and future greenhouse gas emission values when investigating climate-related change. The models typically generate a range of values for potential future air temperatures, ocean surface temperatures, sea level rise, etc., which naturally become increasingly variable the longer into the future the model predicts. This approach gives communities a range of projections to consider when developing climate change vulnerability assessments and adaptation plans.*

*Sources: Sharp 2012, Hawkins and Sutton 2009*

dict change at global or regional levels, not at watershed scales (see sidebar). In addition, coastal watershed plant communities are adapted to variables associated with local topography, as well as exposure to sun, wind, and precipitation; they will have highly variable responses to the local effects of climate change (Scavia et al. 2002, USGS n.d.).

This uncertainty notwithstanding, it's widely accepted that certain plant communities are particularly vulnerable to climate change. For example, tidal wetland vegetation bordering hard coastal defenses such as dikes, seawalls, and other armoring structures are unlikely to be permitted to migrate inland in response to rising sea level (Scavia et al. 2002, Erwin 2009). Rising air temperatures or changing groundwater hydrology may also reduce the viability of habitats supporting already endangered species such as the Western lily (*Lillium occidentale*), and may impede their reproductive function (USFWS 2009).

Changing Weather Patterns and Altered Hydrology

In addition to being vulnerable to sea level rise, tidal wetlands will be affected by the expected increase in the frequency and severity of extreme weather events and associated wind-generated waves, which are expected to erode exposed wetlands and potentially alter their hydrological characteristics (see sidebar) (Erwin 2009, Scavia et al. 2002). Research suggests that extreme hydrological changes (e.g., changes in the frequency and duration of storm-generated flooding) can cause "sudden and dramatic changes in the abundance

*Changes in Precipitation Timing, Frequency and Intensity*

*In the future, precipitation in coastal Oregon is expected to remain a predominately wintertime phenomenon (i.e., most precipitation will continue to occur in the winter). However, the extent to which precipitation timing, frequency and intensity on the Oregon coast may change in the future remains uncertain. There is evidence that high-intensity storms are becoming more frequent, and that the frequency of weak to moderate-strength storms is declining.*

*Sources: Sharp 2012, OCCRI 2010, OSU 2005*

and spatial arrangement of dominant plants" (Gitlin et al. 2006). Storm-generated alterations to freshwater runoff have been shown to change the salinity gradient in estuaries, potentially resulting in recruitment of freshwater plant species in brackish and saline habitats (Scavia et al. 2002, Dettinger and Cayan 1995).

Although most research focuses on the anticipated effects of extreme weather events, experts point out that even low energy storms can create flooding events, which can reduce habitat availability (especially if these events correspond with high tides)(USGS n.d.). One important caveat is that these flood events also deliver sediment to marshes, which is an essential process to assure their persistence (Scavia et al. 2002, USGS n.d.).

Changing weather patterns are likely to affect many other important natural processes that influence the productivity and function of marsh habitats, including evapotranspiration, biogeochemical processes, sediment accumulation, fire regime, tidal and storm water inundation regime, and wave energy (Burkett and Kusler 2000, Gornitz 2001, Gornitz et al. 2001, IPCC 1998, Karl et al. 1995, USGCRP 2000, USGS n.d.). The persistence of eelgrass (*Zostera marina*) beds that are relatively exposed (e.g., in the South Slough Subsystem) may be jeopardized if more frequent and intense storms result in larger storm-generated waves propagating through the lower estuary (Cornu et al. 2012).

Altered weather patterns have been known to effect "phytopathology" (i.e., diseases and infections in plants). Although research on the anticipated effects of climate change on phytopathology is limited, the existing literature generally concludes that climate change is likely to alter plant-pathogen interactions (Coakley et al. 1999, Chakraborty et al. 2000, Garrett et al. 2006). Abiotic stressors resulting directly from climate change (e.g., warmer temperatures and drought) may alter plant susceptibility to pathogens (Garrett et al. 2006). Climate-related changes may also affect phytopathology indirectly by altering the structure of existing plant communities. For example, research shows that increased plant density tends to create wetter conditions in vegetated areas, thus increasing the likelihood of infection from certain pathogens (e.g., foliar pathogens)(Burdon 1987, Huber and Gillespie 1992). These anticipated changes may exacerbate phytopathology concerns that already exist in the project area. In particular, prolonged wet weather in spring is very conducive to Swiss needle cast infection (Stone et al. 2008, Zhao et al. 2011), which causes premature needle loss (i.e. "casting" of needles) in Douglas fir trees, resulting in substantially reduced growth and potentially eliminating the ability to compete with neighboring trees (Shaw 2008).

Increasing Temperatures

Although the long term effects of elevated atmospheric carbon dioxide ($CO_2$) on aquatic, emergent, and terrestrial plant growth, nutrient cycling, and other ecosystem processes are uncertain, some research suggests that more $CO_2$ (a condition often associated with warmer temperatures) may correspond to greater plant growth in forested and emergent wetland systems, especially in seedlings (Rozema et al. 1990, 1991; Farnsworth et al. 1996; Ball et al. 1997; Scavia et al. 2002). However, it's important to note that these benefits may be offset by other climate-related changes that would limit plant production (e.g., changes in precipitation, nutrient delivery)(Scavia et al. 2002).

In some cases, the persistence of endangered species may be jeopardized by increasing local air temperatures. For example, researchers in northern California suggest that springtime air temperature explains much of the variation in the timing of Western lily reproduction across its range (Bencie and Imper 2003a, 2003b). Since the Western lily requires specific temperatures to facilitate reproduction, it's likely that climate change will add additional stressors to this endangered species (USFWS 2009).

Sea Level Rise

Sea level rise (SLR) poses "the most obvious threat to coastal wetlands" (see sidebar) (Scavia et al. 2002). Although the magnitude of SLR on the Pacific coast varies substantially according to varying rates of tectonic elevation change (SLR at Astoria, OR = -0.27 mm/yr; SLR at Eureka, CA = +4.32 mm/yr), it's very likely that much of the Pacific Northwest will experience more frequent occurrences of erosion and tidal inundation by 2100 (Mote et al. 2008, Glick et al. 2007, Dalton et al. 2013). Under modest to extreme SLR scenarios, experts project that nearshore habitats on the Oregon coast could face a "dramatic shift in their composition" (Dalton 2013)(see sidebar).

Many of the region's tidal freshwater marshes and swamps are expected to convert to brackish marshes due to seawater intrusion from rising sea levels (Glick et al. 2007, Scavia et al. 2002). These changes have the potential to reduce the extent of tidal freshwater marshes and swamps if those habitats are

*Sea Level Rise*

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, the National Research Council (NRC), predicted SLR rates as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100 for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary).*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

prevented (by hardened shorelines like dikes, sea walls, and other structures) from migrating further inland in response to SLR (Glick et al. 2007, Scavia et al. 2002, Erwin 2009, Dalton et al. 2013, Shaughnessy et al. 2012, Hartig et al. 2002). Because inland migration will be possible for tidal wetlands in some systems and the elevation of some wetlands will keep pace with SLR though natural processes (vertical accretion- see sidebar), the changes described above will not necessary result in the loss of wetland area (Reed 1990, Erwin 2009).

*Marsh Accretion and Sea Level Rise (SLR)*

*Vegetated tidal wetlands form and are maintained through the accumulation of tidally-delivered sediments and organic material in a process called "vertical accretion." The rate of vertical accretion determines the fate of tidal wetlands in the face of sea level rise (SLR). Wetlands whose vertical accretion rates keep pace with SLR will remain largely unaffected, while those not keeping pace will change dramatically. Although the fate of southern Oregon coast's tidal wetlands remains uncertain, researchers suggest substantial change may occur under moderate and extreme SLR scenarios. Researchers estimate that Bandon Marsh National Wildlife Reserve may lose anywhere from 19% (+40 cm SLR) to 92% (+200 cm SLR) of its forested swamp habitat by 2100. Further research suggests that high, mid, and low marsh emergent plant communities on Bull Island on the Coos estuary (Upper Bay subsystem) could convert entirely to a low marsh plant community under moderate SLR scenarios (+ 63 cm), and convert entirely to non-vegetated mudflat under extreme SLR scenarios (+ 142 cm).*

*Sources: Dijkema 1987, Kolker et al. 2009, Erwin 2009, Reed 1990, USGS n.d., Scavia et al. 2002, Clough and Larson 2010, Buffington et al. 2015*

While wetland areas may not change dramatically, even small persistent changes in sea level are likely to affect the distribution of species with narrowly defined habitat requirements.

Changes in plant community distribution are particularly important for rare and endangered species. Two rare plant species, silvery phacelia (*Phacelia argentea*) and wolf's evening primrose (*Oenothera wolfii*) occur just south of the project area. If climate change results in favorable conditions for the northward expansion of these species, the project area could represent an important refuge for plant species struggling to survive in nearby ecosystems. However, it should also be noted that climate-related habitat changes could have deleterious effects on rare and endangered plant species that are not well suited to adaptation (e.g., Western lily)(USFWS 2009).

SLR may be intensified by cyclical long term climatic patterns (see sidebar). For example, Barnard et al. (2011) note that El Niño events may increase regional sea level by as much as 30 cm (~12 in) for several months at a time. Historically, these events have been associated with increased coastal erosion and flooding. They're likely to periodically intensify the effects of SLR in the future (Dalton et al. 2013).

*El Niño Southern Oscillation*

*The El Niño Southern Oscillation (ENSO) is a cyclical climatic pattern that affects weather and ocean currents in and around the Pacific ocean. ENSO is an event that tends to occur every two to seven years and is characterized by anomalous warming of tropical Pacific waters. Locally, this warming is associated with drier conditions, warmer temperatures, and lower precipitation and streamflow, although it can also result in greater winter "storminess" and flooding.*

*Source: Mysak 1986*

## References

Ball, M.C., M.J. Cochrane, and H.M Rawson. 1997. Growth and water use of the mangroves *Rhizophora apiculata* and *R. stylosa* in response to salinity and humidity under ambient and elevated concentrations of atmospheric $CO_2$. Plant, Cell, and Environment 20: 1158-1166.

Barnard, P. L., J. Allan, J. E. Hansen, G. M. Kaminsky, P. Ruggiero, and A. Doria. 2011. The impact of the 2009–10 El Niño Modoki on US west coast beaches. Geophysical Research Letters, 38(13).

Bencie R. and D. K. Imper. 2003a. Table Bluff Ecological Reserve: California Department of Fish and Game, Humboldt County, California. 2002 Monitoring Report, Western Lily. Unpublished Report Prepared under Interagency Agreement. California State University/ California Department of Fish and Game, Redding, California. 41

Bencie R. and D. K. Imper. 2003b. Summary report, Western lily vegetation strategy, Crescent City Marsh Wildlife Area and Table Bluff Ecological Reserve. Unpublished report prepared under Interagency Agreement California State University and California Department of Fish and Game, Redding, California.

Buffington, Kevin, Karen Thorne, Bruce Dugger, Glen McDonald, Rich Ambrose, Chris Janousek, Glenn Gutenspergen, Chase Freeman, Lauren Brown, and James Holmquist. 2015. Coastal Ecosystem Response to Climate Change (CERCC): Sea-level rise effects on tidal marshes along the Pacific Coast. [Unpublished work]. Accessed March 19 2015 at Coos Estuary Research Symposium.

Burdon J. J. 1987. Diseases and Population Biology. New York: Cambridge Univ. Press.

Burkett, V. and J. Kusler. 2000. Climate change: potential impacts and interactions in wetlands of the United States. Journal of American Water Resources Association 36:313–320

Chakraborty, S., A. V. Tiedemann, and P. S. Teng. 2000. Climate change: potential impact on plant diseases. Environmental Pollution, 108(3), 317-326.

Clough, J. S. and E. C. Larson. 2010. Application of the Sea-Level Affecting Marshes Model (SLAMM 6) to Bandon Marsh NWR. Warren Pinnacle Consulting, Inc. Report to U.S. Fish and Wildlife Service, National Wildlife Refuge System, Division of Natural Resources and Conservation Planning Conservation Biology Program.

Coakley, S. M., H. Scherm, and S. Chakraborty. 1999. Climate change and plant disease management. Annual Review of Phytopathology, 37(1), 399-426.

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watershed. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Associations. 225 pp.

Dalton, M. M., P. W. Mote, and A. K. Snover [Eds.]. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press

Dettinger, M. D. and D. R. Cayan. 1995. Large-scale atmospheric forcing of recent trends toward early snowmelt runoff in California. Journal of Climate 8:606–623.

Dijkema, K. S. 1987. Geography of salt marshes in Europe. Zeitschrift Fur Geomorphologie 31: 489–499.

Erwin, Kevin L. 2009. Wetlands and global climate change: the role of wetland restoration in a changing world. Wetlands Ecology Management. 17: 71-84.

Farnsworth, E.J., A.M. Ellison, and W.K. Gong. 1996. Elevated $CO_2$ alters anatomy, physiology, growth, and reproduction of red mangrove (*Rhizophora mangle L.*). Oecologia 028: 599-609.

Garrett, K. A., S. P. Dendy, E. E. Frank, M. N. Rouse, and S. E. Travers. 2006. Climate change effects on plant disease: genomes to ecosystems. Annual Review of Phytopathology. 44, 489-509.

Gitlin, A. R., C. M. Sthultz, M. A. Bowker, S. Stumpf, K. L. Paxton, K. Kennedy, and T. G. Whitham. 2006. Mortality gradients within and among dominant plant populations as barometers of ecosystem change during extreme drought. Conservation Biology, 20(5), 1477-1486.

Glick, P., J. Clough, and B. Nunley. 2007. “Sea-Level Rise and Coastal Habitats in the Pacific Northwest.” National Wildlife Federation, Seattle, WA.

Gornitz, V. 2001. Sea-level rise and coasts. p. 21–46. In C. Rosenzweig and W. Solecki (eds.) Climate Change and a Global City: the Potential Consequences of Climate Variability and Change– Metro East Coast. Report for the U.S. Global Change Research Program, National Assessment of the Potential Consequences of Climate Variability and Change for the United States. Columbia Earth Institute, New York, NY, USA

Gornitz, V., S. Couch, and E. K. Hartig. 2001. Impacts of sea level rise in the New York City metropolitan area. Global and Planetary Change 32:61–88. Elsevier Science, Amsterdam, The Netherlands

Hartig, E. K., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon. 2002. Anthropogenic and climate-change impacts on salt marshes of Jamaica Bay, New York City. Wetlands, 22(1), 71-89.

Hawkins, E. and R. Sutton. 2009. The potential to narrow uncertainty in regional climate predictions, Bulletin of the American Meteorological Society (BAMS) 90, 1095-1107, doi:10.1175/2009BAMS2607.1

Huber L. and T. J. Gillespie. 1992. Modeling leaf wetness in relation to plant disease epidemiology. Annual Review of Phytopathology. 30:553–77

International Panel on Climate Change (IPCC). 1998. The regional impacts of climate change: an assessment of vulnerability. In: Watson RT, Zinyowera MC, Moss RH (eds) A special report of IPCC working group II. Cambridge University Press, Cambridge

Karl, T. R., R. W. Knight, D. R. Easterling, and R. G. Quayle. 1995. Indices of climate change for the United States. Bulletin of the American Meteorological Society 77:279–292.

Kolker, A. S., S. L. Goodbred Jr., S. Hameed, and J. K. Cochran. 2009. High-resolution records of the response of coastal wetland systems to long-term and short-term sea-level variability. Estuarine, Coastal and Shelf Science 84: 493–508.

Mote, P., A. Petersen, S. Reeder, H. Shipman, and L. Whitely Binder. 2008. “Sea Level Rise in the Coastal Waters of Washington State.” Joint Institute for the Study of the Atmosphere and Ocean publication #1474, University of Washington, Seattle, Washington. http://cses.washington.edu/db/pdf/moteetalslr579.pdf

Mysak, L. A. 1986. El Niño, interannual variability, and fisheries in the Northeast Pacific Ocean. Can J Fish Aquat Sci 43:464–97.

National Oceanic and Atmospheric Administration (NOAA) Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Retrieved from: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. The National Academies Press, Wash¬ington, DC. 201 pp.

Oregon Climate Change Research Institute (OCCRI). 2010. “Chapter 6. Impacts of Climate Change on Oregon’s Coasts and Estuaries”, in Oregon Climate Assessment Report. K.D. Dello and P.W. Mote (eds). College of Ocean¬ic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Oregon State University (OSU). 2005. Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest. Unpublished report no. 2004-3. Corvallis OR. Retrieved from: http://ir.library.oregonstate.edu/jspui/handle/1957/113

Reed, D. J. 1990. The impact of sea-level rise on coastal salt marshes. Prog. Phys. Geog. 14 (4), 465–481.

Rozema, J. G.M. Lenssen, R.A. Broekman, and W.P. Arp. 1990. Effects of atmospheric carbon dioxide enrichment on salt-marsh plants. p. 49-54. In J.J. Beukema (ed.), Expected Effects of Climatic Change on Marine Coastal Ecosystems. Kluwer Academic Publishers, Amsterdam, the Netherlands.

Rozema, J., F. Dorel, R. Janissen, G.M. Lessen, R.A. Brooekman, W.J. Arp, and B.G. Drake. 1991. Effect of elevated atmospheric $CO_2$ on growth, photosynthesis and water relations on salt marsh grass species. Aquatic Botany 39:45.

Scavia, D., J. C. Field, D. F. Boesch, R. W. Buddemeier, V. Burkett, D. R. Cayan, and J. G. Titus. 2002. Climate change impacts on US coastal and marine ecosystems. Estuaries, 25(2), 149-164.

Sharp, D. 2012. Climate Change and the Lower Coquille Watershed. Unpublished report. Oregon Climate Change Research Institute/ EcoAdapt. Retrieved from: http://ecoadapt.org/data/documents/CoquilleClimate_02n-ov2012_FINAL.pdf

Shaughnessy, F. J., W. Gilkerson, J. M. Black, D. H. Ward, and M. Petrie. 2012. “Predicted Eelgrass Response to Sea Level Rise and its Availability to Foraging Black Brant in Pacific Coast Estuaries.” Ecological Applications 22 (6): 1743-1761. doi: 10.1890/11-1083.1.

Shaw, D. 2008. Swiss Needle Cast of Douglas-fir in Oregon: Forest Health Fact Sheet. University of Oregon Extension Service. EC 1615-E.

Stone, Jeffery K., Leonard B. Coop, and Daniel K. Manter. 2008. Canadian Journal of Plant Pathology. 30:169-176.

United States Fish and Wildlife Service (USFWS). 2009. *Lilium occidentale* (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Arcata, CA. 48 pp.

United States Geological Survey (USGS). n.d. Coastal Ecosystem Response to Climate Change. [An overview of Coastal Ecosystems Response to Climate Change (CERCC) program of the Western Ecological Research Center]. Accessed 9 April 2015 from http://www.werc.usgs.gov/project.aspx?projectid=222

United States Global Change Research Program (USGCRP). 2000. Climate change and america: overview document. A report of the national assessment synthesis team. US global change research program, Washington DC.

Zhao, Junhui, Douglas B. Mainwaring, Douglas A. Maguire, and Alan Kanaskie. 2011. Regional and annual trends in Douglas-fir foliage retention: Correlations with climatic variables. Forest Ecology and Management. 262: 1872-1886.

# Terrestrial Vegetation in the Lower Coos Watershed


*Summary:*

- *The size of old-growth and mature forest stands continues to decline.*
- *The greatest terrestrial vegetation shift has been from mature forests to lands dominated by young trees and shrubs.*
- *Forests in the lower Coos watershed have become fragmented with "core forests" being lost at a high rate.*
- *Swiss needle cast and Port-Orford-cedar root rot cause the greatest pathogen-induced tree damage and mortality in the project area.*
- *Douglas-fir is the most common overstory tree species in the lower Coos watershed; western sword fern is the most dominant herbaceous plant species.*


Western Hemlock Cones

Top: Dune plant communities
Middle: Mature Douglas-fir forest
Bottom: Sitka spruce swamp

**Evaluation**

Older forests are fragmented and in decline; diseases such as Swiss needle cast are more prevalent than ever.

**What's happening?**

In summarizing available information about terrestrial vegetation in the lower Coos watershed, we discuss forest structure (e.g., old-growth structure vs. younger forests), forest fragmentation, vegetation type, species and common associates, and the status and causes of damaged and diseased forests.

Forest Structure

A 15 year status report on the Northwest Forest Plan describes status and trends of late-successional and old-growth forests (LSOG) between 1996 and 2006 in Washington and Oregon (Moeur et al. 2011). Report authors use a simple definition of LSOG forests: conifer canopy cover = 10 to 100%; average diameter at breast height (DBH) = ≥20 inches (50.8cm)(Moeur et al. 2011).

The report describes a nearly 5% region-wide net loss of LSOG forests on forested lands between 1996 and 2006. Losses on federal lands, nearly all of which occurred in forest reserves, were generally caused by stand-replacing disturbances such as wildfire. In contrast, of the known causes of LSOG forest losses on non-federal lands, harvesting was the highest.

Moeur et al. (2011) also examined the region by physiographic provinces, including the Oregon Coast Range, which encompasses the project area (the lower Coos watershed). Net LSOG losses in the Oregon Coast Range were over 17% (123,000+ acres) from 1994-2006. Almost 40% of losses were attributable to timber harvest activities while over 60% of the losses were unexplained.

The Moeur et al. (2011) report found nearly 23% of the "forest-capable" land in the Oregon Coast Range contained LSOG forests in 2006 (Figure 1). In contrast, Rapp (2003) reported that old-growth forests (defined as those where the upper canopy is dominated by trees older than 200 years) would historically (over the last several thousand years) have covered 30-70% of the forested land in the Oregon Coast Range at any one time.

*Late Successional and Old Growth Forests*

*There's no single agreed-upon definition of late successional and old-growth forests. Older forests have distinctive structural features; therefore, a suite of factors should be considered in addition to tree age when determining late successional and old-growth forest characteristics. Among these are: diameter at breast height (DBH) and height of dominant trees, density and diameter of snags, canopy tiers, understory cover, density and diameter of downed logs, and tree biodiversity.*

*Sources: Bingham and Sawyer, Jr. 1991; Ohmann et al. 2012*

Additional information about LSOG forests is available from the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) research team (collaboration between United States Forest Service's [USFS] Pacific Northwest Research Station and Oregon State University [OSU]) and their online database. The LEMMA team investigated LSOG forests in the Pacific Northwest using their regional GIS model of forest structure coverage based on 2012 Landsat imagery (LEMMA 2014b). They used an old growth structure index (based on

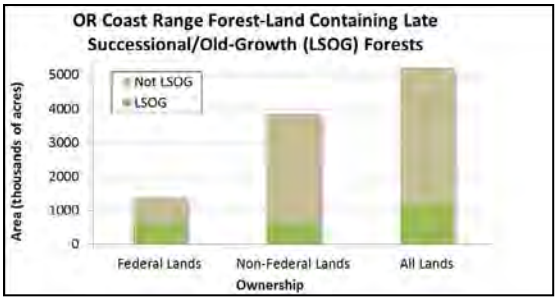
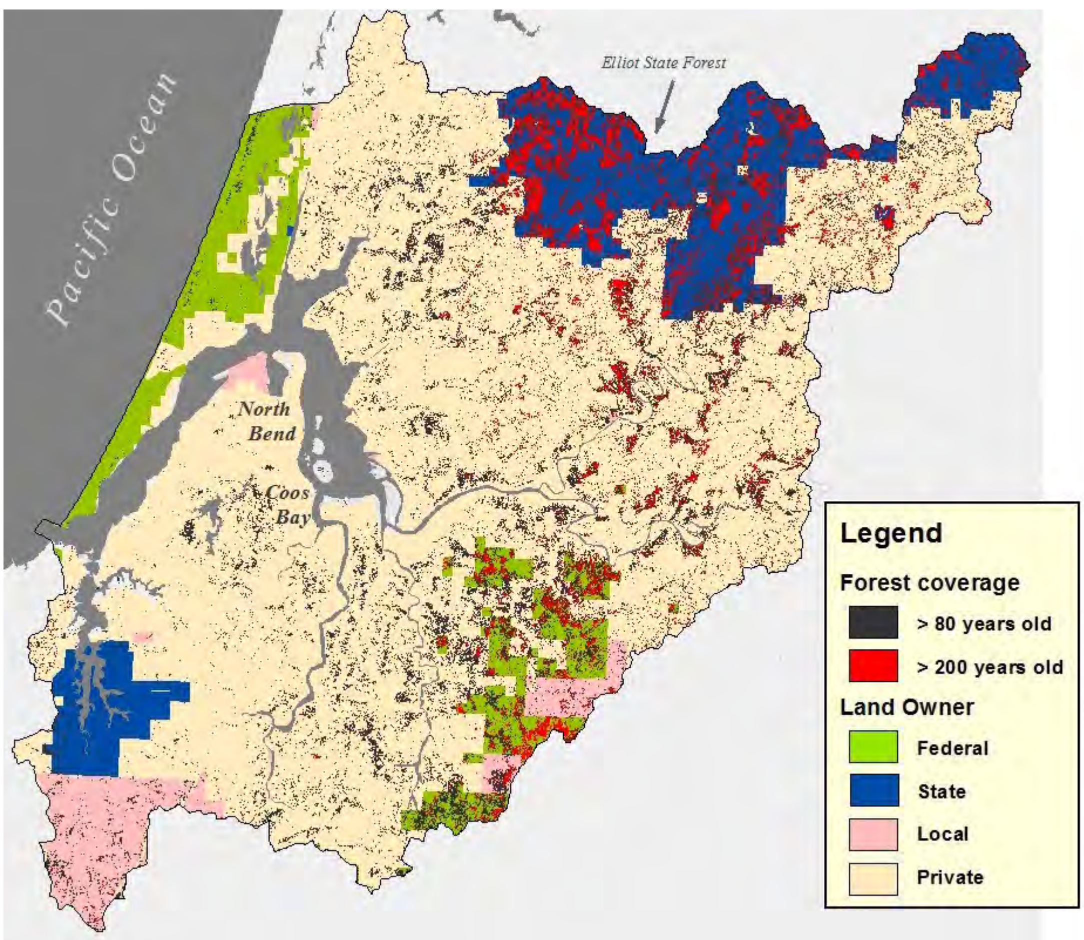



Figure 1. Area of late successional and old-growth forest as compared to younger forest lands on federal, non-federal and all lands combined in the Oregon coast range. Non-federal lands include state, tribal, and private ownership.
Data: Moeur et al. 2011

Figure 2. Distribution of late successional forests (> 200 years old) and mature forests (> 80 years old) in the project area. Land ownership categories are also indicated. Federal holdings include US Army Corps of Engineers, US Bureau of Land Management, and US Forest Service. State holdings include OR Department of State Lands, OR Parks and Recreation Department, and OR Department of Forestry. Local governments (cities) and Coos County lands are grouped together. Tribal lands were not designated in this data set. Data: LEMMA 2014b; ODF 2014a.

stand age, density of large live conifers and large snags, volume of downed wood, and tree size diversity) to analyze their project area for forest structures indicating 80 year or older forests (mature) and those structures indicating 200 year or older forests (LSOG), as recommended by Ohmann et al. (2012). Mature forests are those that have a majority of trees reaching maximum heights, which for Douglas-fir occurs at the age of about 80 years (Rapp 2003).

Results show that mature forests cover ~43 mi$^2$, or nearly 18%, of forested land in the project area, while LSOG forest structure can be found on ~15 mi$^2$ or 6% of forested land



(Figure 2). Mature forests in the project area were most likely to occur on private forest lands which comprise over 73% of all project area forests (Figure 2).

The LEMMA team quantified mature and LSOG forest coverage as a percentage of total landowner forestland holdings (Figures 3 and 4). State owned lands contained the greatest percentage of mature forest coverage in the project area (over 33% or ~13 $mi^2$), primarily in the Elliot State Forest; federal lands contained over 30% (or ~5 $mi^2$); and private lands contained approximately 14% (or ~24 $mi^2$) (Figure 3). Local ownership (City and County lands) contained the lowest percentage of mature forest.

For LSOG forest coverage (Figure 4), state lands contained the highest percentage (nearly 20% or ~8 $mi^2$), concentrated in the Elliot State Forest (Figure 2); federal lands contained nearly 12%, primarily on United States Bureau of Land Management (BLM) holdings; private lands contained only ~3%. Local ownership contained the lowest percentage of LSOG forest coverage.

## Fragmentation

The National Oceanic and Atmospheric Administration's (NOAA) Coastal Change Analysis Program (C-CAP) initiated a national land cover database in 1985 which is updated every five years. We used C-CAP data to examine changes to project area forest fragmentation between 1996 and 2010 (C-CAP 2014). Four fragmentation classes were developed by NOAA as indicators of forest ecosystem quality. The classes include: Core (forest surrounded by forest), Edge (forest bordering both core forest and non-forest ecosystems), Perforated (forest within the core forest that includes relatively small clearings), and Patch (small isolated forest stands).


Figure 3. Distribution of mature forest by land ownership in the project area. Federal lands include those held by US Army Corps of Engineers, US Bureau of Land Management, and US Forest Service. State lands include those held by OR Department of State Lands, OR Parks and Recreation Department, and OR Department of Forestry. City and Coos County lands are grouped together as local ownership. Tribal lands were not designated in this data set. Data: LEMMA 2014b; ODF 2014a.

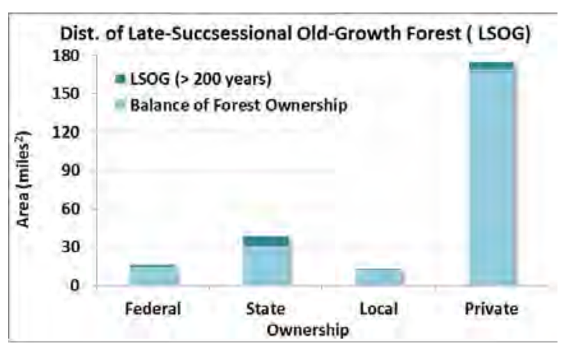



Figure 4. Distribution of late successional and old growth forests (LSOG) by land ownership in the project area. Federal lands include those held by US Army Corps of Engineers, US Bureau of Land Management, and US Forest Service. State lands include those held by OR Department of State Lands, OR Parks and Recreation Department, and OR Department of Forestry. City and Coos County lands are grouped together as local ownership. Tribal lands were not designated in this data set. Data: LEMMA 2014b; ODF 2014a.

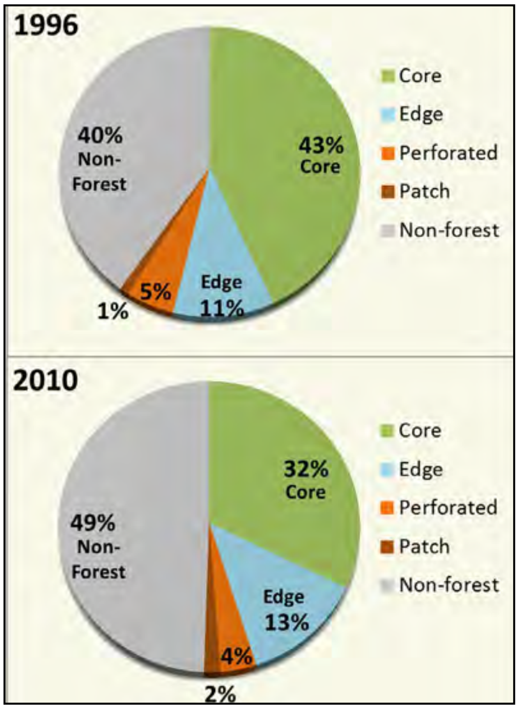



Figure 5. Net change in forest fragmentation classes from 1996 and 2010. Core = forest surrounded by forest; Edge = forest on the edge of a core forest; Perforated = forest within core forest next to small clearings; Patch = small fragments of forest. Data: C-CAP 2014

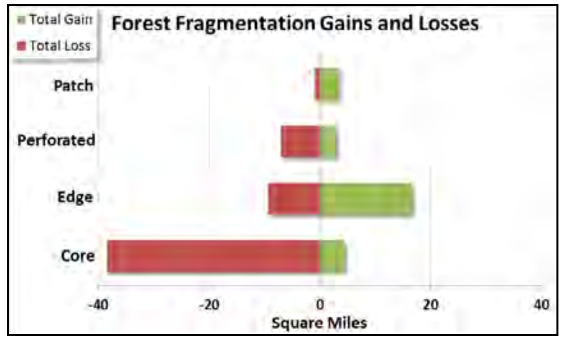



Figure 6. Distribution of gains and losses of each forest fragmentation class from 1996 to 2010. Gains/losses are conversions from non-forest lands as well as from other forest fragmentation classes. Data: C-CAP 2014

According to the C-CAP database, net forest coverage in the project area declined from 60% to ~50% between 1996 and 2010 (Figure 5). Eight square miles of non-forested land were converted to forest during that period, while 37 $mi^2$ of forest were converted to non-forested land. Of the forested lands lost to non-forest lands, 76% (28 $mi^2$) were classified as core forests. Core forest classes experienced the greatest net decrease (from nearly 44% in 1996 to 32% in 2010)(a gross loss of 38 $mi^2$) which includes conversion of core to other forest fragmentation types (Figure 6). Patch and edge forest types had slight net gains due to conversion from core forest. The spatial extent of the gains and losses of core forest can be seen in Figure 7.

When fragmentation data were further broken down by subsystem, the highest gross loss of core forest land area (as a percentage of total land area in the subsystem) was found in the Coos River subsystem (~18%) followed by South Slough (~16%)(Figure 8). The lowest percentage of core forest loss occurred in the Lower Bay subsystem, which also happens to include very little forested land.

Land Cover/Vegetation Type

In addition to forest fragmentation, the NOAA C-CAP program provided information about land cover classes. In the project area, all forest cover classes, including deciduous, evergreen, mixed (both deciduous and evergreen), and palustrine (freshwater wetlands dominated by woody vegetation), experienced a net decrease of over 28 $mi^2$ between 1996 and 2010. This represents a decrease of forest land cover in the project area (~315 $mi^2$) from 59% in 1996 to 50% in 2010 (Figure 9). By contrast, lands identified by C-CAP as scrub/shrub cover (areas dominated by young trees and shrubs) increased by 36 $mi^2$, from

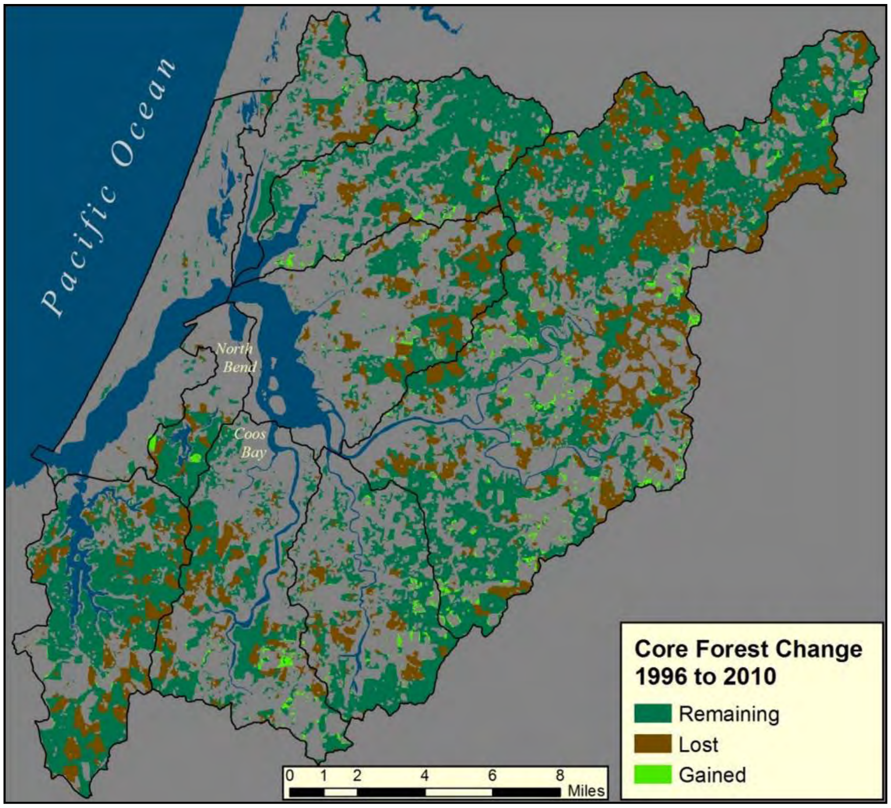



Figure 7. Gains, losses and remaining core forest from 1996 to 2010 in each subsystem. Gains/losses are conversions from non-forest lands as well as from other forest fragmentation classes. Data: C-CAP 2014

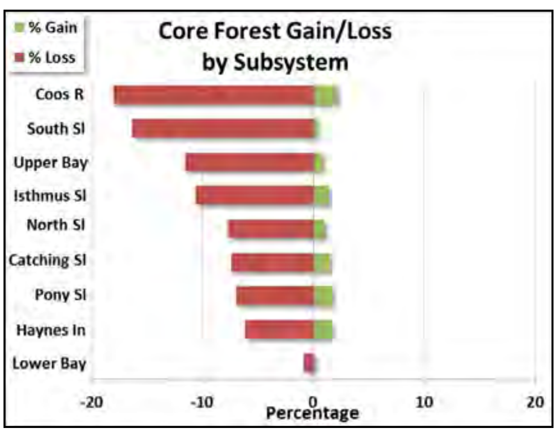



Figure 8. Distribution of gains and losses of core forest from 1996 to 2010 at each subsystem as a percentage of square miles/total subsystem land area. Gains/losses are conversions from non-forest lands as well as from other forest fragmentation classes. Data: C-CAP 2014.

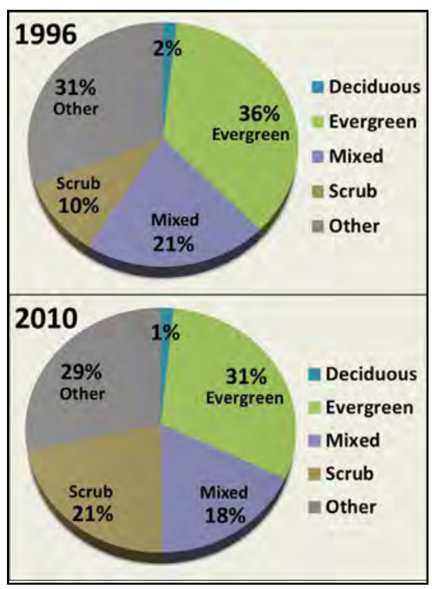



Figure 9. Percent scrub/shrub and three forest types in the project area (deciduous, evergreen and mixed) in 1996 and 2010. Data: C-CAP 2014

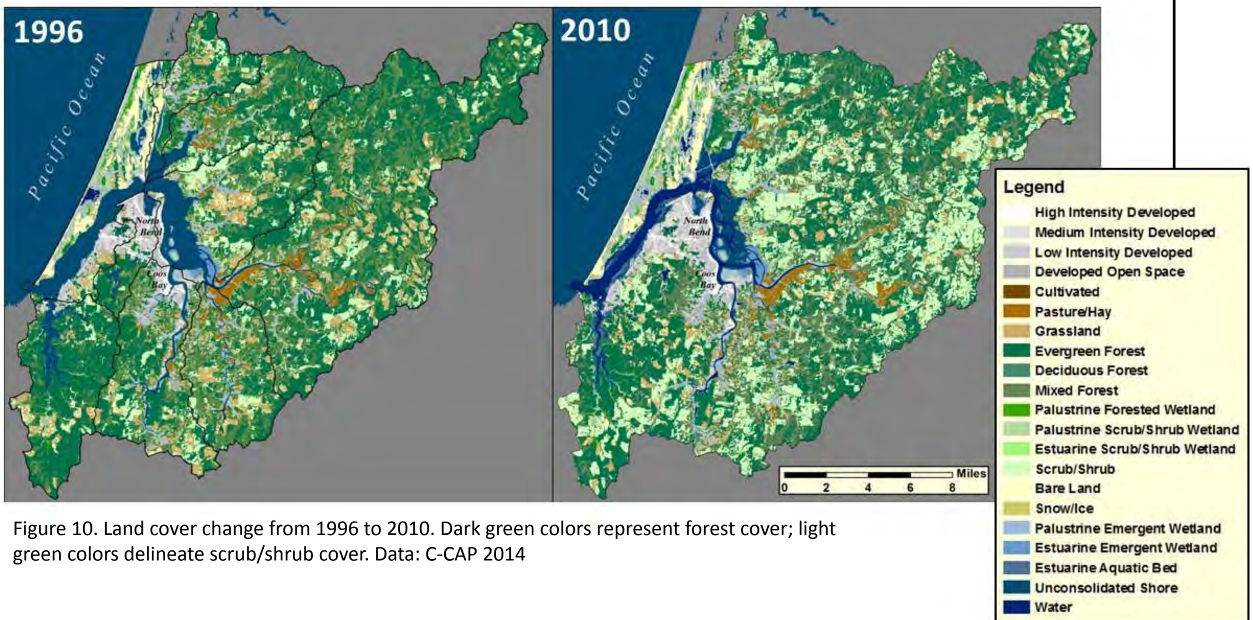



Figure 10. Land cover change from 1996 to 2010. Dark green colors represent forest cover; light green colors delineate scrub/shrub cover. Data: C-CAP 2014

10% in 1996 to over 21% in 2010. In fact, the greatest shift in vegetation cover in the project area was the conversion of forest cover classes to the scrub/shrub cover class. Over 18 mi² of forested land were converted to scrub/shrub during the 14 year study period (Figures 10 and 11). Conversion to grasslands was the next greatest shift in vegetation cover, with nearly 8 mi² of forest land converted to grasslands. Note that C-CAP's "scrub/shrub" and "grassland" designations are most likely timber harvest areas at different stages of re-growth (younger = grasslands; older = scrub/shrub). Conversion from forest land cover to barren, developed, and agricultural cover (cultivated crops and pasture land) was also notable.

The greatest net change in forest type was in evergreen forests (decreased from 36% to 31%). Evergreen forests also had the highest gross loss (24 mi² lost )(Figure 12), followed by mixed forests with a loss of just over 13 mi². The greatest net gain to scrub/shrub

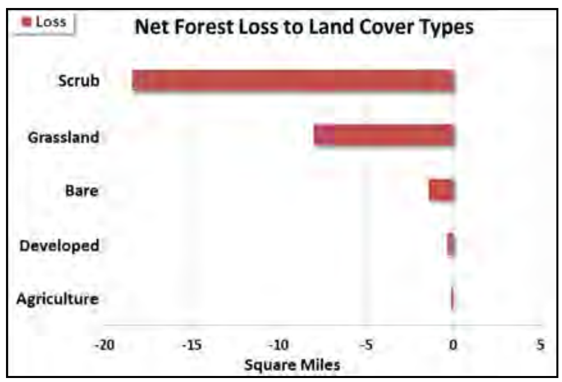



Figure 11. Net loss of all forest types (evergreen, deciduous and mixed) to different land cover type categories from 1996 to 2010. "Bare" land covers include unconsolidated shores, and barren lands. "Developed" groups low, medium and high intensity development with developed open space. "Agriculture" combines pasture/hay with cultivated crop land. Data: C-CAP 2014

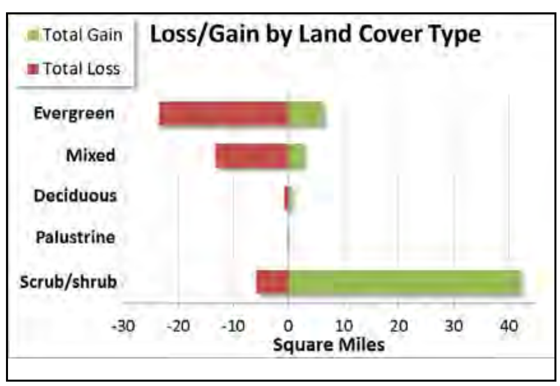



Figure 12. Distribution of gains and losses of forest and scrub/shrub cover from 1996 to 2010. Data: C-CAP 2014

lands (over 18 mi²) was due to conversion from forested lands, followed closely by conversion from grasslands (nearly 16 mi²)(Figures 10 and 13). Total (gross) gains in scrub/shrub land numbered over 42 mi² (Figure 12).

As noted previously, many of these reported changes, particularly changes from forest to scrub/shrub or grassland cover classes, are likely the result of timber harvest activities and therefore occur frequently in the project area. Because of sizable land ownership in the project area by industrial and small lot timber producers, it's not surprising that changes in forest cover in the project area is so dynamic.

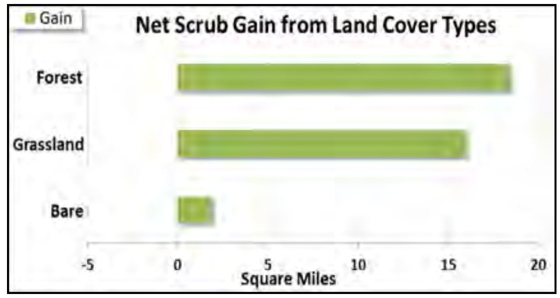



Figure 13. Net gain to scrub/shrub lands from three land cover type categories from 1996 to 2010. "Bare" land covers include unconsolidated shores, and barren lands. "Forest" lands group evergreen, deciduous and mixed forest types together. Data: C-CAP 2014

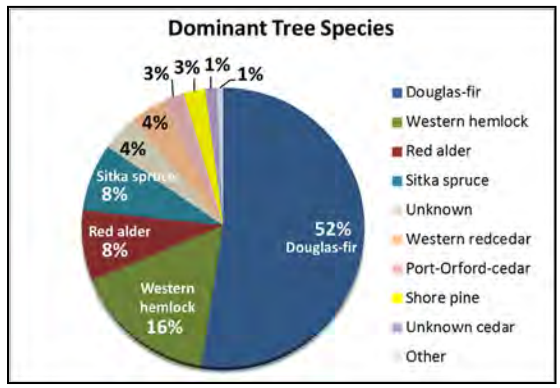



Figure 14. Percent cover of dominant tree species in the forested regions of the project area. Incense cedar (*Calocedrus decurrens*) dominated 1% of the project area according to the data, but was changed to "Unknown cedar" since incense cedar is not known to occur near the coast. The category "Other" includes combined cover from species that are dominant in less than 1% of the forested area, including: white fir, grand fir, white fir/grand fir cross, bigleaf maple, vine maple, white alder, and bay laurel. Forest land that was not tallied by species is designated "Unknown". Data: LEMMA 2014a

Terrestrial Vegetation Species

The LEMMA program is a collaborative research group which includes participants from USFS's Pacific Northwest Research Station and OSU. The following summary is based on LEMMA's GIS model of forest species coverage using data from multiple agencies and years (e.g., BLM vegetation annual surveys 1997-2003)(LEMMA 2014a). Tree species percent cover in the project area is summarized in Figure 14. The most recent data show Douglas-fir (*Pseudotsuga menziesii*) with the highest tree species percent cover in the project area (over 125 mi² or 52% cover of forested lands).

When analyzing spatial extent of each species, Douglas-fir and western hemlock (*Tsuga heterophylla*) were distributed fairly evenly across the entire project area (Figure 15). Shore pine (*Pinus contorta*), Port-Orford-cedar (*Chamaecyparis lawsoniana*), and Sitka spruce (*Picea sitchensis*) were concentrated closer to the coast while western redcedar (*Thuja plicata*) and red alder (*Alnus rubra*) were concentrated more inland.

LEMMA quantified species richness, an important indicator of forest status, for project area conifer and hardwood forests (Figure

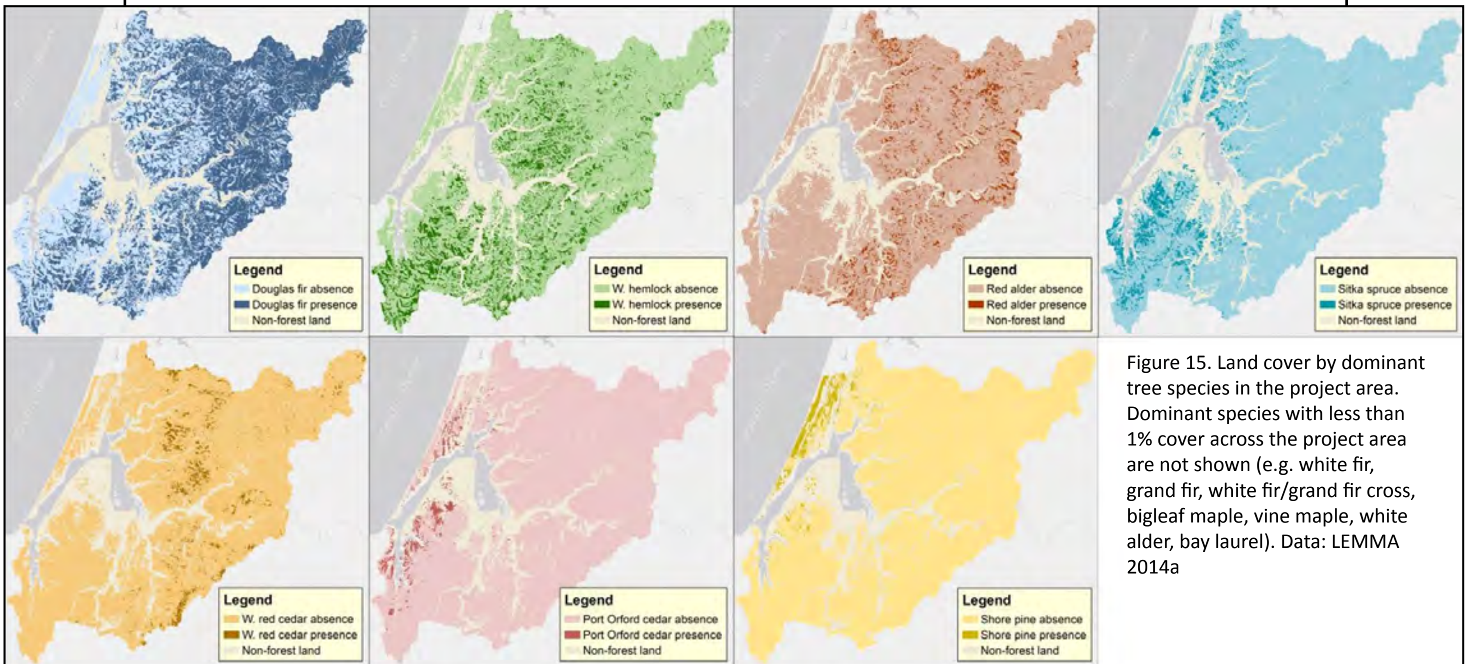



Figure 15. Land cover by dominant tree species in the project area. Dominant species with less than 1% cover across the project area are not shown (e.g. white fir, grand fir, white fir/grand fir cross, bigleaf maple, vine maple, white alder, bay laurel). Data: LEMMA 2014a

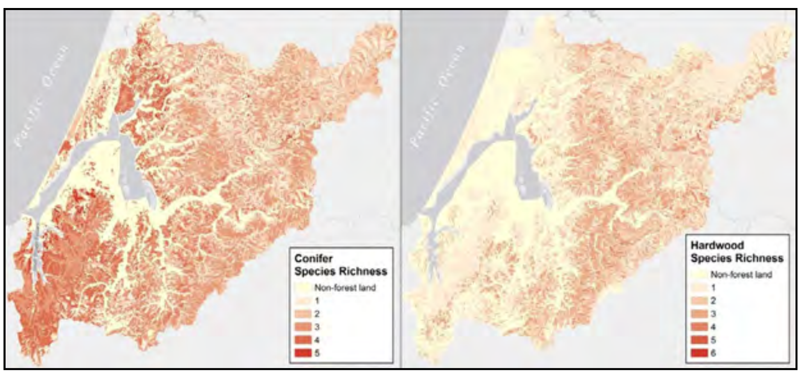



Figure 16. Conifer and hardwood tree species richness in the project area. Lighter colors indicate fewer species counts than darker colors. Conifer species include but are not limited to: Douglas-fir, Port-Orford-cedar, incense cedar, western redcedar, western hemlock, shore pine, white fir, grand fir, and Sitka spruce. Hardwood species include but are not limited to: red alder, white alder, bay laurel, vine maple, and bigleaf maple. Data: LEMMA 2014a

16). Coniferous species richness was high in the entire project area, but highest in the areas closest to the coast, particularly in the South Slough watershed. Species richness for hardwood species was higher in regions further inland. In the entire project area, coniferous tree species richness was higher than that of hardwood tree species.

The model also characterizes understory species distribution (both herbaceous and woody species). Western sword fern (*Polystichum munitum*) was by far the most dominant understory species in the project area, followed by evergreen huckleberry (*Vaccinium ovatum*), salal (*Gaultheria shallon*) and Salmonberry (*Rubus spectabilis*)(Figures 17 and 18). Over 30 species are present in less than 1% of the project area's forests including elderberry (*Sambucus spp.*), blackberry (*Rubus spp.*), huckleberry (*Vaccinium spp*.), and thimbleberry (*Rubus parviflorus*). All dominant understory vegetation are listed in Table 1.

When dominant tree species were compared with dominant understory species, Douglas-fir/western sword fern emerged as the most common association (Table 2). Western hemlock/western sword fern, Douglas-fir/

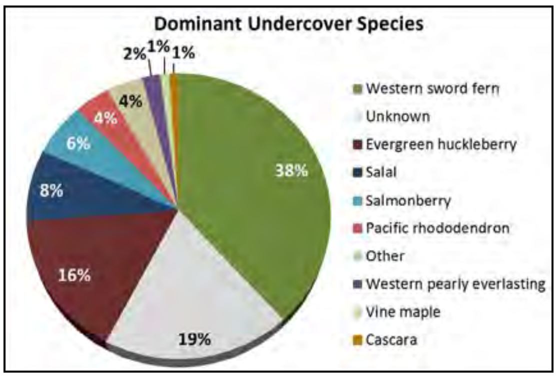



Figure 17. Percent cover of dominant understory species in the project area. The category "Other" includes combined cover from 33 species that are dominant in less than 1% of the project area, including: elderberry, various blackberry species, thimbleberry and foxglove. Non-forest land and land not tallied by species is designated "Unknown". Data: LEMMA 2014a

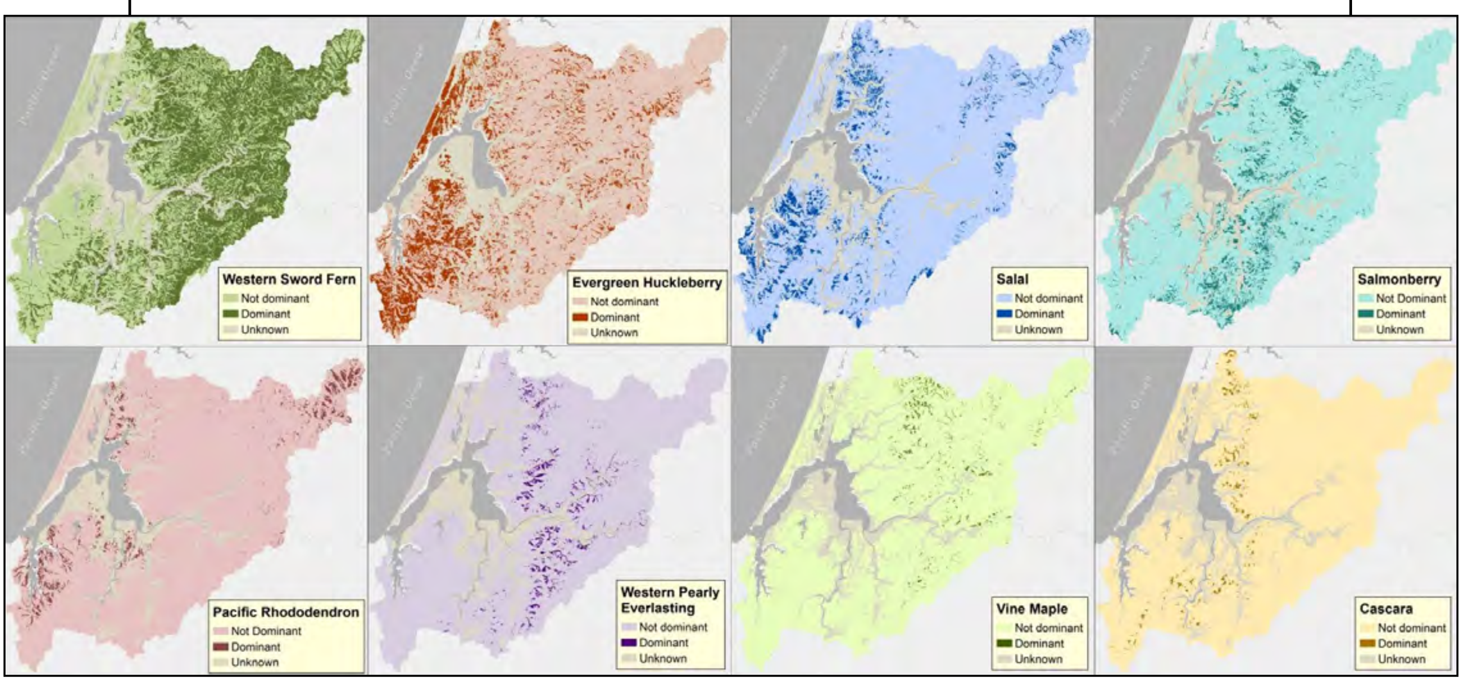
salal, and Douglas-fir/evergreen huckleberry were also common associates. The greatest variety of understory associates were found in Douglas-fir dominated forests, followed by western hemlock and Sitka spruce dominated forests.

<u>Damage/Disease</u>

Forests damage can come from multiple sources including insects, diseases, environmental events (e.g., wind, fire). The major causes of forest damage in our project area are discussed below.

Swiss Needle Cast (SNC)(*Phaeocryptopus gaeumannii*), an endemic fungus that targets Douglas-fir trees, is the primary cause of tree damage in the project area. The effects of SNC are monitored annually by aerial surveys conducted by Oregon Department of Forestry (ODF). Results from 19 years of surveys (1996-2014) indicate the highest incidence

Figure 18. Spatial cover of the most dominant understory species in the project area. Dominant species with less than 1% cover across the project area are not shown. Data: LEMMA 2014a



| Common name | Species name |
|---|---|
| **Fern** | |
| Deer fern | *Blechnum spicant* |
| Western sword fern | *Polystichum munitum* |
| **Forb** | |
| British Columbia wild ginger | *Asarum caudatum* |
| False lily-of-the-valley | *Maianthemum dilatatum* |
| Foxglove * | *Digitalis purpurea* |
| Fragrant bedstraw | *Galium triflorum* |
| Herbaceous forb | multiple species |
| Iris | *Iris tenax* |
| Redwood-sorrel | *Oxalis oregana* |
| Western pearly everlasting | *Anaphalis margaritacea* |
| **Grass/sedge** | |
| Columbia brome | *Bromus vulgaris* |
| European beachgrass * | *Ammophila arenaria* |
| Graminoid (grass) | multiple species |
| Sedge | *Carex* spp. |
| Silver hairgrass * | *Aira caryophyllea* |
| Slough sedge | *Carex obnupta* |
| Sweet vernalgrass * | *Anthoxanthum odoratum* |
| **Shrub** | |
| Bog blueberry | *Vaccinium uliginosum* |
| California blackberry | *Rubus ursinus* |
| Cascade azalea | *Rhododendron albiflorum* |
| Evergreen huckleberry | *Vaccinium ovatum* |
| Hairy manzanita | *Arctostaphylos columbiana* |
| Himalayan blackberry * | *Rubus discolor* |
| Kinnikinnick | *Arctostaphylos uva-ursi* |
| Oceanspray | *Holodiscus discolor* |
| Oregon boxleaf | *Paxistima myrsinites* |
| Oregon grape | *Mahonia nervosa* |
| Oval-leaf blueberry | *Vaccinium ovalifolium* |
| Pacific poison oak | *Toxicodendron diversilobum* |
| Red huckleberry | *Vaccinium parvifolium* |
| Salal | *Gaultheria shallon* |
| Salmonberry | *Rubus spectabilis* |
| Saskatoon serviceberry | *Amelanchier alnifolia* |
| Thimbleberry | *Rubus parviflorus* |
| Western labrador tea | *Ledum columbianum* |
| Whitebark raspberry | *Rubus leucodermis* |
| **Tree/shrub** | |
| Cascara | *Frangula purshiana* |
| Elderberry | *Sambucus* spp. |
| Pacific rhododendron | *Rhododendron macrophyllum* |
| Vine maple | *Acer circinatum* |

Table 1. Complete list of dominant understory vegetation in the project area. * Species that are not native to the project area. Data: LEMMA 2014a

| Dominant Overstory/ Understory | % Cover |
|---|---|
| **Douglas-fir** | |
| Western sword fern | 23 |
| Salal | 7 |
| Evergreen huckleberry | 7 |
| Pacific rhododendron | 4 |
| Salmonberry | 3 |
| Western pearly everlasting | 3 |
| Vine maple | 1 |
| Cascara | 1 |
| **Western hemlock** | |
| Western sword fern | 9 |
| Evergreen huckleberry | 5 |
| Salmonberry | 1 |
| **Red alder** | |
| Western sword fern | 6 |
| Salmonberry | 2 |
| **Western red cedar** | |
| Western sword fern | 4 |
| **Sitka spruce** | |
| Evergreen huckleberry | 4 |
| Salal | 3 |
| Western sword fern | 1 |
| **Shore pine** | |
| Evergreen huckleberry | 2 |
| **Port Orford cedar** | |
| Evergreen huckleberry | 2 |

Table 2. Most common overstory/understory associates in the forested regions of the project area. Combinations that represent <1% cover are not shown. Data: LEMMA 2014a

of SNC in western Oregon occurred the last four years of the surveys (2011-2014), each successive year reaching an “all time high” for observed SNC symptoms (Kanaskie and Norlander 2014).

ODF (2014b) SNC aerial survey results for the project area from 2006 to 2014 show the highest extent of SNC-damaged trees occurred in 2011 (over 79 mi$^2$) followed closely by SNC damage in 2014 (over 78 mi$^2$)(Figure 19). Surveyors classified affected areas as “severe” (extremely sparse crowns and brown foliage) or “moderate” (yellow foliage and slightly sparse crowns). The most extensive “severe” SNC damage was seen in the 2011 survey (nearly 11 mi$^2$). The smallest area with “severe” SNC damage was seen in the 2006 survey, which also showed the smallest area affected by SNC. Figure 20 shows the spatial extent of SNC based on 2006 and 2011 survey data.

Since 1947, USFS and ODF have conducted annual aerial surveys across Oregon and Washington to assess damage to forests by agents other than SNC (USFS 2014). Results clearly demonstrate that the greatest

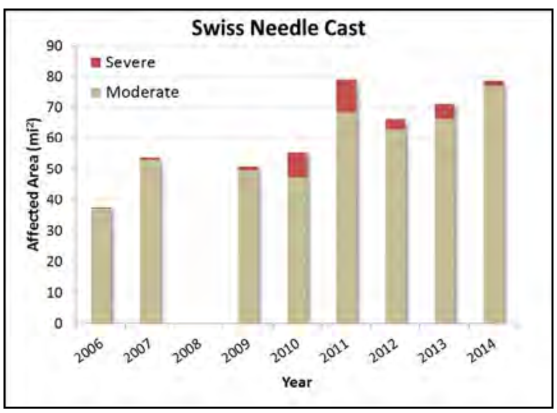



Figure 19. Total square miles in the project area affected by Swiss needle cast disease from 2006 to 2014. Data from 2008 were incomplete, and thus were excluded from this analysis. Data: ODF 2014b.

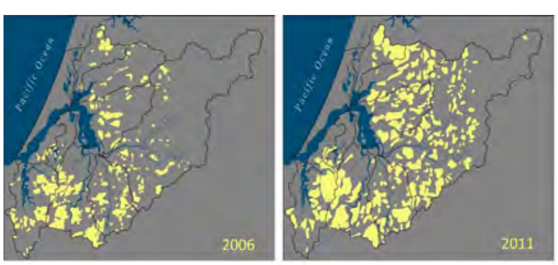



Figure 20. Spatial extent of Swiss needle cast disease in Douglas-fir populations in the project area in 2006 and 2011 (the lowest and highest (respectively) SNC occurrences betrween 2006 and 2014). Data: ODF 2014b.

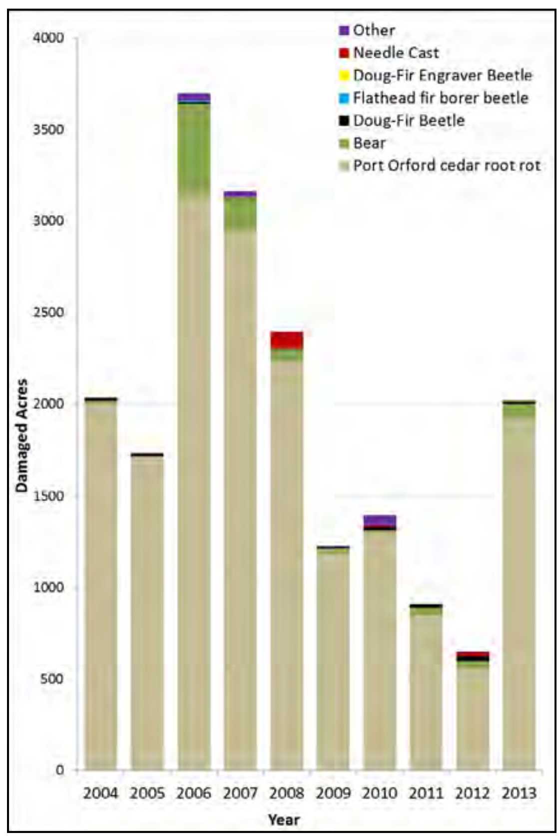



Figure 21. Acres of damaged forest land caused by insect, disease or environmental events. Data collected during annual summertime aerial surveys (July-September) in the project area. Data: USFS 2014.

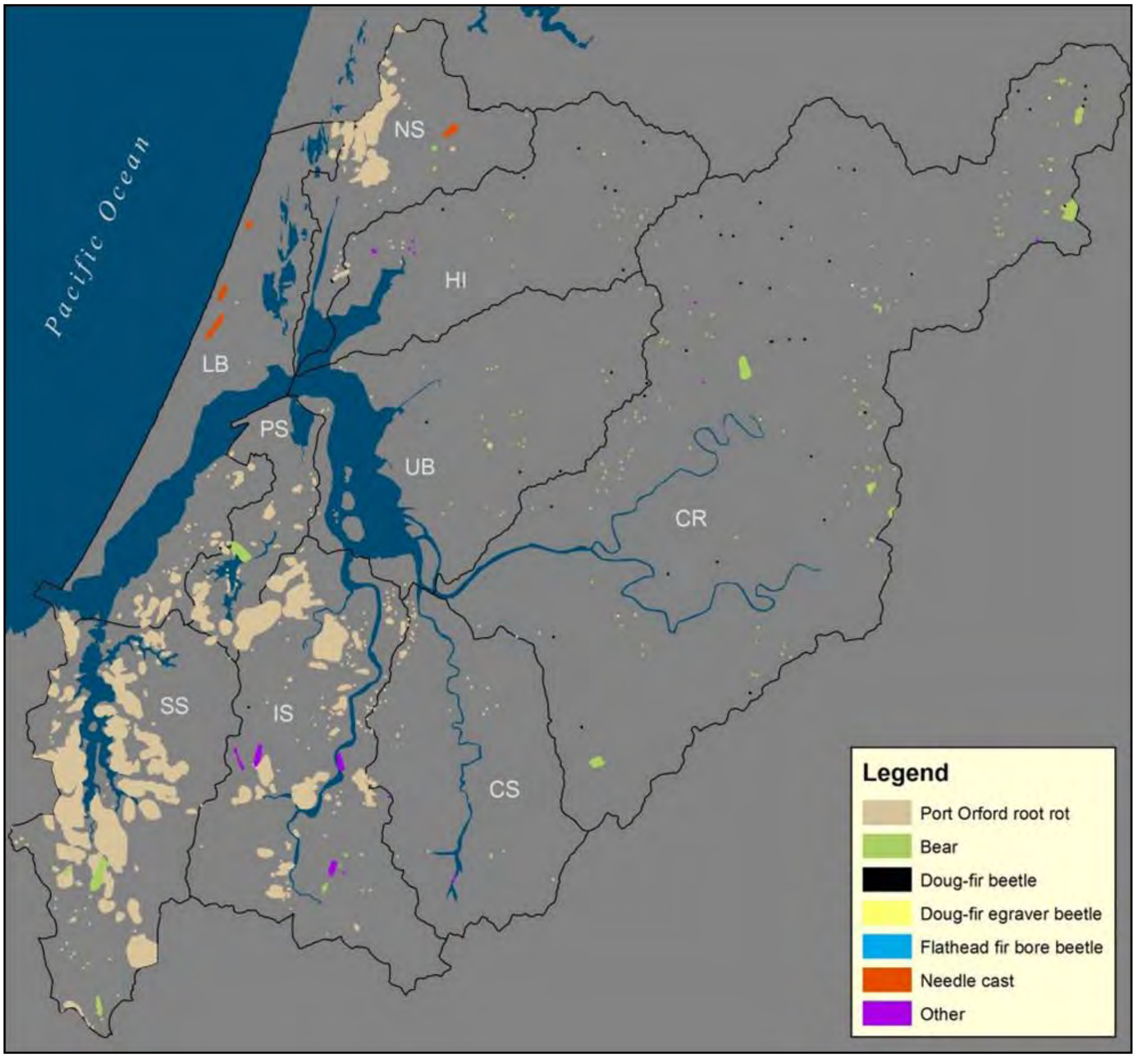



Figure 22. Distribution of forest land damaged by insects, disease or environmental events from 2004-2013. Subsystems are labeled as follows: CR – Coos River; CS – Catching Slough; HI – Haynes Inlet; IS – Isthmus Slough; LB – Lower Bay; PS – Pony Slough; UB – Upper Bay; SS – South Slough. Data: USFS 2014.

non-SNC damage to forests in the project area is caused by Port-Orford-cedar root rot (*Phytophthora lateralis*)(POCRR), a non-native fungus which targets Port-Orford-cedar trees (Figure 21). Ten years of survey results (2004-2013) indicate particularly high incidence of POCRR damage in 2006, 2007 and 2008 (2006 results: over 3,700 acres [~5.8 mi$^2$] damaged); the 2012 survey results showed the least damage (~650 acres [~1.0 mi$^2$] damaged). POCRR damage is concentrated in forested lands closer to the coast (particularly South Slough, Isthmus Slough, and North Slough subsystems)(Figure 22). Effects of POCRR were most evident in the South Slough subsystem, likely explained by the lack of extensive upland management in South Slough Reserve forests since the early

1970's which resulted in the accumulation of diseased Port-Orford-cedar trees identified in the surveys. Both diseased and disease-free Port-Orford-cedars have been removed in the other more actively managed project area forest lands. In fact, we should note that extensive forest management practices in the project area is a factor to consider when evaluating disease damage survey results (e.g., SNC, POCRR). Variable harvest levels in any given year will affect the number of diseased trees observed.

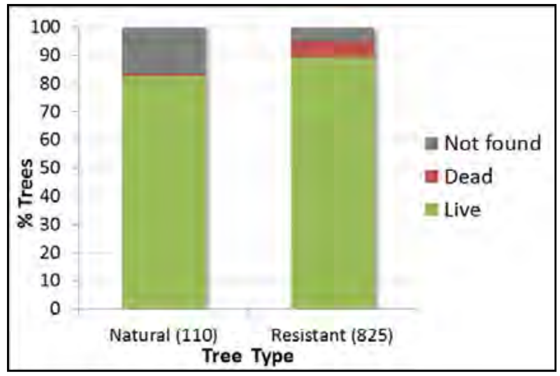


Figure 23. Percentage of Port-Orford-cedars from the 2014 survey that were live, dead or not found. Numbers next to Tree Type categories are the number of trees identified (Natural) or out-planted (Resistant) in 2013. Data: SSNERR 2014.

In the South Slough Reserve, where 62% of Port-Orford-cedars were dead or dying from POCRR in 2011 (Cornu et al. 2012), several projects are underway using POCRR-resistant Port-Orford-cedar seedlings for upland restoration or long-term field trials. In spring 2013, 825 tagged disease resistant Port-Orford-cedar seedlings were planted among 110 tagged naturally recruited seedlings at three sites in the South Slough Reserve as part of remnant logging road restoration efforts. Monitoring results in 2014 showed survival rates for naturally recruited seedlings at ~83%, compared with ~89% for the disease resistant seedlings (Figure 23). Only one tagged naturally recruited seedling did not survive while 44 or ~5% of the disease resistant seedlings had died. However, many of the tagged naturally recruited seedlings were not found (~16%). We assume at least some of these seedlings were not survivors. In addition, several tags were found unattached to seedlings. At the seedling stage, it's unlikely that mortality was caused by POCRR; it's more likely that many of the seedlings died from especially dry conditions in 2013. In addition, seedlings were planted and had naturally recruited in both compacted road bed soils and un-compacted roadside soils. The data have not yet been analyzed to quantify the effects of compacted soils on seedling mortality. It's should be noted that the Port-Orford-cedar seedlings were from an "open-pollinated orchard" so only a subset of those seedlings would show resistance to POCRR.

Since genetically different Port-Orford-cedar trees have different resistance to POCRR, USFS has been identifying and collecting disease-resistant strains from natural cedar stands. Long-term field trials on these disease resistant strains are essential for understanding their "durability" under a variety of environmental conditions (Sniezko et al. 2012). In cooperation with the South Slough Reserve, USFS implemented long-term field trials at three locations within the Reserve in 2011 and 2012 by outplanting a diverse assortment of genetic strains of Port-Orford-cedar beneath a canopy of large dead and living Port-Orford-cedar. Early results from 2014 have shown that mortality varies between

6% and 45% depending on both genetic strain and location (Sniezko 2014). A direct link between seedling mortality and POCRR presence has not yet been established. Care will be taken to factor in non-POCRR related mortality (e.g., environmental stressors).

**Background**

Forest Structure

The complex structure of old-growth forests provides diverse habitat which supports the rich biodiversity found in older forest ecosystems (Means et al. 1996). In general, complex forest structure contains more microhabitats for a larger variety of species, which in turn provides more diverse food resources (Brokaw and Lent 1999). For example, insect species richness and density increases with forest age and complexity in Oregon Douglas-fir forests (Schowalter 1995 as cited in Brokaw and Lent 1999).

*Temperate rainforests*

*Temperate rainforests on the coast (including those in the project area) are subject to infrequent fires, are almost completely dominated by conifers, and have a highly complex structure (due to large size of mature trees, diversity of epiphytes [plants that grow on other plants but are not parasitic], and dense shrubby understory). Local temperate rainforests include some of the largest representatives of Pacific Northwest conifer species.*

*Sources: Pojar and MacKinnon 2004, Franklin and Dyrness 1973*

Spatial complexity is one of the key components underlying this habitat diversity. Standing snags scattered among living trees provide microhabitats for a wide variety of organisms (e.g., invertebrates and woodpeckers). Large conifer (≥40 cm DBH and ≥4 m tall) snag density in southern Oregon Douglas-fir dominated old-growth forests is typically very high (Bingham and Sawyer, Jr. 1991). Snag longevity and probability of containing cavities suitable for bird nesting increases with snag diameter, an important feature since up to 40% of bird species in North America are cavity nesters (Scott et al. 1977 as cited in McComb and Lindenmayer 1999).

Likewise, downed wood is a source of nutrients as nursery logs (fallen trees that decay and contribute to forest soil development). Interestingly, in young forests a high abundance of wood can be found on the forest floor (especially those with a history of timber harvest) while older forests in areas subject to regular fires can include very little downed wood (Bingham and Sawyer, Jr. 1991). Size of wood is important, as large pieces can provide habitat for numerous species for centuries (Tyrrell and Crow 1994).

Finally, old-growth stands have a well-defined multi-tiered canopy, which creates microhabitats for many species (Binham and Sawyer, *Forested Swamps*

*Forested swamps are distinguished by a high water table for all or most of the year (e.g., tidal freshwater wetlands, near beaver dams). Common dominant tree species found in forested wetlands are Port Orford and western redcedars, red alder, Sitka spruce and Pacific willow. Moss, liverworts and lichens can make up a high percent of the ground cover (e.g., 85% in coastal British Columbia).*

*Once common in the Pacific Northwest, forested swamps such as Sitka spruce swamps are now one of the rarest wetland types in the region. These communities have largely disappeared due to timber harvesting and high sediment deposition from historic logging, conversion of wetlands to agriculture, and the naturally slow recovery times associated with forested wetlands.*

*Sources: Peterson et al. 1997, Adamus et al. 2005*

Jr. 1991; Spies and Franklin 1996). Varying combinations of dominant and sub-dominant trees and shrubs create an intricate and spatially complex canopy, and a diverse forest structure (Rapp 2003).

Additionally, old-growth forest structures can store more carbon, lower forest soil erosion potential, and support greater numbers of organisms such as nitrogen-fixing lichens than younger forests (Spies and Franklin 1996).

Fragmentation

Forest fragmentation occurs when forests become divided into an 'archipelago' of small isolated 'island' stands in a sea of non-forest ecosystems due to natural disturbance (e.g., fire) or human activities (e.g., roads, agriculture, urbanization)(Haila 1999). Determining the extent of forest fragmentation helps determine the status of the forest ecosystem– including biological diversity and air and water quality. Fragmented forests are more susceptible to attacks from insect or disease and often are stressed to a point of chronically unhealthy conditions (Lynch and Swetnam 1992 as cited in Spies and Franklin 1996).

Animal species that depend on intact forest structures are affected by extensive forest fragmentation. For example, spotted owl ranges were found to be 85% more expansive in heavily fragmented forests compared with spotted owls inhabiting lightly fragmented areas (Carey et al. 1990). In addition, patchy forest stands prevent the establishment and maintenance of stable animal travel corridors for larger mammals (e.g., wolves: Jędrzejewski et al. 2004).

Forest fragmentation creates more edge forests, which can lead to destructive edge effects such as windthrow (Haila 1999). Human-caused forest edges are commonly uniform, following rectininear property lines, in contrast to naturally complex, jagged edges

*Dune Habitat*

*Dune habitats on the Oregon coast provide dynamic microhabitats that benefit a variety of plant communities. Dune forest communities are often engulfed by moving sand; however in areas of minimal activity (e.g. in deflation planes where high water tables effectively stop sand movement), dune forests develop with shore pine as an early seral species, replaced by the longer-lived Sitka spruce, and finally western hemlock as the climax species. In wind-exposed, unstabilized dune areas, low-lying herbaceous plants (e.g., lupine [*Lupinus littoralis*]) dominate but have a low percent cover (10%), while the more wind-protected dune edges are aggressively colonized by various grass species (e.g.,* Festuca rubra*) and herbs (e.g., western pearly everlasting) in plant communities with percent coverage as great as 94%.*

*Sources: Franklin and Dyrness 1973, Kumler 1969*

caused by natural disturbance (e.g., from fire) which provide greater spatial diversity in the landscape (Matlack and Litvaitis 1999). Matlack and Litvaitis (1999) also describe edge zones as often hotter, drier, and having more light and wind exposure than non-fragmented forests (or "core" forests).

Species

The project area falls within the United States Environmental Protection Service's (USEPA's) Coast Range Ecoregion (Thorson et al. 2003). The Coast range ecoregion comprises seven subregions, three of which are represented in the project area:

1a Coastal Lowlands, characterized by the following terrestrial vegetation species: Sitka spruce, western hemlock, Douglas-fir overstory; salal, western sword fern, vine maple (*Acer circinatum*), and Oregon grape (*Mahonia aquifolium*) understory; red alder, western redcedar, bigleaf maple (*Acer macrophyllum*) and salmonberry in riparian areas; stabilized dunes are dominated by shore pine, salal, rhododendron (*Rhododendron spp.*), and evergreen huckleberry.

1b Coastal Uplands characterized by the following species: Douglas-fir, and/or western hemlock overstory; salal, sword fern, vine maple, Oregon grape, rhododendron, and evergreen huckleberry understory; red alder, bigleaf maple, western redcedar and salmonberry in riparian areas.

1g Mid-Coast Sedimentary characterized by the following species: Douglas-fir, and/or western hemlock overstory; salal, sword fern, vine maple, Oregon grape, and rhododendron understory; bigleaf maple, western redcedar, grand fir (*Abies grandis*), red alder, salmonberry and oxalis (*Oxalis spp.*) in riparian areas.

It should be noted that USEPA's inclusion of bigleaf maple (rare on the coast) in the coastal lowlands and uplands subregions and their

| Common Name | Species Name | Range | Typical Mature Height/ Diameter*/Age | Max Height/ Diameter*/ Age | Economic uses | Historical uses | Ecological value |
|---|---|---|---|---|---|---|---|
| Douglas-fir | *Pseudotsuga menziesii* |  | 100-250' or more tall; 3-6' diameter; 750 years | 330' tall; 14' diameter; 1300 years | Wood: structural lumber (dimensional and plywood) | Pitch: sealing joints (e.g., water vessels), medicinal; wood: salmon weirs; spear handles, hooks, etc | Cones food (e.g. Douglas squirrel, winter wren, porcupine, etc); mature/old-growth important habitat (e.g. red tree vole, spotted owl) |
| Port Orford cedar | *Chamaecyparis lawsoniana* |  | 125-200' tall; 3-6' diameter; > 500 years | 230' tall; 12' diameter; 700 years | Tree: ornamental; wood: decking, fence posts, logs exported to Japan for a wide variety of uses; boughs: floral arrangements | Wood: stools, sweat lodges; boughs: brooms; bark: medicinal, baskets, clothing, mats; shoots and needles: medicinal | Downed wood makes long-lasting stream structures, bank stability, streamside shade |
| Red alder | *Alnus rubra* |  | 120' tall; ~2.5' diameter; 70 years | 130' tall; 6' diameter; 100 years | Wood: furniture and cabinetry; firewood | Wood: firewood (smoking salmon), bowls, masks; bark: dye, medicinal uses | Nitrogen fixer and high organic input fertilizes soil |
| Shore pine | *Pinus contorta* var. *contorta* |  | 20-50' tall; 1-2' diameter; 100 years | 100' tall; 3' diameter; 250 years | Wood: pulpwood, railroad ties | Roots: rope; bark: splints, medicinal; pitch; waterproofing agent (e.g., canoes), glue, medicinal | Pine nuts are food for squirrels and birds; cambium food for porcupines; important edge habitat for larger animals |
| Sitka spruce | *Picea sitchensis* |  | 180' tall;3-5' diameter; > 500 years | 310' tall; 17' diameter; 1350 years | Wood: musical instruments, masts, ladders, aircraft | Boughs: ceremonies; bark and shoots: food; pitch: medicine; roots: baskets | Downed wood provides nurse logs |
| Western hemlock | *Tsuga heterophylla* |  | 165-210' tall; 3-4' diameter; 300 years | 250' tall; 9' diameter; 1240 years | Wood: pulpwood, plywood, flooring, pilings, railroad ties | Bark: tanning agent, dye; wood: spoons, hooks, bowls, etc; boughs: fish egg collection, bedding; pitch: medicinal | Food for Roosevelt elk and black-tailed deer; habitat and cover for a large variety of species (e.g., birds, bear, rodents etc) |
| Western red cedar | *Thuja plicata* |  | 150-200' tall; 3-10' diameter; > 1000 years | 230' tall; 20' diameter; 1400 years | wood: shingles, siding, decking, boat building; oil: pesticides | Spritual, medicinal; bark: baskets, rope, clothing, etc; wood: canoes, house planks, tools, cutlery, ceremonial, firewood, etc. | Food for Roosevelt elk, black-tailed deer, and bear; habitat for bears, raccoons, skunks, birds, etc. |

Table 3. Range, size, age and uses of the most common tree species in the project area. Sources: Randall et al. 1981, Pojar and MacKinnon 1994, Harris 1990, Harrington 1990; range maps from Wikipedia. * Diameter at breast height.

| Common Name | Species Name | Image | Range | Size | Economic uses | Historical uses | Ecological value | Notes |
|---|---|---|---|---|---|---|---|---|
| Cascara | *Frangula purshiana* (a.k.a. *Rhamnus purshiana*) |  | B.C. to northern California | Up to 30' tall | Pharmaceutical (laxative) | Bark: medicinal | Berries eaten by birds; provides cover | Deciduous shrub or small tree often found in shady sites |
| Evergreen huckleberry | *Vaccinium ovatum* |  | B.C. to central California | Up to 12' tall | Ornamental; berries: raw, frozen, preserved, wine; branches: floral greenery | Berries: food | Food and cover for birds, elk and other mammals | Can handle salt spray |
| Pacific rhododendron | *Rhododendron macrophyllum* |  | B. C. to southern California | Up to 24' tall | Ornamental | | Cover for variety of animals | Evergreen shrub; indicator of low soil nitrogen |
| Pearly everlasting | *Anaphalis margaritacea* |  | All of North America | 8"-36" tall | Dried floral arrangements | Medicine | Flowers attract moths and butterflies | Weedy native perennial herb found in meadows and clearings |
| Salal | *Gaultheria shallon* |  | Southeast Alaska to southern California | Up to 15' tall | Ornamental, landscaping, floral greenery | Berries: food, dye; leaves: medicine, dye; stems: utensils | Food: many birds and animals; cover for many animals | Evergreen |
| Salmonberry | *Rubus spectabilis* |  | Alaska to southern California | Up to 12' tall | Ornamental; berries: raw and preserves | Berries: food; sprouts: food; bark and leaves: medicinal | Cover for many birds and mammals; food for many animals (e.g., bear, deer, hummingbirds) | Deciduous shrub; can form thickets especially in disturbed areas and stream edges; shade tolerant |
| Vine maple | *Acer circinatum* |  | Southwestern B. C. to northern California | Up to 21' tall | Ornamental, firewood | Wood: utensils; branches: baskets, scoop nets, drum hoops | Food and cover for deer and elk, birds and small mammals | Small deciduous tree that can tolerate moist places |
| Western sword fern | *Polystichum munitum* |  | Southeast Alaska to southern California | Up to 4' tall | Landscaping, floral greenery | Leaves: food storage, bedding; rhizomes: food, medicinal | One of most frequently browsed food of Roosevelt elk and deer | Evergreen with serrated leaves found in moist forests |

Table 4. Range, size, and uses of the most common understory species in the project area. Sources: Garrison and Smith 1974, Randall et al. 1981, Pojar and MacKinnon 1994, Tirmenstien 1990

exclusion of Port-Orford-cedar (common on the coast) are not accurate within the project area.

Table 3 provides a comparison of range, size, maximum age, and economic, historical and ecological uses of the ~15 dominant tree species in the project area. Other information not included in the table is provided below. Table 4 provides the same information for the most commonly found shrub and herbaceous species in the project area.

Douglas-fir is the most common tree in the Pacific Northwest, and prefers deep, moist sandy loam soils (Randall et al. 1981). The tallest known living specimen (the 'Doerner Fir' at 327 ft) is found in Coos County. Douglas-firs are the most important timber species in the nation due to their high timber yields and use in structural lumber (e.g., dimensional lumber and plywood)(Randall et al. 1981). Historically, regular fires would clear most species save Douglas-fir (due to its thick bark), creating nearly pure old-growth Douglas-fir stands (with the also fire-resistant Port-Orford-cedar trees in their range)(Hermann and Lavender 1990).

Port-Orford-cedar is only found in the coastal region from southwestern Oregon to northwestern California and is highly susceptible to Port-Orford-cedar root rot (see Disease/Damage section below). It is a shade-tolerant slow growing species. There are climax communities where Port-Orford-cedar is a dominant species and is commonly associated with western hemlock (Zobel 1990). Old-growth Port-Orford-cedars develop thick bark, allowing them to be highly fire resistant (Franklin and Dyrness 1973).

Sitka spruce is the largest spruce in the world (Randall et al. 1981). It is a shade-tolerant fogbelt species and is highly susceptible to decay when damaged. It's rarely found more than 50 miles from the ocean and is found in moist or boggy sites (Harris 1990; Pojar and MacKinnon 1994; Randall et al. 1981).

Western hemlock prefers deep, moist, well-drained soils (Randall et al. 1981). A shade-tolerant tree, it requires significant organic content in the soil. The thin bark of this species makes it vulnerable to damage from logging and fire (Pojar and MacKinnon 1994; Randall et al. 1981).

Western redcedar is a very shade-tolerant species. It can reach considerable sizes, and is second only to the sequoias and redwoods as the largest tree in the world (Pojar and MacKinnon 1994).

Shore pine is the common name used when this species occurs near the ocean, where wind stress contorts these trees into malformed, twisted shrubs that rarely grow higher than 45 ft (Randall et al. 1981). Known as the lodgepole pine in the Cascades, this species ranges from southern Alaska to Baja, California, making it the widest ranging conifer species in North America (Randall et al. 1981). On the coast, this species can be found in dunes and in coastal swamp or bog habitats due to its tolerance to low nutrient conditions and salt spray (Pojar and MacKinnon 1994; Randall et al. 1981). However, this species is very intolerant of shading from other species (Lotan and Critchfield, 1990).

Red alder is a deciduous tree. It is one of the few tree species that can fix nitrogen, the result of a symbiosis between its root nodules and bacteria (Harrington 1990). Alder can tolerate poor drainage conditions and some flooding so are often found along stream banks or in swamp/marsh habitats (Harrington 1990). Shade intolerant, red alder is a pioneer species that grows abundantly and rapidly in disturbed areas (Franklin and Dyrness 1973).

Disease/Damage

The two diseases causing the most damage to forests in the project area are Swiss needle cast (SNC) and Port-Orford-cedar root rot (POCRR). Except where otherwise noted, the following information on SNC comes from OSU's Swiss Needle Cast Cooperative (SNCC 2014) while information on POCRR originates from Hansen et al. (2000).

First discovered on a plantation in Switzerland in the 1920's, SNC is caused by the native fungus *Phaeocryptopus gaumannii*, which attacks

Douglas-fir trees. Diseased trees develop yellow needles, reduced needle retention, reduced tree diameter and height, and sparse crowns. Caused by an historically present pathogen, SNC was not considered a problem until the mid-1980's – likely due to changes in forest management practices. Sixty years ago Douglas-fir made up ~ 20% of a diverse forest landscape that included hemlock, cedar, alder and spruce, stands. Douglas-fir is now frequently the dominant species in these same forests (Shaw 2008). Oregon forests closer to the coast tend to have the highest incidence of SNC due to moist climate conditions and mild winter temperatures.

Betlejewski at al. (2011) and USFS (n.d.) describe POCRR as a disease caused by the non-native pathogen *Phytophthora lateralis*, which primarily infects Port-Orford-cedar trees (can also infect the native Pacific yew, *Taxus brevifolia*). First seen in Oregon's Port-Orford-cedar forests in 1952 and likely introduced from infected soil from a nursery, *P. lateralis* is a fungus-like mold (closely related to brown algae) that actively swims in water during one part of its life stage (zoospore), enabling it to infect tree roots. Hyphae (long, branching filamentous structures) from the mold then spread up roots, killing the phloem of the roots as they advance into the trunk. First signs of infected trees are a change in foliage from green to yellow or light brown, followed by foliage withering and then death. Infected seedlings can die within weeks of infection, while larger trees can take several years. In many areas, larger trees have died from this pathogen, dramatically changing the age/size distribution of Port Orford dominated forests.

POCRR is primarily spread as zoospore-carrying water moves downhill through forest soils. It is also spread through the transport of infected soils (e.g. animal paws/hooves and human boots, particularly the boots of those who harvest Port-Orford-cedar boughs, or car and truck tires covered with infested soil transported to uninfected areas). The pathogen has now spread to nearly all forests containing Port-Orford-cedar and there is no known way to eradicate it. Most heavily affected Port-Orford-cedar stands are those located in riparian and wetland zones where the pathogen can easily spread via water.

Forest management practices have been employed to help prevent spread of the disease, including: wet-season road closures; harvesting and moving heavy equipment in dry season only; washing vehicles before entering uninfected areas; contouring road surfaces to direct surface water away from Port-Orford-cedar stands; and planting trees on sites unfavorable to disease spread (e.g., upslope of roads).

There are diseases not currently a problem in the project area which may affect the project area in the future (e.g., sudden oak death). These diseases are discussed in this chapter's climate change summary.

Insects

Douglas-Fir beetles (*Dendroctonus pseudotsugae*), Douglas-fir engravers (*Scolytus ventralis*), and flatheaded fir borers (*Melanophila drummondi*) are all beetles that attack Douglas-fir trees (the flatheaded fir borer can also infest spruce and western hemlock). These beetles are all attracted to and more easily infest already stressed trees (e.g. shocked trees on the edge of a recently opened stand; or stress due to drought). Beetle infestations are more likely to occur when downed wood is available to provide a suitable breeding ground for the beetles (e.g., when large slash is left after logging operations)(Flowers and Kanaskie 2007a, 2007b, 2007c).

Douglas-fir beetles can kill large diameter trees by feeding under the phloem layer, allowing sapwood to be infiltrated by wood-decaying fungi (Flowers and Kanaskie 2007a). Flatheaded fir borers are responsible for a substantial amount of large tree mortality in Oregon and can top-kill or infest and kill the entire tree (Flowers and Kanaskie 2007c). Douglas-fir engravers tend to kill smaller trees or cause branch mortality and top-kill in larger trees (Flowers and Kanaskie 2007b).

For any of these pests, the best management method to prevent outbreaks is to manage forests for high stand vigor. Thinning (selecting for non-Douglas-fir species), removing windthrown or downed logs and removing large diameter slash are some methods to accomplish this.

Bears

According to Kanaskie et al. (2001), black bears peel tree bark and eat the cambium layer (inner tissue) in springtime. Bear activity can reduce the growth rate and health of trees, cause decay (lowering wood quality and value) or lead to mortality (most common when bears girdle the tree).

**References**

Adamus, P. R., J. Larsen, and R. Scranton. 2005. Wetland Profiles of Oregon's Coastal Watersheds and Estuaries: Part 3 of a Hydrogeomorphic Guidebook. Report to Coos Watershed Association, US Environmental Protection Agency, and Oregon Department of State Lands, Corvallis, OR. 89 pp.

Betlejewski, F., D. J. Goheen, P. A. Angwin, and R. A. Sniezko. 2011. Port-Orford-Cedar Root Disease: Forest Insect and Disease Leaflet 131. U.S. Forest Service. U.S. Department of Agriculture. 12 pp.

Bingham, B. B. and J. O. Sawyer, Jr. 1991. 'Distinctive Features and Definitions of Young, Mature, and Old-Growth Douglas-Fir/Hardwood Forests.' In Ruggiero, L. F., K. B. Aubry, A. B. Carey and M. H. Huff (eds), Wildlife and Vegetation of Unmanaged Douglas-Fir Forests. US Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, p363-424.

Brokaw, N. and R. Lent. 1999. 'Vertical Structure'. In: Hunter, M.L., Jr.(ed), Maintaining Biodiversity in Forest Ecosystems. New York: Cambridge University Press, p 373-399.

Carey, A. B., J. A. Reid, and S. P. Horton. 1990. Spotted Owl Home Range and Habitat use in Southern Oregon Coast Ranges. The Journal of Wildlife Management. 54(1): 11-17.

Coastal Change Analysis Program (C-CAP). 2014. C-CAP FTP Download, GIS data files, viewed 23 October 2014: http://coast.noaa.gov/ccapftp/

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Flowers, R. and A. Kanaskie. 2007a. Forest Health Note: Douglas-Fir Beetle (*Dendroctonus pseudotsugae*). Oregon Department of Forestry, Salem. 2pp.

Flowers, R. and A. Kanaskie. 2007b. Forest Health Note: Fir-Engraver Beetle (*Scolytus ventralis*). Oregon Department of Forestry, Salem. 2pp.

Flowers, R. and A. Kanaskie. 2007c. Forest Health Note: Flatheaded Fir Borer (*Melanophila drummondi*). Oregon Department of Forestry, Salem. 2pp.

Franklin, J. F. and C. T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Dept. of Agriculture, Portland, OR: 417 pp.

Garrison, G. A. and J. G. Smith. 1974. 'Habitat of grazing animals'. In: Cramer, Owen P., (ed.) Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. U.S. Department of Agriculture, Pacific Northwest Forest Station, Portland, OR: 10pp.

Haila, Y. 1999. 'Islands and Fragments'. In: Hunter, M.L., Jr.(ed), Maintaining Biodiversity in Forest Ecosystems. New York: Cambridge University Press, p210–233.

Hansen, E. M., D. J. Goheen, E. S. Jules, and B. Ullian. 2000. Managing Port-Orford-Cedar and the Introduced Pathogen *Phytophthora lateralis*. Plant Disease. 84: 4-14.

Harrington, C. A. 1990. 'Red Alder'. In Burns, R. M. and Honkala, B. H. (eds.) Silvics of North America: Volume 2: Hardwoods. U.S. Department of Agriculture, Forest Service, Washington, DC. p257-274.

Harris, A. S. 1990. 'Sitka Spruce'. In Burns, R. M. and Honkala, B. H. (eds.) Silvics of North America: Volume 1. Conifers. U.S. Department of Agriculture, Forest Service, Washington, DC. p513-529.

Hermann, R. K. and D. P. Lavender. 1990. 'Douglas-fir'. In Burns, R. M. and Honkala, B. H. (eds.) Silvics of North America: Volume 1. Conifers. U.S. Department of Agriculture, Forest Service, Washington, DC. p1080-1109.

Jędrzejewski, W., M. Niedziałkowska, S. Nowak, and B. Jędrzejewska. 2004. Habitat Variables Associated with Wolf (*Canis lupus*) Distribution and Abundance in Northern Poland. Diversity and Distributions. 10 (3): 225-233.

Kanaskie, A., M. McWilliams, D. Overhulser, and R. Christian. 2001. Black Bear Damage to Forest Trees in Northwest Oregon: Aerial and Ground Surveys, 2000. Oregon Department of Forestry, Salem. 33 pp.

Kanaskie, A. and D. Norlander. 2014. 2014 Swiss Needle Cast Aerial Survey. Oregon Department of Forestry, Salem. 5 pp.

Kumler, M. L. 1969. Plant Succession on the Sand Dunes of the Oregon Coast. Ecology. 50(4):695-704.

Landscape Ecology, Modeling, Mapping and Analysis (LEMMA). 2014a. GNN Species Maps, GIS data files, viewed 4 December 2014: http://lemma.forestry.oregonstate.edu/data/species-maps

Landscape Ecology, Modeling, Mapping and Analysis (LEMMA). 2014b. GNN Structure (Species-Size) Maps, GIS data files, viewed 4 December 2014: http://lemma.forestry.oregonstate.edu/data/structure-maps

Lotan, J. E. and W. B. Critchfield. 1990. 'Lodgepole Pine'. In Burns, R. M. and Honkala, B. H. (eds.) Silvics of North America: Volume 1. Conifers. U.S. Department of Agriculture, Forest Service, Washington, DC. p605-629.

Lynch, A. M. and T. W. Swetnam. 1992. Old-growth mixed-conifer and western spruce budworm in the southern Rocky Mountains. In: Kaufmann, M. R., W. H. Moir, and R. L. Bassett (tech. coords.). Old-growth Forests in the Southwest and Rocky Mountain Regions, Proceedings of a Workshop. [United States Department of Agriculture Forest Service GTR RM-213]. Fort Collins, CO: 81-99.

Matlack, G. and J. Litvaitis. 1999. 'Forest edges'. In: Hunter, M.L., Jr.(ed), Maintaining Biodiversity in Forest Ecosystems. New York: Cambridge University Press, p210-233.

McComb W. and D. Lindenmayer. 1999. 'Dying, dead and down trees'. In: Hunter, M.L., Jr.(ed), Maintaining Biodiversity in Forest Ecosystems. New York: Cambridge University Press, p335-372.

Means, J., T. Spies, S. Chen, J. Kertis, P. Teensma. 1996. Forests of the Oregon Coast Range – Consideration for Ecological Restoration. In Hardy, C. C. and S. F. Arno (eds), The Use of Fire in Forest Restoration. U.S. department of Agriculture, Forest Service, Ogden, UT, p68-71.

Moeur, M., J. L. Ohmann, R. E. Kennedy, W. B. Cohen, M. J. Gregory, Z. Yang, H. M. Roberts, T. A. Spies, and M. Fiorella. 2011. Status and trends of late-successional and old-growth forests. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 56 p.

Ohmann, J. L., M. J. Gregory, H. M. Roberts, W. B. Cohen, R. E. Kennedy, and Z. Yang. 2012. Mapping Change of Older Forest with Nearest-Neighbor Imputation and Landsat Time-Series. Forest Ecology and Management. 272:13-25.

Oregon Department of Forestry (ODF). 2014a. Public Ownership, GIS data files, last updated 2005, viewed 4 December 2014: http://www.oregon.gov/odf/pages/gis/gisdata.aspx

Oregon Department of Forestry (ODF). 2014b. Swiss Needle Cast (SNC) Aerial Surveys, GIS data files, viewed 21 November 2014: http://www.oregon.gov/ODF/privateforests/Pages/fhMaps.aspx

Peterson, N. M., P. M. Peterson, G. F. Weetman, and P. J. Martin. 1997. Ecology and Management of Sitka Spruce: Emphasizing its Natural Range in British Columbia. UBC Press,Vancouver, British Columbia.

Pojar, J. and A. MacKinnon. (eds.). 1994. Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia and Alaska. Lone Pine Publishing, Vancouver, British Columbia.

Randall, W. R., D. N. Bever, W. R. Randall, and R. F. Keniston. 1981. Manual of Oregon Trees and Shrubs. O.S.U. Book Stores, Inc, Corvallis, OR: 305pp

Rapp, V. 2003. New Findings about old-Growth Forests. Science Update, US Department of Agriculture, Pacific Northwest Research Station. 12 pp.

Schowalter, T. D. 1995. Canopy invertebrate community response to disturbance and consequences of herbivory in temperate and tropical forests. Selbyana. 16: 41-48.
Scott, V.E., K. E. Evans, D. R. Patton, and C. P. Stone. 1977. Cavity-nesting birds of North American Forests. USDA Forest Service Agriculture Handbook 511. 112 pp.

Shaw, D. 2008. Forest Health Fact Sheet: Swiss Needle Cast of Douglas-fir in Oregon. Oregon State University Extension Service, Corvallis. 4 pp.

Sniezko, R. A., J. Hamlin, and E. M. Hansen. 2012. 'Operational Program to Develop *Phytophthora lateralis*-Resistant Populations of Port-Orford-Cedar (*Chamaecyparis lawsoniana*)', Proceedings of the fourth international workshop on the genetics of host-parasite interactions in forestry: Disease and insect resistance in forest trees.US Department of Agriculture, Albany, California, p65-79.

Sniezko, R. 2014. [South Slough NERR 2014 POC field trials survey]. Unpublished data.

South Slough National Estuarine Research Reserve (SSNERR). 2014. [Port-Orford-cedar 2013 disease-resistant outplantings and follow-up surveys]. Unpublished raw data.

Spies, T. A. and J. F. Franklin. 1996. 'The Diversity and Maintenance of Old-Growth Forests'. In: Szaro, R.C.; Johnston, D.W., (eds), Biodiversity in managed landscapes. New York, NY: Oxford University Press, p296–314.

Swiss Needle Cast Cooperative (SNCC). 2014. Oregon State University, Corvallis, viewed 24 November 2014: http://sncc.forestry.oregonstate.edu/

Thorson, T. D., S. A. Bryce, D. A. Lammers, A. J. Woods, J. M. Omernik, J. Kagan, D. E. Pater, and J. A. Comstock. 2003. Ecoregions of Oregon (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

Tirmenstein, D. 1990. 'Gaultheria shallon'. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 24 December 2014: http://www.feiscrs.org/beta/

Tyrrell, L. E. and T. R. Crow. 1994. Dynamics of Dead Wood in Old-Growth Hemlock-Hardwood Forests of Northern Wisconsin and Northern Michigan. Canadian Journal of Forest Research. 24: 1672-1683.

United States Forest Service (USFS). 2014. Aerial Survey Detection Data, GIS data files, viewed 24 November 2014: http://www.fs.usda.gov/detail/r6/forest-grasslandhealth/insects-diseases/?cid=stelprdb5448186

United States Forest Service (USFS). n.d. Decayed Wood Advisor: Port-Orford-cedar Root Disease, viewed 30 December 2014: http://www.fs.fed.us/r6/nr/wildlife/decaid/IandDSpecies/Port-Orford-cedar%20root%20disease.html

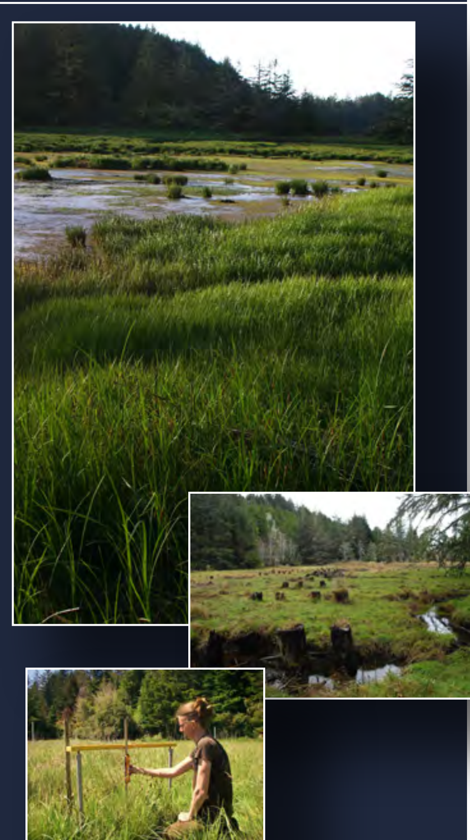
Zobel, D. B. 1990. 'Port-Orford Cedar'. In Burns, R. M. and Honkala, B. H. (eds.) Silvics of North America: Volume 1. Conifers. U.S. Department of Agriculture, Forest Service, Washington, DC. p155-170.

# Tidal Wetland Vegetation in the Lower Coos Watershed

CLW DATA SOURCE

*Summary:*

- *The Coos estuary has lost most of its historic tidal marshes and forested swamps. However, remaining tidal marsh and swamp acreage appears to be relatively unchanged since 1979.*
- *Tidal wetlands in the Coos estuary host diverse plant communities characterized by several dominant species, including pickleweed in marine-dominated marshes and sedges in brackish marshes.*
- *Data from undisturbed marshes in the project area show that the composition of undisturbed marsh plant communities in the Coos estuary appears to be stable.*
- *There are a few non-native, invasive, and endangered tidal wetland plant species of concern in the Coos estuary.*



**Evaluation**

Most of Coos estuary's original tidal marshes and forested swamps have been converted to other uses; remaining tidal wetland plant communities appear stable.

**Evaluation**

We do not have enough historic data to fully evaluate the status of scrub-shrub and forested tidal wetlands

DATA GAP

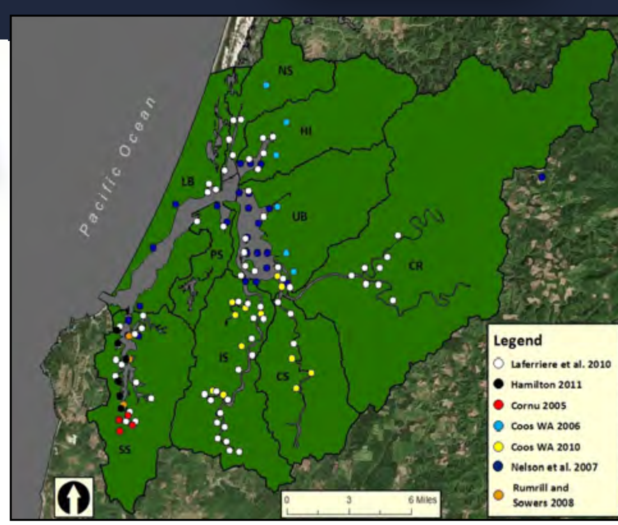



Figure 1. Spatial extent of marsh vegetation studies in the project area.

**What's happening?**

Change in Tidal Wetland Area

Several studies have quantified the extent of wetland conversion in the Coos estuary since European settlement (ca. 1800). Hofnagle et al. (1976) estimated that almost 90% of Coos Bay's tidal wetlands have been converted to other land uses. Good (2000) estimated the total loss between 1870 and 1970 to be 66%. In a 2006 report, the Coos Watershed Association (CoosWA) examined estuarine sediment and vegetation to determine the historical extent of wetland areas in six lowland streams (CoosWa 2006)(Figures 1 and 2). Their analysis suggests that wetland areas in these basins appear to have decreased by 70-95% of their historic extent (Table 1). Over the past 30 years, some of these converted wetlands have been restored to their original function (see the Marsh Restoration sections below).

This data summary uses the National Wetlands Inventory (NWI) habitat classification (Cowardin et al. 1979)(see sidebar) to analyze recent change to wetland area based on available NWI data from 1979 and from

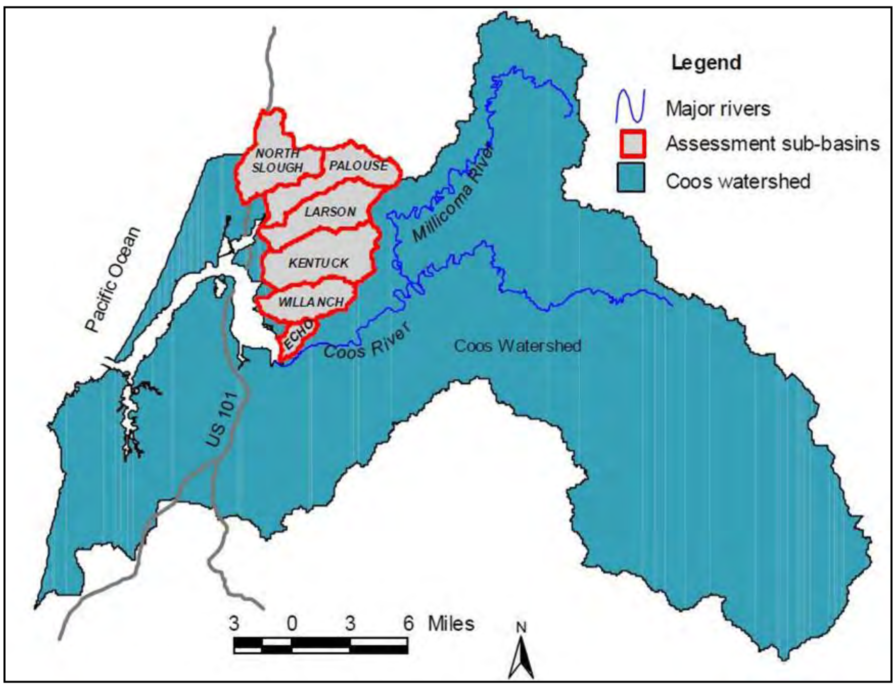



Figure 2. Coos Watershed Association lowland assessment sub-basins . Figure: CoosWA 2006

| Lowland Creek | Historic Wetlands (Pre-settlment Acres) | Current Wetlands (2006 Acres) | Long term (% change) |
|---|---|---|---|
| Palouse Creek | 555 | 30 | -95% |
| North Slough | 508 | 165 | -68% |
| Larson Creek | 587 | 46 | -92% |
| Kentuck Creek | 608 | 37 | -94% |
| Willanch Creek | 256 | 17 | -93% |
| Echo Creek | 194 | 60 | -69% |

Table 1. Estimates of historic wetland habitat loss since European settlement in six lowland sub-basins of the Coos estuary (see Figure 2). Data: CoosWA 2006

*National Wetland Inventory*

*In the late 1970s, the United States Fish and Wildlife Service (USFWS) established a federal standard for wetland and deep water habitat classification. The new system was used to conduct a nationwide wetland habitat inventory to provide information about the distribution of wetlands in the United States and aid in conservation efforts.*

*This classification scheme defines wetland habitat according to its ecological and physical characteristics, including water-loving plants (hydrophytes), wetland soils (hydric soils), and flooding frequency. At the highest level of the classification hierarchy, "systems" are defined by one of five types: marine, estuarine, riverine, lacustrine, and palustrine. Each system is further classified by substrate material (e.g., unconsolidated gravel bottom), flooding regime (e.g., regularly flooded intertidal habitat) and vegetation (e.g., scrub-shrub wetlands dominated by small trees or shrubs).*

*Sources: Cowardin et al. 1979, USFWS 2014b*

2003 (see 2003 data in Figure 3). The NWI system classifies wetland habitat into several broad "Systems" including Marine, Estuarine, Riverine, Lacustrine, and Palustrine (Table 2 and Figure 4). Each System consists of a series of "Classes", "Subclasses" and "Dominance Types". This data summary focuses on the vegetation classes within NWI's Estuarine system: Aquatic Bed (e.g. seagrasses), Emergent Wetland (rooted vegetation whose leaves and stems extend above the water surface), Scrub-Shrub Wetland, and Forested Wetland (Figure 5). For additional information about the NWI classification system for other wetland types see NWI's online Wetlands Mapper tool (USFWS 2014a). We note here that there is little information available about the historic extent of scrub-shrub and forested tidal wetlands in the Coos estuary which would have been almost entirely converted prior to NWI wetland mapping in 1979. This data summary does not reflect the true loss of those habitats and recognizes the omission as a key information gap.

At the System level, the NWI data suggest that wetlands in the project area have remained relatively unchanged between 1979 and 2003 (Table 3), after years of wetland loss documented in Hofnagle at al. (1976), Good (2000), and CoosWA (2006). At the more refined Class level, the data actually indicate an increase (40%) in vegetated wetland acreage within all Systems (excluding Marine) from 1979 to 2003 (USFWS 1979, 2003)(Table 4). This change is driven by the Aquatic Beds Class in the Estuarine System, which experienced an apparent net increase of approx-

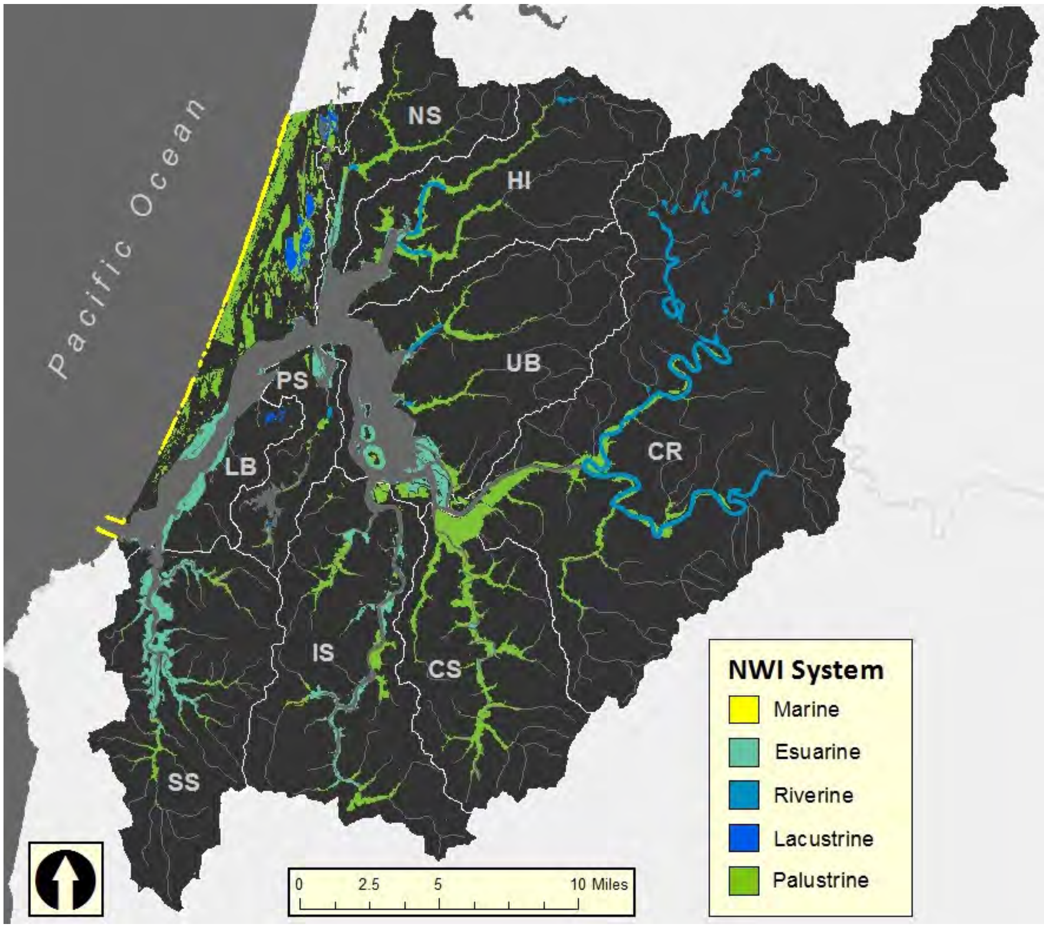



Figure 3. Distribution of wetland habitat at the System level in the lower Coos watershed (project area) in 2003. Map generated from most current National Wetlands Inventory (NWI) data. Data: USFWS 2003

| System | Associated Terms | NWI Definition |
|---|---|---|
| Marine | ocean, sea, bay, reef | Open ocean overlying the continental shelf and its associated high-energy coastline. Salinities exceed 30 ppt, with little or no dilution. |
| Estuarine | estuary, marsh, slough, tidal flat, delta | Deepwater tidal habitats and adjacent tidal wetlands that are usutally semienclosed by land but have open, partly obstructred, or sporadic access to the open ocean, and in which ocean water is at least occasionally dilluted by fresh-water runoff from the land. |
| Lacustrine | lake, pond, reservoir | Wetlands and deepwater habitats with following characteristics : 1) situation in a topographic depression aor a dammed river channel, 2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30% areal coverage, and 3) total area exceeds 20 acres. Lacustrine waters may be tidal, but ocean-derrived salinity is always less than 5 ppt. |
| Palustrine | bog, marsh, fen, swamp, prarie, slough | All nontidal wetlands that aredominated by trees, shrubs, persistent emergents, emergent mosses or lichens. Also includes tidal areas were 1) salinity is less than 5 ppt and water depth is less than 2 meters at low water. |
| Riverine | river, stream, brook | All wetlands and deepwater habitats contained within a channel with two exceptions: 1) wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and 2) habitats with water containing ocean-derived salts |

Table 2. Definition of five NWI systems. Data: Cowardin et al. 1979.


Figure 4. Examples of habitat representing four NWI Systems. See Figure 1 for distribution of Systems within project area and Table 2 for definitions. Top left: Millicoma River, Coos River Subsystem; Top right: Empire Lakes, Lower Bay Subsystem; Bottom left: Hidden Creek marsh, South Slough Subsystem; Bottom right: Matson Creek marsh, Catching Slough Subsystem.

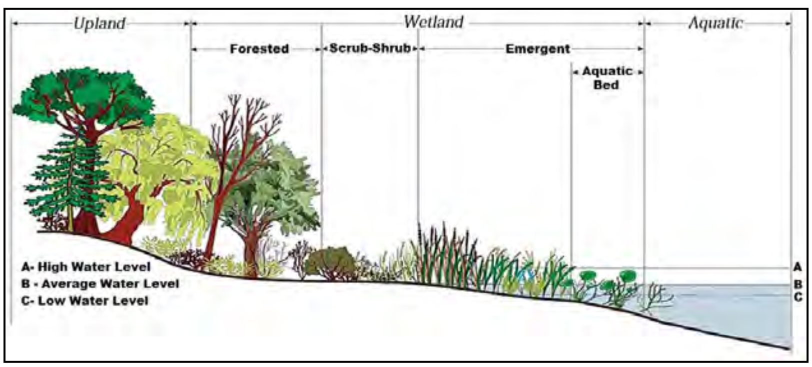



Figure 5. Schematic representation of NWI vegetation classes within a wetland setting. Image modified from Wilcox et al. 2007

| System Form | 1979 Acreage | 2003 Acreage | Percentage Change (1979-2003) |
|---|---|---|---|
| Estuarine | 13,349.96 | 13,381.70 | 0.2% |
| Lacustrine | 937.21 | 937.19 | 0.0% |
| Palustrine | 9,830.30 | 9,830.17 | 0.0% |
| Riverine | 412.38 | 412.37 | 0.0% |
| **All System Forms** | **24,529.85** | **24,561.43** | **0.1%** |

Table 3. Summary of wetland habitat change within the lower Coos estuary (1979-2003) based on NWI data aggregated at the System level. Data: USFWS 1979, 2003

| Vegetation Class (Estuarine System Form) | 1979 Acres | 2003 Acres | Percentage Change (1979-2003) |
|---|---|---|---|
| Aquatic Bed | 903.8 | 1476.1 | 63% |
| Emergent | 1797.9 | 1797.9 | 0% |
| Forested | 0.0 | 0.2 | N/A |

Table 4. Summary of wetland habitat change within the lower Coos estuary (1979-2003) based on NWI data aggregated at the Class level in the Estuarine System. Data: USFWS 1979, 2003

imately 570 acres (63% increase from 1979 levels). Acreage for all other vegetation Classes decreased slightly; declines in Emergent, Forested, and Scrub-Shrub Wetland Classes collectively accounted for less than 3 acres of lost wetland in the lower Coos estuary from 1979- 2003.

It's important to note some limitations of the NWI data. While gains or losses may be indicative of actual trends, they could also reflect a reclassification of existing wetland areas. For example, a parcel that was unclassified in 1979 may be classified as aquatic vegetation in 2003. In this case, the data would suggest a net gain of aquatic vegetation habitat, even though this gain may only reflect a reclassification of pre-existing wetlands. Since the data do not account reclassifications, it's possible that the observed increase in aquatic vegetation beds within the estuarine systems of Coos Bay (Table 4) may be exaggerated (see Chapter Summary for data limitations). We are missing data with which to independently check these results since eelgrass has been comprehensively mapped only once in the Coos estuary (in 2005)(see Seagrasses and Algae in the Lower Coos Watershed data summary in this chapter). In general, more data characterizing the current and historic extent of tidal wetlands for the Coos estuary are needed to improve our understanding of local tidal wetland status and trends.

<u>Tidal Wetland Community Composition and Diversity</u>

In 2007, the Western Ecology Division of the United States Environmental Protection Agency (USEPA) published a report that included information about the distribution of emergent marsh vegetation in the extensive estuarine intertidal habitats (tidal wetlands) in California, Oregon and Washington estuaries (Nelson et al. 2007). Sampling did not include high marsh habitats; they focused on characterizing low emergent marshes and intertidal mud and sand flats. In summer 2002, they collected data from 217 sites, with almost half of the 65 sites in Oregon located in the Coos estuary (30 sites). USEPA results indicate that overall low marsh vegetation percent cover for West Coast tidal wetlands is low, underscoring the dominance of intertidal mud and sand flats in the total area of West Coast estuaries (Figure 6). It is important to note that these data are relative to low marsh habitats only; if high marsh habitats were included in the study, mud and sand flat habitat would not have been as dominant. USEPA add that low marsh and intertidal flat vegetative cover from non-native species was very low (8% overall), having encountered only two such species: Japanese eelgrass (*Zos-*

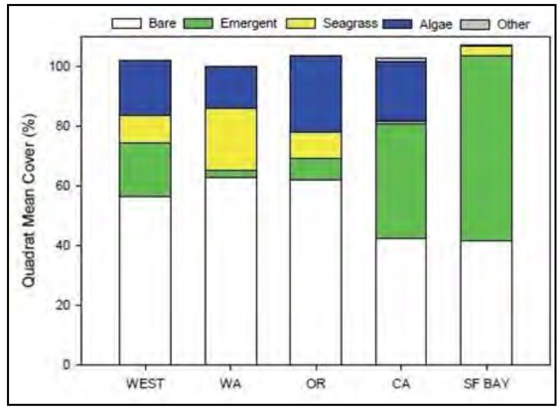



Figure 6. Mean relative abundance of vegetation groups and bare (unvegetated) area in low marsh vegetation plots. Nelson et al. 2007

*tera japonica*)(estuaries in all three states) and smooth cordgrass (*Spartina alterniflora*) (Washington estuaries only). Japanese eelgrass is commonly found in the low intertidal zones of the Coos estuary (see Seagrasses and Algae in the Lower Coos Watershed data summary in this chapter). Smooth cordgrass is not found in the Coos estuary (see Chapter 18: Non-Indigenous/Invasive Species).

Other studies characterize the emergent marshes (both low and high marshes) of the Coos estuary. Rumrill and Sowers (2008) characterized emergent marsh vegetation along the estuarine gradient in the Coos estuary's South Slough, with one site representing habitats subject to marine-dominated tidal hydrology (full salinity- 33); one site representing habitats subject to polyhaline tidal hydrology (salinity 18-30); and one site representing habitats subject to riverine/mesohaline tidal hydrology (salinity 0-18). All study sites were considered to be "least disturbed", meaning they've not been converted to other land uses and remain relatively undisturbed by other human activities. Not surprisingly, Rumrill and Sowers report that emergent marsh communities displayed "substantial spatial variability" along the estuarine gradient. The greatest species richness was recorded at the riverine/mesohaline site, while the polyhaline and marine-dominated sites

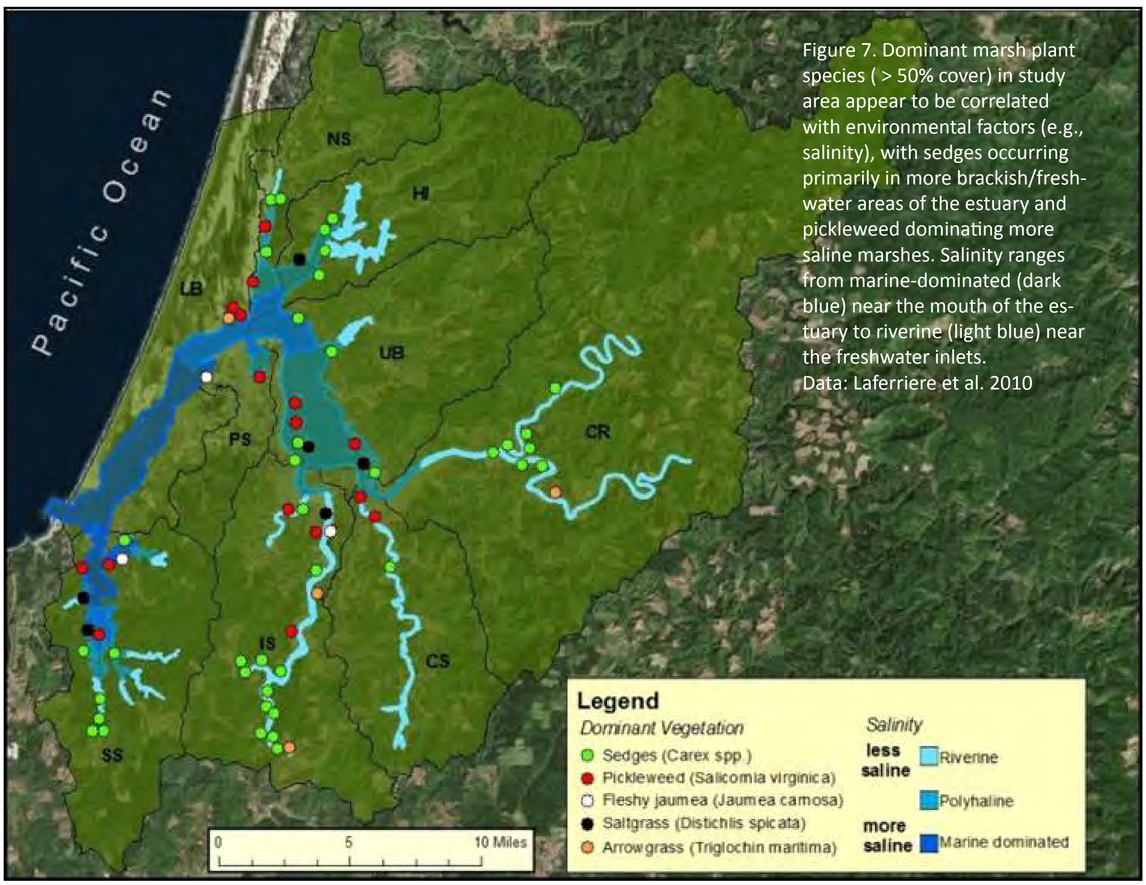



Figure 7. Dominant marsh plant species ( > 50% cover) in study area appear to be correlated with environmental factors (e.g., salinity), with sedges occurring primarily in more brackish/freshwater areas of the estuary and pickleweed dominating more saline marshes. Salinity ranges from marine-dominated (dark blue) near the mouth of the estuary to riverine (light blue) near the freshwater inlets.
Data: Laferriere et al. 2010

displayed lower species richness (due to the relatively fewer number of emergent plant species adapted to higher salinity growing conditions). Plant communities in the study sites were generally characterized by a group of four to seven dominant species (>10% cover) with up to eight other sub-dominant species characterized in the study.

Least disturbed intertidal wetlands in the Coos estuary typically host communities comprising "a mixed assemblage of 25-30 common emergent vascular plants." Marshes are often dominated by the relatively high abundance of a few species, including pickleweed (*Salicornia virginica*), fleshy jaumea (*Jaumea carnosa*), salt grass (*Distichlis spicata*), tufted hairgrass (*Deschampsia caespitosa*), creeping bentgrass (*Agrostis stolonifera*), Lyngby's sedge (*Carex lyngbyei*), and arrowgrass (*Triglochin maritimum*)(Hamilton 2011; Nelson et al. 2007; Laferriere et al. 2010; Cornu 2005a; CoosWA 2010; Rumrill and Sowers 2008).

Another study, by Laferriere et al. (2010), surveyed emergent intertidal marsh vegetation at sites throughout the Coos estuary as part of an investigation into the abundance and distribution of *Assiminea parasitologica*, a small, invasive snail native to Japan (Figures 1 and 7)(see more information about the snail in Chapter 18: Non-Indigenous/Invasive Species). Since the sampling design for this study was focused on the invasive snail, the emergent marsh data, while still very useful, include gaps and should not be considered a comprehensive characterization of Coos estuary emergent marsh plant communities. For example, the investigators recorded the presence of generic sedge species (*Carex sp.*), missing the opportunity to distinguish the critical difference between the dominant freshwater sedge (*Carex obnupta*) and the salt-tolerant sedge (*Carex lyngbyei*)(see Data Gaps and Limitations in Chapter Summary).

Laferriere et al. (2010) reports that sedges (*Carex spp*.) are the most abundant plant species in marshes in the upper reaches and freshwater dominated portions of the estuary, while pickleweed dominates marshes in the more marine-dominated (saline) environments. The distribution of other dominant species appears to be patchy throughout the lower watershed. Data from other studies in the South Slough Subsystem support these conclusions (Hamilton 2011)(Figure 8).

Species "richness" or other measures of species diversity (see sidebar) also appear to be a function of ecosystem "drivers", such as tidal inundation period (determined by tidal magnitude and marsh surface elevation- low elevation marshes experience longer periods of tidal inundation than high marshes) and salinity regime (tidewater salinity and resulting marsh soil salinity)(Hamilton 2011)(Figure 9).

Hamilton (2011) compared diversity metrics in multiple years at South Slough's overlapping "biomonitoring" marsh study sites (Figure 1)(Rumrill and Sowers 2008, Hamilton 2011). Both diversity and species richness appear to have increased from 2004-2010 (Figure 10). This trend is most apparent when comparing the average species richness, a

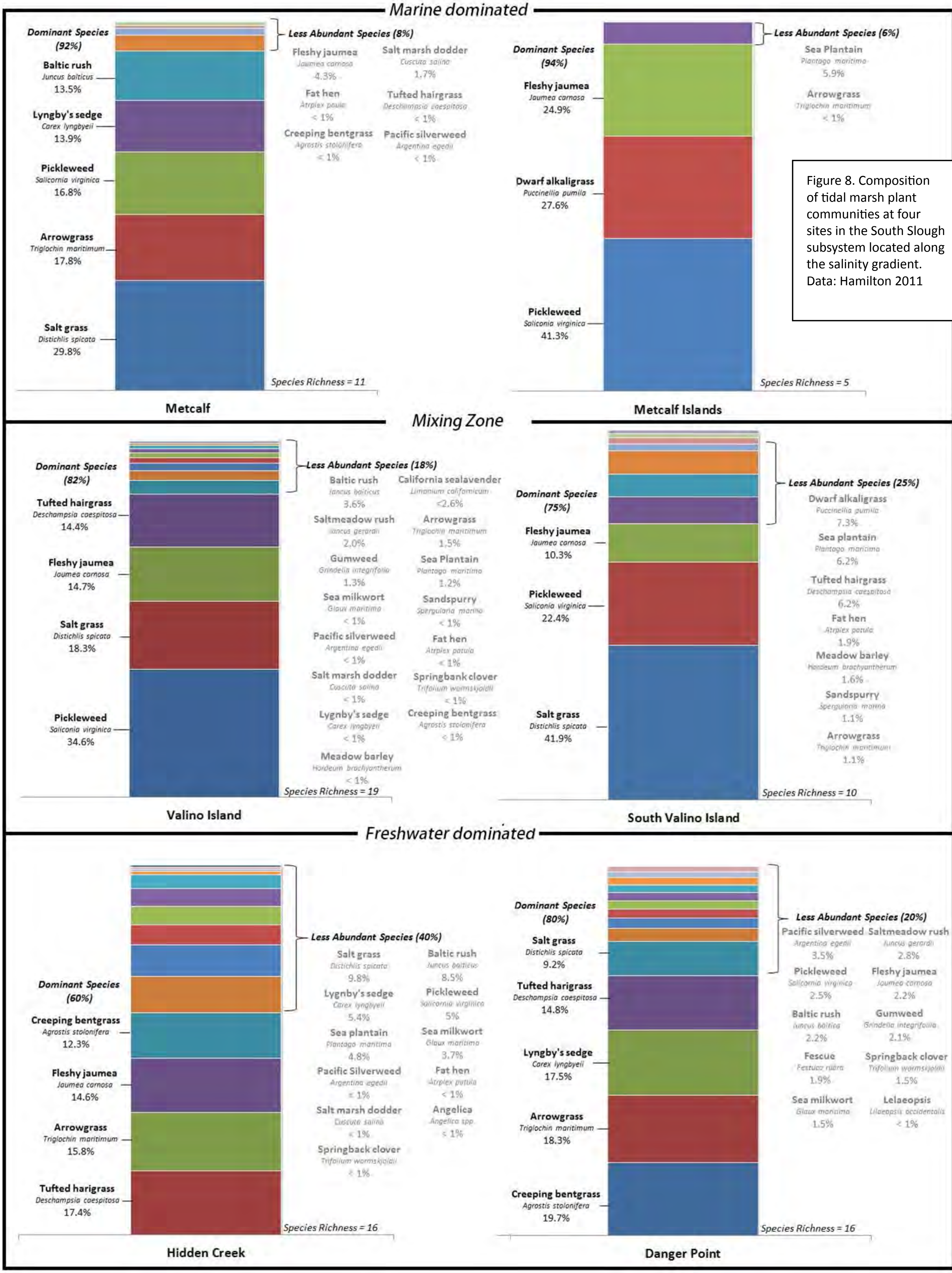



Figure 8. Composition of tidal marsh plant communities at four sites in the South Slough subsystem located along the salinity gradient. Data: Hamilton 2011

*Measuring Biodiversity*

*Because quantifying diversity can be a complex process, several measures or "indices" have been developed. The following list explains a few common indices:*

*Species Richness: the total number of species in a community.*

*Species Evenness: a measure of how evenly individual species are distributed within a community, with a value of 1 being perfect parity (i.e., exact same number of each species in community).*

*Shannon-Weiner Index: a "composite index" that incorporates both richness and evenness. Values range from 1.5-3.5 in most ecological communities, with high values representing greater diversity.*

*Effective number of species: a measure of species richness based on composite indices calculated by imposing the assumption of perfect evenness and calculating the number of species necessary to achieve a specified diversity value.*

*Sources: Magurran 2004; Heip et al. 1998; Gotelli and Chao 2013; Kerkhoff 2010*

metric that showed substantial increases at both Danger Marsh (33% increase from 2004 levels) and Valino Island (58% increase). It's important to note, however, that while these trends may reflect true ecological changes, they may also be attributable to differences in methods used in the different studies. Data to be collected in the future at the same long-term monitoring sites will shed light on these findings (Hamilton 2011).

Emergent Marsh Restoration

Tidal wetland restoration projects, most commonly focused on emergent marsh habitat classes, have been almost commonplace in the project area over the past 20 years. The most complete record of restored acres in the project area comes from the Oregon Watershed Restoration Inventory (ORWI 2013a, 2013b). The ORWI catalogs all projects funded by the Oregon Watershed Enhancement Board (OWEB), a state agency that is a substantial source of grant funding for wetland restoration projects. These records suggest that OWEB funding has resulted in approximately 268 acres of tidal wetland restoration within the project area since 2002. South Slough National Estuarine Research Reserve (SSNERR) staff have worked with partners since 1996 to restore approximately 80 acres of tidal wetlands within the Reserve (see below). Figures for tidal wetland restoration conducted by others in the project area and for tidal wetlands acreage restored through the compensatory mitigation process were not available at the time of this writing.

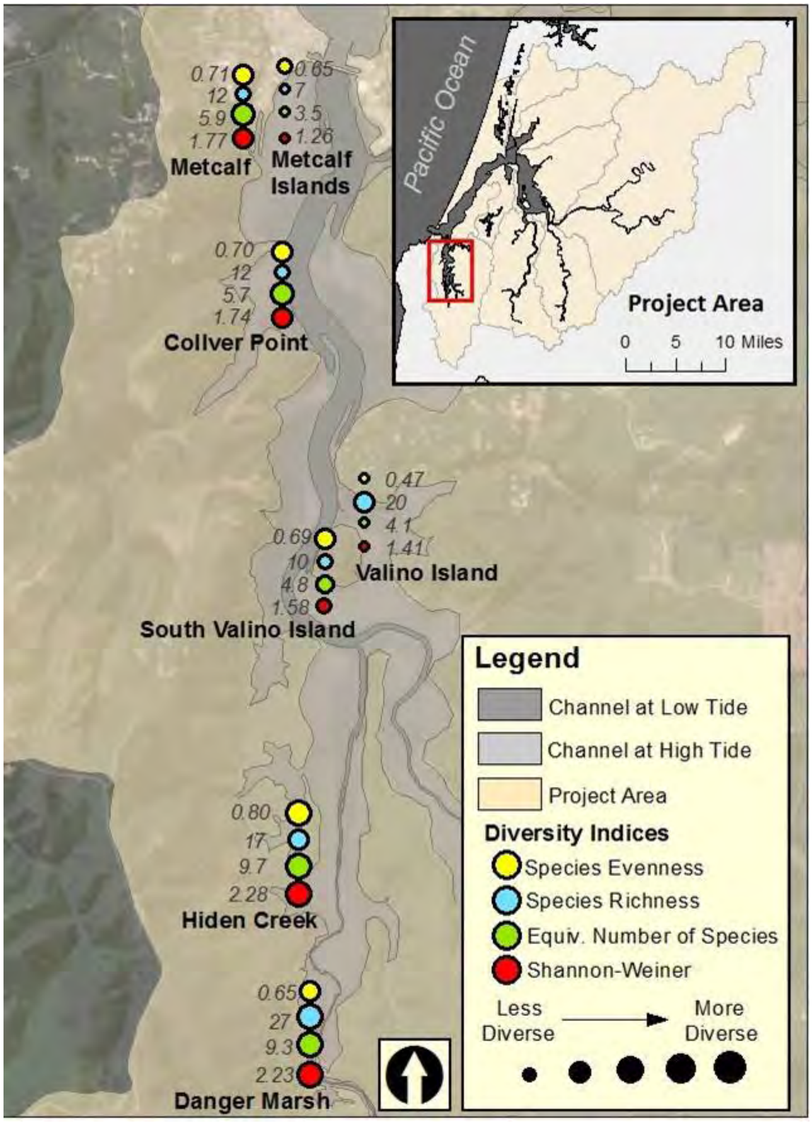



Figure 9. Diversity metrics describing the species evenness and species richness (see "measuring biodiversity" sidebar) of marsh plant communities in South Slough. Data collection occurred at South Slough Reserve "biomonitoring" sites that span South Slough's salinity gradient. More saline sites occur in the north part of the slough (Metcalf); more brackish and freshwater sites occur in the south part of the slough (Danger). Data : Hamilton 2011

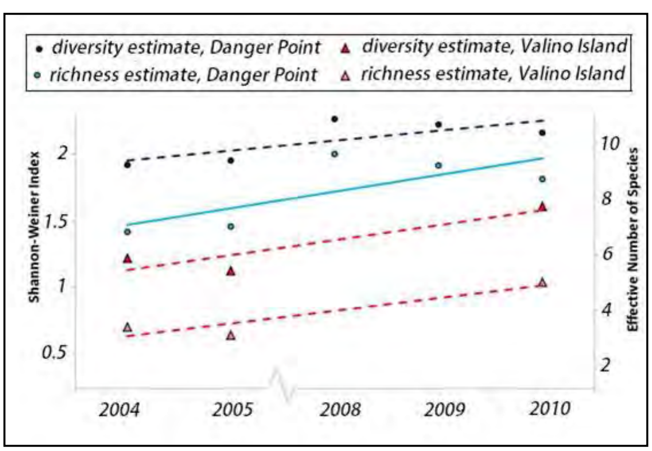



Figure 10. Diversity and species richness of marsh plant communities at Danger Point marsh (blue). Linear trendlines show general increase in both diversity (dashed) and richness (solid) at these two sites. Sampling did not occur in 2006 and 2007. Data: Hamilton 2011

Figure 11. Aerial photo of Kunz Marsh in 1997. The restoration area is divided into four cells by temporary partitions. The elevation of each cell varies with lowest elevation occurring closer to the bottom of the photo and the highest elevation occurring nearer the top. The division of the marsh into cells allowed researchers to examine the effect of marsh elevation on the natural recruitment of emergent salt marsh vegetation and the development of marsh function.

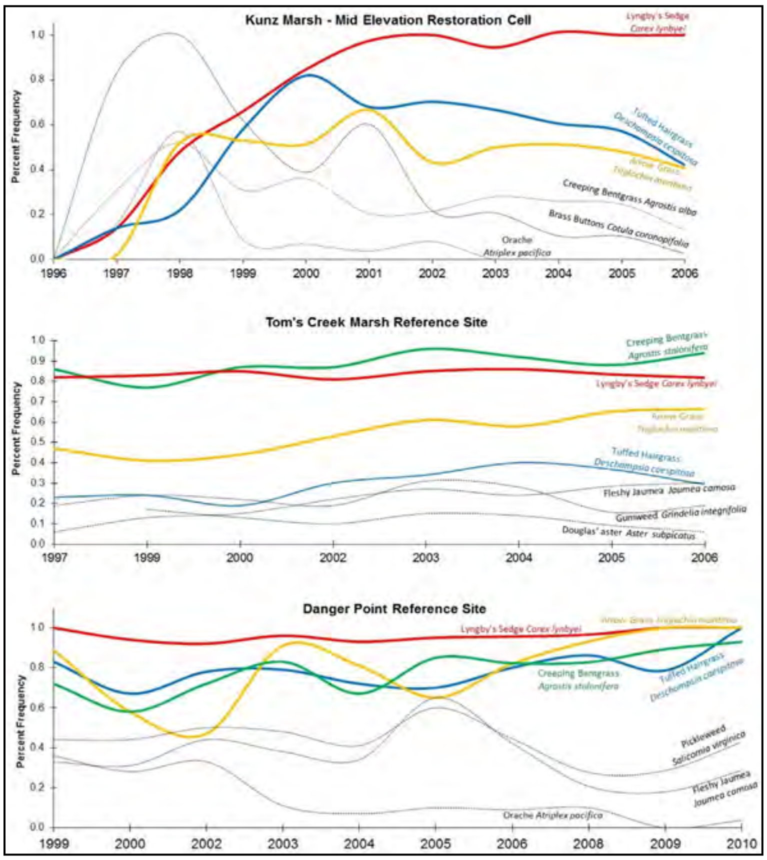



Figure 12. Percent frequency of the most dominant plant species found at Kunz Marsh (restoration site- only mid elevation marsh represented here) as well as Tom's Creek and Danger Point Marshes (reference sites). Data are displayed for both generally abundant species (solid colored lines) as well as less abundant species (black dashed lines). The Kunz Marsh data show a shift in species composition. From 1996 to approximately 2000, the plant community was dominated by early colonizers, including creeping bentgrass (*A. stolonifera*), brass buttons (*C. coronopifolia*), and orache (*A. patula*). In later years, Lyngby's sedge (*C. lyngbyei*), tufted hairgrass (*D. caespitosa*), and arrowgrass (*T. maritima*) were the most dominant species. In comparison, the reference sites show relatively stable plant communities; species composition dominated by the same species that colonized Kunz marsh in the post-2000 years. Data were not collected at the reference sites in 1998, 2001, and 2007. Plant species abundance for these years was interpolated at these sites based on the data that are available for all other years. Data: Cornu 2005a; graphic modified from Cornu et al. 2012.

Figure 13. Excavation of the Anderson Creek high flow channel in the regraded Anderson Creek floodplain.

Several emergent marshes in the project area's South Slough Subsystem (historically converted to agricultural land uses) have been the focus of extensive marsh restoration. These efforts provide insight into the response of brackish marsh plant communities to major "disturbance" events such as re-establishing tidal flooding at a site not flooded for many years. Restoration projects provide insights into the recovery of marsh ecosystems, informing subsequent restoration project planning and design (Cornu 2005a).

Kunz Marsh Restoration Project

In 1997, SSNERR staff began a yearly vegetation monitoring effort at Kunz Marsh, where, in 1996, dike material was used to regrade the subsided marsh to three intertidal elevations and partitioned into four "research cells" (Cornu 2005a)(Figure 11). Kunz marsh presented a unique opportunity to observe the development of a tidal wetland plant community recruited naturally on unvegetated marsh soils at three intertidal elevations (the regraded marsh was not planted). SSNERR staff collected vegetation data (in addition to other data, such as sediment accretion) in each of the Kunz marsh cells to understand the effects of marsh surface elevation on tidal wetland vegetation recruitment and plant community development over time. Kunz marsh vegetation data were compared with vegetation data also collected yearly at adjacent least disturbed marsh sites (Danger Point and Tom's Creek "reference" marshes) to evaluate the rate at which the plant communities developing in the Kunz marsh research cells were progressing towards the "target" marsh plant communities in the reference sites (Cornu 2005a).

Percent frequency vegetation data (i.e., percent of plots in which individual species are encountered) from the two reference sites indicate relative plant community stability compared with Kunz marsh vegetation data (Figure 12). Kunz marsh data document the

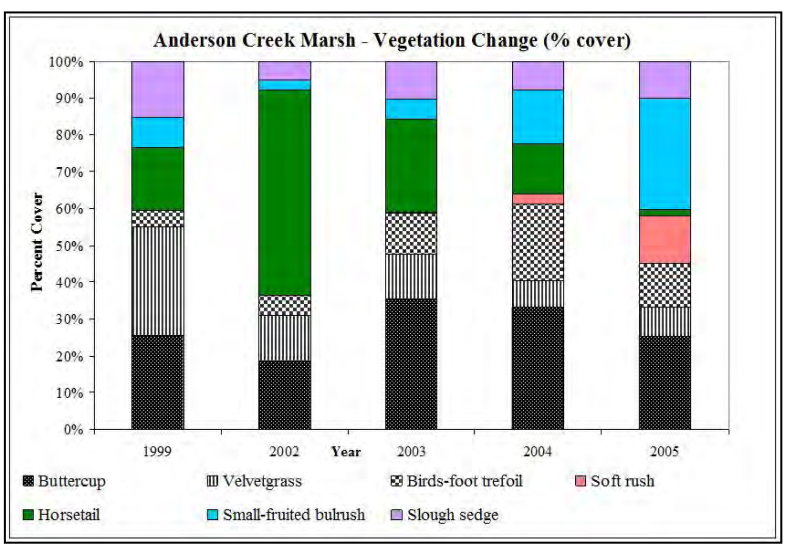



Figure 14. Vegetation change in Anderson Creek floodplain, 1999-2005. Solid colors represent native species. Black and white patterns represent non-native species. Data and graphic: Cornu 2005b


Figure 15. Progression of marsh plant community development in Anderson floodplain 2006-2010 shows continued domination of the native slough sedge (*Carex obnupta*) in areas of slightly less saturated wetland.

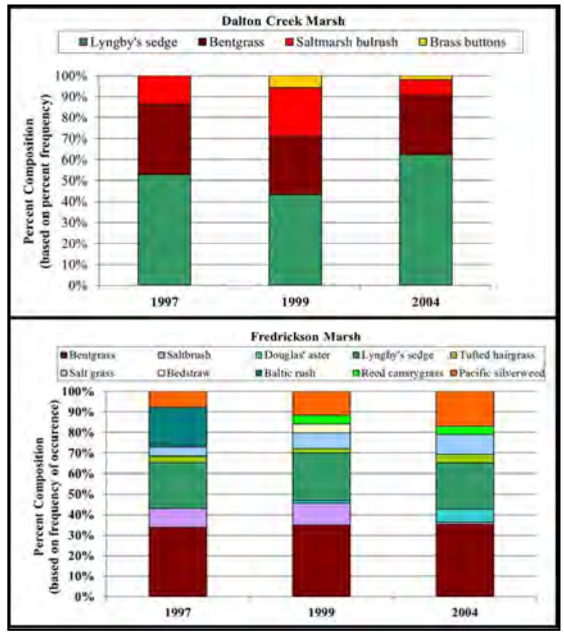



Figure 16. Changes to the brackish plant community at Dalton Creek and Fredrickson marsh restoration sites in the South Slough Subsystem. Data and figure: Cornu 2005c

recruitment of early colonizing vegetation and both the recruitment and establishment of later, permanently colonizing vegetation species, a very dynamic successional process (Figure 12). There are distinct differences in the timing and rate of vegetation recruitment and the colonization trajectories of individual species associated with the Kunz research cell elevations. For more information on monitoring results, see Cornu 2005a, and Cornu and Sadro 2002.

Anderson Creek Marsh Restoration Project

SSNERR staff conducted five years of vegetation monitoring at Anderson Creek marsh, including one year of monitoring in 1999 before restoration began, and four years monitoring after restoration actions were completed in 2002. In 2001, SSNERR staff initiated the restoration of Anderson Creek by regrading the floodplain and generating fill material to eliminate the 850 meter (2,800 ft) deeply downcut ditch that Anderson Creek had become (Cornu 2005b)(Figure 13). Since all existing vegetation was removed during site regrading, and invasive species, including reed canary grass, were among the plant species expected to recruit to the site, Reserve staff re-planted the site aggressively with native wetland and riparian vegetation.

Similar to Kunz Marsh, data from Anderson Creek suggest that the species composition and relative abundance of individual species in the developing plant communities at the site were dynamic. Cornu (2005b) explains that residual pasture grasses and exotic forbs dominated the Anderson floodplain during the growing season in 2003. However, he adds that, by summer 2004, native wetland grasses and forbs had increased in abundance (Figure 14). In subsequent years, the plant community continued to develop, with native vegetation steadily becoming more abundant in the Anderson floodplain, beginning to push out the non-native species by 2005 (Figure 15).

Figure 17. Salt marsh bird's beak. Photo: Institute for Applied Ecology

Figure 18. Pacific reedgrass. Photo: University of California, Berkley

Restoration at Cox, Dalton, and Fredrickson Creek Marshes

Cox, Dalton, and Fredrickson Creek brackish marshes are located near the southern end of the South Slough Reserve boundary. Similar to Kunz and Anderson Creek Marshes, the floodplains of these three sites were diked and converted to agricultural uses in the early 1900's (Cornu 2005c). Restoration began in 1996 for Cox Marsh and 1998 for both Dalton and Fredrickson.

Post-restoration vegetation monitoring revealed very little change to species composition at the Dalton Creek and Fredrickson marsh sites (Figure 16). At the Cox marsh site, a large and now permanent beaver dam was constructed across the mouth of the marsh, raising the freshwater water table all through the marsh. This change is influencing the development of a plant community featuring many more freshwater species than would be represented without the beaver dam, including some non-native (and potentially invasive) species like velvet grass (*Holcus lanatus*), birdsfoot trefoil (*Lotus corniculatus*), and reed canary grass (*Phalaris arundinacea*)(Cornu 2005c).

Plants of Special Concern

The Coos estuary salt marshes are inhabited by a few plant species of special concern. Salt marsh bird's beak (*Chloropyron maritimum ssp. palustre*- formerly known as *Cordylanthus maritimus* ssp. *palustris*) is federally listed as a species of concern and also listed as endangered by the state of Oregon (ORBIC 2013)(Figure 17). This species is found in fringing low marshes in the lower portion of South Slough and in a few locations in the lower Coos estuary (Lower Bay subsystem) (Rumrill and Sowers 2008). SSNERR staff work with partners to keep track of the locations of the plant, which tends to grow in the lower estuary in sandy soils among plants like pickleweed and fleshy jaumea (Cornu et al. 2012).

Pacific reedgrass fen (*Calamagrostis nutkaensis*), a rare native plant, was also found in the South Slough Subsystem in 2005 (Brophy 2005)(Figure 18). For more information about rare and endangered plants in the project area, refer to the Rare and Endangered data summary of this chapter.

In addition to the species mentioned above, the lower Coos watershed also contains non-native and invasive vegetation. The following species are regarded as the biggest non-native or invasive threats to plant communities in the marsh habitats in the project area: reed canary grass, purple loosestrife (*Lythrum salicaria*), knotweeds (*Polygonum spp.*), and cordgrasses (*Spartina spp*.). Grass-leaf rush (*Juncus marginatus*), a species considered to be a non-native invasive plant in the Willamette Valley, was also discovered in the South Slough Subsystem (Brophy 2005). Continued monitoring and control of these and other non-native/invasive threats will help ensure the resiliency of native plant communities. For more information about non-native and invasive plants in the project area, refer to Chapter 18: Non-indigenous/Invasive Species.

**Why is it happening?**

Tidal Wetland Alterations and Restoration

Tidal wetland plant communities are sensitive to natural and human-generated alterations, because the manipulation of wetlands can result in complex (and sometimes extreme)

_*Marsh Subsidence*_

*The soil surface elevation of diked tidal wetlands tends to decrease over time in a process called "marsh subsidence." Subsidence occurs in areas were wetlands have been diked to accommodate alternative land uses. Since wetlands behind dikes are excluded from tidal flooding, they are prevented from the delivery of sediment that helps maintain marsh surface elevation in a healthy, functioning wetland. When diked wetlands dry out, their soils begin to oxidize, decompose, and consolidate. The marsh vegetation, which once added organic material to the soil, is replaced by pasture vegetation that is continuously removed by grazing, and the soil is heavily compacted by livestock and machinery. Over time, the original marsh soil consolidates and subsides, sometimes significantly (e.g., 80 cm [31 in] at South Slough's Kunz Marsh).*

*Sources: Cornu 2005a; Roman et al. 1984; Frenkel and Morlan 1991; Anisfeld et al. 1999; Weinstein and Weishar 2002*

changes to the hydrology of wetland ecosystems (Cornu 2005a, 2005b, 2005c; Hood 2004, Gedan et al. 2009). Historically, tidal wetland alterations occurred throughout the Coos estuary. Tidal marshes, forested tidal swamps, and scrub shrub tidal wetlands were eliminated through wetland filling (often using dredge spoils), or were diked and drained, and their meandering tidal channels filled and replaced with linear drainage ditches, and marsh, forest, and shrub communities converted or removed. All of these changes were made to accommodate other uses (e.g., agriculture, urban, industry, silviculture)(CoosWA 2006).

In most cases, diking and draining tidal wetlands initiates natural processes that can result in significant elevation loss of those lands behind dikes which can be exacerbated by normal agricultural activities such as livestock grazing and transport of heavy equipment across the site (see sidebar). Subsidence makes agricultural activities increasingly difficult over time because the lower the land, the harder it is for the land to drain, especially after sustained wintertime rainfall. Some subsided agriculture lands drain so poorly that their soils remain saturated for most of the year, greatly limiting or eliminating their agricultural productivity. Many of these lands are simply abandoned.

These same lands, however, can be made productive in other ways that benefit human communities. Restoring dikes and drained wetlands to their fully functioning former tidal wetland condition re-establishes beneficial "ecosystem services" such as critical nursery habitat for commercially important fish and shellfish species (e.g., salmon and Dungeness crabs), floodwater retention (tidal wetlands act like sponges and soak up wintertime floodwaters, which reduces flooding in developed areas), and improvements to water quality (sediments are trapped by tidal wetlands, helping clear turbid waters; excess nutrients and many water soluble compounds considered pollutants are taken up by natural biogeochemical processes constantly occurring in tidal wetlands). When restoring wetlands, subsidence is a common issue that must be addressed by restoration practitioners. The Kunz marsh restoration project described above is one approach to be considered for accelerating the recovery of subsided former tidal wetlands.

Figure 19. Development of a low marsh tidal channel network at the Kunz marsh restoration site, South Slough.

**Background**

Tidal wetlands form over many decades as layers of sediment from both terrestrial and marine sources are slowly but steadily deposited on tidal flats through daily tidal flooding. Eventually, the tide flats reach elevations relative to the tide that allow their colonization by vascular plants. Many saltwater, brackish and freshwater marsh plant species are adapted to colonize and persist in higher elevation tide flats whose flooding frequency and duration (dictated by tide flat elevation) do not exceed maximum thresholds. Different species have different thresholds- for example, pickleweed, a common low marsh plant, is adapted to withstand more frequent and longer tidal flooding than Pacific silverweed (*Argentina egedii*), a high marsh plant. Tide water salinity also plays a significant role in determining which plants are able to colonize which tide flats; more salt tolerant species (e.g., pickleweed, fleshy jaumea, arrowgrass) can colonize tide flats located in the lower portions of estuaries nearer to the ocean (subject to high salinity levels), while less salt tolerant species, (e.g., pacific silverweed, baltic rush [*Juncus balticus*]) will colonize tide flats located in the upper portions of estuaries further away from the ocean and more influenced by river and stream flows (Cornu 2005a).

Once colonized with low marsh vegetation, tide flats continue to build upwards, accelerated by vegetation's tendency to help trap sediments and contribute their own organic material (through yearly senescence), in a process called "vertical accretion (Kerney et al. 1994; Cahoon et al. 1995; Cornu and Sadro 2002). Mature tidal marshes, also known as high marshes, stop growing vertically when they reach an elevation equal to, or a little higher than the mean of all the higher high tides (mean higher high water- MHHW) that flood the marsh. Mature/high marshes still require regular sediment deposits from tidal flooding to maintain their elevation relative to the tide (Cornu and Sadro 2002).

Tidal channels form largely through the same accretion processes that form vegetated tidal wetlands. Tidal wetlands build up around tidal channels, whose steep banks are stabilized by the cohesiveness of the tide flat sediments (mostly clays and silts except near estuary mouths, where sediments have higher sand content), and by the extensive and persistent root systems associated with tidal wetland plant communities (Cornu 2005a)(Figure 19). Tidal channels serve an important function, providing habitat structure and foraging access for animals as well as pathways for the import and export of materials that help sustain life in the marsh, including nutrients, detritus, and propagules (e.g., plant seeds, benthic invertebrate and insect eggs)(Cornu 2005a).

The composition and distribution of vegetation in estuaries depends on several factors:

- On an macro-scale, the hydrology of an estuary determines the characteristics of the brackish plant community. For exam-

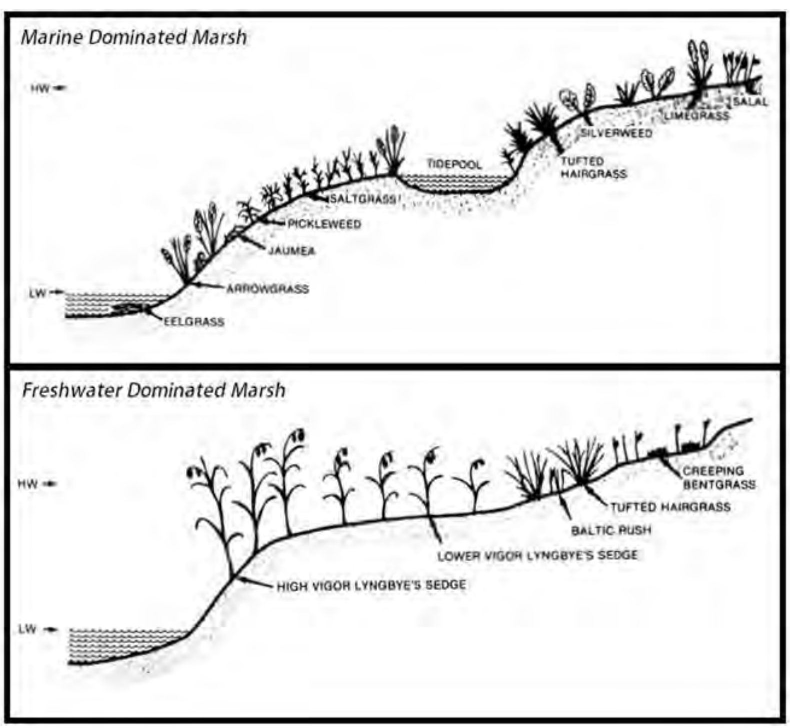



Figure 20. Typical zonation of Pacific Northwest estuarine vegetation showing the distribution of plants relative to marsh elevation. Figure: Seliskar and Gallagher 1983

| Common Name | Scientific Name | Photo |
| --- | --- | --- |
| Angelica | *Angelica spp.* |  Photo: Mdidea.com |
| Arrowgrass | *Triglochin maritimum* |  Photo: USDA |
| Baltic rush | *Juncus balticus* |  Photo: Brent Miller |
| Creeping bentgrass | *Agrostis stolonifera* |  Photo: Zirpe |
| Douglas Aster | *Symphyotrichum subspicatum* |  Photo: nwplants.com |
| Fat hen | *Atriplex patula* |  Photo: Netartsbaytoday.org |
| Fleshy jaumea | *Jaumea carnosa* |  Photo: Aaron Schusteff |
| Gumweed | *Grindella integrifolia* |  Photo: peardg |
| Lyngby's sedge | *Carex lyngbyei* |  Photo: Hordur Kristinsson |
| Pacific silverweed | *Argentina egedii* |  Photo: Jill Weber |
| Pickleweed | *Saliconia virginica* |  Photo: LTER |
| Salt grass | *Distichlis spicata* |  Photo: William Skaradek |
| Salt marsh dodder | *Cuscuta salina* |  Photo: St. Mary College of CA |
| Tufted hairgrass | *Deschampsia caespitosa* |  Photo: Christian Fischer |

Table 5. Commonly occurring native plants in the marshes of the lower Coos estuary.

ple, Nelson et al. (2007) explain that in Washington, where estuaries are dominated by tidal flat habitats, seagrass and macroalgae appear to be more abundant. By contrast, emergent vegetation appears to be abundant in California estuaries, where marsh habitats are more readily available. Since Oregon is a mixture of these two habitat types, the plant communities of its estuaries tend to contain a mixture of macroalgae, seagrass, and emergent vegetation.

- On a smaller scale, the topography and land-use history of a specific waterway as well as the individual features of each tidal wetland (e.g., tidal channels, large wood or lack thereof, shallow pools, filled or excavated areas) all influence the composition and spatial distribution of specific marsh plant communities (Laferriere et al. 2010).

Tidal wetlands in the Coos estuary are subject to a range of environmental conditions. Many are additionally affected either directly or indirectly by a variety of land use histories. As a result, a diversity of plant communities in various stages of successional development continue to persist or have become established in these habitats (Figure 20). Table 5 presents several native plant species commonly occurring in Coos estuary tidal wetlands.

As mentioned above, tidal wetlands have historically been considered impediments to productive land use, and have commonly been altered to accommodate uses that are traditionally viewed as high-value alternatives (e.g., agriculture, urban development, etc.) (Giannico and Souder 2005). In Europe, this practice began as early as the seventh century, and the continued conversion of low-lying coastal zones throughout the globe is the greatest contributing factor to the destruction of wetlands worldwide (Daiber 1986; Middleton 1999; Giannico and Souder 2005). For more information about human structures in tidal wetlands, including dikes and tide gates in the project area, refer to the Land Use section of Chapter 8: Physical Description.

Public health concerns have provided another historic impetus for altering wetlands. The practice of filling or draining wetlands to control the threat of malaria began over 2,000 years ago in Italy (Doody 2001). In North America, this type of mosquito-control began in the southeastern United States in the early 19th century and was adopted by some northern states with the help of returning soldiers who served in the south during the American Civil War (Doody 2001; Dreyer and Niering 1995). Although the threat of malaria has abated, tidal marsh alteration for the purpose of insect control is still common practice in parts of the U.S. (Montague et al. 1987; Giannico and Souder 2005).

In 2013, the significant nuisance associated with mosquitoes was raised in the Bandon area. After a large-scale (420 acres) tidal wetland restoration project was completed at the Bandon Marsh National Wildlife Refuge's Ni-les'tun site, shallow man-made pools remained. These pools combined with a particularly warm and wet spring to cause a boom in the local salt marsh mosquito (*Aedes dorsalis*) population. While the project was undertaken in 2011 to benefit wildlife, including migratory waterfowl and shorebirds, and commercially important fish species (including the threatened Coho salmon), the unintentional increase occurred during the spring and summer of 2013.

Mosquito populations took advantage of the breeding habitats formed by shallow pools remaining at the restored and recovering Ni-les'tun restoration site. The pools were created inadvertently as filled ditches subsided or as ruts left by equipment collected water.

Though mosquitoes are present in tidal wetlands all along the Oregon coast, and many similar tidal wetland restoration projects have been constructed over the past 30 years, no other tidal wetland restoration effort has experienced this issue at such a large scale.

In 2014, USFWS undertook adaptive management measures to eliminate the pools and reduce mosquito breeding populations at the site with very favorable results. For more information about this mosquito issue, see the Bandon Marsh Wildlife Refuge website: http://www.fws.gov/oregoncoast/bandonmarsh/Mosquito.html .

Understandably, this problem became very controversial among local residents (the local mosquito population was truly unacceptable by anyone's standards). Some called for the re-diking and draining of the site (e.g., Taylor 2014). It should be noted that it's common for habitat restoration projects to require adjustment after restoration construction is completed; adjustments are typically made to redirect natural processes in such a way that ensures the full recovery of the restored habitat without adversely affecting neighboring landowners or local residents.

In the case of the Ni-les'tun project, the mosquito population explosion in 2013 was addressed through adaptive management methods, because local residents were so adversely affected there was not time to wait for natural processes to reduce the mosquito populations. Over time, natural habitat recovery processes will develop and ultimately control mosquito populations on their own (i.e., the shallow pools would have slowly filled with sediments and salt marsh vegetation, eliminating mosquito breeding habitat; populations of aquatic mosquito larvae predators would have grown with the availability of mosquito larvae as prey ).

| Ecosystem Service | Example of Human Benefit | Avg. Value (adj. 2015 $ $ha^{-1} yr^{-1}$) | Avg. Value in Project Area (Adj. 2015 $) |
|---|---|---|---|
| Disturbance regulation | Storm protection and shoreline protection | $2,912 | $28,944,310 |
| Waste treatement | Nutrient removal and transformation | $10,605 | $105,410,167 |
| Habitat/refugia | Fish and shrimp nurseries | $268 | $2,663,831 |
| Food production | Fishing, hunting, gathering, and aquaculture | $738 | $7,335,474 |
| Raw materials | Fur trapping | $257 | $2,554,494 |
| Recreation | Fishing, hunting, and birdwatching | $1,042 | $10,357,133 |
| **TOTAL** | | **$15,822** | **$157,265,409** |

Table 6. Average annual value of ecosystem services associated with one hectare of tidal wetlands (1 hectare = 2.47 acres). Dollar values were adjusted for inflation from original data, presented in 1994 dollars (Costanza et al. 1997). This calculation was done using the United States Department of Labor Inflation Calculator, which uses the Consumer Price Index to adjust for inflation over time (BLS n.d.). Estimates for the average annual value of services associated with tidal wetlands in the project area are calculated using a total wetland acreage of 24,564, which is the sum of wetland areas of all systems from the 2003 National Wetlands Inventory (USFWS 2003). It should be noted that the valuation methods in Contanza et al. 1997 are not universally accepted by all economists (see Bockstael et al. 2000). Data: Costanza et al. 1997 Table and caption modified from Gedan et al. 2009

There's no evidence to suggest it will be necessary to go to the massive expense of re-diking and re-draining tidal wetland restoration projects to control mosquito populations when natural processes/ecosystem functions occurring in the wetlands themselves maintain acceptable populations at no cost to coastal communities. To our knowledge, the naturally functioning ~300 acre tidal wetland just to the southwest of the Ni-les'tun project site (also part of the Bandon Wildlife Refuge), which local residents have been living next to for many decades, has never been a source of mosquito-related controversy.

Researchers have long recognized the value of tidal wetlands. As mentioned, tidal wetlands provide many important "ecosystem services," including processing and cycling of sediments and nutrients, improving water quality, buffering human communities from floods and destructive waves, providing critical rearing habitat for juvenile fish and crabs, and facilitating recreational activities like hunting, fishing, and wildlife watching (Cornu 2005d; Gedan et al. 2009; Portnoy and Giblin 1997).

In many cases, these ecosystem services have direct ties to high-value economic goods. For example, experts estimate that over 75% of all commercially and recreationally caught fish species depend on estuaries and tidal wetlands at some point in their life cycles (Norse 1993; USEPA 1995; Cornu 2005d). In other cases, these services are "non-market" goods, and although the economic value of these goods are not revealed by a market price, it's widely accepted that they have real (and sometimes substantial) economic value (Cummings et al. 1986; Mitchell and Carson 2013; Champ 2003; Costanza 1997)(Table 6). For example, tidal marshes promote biodiversity (e.g., by providing habitat structure as well as distributing nutrients, detritus, seeds, and eggs)(Cornu et al. 2005a). Although "biodiversity" itself cannot be bought and sold in a marketplace, the persistence of a variety of plants and animals that support economic activity (e.g., hunting, fishing, wildlife watching) must have some value, because if they did not, "consumers" of these non-market goods (e.g., hunters, anglers, and wildlife watchers) would have no reason to purchase goods and services associated with those activities (e.g., fuel, fishing tackle, hunting and wildlife-watching optics, licensing fees, etc.).

In recent decades, as the ecological importance and economic value of wetlands has become increasing recognized, public policies have been put in place to protect these resources. The cornerstone of these policies is wetland "mitigation," which requires that the loss of a wetland be offset by restoration, enhancement, or creation of new wetlands. Early indications suggest that, although these policies have slowed the pace of wetland loss, they have not met their goal of "no net loss" (Ambrose 2000).

## References


Ambrose R. F. 2000. Wetland mitigation in the United States: assessing the success of mitigation policies. Wetlands (Australia) 19:1–27

Anisfeld, S. C., M. J. Tobin, and G. Benoit. 1999. Sedimentation and rates in flow-restricted and restored salt marshes in Long Island Sound. Estuaries 22:23-224.

Bockstael N. E., A. Myrick Freeman III, R. J. Kopp, P. R. Portney, and V. K. Smith. 2000. On measuring economic values for nature. Environ. Sci. Technol. 34:1384–89

Brophy, Laura. 2005. Restoring Freshwater Wetlands in the South Slough National Estuarine Research Reserve: Links between water table elevation, soils, and plant communities in restored, altered, and undisturbed wetlands. [Report prepared for SSNERR by Green Point Consulting].

Cahoon, D. R., D. J. Reed, and J. W. Day Jr. 1995. Estimating shallow subsidence in microtidal salt marshes of the southestern United States: Kaye and Barghoorn revisited. Marine Geology 128: 1-9.

Champ, P. A., K. J. Boyle, and T. C. Brown. (Eds.). 2003. A primer on nonmarket valuation (Vol. 3). Springer.

Coos Watershed Association (CoosWA). 2006. Coos Bay Lowland Assessment and Restoration Plan. March, 2006, Charleston, OR: Coos Watershed Association. Accessed 07 April 2015 from http://www.cooswatershed.org/publications.html

Coos Watershed Association (CoosWA). 2010. Coos Bay Tidal Wetlands Assesment: Isthmus Slough, Coalbank Slough, Catching Slough, and Echo Creek Sub-basins. [Draft of a technical report]. May, 2010, Charleston, OR: Coos Watershed Association. Accessed 07 April 2015 from http://www.cooswatershed.org/publications.html

Cornu, C. E. and S. Sadro. 2002. Physical and Functional Responses to Experimental Marsh Surface Elevation Manipulation in Coos Bay's South Slough. Restoration Ecology 10: 474-486.

Cornu, C. E. 2005a. Restoring Kunz Marsh. South Slough NERR Coastal Resource Management Series. CRMS-2005-1. Coos Bay, Oregon.

Cornu, C. E. 2005b. Restoring Anderson Creek Marsh. South Slough NERR Coastal Resource Management Series. CRMS-2005-3. Coos Bay, Oregon.

Cornu, C. E. 2005c. Restoring Cox, Dalton, and Fredrickson Creek Marshes. South Slough NERR Coastal Resource Management Series. CRMS-2005-2. Coos Bay, Oregon.

Cornu, C. E. 2005d. Winchester Tidlands Restoration Project: Introduction. South Slough NERR Coastal Resource Management Series. Accessed 8 April 2015 from http://www.oregon.gov/dsl/SSNERR/Pages/CRMSmain.aspx

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Costanza R., R. D'Arge, R. DeGroot, S. Farber, M. Grasso, et al. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253–80

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service Report No. FWS/OBS/-79/31.Washington, D.C.

Cummings, R. G., D. S. Brookshire, R. C. Bishop, and K. J. Arrow. 1986. Valuing environmental goods: an assessment of the contingent valuation method. Rowman & Littlefield Pub Incorporated.

Daiber, F. C. 1986. Conservation of tidal marshes. Van Nostrand Reinhold, New York.

Doody, J. P. 2001. Coastal conservation and management: an ecological perspective. Kluwer Academic Publishers, Boston, Massachusetts.

Dreyer, G. S. and W. A. Niering. 1995. Tidal marshes of Long Island Sound: ecology, history and restoration. Connecticut College Arboretum Bulletin, Connecticut College Arboretum, New London, Connecticut.

Frenkel, R.E. and J.C. Morlan. 1991. Can we restore our salt marshes? Lessons from the Salmon River, Oregon. USA. The Northwest Environmental Journal 7:119-135.

Gedan, K. B., B. R. Silliman, M. D. Bertness. 2009. Centuries of human-driven change in salt marsh ecosystems. Annual Review of Marine Science, 1, 117-141.

Giannico, Guillermo, and Jon A. Souder. 2005. Tide Gates in the Pacific Northwest: Operation, Types, and Environmental Effects. Oregon Sea Grant. Report ORESU-T-05-001. Corvallis, Oregon.

Good, J. W. 2000. Summary and current status of Oregon's estuarine ecosystems. Pp. 33-44 in: The Oregon State of the Environment Report 2000. 214 pp. Oregon Progress Board, Salem.

Gotelli Nicholas J. and Anne Chao. 2013. Measuring and Estimating Species Richness, Species Diversity, and Biotic Similarity from Sampling Data. In: Levin S.A. (ed.) Encyclopedia of Biodiversity, second edition, Volume 5, pp. 195- 211. Waltham, MA: Academic Press.

Hamilton, Judy. 2011. SWMP Bio-monitoring: Final Report. [Un-published report from South Slough National Estuarine Research Reserve]. Accessed at the Estuarine and Coastal Sciences Laboratory of SSNERR. 10 March, 2015.

Heip, Carlo H.R., Peter M.J. Herman, and Kaline Soetaert. 1998. Indices of Diversity and Evenness. Océanis: 24 (4).

Hofnagle, J., R. Ashley, B. Cherrick, M. Gant, R. Hall, C. Magwire, M. Martin, J. Schrag, L. Stuntz, K. Vanderzanden, and B. Van Ness. 1976. A comparative study of salt marshes in the Coos Bay Estuary. National Science Foundation Student Originated Project. Summer, 1976. University of Oregon, Oregon Institute of Marine Biology, Charleston, Oregon.

Hood, W. G. 2004. Indirect environmental effects of dikes on estuarine tidal channels: thinking outside of the dike for habitat restoration and monitoring. Estuaries, 27(2), 273-282.

Kerkhoff, Andrew. 2010. Measuring Biodiversity of Ecological Communities. [Unpublished lab notes from Kenyon College based on of published content from Magurran 2004]. Accessed 11 March 2015 from

Kerney, M. S., J. C. Stevenson, and L. G. Ward. 1994. Spatial and temporal changes in marsh vertical accretion rates at Monie Bay: Implications for sea-level-rise. Journal of Coastal Research 10: 1010-1020.

Laferriere, Alix M., Heidi Harris, and John Schaefer. 2010. Early detection of a new invasive mesogastropod, *Assiminea parasitological*, in Pacific Northwest estuaries. [Unpublished technical report from South Slough National Estuarine Research Reserve and Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians]. Accessed 23 March 2015 from https://scholarsbank.uoregon.edu/xmlui/handle/1794/10146

Magurran, A. E. 2004. Meausuring Biological Diversity. Blackwell.

Middleton, B. 1999. Wetland restoration, flood pulsing, and distribution dynamics. John Wiley & Sons, New York.

Mitchell, R. C. and R. T. Carson. 2013. Using surveys to value public goods: the contingent valuation method. Routledge.

Montague, C. L., A. V. Zale, and H. F. Percival. 1987. Ecological effects of coastal marsh impoundments: a review. Environmental Management 11:743–756

Nelson, Walter G., Henry Lee II, Janet O. Lamberson, Faith A. Cole, Christine L. Weiloefer, and Patrick J. Clinton. 2007. The Condition of Tidal Wetlands of Washington, Oregon, and California – 2002. Office of Research and Development, National Health and Environmental Effects Research Laboratory, EPA/620/R-07/002.

Norse, E. A. ed. 1993. Global Marine Biological Diversity: A Strategy for Building Conservation into Decision Making. Island Press. Covelo, California.

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Institute for Natural Re¬-sources, Portland State University, Portland, OR. 111 pp.

Oregon Watershed Restoration Inventory (OWRI). 2013a. ORWI Access Database. [Downloadable file available through Oregon Explorer]. Accessed 18 May 2015 from http://oregonexplorer.info/EnhancingWatershedsOregon#TheOWRIDatabaseandGISdata

Oregon Watershed Restoration Inventory (OWRI). 2013b. ORWI GIS geodatabase. [Downloadable shapefile available through Oregon Explorer]. Accessed 18 May 2015 from http://oregonexplorer.info/EnhancingWatershedsOregon#TheOWRIDatabaseandGISdata

Portnoy, J. W. and A. E. Giblin. 1997. Effect of historic tidal restrictions on salt marsh sediment chemistry. Biogeochemistry 36: 275-303.

Roman, C. T., W. A. Nierring, and R. S. Warren. 1984. Salt marsh vegetation change in response to tidal restriction. Environmental Management 8:141-150.

Rumrill, Steven S. and Derek C. Sowers. 2008. Concurrent Assesment of Eelgrass Beds (*Zostera marina*) and Salt Marsh Communities along the Estuarine Gradient of the South Slough, Oregon. Journal of Coastal Research. 55: 121-134.

Seliskar, D. M. and J. L. Gallagher. 1983. The ecology of tidal marshes of the Pacific Northwest coast: a community profile. U.S. Fish and Wildlife Service, Division of Biological Services, Washington, D.C. FWS/OBS-82/32. 65 pp.

Taylor, Rob. 2014. Officials obscuring facts on Bandon Marsh mosquito infestation. Article in the Oregon Catalyst. Accessed 8 May 2015 from http://oregoncatalyst.com/28441-officials-obscuring-facts-bandon-marsh-mosquito-infestation.html

United States Bureau of Labor Statistics (BLS). n.d. CPI Inflation Calculator. Accessed 8 April 2015 from http://www.bls.gov/data/inflation_calculator.htm

United States Environmental Protection Agency (USEPA). 1995. Wetlands Fact Sheet #2. Washington D.C.

United States Fish and Wildlife Service (USFWS). 1979. National Wetlands Inventory Shapefiles. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

United States Fish and Wildlife Service (USFWS). 2003. National Wetlands Inventory Shapefiles. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

United States Fish and Wildlife Service (USFWS). 2014a. National Wetlands Inventory website. [Wetlands Mapper: Online Data Query Resource]. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.Accessed 23 January 2015 from http://www.fws.gov/wetlands/http://www.fws.gov/wetlands/Data/Mapper.html

United States Fish and Wildlife Service (US-FWS). 2014b. National Wetland Inventory Overview. Accessed 23 January 2015 from http://www.fws.gov/wetlands/NWI/index.html

Weinstein, M. P. and L. L. Weishar. 2002. Beneficial use of dredged material to enhance the restoration trajectories of formerly diked lands. Ecological Engineering 19:187-201.

Wilcox, D. A, T. A. Thompson, R. K. Booth, and J. R. Nicholas. 2007. Lake-level variability and water availability in the Great Lakes: U.S. Geological Survey Circular 1311, 25 p.

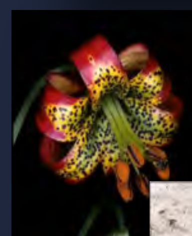
# Rare and Endangered Plants in the Coos Estuary


*Summary:*

- *Three plant species in the project area are federally or state listed as either Threatened or Endangered.*
- *Two additional listed species occur just south of the project area; suitable habitat for these species occurs within project boundaries.*
- *Habitat loss is the primary reason behind population declines for most species.*


Silvery Phacelia
Photo: OR Wild

Salt Marsh Bird's Beak



Western Lily

Pink sand verbena

**Evaluation**

All species in this section are in need of significant action and should be closely monitored.


Figure 1. Location of rare and endangered plants in and near the project area. All locations are general sites where populations are known to exist. Data: pink sand verbena – Giles-Johnson and Kaye 2012; salt marsh bird's beak – Giles-Johnson et al. 2013; western lily – USFWS 2009, SSNERR 2013

**What's happening?**

Five rare or endangered plant species are known or thought to occur within the project area: Pink sand verbena (*Abronia umbellata breviflora*), Salt marsh bird's beak (*Chloropyron maritimum palustre*, formerly *Cordylanthus maritimus palustris*), Silvery phacelia (*Phacelia argentea*), western lily (*Lilium occidentale*), and Wolf's evening primrose (*Oenothera wolfii*)(Figure 1, Table 1). This data summary describes the current status and trends of those species in the project area.

Pink sand verbena

Pink sand verbena is listed as Endangered by the State of Oregon due to small populations facing numerous threats. It is federally listed as a Species of Concern (see sidebars).

Once occurring from British Columbia to central California, the range for pink sand verbena has shrunk to limited populations in southern Oregon and northern California. Rittenhouse (1996) described fewer than 10 populations (groups of reproductive-age plants) remaining in Oregon by 1996. Ten years following Rittenhouse's report, 3-5 "wild" populations remained, varying from year to year (wild populations do not include

Table 1. Summary of rare and endangered species with ranges within the project area. Photos: Oregon Department of Agriculture, except western lily (USFWS).

| Common name | Species Name | Photo * | Federal/ State Status | Range | Habitat | Found in project area | Citation(s) |
|---|---|---|---|---|---|---|---|
| **Pink Sand Verbena** | *Abronia umbellata breviflora* |  | Species of Concern/ Endangered | Cape Blanco, Oregon to Pt. Reyes, California; historically B.C. to northern California | dynamic beach zones | yes | ORBIC 2013 |
| **Salt Marsh Bird's Beak** | *Chloropyron maritimum palustre* |  | Species of Concern/ Endangered | Tillamook, Oregon to Santa Clara, California; in Oregon primarily Coos Bay | tidal salt marshes | yes | ORBIC 2013 |
| **Silvery Phacelia** | *Phacelia argentea* |  | Species of Concern/ Threatened | Bandon, Oregon to Cresecent City, California | open sand, dunes, and coastal bluffs | yes | ORBIC 2013 |
| **Western Lily** | *Lilium occidentale* |  | Endangered/ Endangered | Coos Bay, Oregon to Eureka, California, within 4 miles of coast | early successional bogs or coastal scrub on poorly drained soils | yes | ORBIC 2013 |
| **Wolf's Evening Primrose** | *Oenothera wolfii* |  | Species of Concern/ Threatened | Port Orford, Oregon to northern California | sandy soil along coastal bluffs | unknown | ORBIC 2013 |

**Federal listing:**

**Definitions:**
**Endangered** species = species that is in danger of extinction throughout all or most of its range.

**Threatened** species = species that is likely to become endangered throughout all or most of its range.

**Species of Concern** = species that may be in need of conservation actions.

**What it means:**
**Endangered** and **Threatened** species:

- Are required to have a recovery plan developed and implemented.
- Have restrictions on take
- Lands under federal jurisdiction prohibit damage or collection of these plants.

**Species of Concern** have no legal protection at the federal level.

**State of Oregon listing:**

**Definitions:**
**Endangered** species = species that is in danger of extinction throughout all or most of its Oregon range.

**Threatened** species = species that is likely to become endangered throughout all or most of its Oregon range.

**Sensitive** species = species that is facing one or more threats to the population that may cause it to become eligible for Threatened or Endangered listing.

**What it means:**
**Endangered** and **Threatened** species:

- State listed plants are not protected on private lands in Oregon and plant surveys are not required prior to development activities.
- Taking, cutting or mutilation of these plants is prohibited on public lands.
- Oregon Department of Agriculture is responsible for developing and implementing conservation and protection programs for these species.

reintroduced/restored plants/populations) (Kaye et al. 2006).

Locations within and surrounding the project area that now have populations include the North Spit, and a population at Bastendorff Beach State Park (Figure 1). A third site near the mouth of South Slough was surveyed in 2010 but no individuals were found (Giles-Johnson and Kaye 2012).

The North Spit population was considered extinct until a successful reintroduction from a large wild Port Orford population in 1997. The North Spit site now contains the largest population of pink sand verbena in the world (Kaye et al. 2006). Kaye (2004) described how multiple sites in Oregon were reintroduced with pink sand verbena, but the North Spit was by far the most successful because: 1) location – the population is behind the foredune and thus not exposed to winter storm overwash; and 2) annual habitat maintenance – the site is in an area occupied by the federally threatened western snowy plover and therefore receives annual mechanical treatments to remove European beachgrass (*Ammophila arenaria*). This disturbance regime favors both plovers and pink sand verbena, both of which depend upon sparsely vegetated open sand habitats. The North Spit population had 1700 plants the first year of reintroduction and peaked in 2012 with nearly 350,000 reproductive individuals (Giles-Johnson and Kaye 2012).

Giles-Johnson and Kaye (2012) also describe the history of pink sand verbena at the Bastendorff site. Despite annual reintroductions of both seeds and transplants starting in 1995, by 2000 no plants were found at the Bastendorff site. After seeding again in 2002, 13 individuals were established that year, substantially increasing to 110 individuals the following year with no new seeding effort. The Bastendorff population peaked in 2005 with 536 total plants (410 of which were reproductive), but drastically declined to 2 plants in 2010.

Salt marsh bird's beak

Listed as a Species of Concern federally and as Endangered by the State of Oregon, the majority of Oregon occurrences of salt marsh bird's beak occur in the Coos estuary (Rittenhouse 1996).

Of the multiple populations within the project area, the largest populations in 1999 were found near Empire (~25,000 plants) and the Pony Slough (~10,000 plants)(Rittenhouse 1999)(Figure 1). The population on United States Bureau of Land Management (BLM) land at the North Spit in 2001 was estimated at 20,000 plants (BLM 2006). Rittenhouse (1999) additionally documented a large population (~3,000 individuals) east of the distant water fleet docks south of the Charleston Bridge (Figure 1).

The North Spit population was damaged by off-road vehicle use, which led BLM to install traffic barriers. A report by Giles-Johnson et al. (2013) noted that after protection was initiated the species recovered substantially, peaking at ~670,000 individuals in 2012. Since then, the population has begun to slowly decline. The absence of disturbance, which allows pickleweed (*Salicornia depressa*) and western marsh-rosemary (*Limonium californicum*) populations to spread, has been potentially inhibiting salt marsh bird's beak's reproductive success. It should be noted that other salt marsh bird's beak populations (e.g., in South Slough) remain robust in undisturbed locations (C. Cornu, pers. comm., 2014).

Across its Oregon range, salt marsh bird's beak averages about 2,000 individuals for each of 18 remaining populations (Kaye 1991 as cited in Giles-Johnson et al. 2013).

Silvery phacelia

Silvery phacelia is considered a Species of Concern federally and is listed as Threatened by the State of Oregon.

No known occurrences of this species occur in the project area; however, suitable sandy bluff habitat (e.g., in South Slough or the North Spit) occurs here (SSNERR 2013). Close-by populations exist, the nearest being north of Bandon at the Oregon Dunes Golf Resort (Kalt 2008). This is also the largest population with ~3,000 individuals in 2007 (Kalt 2008).

According to Curry (2014), of 36 populations documented since 1916, only 22 are presumed to still exist, all in Oregon. Six new populations have been discovered, also in Oregon. The remaining populations are small (average populations are under 100 plants), highly fragmented, and most appear to be declining (Kalt 2008). Small fragmented populations are especially common in areas where

European beachgrass dominates (Rittenhouse 1995 as cited in Curry 2014), suggesting that beachgrass adversely affects this species.

Western lily

The western lily is listed as Endangered at both the federal and the state level. Except where otherwise noted, the following information comes from USFWS (2014).

Since its federal listing in 1994, western lily populations have continued to decline in both numbers and distribution (USFWS 2009). Within and near the project area, many known populations have been lost (e.g., some populations at Shore Acres and Sunset Bay State Park); other populations have grown (Hauser Bog) or have remained relatively stable (Bastendorff Bog)(Figure 1).

Within the project area, the Hauser Bog population was recently (2014) estimated at 776 reproductive individuals. This total includes individual plants resulting from 498 bulbs planted in 2013 by the Oregon Department of Agriculture (ODA) to augment the population. Ninety percent of the Hauser Bog is located on private property, with the remainder on an Oregon Department of Transportation (ODOT) right-of-way designated as a Special Management Area.

A newly discovered western lily population (2013) was documented within the project area at Indian Point in South Slough (Figure 1). A cursory population estimate of reproductive and nonreproductive plants indicated that the Indian Point site may contain one of the largest populations in Oregon. The population resides entirely on state of Oregon land (acquired in 2014) which is managed by the South Slough Reserve.

Just outside the project boundary, Bastendorff Bog (part of Sunset Bay State Park) supported 47 reproductive individual western lily plants in 2014, and increase from the 10 plants found in 1994. The increase can be partially attributed to habitat maintenance including the removal and thinning of encroaching vegetation. In addition to the 47 reproductive plants counted in the natural or 'wild' population in 2014, over 100 western lilies of all age classes were observed, the result of augmentation with 173 bulbs in 2013 (Brown et al. 2013). Other historic populations at Sunset Bay State Park appear to have been lost due to competition from Sitka spruce and other species (USFWS 2009).

Adjacent to Sunset Bay State Park, Shore Acres State Park contains several small, declining populations. Although a complete survey was not conducted, only 5 reproductive plants were observed in 2014, down from 53 in 2002.

Wolf's evening primrose

Wolf's evening primrose is considered a federal Species of Concern and is listed as Threatened by the State of Oregon. Although not known to occur in our project area (the nearest population occurs in Port Orford), suitable habitat does exist in the project area for wolf's evening primrose. The non-native large-flowered evening primrose (*Oenothera glazioviana*), considered a major threat to the native species, does occur in the project area (DeWoody et al. 2008). See Why is it happening? below for more information on this threat.

According to Currin and Meinke (2004), there were seven known populations of wolf's evening primrose remaining in Oregon in 2004. They describe population sizes in Oregon as ranging from 40 to several thousand individuals.

**Why is it happening?**

Pink sand verbena

As with many rare and endangered species, pink sand verbena's decline can be attributed to habitat loss. The biggest factor is dune stabilization and competition for space from the non-native European beachgrass; a secondary threat is disturbance from off-road vehicles (Kaye 2004).

Additionally, bee species native to dune habitats are the primary pollinators of pink sand verbena (CPC 2010a). However, populations of these solitary bees are negatively correlated with dune communities dominated by European beachgrass (Julian 2012).

Salt marsh bird's beak

The primary threats to salt marsh bird's beak are habitat loss due to wetland alterations (excavation/filling) and repetitive disturbances (e.g., foot traffic, off-road vehicles). This species is also particularly sensitive to water pollution and petroleum spills (BLM 2006).

Silvery phacelia

The primary threat to silvery phacelia is competition from non-native species, especially European beachgrass and gorse (*Ulex europaeus*)(Kalt 2008). Russo et al. 1988 attributed the silvery phacelia's decline to changes in the orientation of the Oregon coast's dune field valleys (technically referred to as "slacks") as a result of the establishment of European beach grass. Historically, many beaches had no foredune running parallel to the ocean shore. Instead, dunes and associated slacks were oriented perpendicular to the shore, shifting with seasonal changes in prevailing winds. The introduction of European beachgrass stabilized the dunes, resulting in their current orientation (parallel to the beach) and steep foredunes. The stabilized foredune greatly reduces sand supply to interior moving dunes, limiting their dynamic nature. Since the introduction of European beachgrass, any species populations adapted to the historically dynamic dune habitat, such as the silvery phacelia, have declined.

Other threats to silvery phacelia are habitat loss from coastal development and destruction from off-road vehicles (Curry 2014).

Western lily

Except where otherwise cited, the following information comes from USFWS 2009.

The decline of western lily populations began historically with heavy extraction by the horticulture trade, followed by habitat loss for development and agriculture, particularly the development of cranberry bogs. Conversion of western lily habitat to cranberry bogs is believed to have contributed to the loss of hundreds of acres of lily habitat in the area between Bandon and Port Orford in the past few decades. This is because cranberries and western lilies share a proclivity for soils that remain saturated and facilitate the seasonal pooling of water. These soils (known as the Blacklock/Bullards/Bandon Complex) are common south of Bandon.

Western lilies are extremely sensitive to site hydrology. The bulbs cannot survive year-round inundation but are reliant on sufficient soil moisture late into the growing season to avoid desiccation during the summer months (Imper 1997b). For example, at Hauser Bog, plants are all within 6” of the same elevation, illustrating the close relationship between bulb viability and soil moisture.

Vegetative succession may speed the western lily’s decline by shading the plants and lowering the site’s water table. This has been cited as a potential reason for the decline of the Bastendorff Bog population, where trees are encroaching upon the formerly open habitat due to lack of disturbance, most likely fire. Historically fires are believed to have maintained early seral conditions in western lily habitat.

Deer grazing seriously reduces reproductive success by consumption of fruit and flowers. The Hauser and Bastendorff populations have exhibited high loss due to deer herbivory. Light cattle grazing, however, appears to have little impact. Lilies tolerate trampling to some degree and may actually benefit by having their seeds pressed into the ground. Cattle also keep surrounding vegetation controlled, and their manure increases soil fertility.

Populations under 5,000 individual plants are additionally threatened by loss of genetic diversity. This limits long-term adaptability to stressors, including disease or the local effects of climate change (e.g., changes in air temperature and hydrology). Furthermore, populations with less than 500 individuals may suffer from the deleterious effects of inbreeding. Most of the populations in Oregon number less than 500 individuals.

<u>Wolf’s evening primrose</u>

According to the Center for Plant Conservation (CPC 2010b), a unique threat to this species is genetic dilution due to hybridization with a non-native ornamental plant of the same genus, the large-flowered evening primrose. Wolf’s evening primrose cannot accept pollen directly from the large-flowered evening primrose, but can accept pollen from hybrid offspring produced by a crossing of large-flowered evening primrose with pollen from wolf’s evening primrose (Imper 1997a). This pollen issue could eventually lead to genetic extinction for Wolf’s evening primrose. Hybrids are more ‘fit’ than parents of either species, allowing them to reproduce and expand their range more rapidly (Imper 1997a). Loss of habitat in a limited range (primarily to the invasive European beachgrass) and destruction from herbicides (many populations are along Highway 101) are secondary threats to this species (Currin and Meinke 2004).

**Background**

<u>Pink sand verbena</u>

According to Kaye (2004), pink sand verbena lives at or below the driftwood line on coastal beaches. Wave overwash from winter storms obliterates adult plants each year requiring the population to re-establish itself each spring from seed. Because of this, population sizes and locations fluctuate widely year to year. Winter storms are highly beneficial to this species as they deposit new sand substrate and carry seeds along shorelines. Storms also remove competitor plants, helping long-term survival of the population.

Salt marsh bird's beak

Salt marsh bird's beak ranges from Morro Bay, California to Netarts Bay, Oregon (Giles-Johnson et al. 2011). According to Chuang and Heckard (1971) this annual plant is a hemi-parasite (i.e., it derives much of its nutrients from other plants), though it does not appear to have a preferred host species. Consequently, habitat quality is likely a more important factor to bird's beak populations than specific host species presence (Giles-Johnson et al. 2011). Preferred habitat for this species is upper elevation salt marshes (~7.5-8.5' above MLLW) with moderate vegetation cover, which allows light to penetrate to the soil (Kaye 1991 and USFWS 1984, as cited in Rittenhouse 1999). Rittenhouse (1999) notes that annual fluctuations in population sizes are highly variable, which is typical of an annual species.

Silvery phacelia

Ranging from Coos County, Oregon to Del Norte County, California, silvery phacelia is a perennial evergreen trailing herb in the forget-me-not family that grows on unstabilized or partially stabilized coastal sand dunes at elevations below 65 feet (CPC 2010c). CPC (2010c) notes that bees are the primary pollinators of this species, especially the native leafcutter bee (*Anthidium palliventre*).

Western lily

Ranging from Coos Bay, Oregon to Eureka, California, all known populations of this species occur within 6 km (3.7 miles) of the coast. According to USFWS (2009), the western lily is a perennial species that dies back each winter. These plants require either impermeable mineral soils or organic marsh soils, both of which keep the bulb moist late in the dry season. Reproductive individuals require open, unshaded habitats. Bright red flowers are hermaphroditic (male and female), and are primarily pollinated by hummingbirds.

Wolf's evening primrose

According to CPC (2010b), wolf's evening primrose is a biennial species (i.e., dies after two years) producing small yellow flowers its second year. Imper (1997a) described the habitat preference for this species. He found they only occur in coastal areas and prefer moist but well-draining sandy soil habitat along coastal bluffs or beaches, sheltered from northwest winds. He added that although it prefers moderately disturbed sites, it does not compete well with other plants. It can tolerate high salt concentrations in the soil, although hybridized versions are not as tolerant of salt. This species thrives with some disturbance. In fact, the Port Orford population is located on a beach where dumping of dredge spoils provides periodic disturbances and keeps European beachgrass in check

(Currin and Meinke 2004). Surprisingly, this population is doing well enough that it is the seed source for experimental reintroductions at other locations (Currin and Meinke 2004).

**References**


Brown, J., K. Amsberry and R. J. Meinke. 2013. Recovery-Based Propagation and Outplanting of *Lilium occidentale*: Preparation for Outplanting Year 3 (2011). Oregon Department of Agriculture, Corvallis. 21 pp.

Bureau of Land Management (BLM). 2006. Final North Spit Plan: An Update to the Coos Bay Shorelands Plan of 1995. Coos Bay District Office, North Bend, Oregon . 104 pp.

Center for Plant Conservation (CPC). 2010a. CPC National Collection Plant Profile: *Abronia umbellate ssp. breviflora*. Missouri Botanical Garden, St. Louis, Missouri, viewed 18 November 2014. Retrieved from: http://www.centerforplantconservation.org/collection/CPC_ViewProfile.asp?CPCNum=9

Center for Plant Conservation (CPC). 2010b. CPC National Collection Plant Profile: *Oenothera wolfii*. Missouri Botanical Garden, St. Louis, Missouri, viewed 18 November 2014. Retrieved from: http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=3004

Center for Plant Conservation (CPC). 2010c. CPC National Collection Plant Profile: *Pacelia argentea*. Missouri Botanical Garden, St. Louis, Missouri, viewed 18 November 2014. Retrieved from: http://www.centerforplantconservation.org/collection/cpc_viewprofile.asp?CPCNum=3339

Chuang, T. I. and L. R. Heckard. 1971. Observations on Root-Parasitism in *Cordylanthus* (Scrophulariaceae). American Journal of Botany. 58: 218-228.

Currin, R. and R. Meinke. 2004. Establishment of Two Experimental Populations of Wolf's Evening Primrose (*Oenothera wolfii*). Final Report for U.S. Fish and Wildlife Service. 32 pp.

Curry, T. R. 2014. Petition to List Silvery Phacelia (*Phacelia argentea*) as Threatened or Endangered under the Endangered Species Act. Center for Biological Diversity, Oregon Wild, Friends of Del norte, Oregon Coast Alliance, Native Plant Society of Oregon, California Native Plant Society, Environmental Protection Information Center, Klamath-Siskiyou Wildlands Center. 20 pp.

DeWoody, J., L. Arguello, D. Imper, R. D. Westfall, and V. D. Hipkins. 2008. Genetic evidence of hybridization between *Oenothera wolfii* (Wolf's evening primrose) and *O. glazioviana*, a garden escape. Madroño. 55(2): 132-142.

Giles-Johnson, D. E. L., A. S. Thorpe, and E. C. Gray. 2011. Habitat Monitoring and Improvement for *Cordylanthus maritimus ssp. palustrs*: 2011 Progress Report. Progress Report. Prepared by Institute for Applied Ecology for Bureau of Land Management; Corvallis, Oregon. 29 pp.

Giles-Johnson, D. E. L. and T. N. Kaye. 2012. *Abronia umbellata* var. *breviflora* on the Oregon Coast: Reintroduction and Population Monitoring. Prepared by the Institute for Applied Ecology for Bureau of Land Management, US Fish and Wildlife Service, USDA Forest Service and Oregon Department of Parks and Recreation. 74 pp.

Giles-Johnson, D. E. L., E. C. Gray, and T. N. Kaye. 2013. Habitat Monitoring and Improvement for *Cordylanthus maritimus ssp. palustris*: 2012 Progress Report. Prepared by Institute for Applied Ecology for Bureau of Land Management; Corvallis, Oregon. 48 pp.

Imper, D. K. 1997a. 'Ecology and Conservation of Wolf's Evening Primrose in Northwestern California', in Kaye, T.N., A. Liston, R.M. Love, D.L. Luoma, R.J. Meinke, and M.V. Wilson (eds.), Conservation and Management of Native Plants and Fungi. Native Plant Society of Oregon, Corvallis. 296 pp.

Imper, D. K. 1997b. 'Ecology and Management of the Endangered Western Lily (*Lilium occidentale*) in Northwestern California', in Kaye, T.N., A. Liston, R.M. Love, D.L. Luoma, R.J. Meinke, and M.V. Wilson (eds.), Conservation and Management of Native Plants and Fungi. Native Plant Society of Oregon, Corvallis. 296 pp.

Julian, L. S. 2012. A Comparison of Bee Fauna in Two Northern California Coastal Dune Systems. Thesis (M.S.)--Humboldt State University.

Kalt, Jennifer. 2008. Appendix C: Status Review and Field Inventory for Silver Phacelia: *Phacelia argentea* (Hydrophyllacease). In: Applicant's Statement, Proposed Findings, and Supplemental Exception Statement for 2010 Text Amendments to Bandon Dunes Resort Master Plan and Bandon Dunes Resort Zoning Ordinance. 2009. Department of Land Conservation and Development. 226 pp.

Kaye, T. 1991. Population monitoring and habitat analysis for salt marsh bird's-beak (*Cordylanthus maritimus ssp. palustris*). Oregon Department of Agriculture. Report submitted to Coos Bay BLM. 40 pp.

Kaye, T. N. 2004. 'Reintroducing the Endangered Pink Sand-Verbena to Pacific Coast Beaches: Direct Seeding and Out-Planting', in Brooks, M.B., S.K. Carothers, and T. LaBanca (eds.), The Ecology and Management of Rare Plants of Northwestern California: Proceedings from a 2002 Symposium of the North Coast Chapter of the California Native Plant Society, California Native Plant Society, Sacramento, CA, p131-139.

Kaye, T., N. Brian, D. Segotta, and N. Bacheller. 2006. Conservation Strategy for Pink Sand-Verbana (*Abronia umbellata ssp. breviflora*). Prepared by the Institute for Applied Ecology for Bureau of Land Management, USFS Siuslaw National Forest, and Oregon Department of Parks and Recreation. 44 pp.

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Institute for Natural Resources, Portland State University, Portland, OR. 111 pp.

Rittenhouse, B. 1995. Conservation Strategy for Silvery Phacelia (*Phacelia argentea* A. Nels. & J.F. Macbr.). Bureau of Land Management, Coos Bay District. 13 pp.

Rittenhouse, B. 1996. Botanizing the Southern Oregon Coast (Coos Bay to Port Orford). Kalmiopsis. 6:1-8.

Rittenhouse, B. 1999. Status of Salt Marsh Bird's Beak (*Cordylanthus maritimus ssp. palustris*) in the Coos Bay Estuary. Status Report by Bureau of Land Management, Coos Bay office. 10 pp.

Russo, M., A. Pickart, L. Morse, and R. Young. 1988. Element Stewardship Abstract for *Ammophila arenaria*. The Nature Conservancy, Arlington, Virginia. 12 pp.

South Slough National Estuarine Research Reserve (SSNERR). 2013. The South Slough Shorelands Project. Proposal submitted to US Fish and Wildlife Service. 121 pp.

United States Fish and Wildlife Service. 1984. Recovery Plan for Salt Marsh Bird's-Beak (*Cordylanthus maritimus ssp. maritimus*), US Fish and Wildlife Service, Portland, Oregon. 92 pp.

United States Fish and Wildlife Service (USFWS). 2009. *Lilium occidentale* (Western lily) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Arcata, CA. 48 pp.

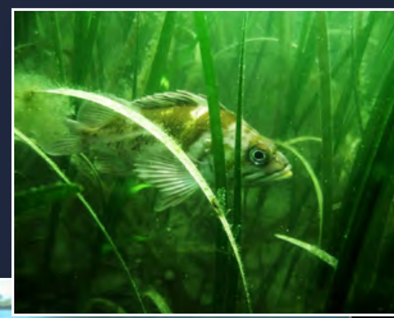
United States Fish and Wildlife Service (USFWS). 2014. [Update to the 5-year Review]. Unpublished data.

# Seagrasses and Algae in the Lower Coos Watershed

*Summary:*

- *The Coos estuary supports expansive eelgrass meadows but little quantitative eelgrass data are available.*
- *In South Slough, where quantitative data are available, eelgrass meadows appear to be stable and may be getting denser.*
- *Algae represent a substantial proportion of the biomass found in intertidal mud and sand flats.*
- *The historic abundance of algae in the Coos estuary suggests they're established constituents of the tidal flat community, not opportunistic species responding to excessive nutrient levels.*

Copper rockfish swims among eelgrass blades. Photo: Sharon Jeffery



Expansive eelgrass meadow. Photo: vims.edu


Figure 1. . Distribution of seagrass beds (green) and location of deep water in the shipping channel (tan). Dense beds (> 50% ground cover from seagrasses) are shown in light green. Seagrass data generated from aerial photos taken in 2005. Data: Clinton et al. 2007, NGDC 2014

## Evaluation

We do not have enough data to adequately evaluate the status of seagrasses or algae in the Coos estuary.

**DATA GAP**

**What's happening?**

<u>Seagrasses (*Zostera spp.*)</u>
Two seagrass species are found in the Coos estuary: common eelgrass (*Zostera marina*) and dwarf eelgrass (*Zostera japonica*). Eelgrass meadows are found throughout the Coos estuary in intertidal and shallow subtidal waters, with the most dense seagrass beds occurring near the mouth of the estuary in the Lower Bay and South Slough Subsystems (Figure 1).

In a 2009 assessment, the United States Environmental Protection Agency (USEPA) characterized the seagrass populations of seven Oregon coast estuaries (Lee II and Brown 2009). Their findings suggest that the native eelgrass (*Zostera marina*) is more abundant in "moderate to large tide-dominated estuaries" (e.g., Coos, Yaquina, and Tillamook)(Table 1). Their conclusions are corroborated by research in Washington, which found that estuaries with these same characteristics (e.g., Willapa and Grays Harbor) had proportionally large areas of suitable eelgrass habitat (Wyllie-Echeverria and Ackerman 2003). In contrast, an estuary's tidal regime does not appear to be closely correlated to the distribution of the non-native dwarf eelgrass in Oregon (Lee II and Brown 2009)(Table 1). For more information about *Z. japonica*, refer to Chapter 18: Non-Indigenous/Invasive Species.

South Slough National Estuarine Research Reserve (SSNERR) staff have been monitoring common eelgrass meadows near Valino Island since 2004 as part of the SeagrassNet global monitoring effort (SSNERR 2015)(Figure 2).

Figure 2. Scientist using a quadrat and meter stick to estimate percent cover, density, and canopy height of a Coos estuary eelgrass meadow.

| | Native seagrass (*Z. marina*) | | Non-native seagrass (*Z. japonica*) | |
|---|---|---|---|---|
| | Presence | Coverage | Presence | Coverage |
| Estuary | (# of sites with Z. marina) | (% of total intertidal area) | (# of sites with Z. japonica) | (% of total intertidal area) |
| Alsea | 0 | 0 | 0 | 0 |
| Coos | 12 | 11.7 | 17 | 19.4 |
| Nestucca | 0 | 0 | 19 | 23.4 |
| Salmon | 0 | 0 | 3 | 3.6 |
| Tillamook | 28 | 34.2 | 9 | 10.5 |
| Umpqua | 8 | 5.5 | 22 | 20.7 |
| Yaquina | 11 | 17.4 | 18 | 11.9 |

Table 1. Seagrass abundance in seven Oregon estuaries. Sampling occurred between 2004-2006, with Coos estuary sampling occurring exclusively in 2005. Sample size is roughly 100 for all estuaries, with the most extensive sampling occurring in Alsea (109 sites) and the least sampling in Tillamook (97 sites). A total of 101 sites were sampled in the Coos estuary. Data: Lee II and Brown 2009

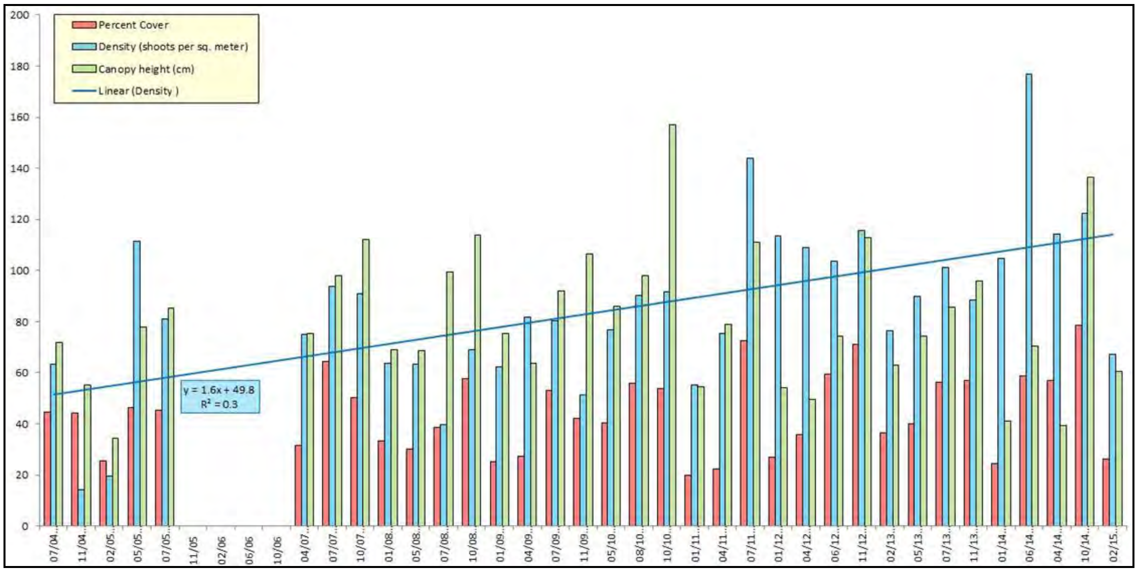



Figure 3. SeagrassNet data from South Slough describing percent cover of eelgrass (red) as well as density (blue) and canopy height (green) of eelgrass meadow at the Valino Island SeagrassNet site. Data show a seasonal trend of decreased growth in the winter months, a signal that is particularly clear in percent cover. Regression analysis indicates a highly significant ($p < 0.01$) increase in density over time, with the average annual increase in density being approximately 1.6 shoots per square meter. Data: SSNERR 2015

Monitoring results so far suggest that the spatial cover and stem density of the Valino Island eelgrass meadows change seasonally: spatial cover and density both decrease during winter months, when daylight hours are fewer and plants senesce (Rumrill and Sowers 2008).

Spatial cover of the Valino Island eelgrass meadows appears to be stable, displaying a statistically significant ($p< 0.01$) trend of increasing density (shoots per $m^2$) over the past 10 years (Figure 3)(SSNERR 2015). Eelgrass percent cover and canopy height, however, do not appear to have changed significantly since 2004 ($p = 0.56$ for percent cover change; $p=0.94$ for canopy height),

Seaweeds and Other Algae

In 2007, the Western Ecology Division of USEPA published a report detailing the intertidal vegetation communities in North American west coast estuaries (Nelson et al. 2007). They collected data from 217 sites in Oregon, Washington, and California, with almost half of their observations in Oregon (65 sites statewide) coming from the Coos estuary (30 sites locally). Their results suggest that algae represent a significant percentage of vegetative cover in Oregon estuaries (Figure 4).

The intertidal sandflats and mudflats of the lower Coos estuary host a variety of benthic algae that accumulate to form mats in mid-to-high intertidal habitats (Rumrill 2006) (Figure 5). The seasonal production of green algae appears to vary substantially from year to year (Hodder 1986). However, green algae,

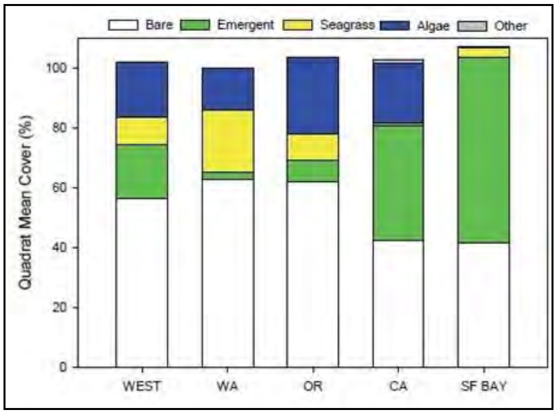



Figure 4. Mean relative abundance of vegetation groups and bare area in Western Ecology Division vegetation quadrats. Figure and caption: Nelson et al. 2007

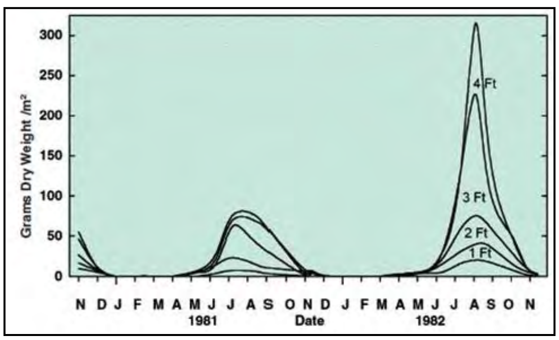



Figure 5. Annual pattern of green algal mat standing crop within the South Slough Subsystem. The uppermost line indicates mean value for the entire site, and the inner delineations represent relative contributions from five tidal elevations (+4, +3, +2, +1 ft. above MLLW) Figure and caption: Rumrill 2008 adapted from Pregnall 1983.

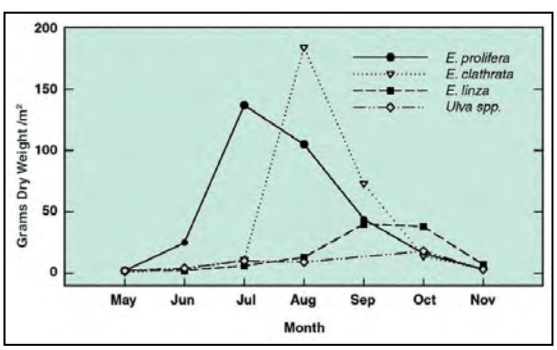



Figure 6. Changes in species composition of green algal mats sampled in the South Slough Subsystem during the growing season of 1982. Figure and caption: Rumrill 2008 adapted from Pregnall 1983.

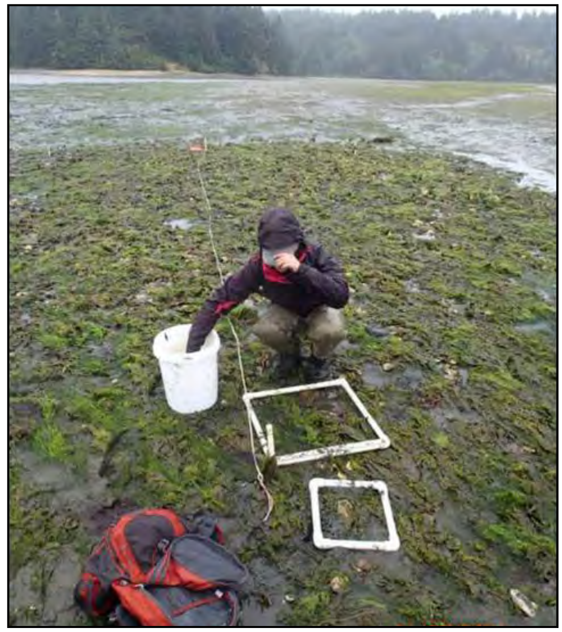


Figure 7. Sea lettuce (*Ulva spp.*) and other green algae dominate the intertidal flats during the summer months. This seasonal phenomenon is apparent in the photo above of a volunteer helping to conduct early summertime fieldwork in South Slough.

including sea lettuce (*Ulva spp*.) and green string lettuce (*Entermorpha spp.*), consistently contribute a substantial amount of biomass of the tideflat community during summer months (Figures 6 and 7).

Historically, green algae have been abundant on the Coos estuary's tidal flats (Sandborn and Dotty 1944, Pregnall 1983, Hodder 1986). Its continued presence suggests that it is an established and persistent member of the local intertidal community rather than an opportunitistic species that may be indicative of excess nutrients or pollution (Rumrill 2006).

**Why is it happening?**

Seasonal growth patterns in intertidal and shallow subtidal vegetation reflect the rhythm of naturally occurring changes in the Coos estuary. In the summer (April-September), increased photoperiod, warming of intertidal flats, and an influx of nutrients from coastal upwelling work together to stimulate plant growth (Pregnall 1983, Hodder 1986, Rumrill 2006). In the winter, reduced photoperiod, colder temperatures, and substantial variation in salinity due to seasonal precipitation limit seagrass production and distribution (Lee II and Brown 2009). In general, the spatial cover and density of eelgrass meadows can vary substantially over time; this growth change is determined by natural (e.g., waves and current) and human-induced (e.g., increased nutrient levels and decreased water clarity) factors (Cornu et al. 2012, Hodder 1986).

The physical characteristics of an estuary are another important determinant of eelgrass growth. Lee II and Brown (2009) explain that the wide expanses of marine-dominated tide flats provide ample opportunity for eelgrass recruitment in estuaries with strong tidal influences such as the Coos estuary. However, modifications to the physical characteristics of intertidal habitat may affect the ability of eelgrass meadows to persist over time. For example, oyster culture in the Coos estuary is associated with significant decreases in eelgrass abundance in the area immediately surrounding the operation (Everett et al. 1995, Pregnall 1993). Similarly, in Florida freshwater diversions into estuaries appear to decrease seagrass productivity (Estevez 2000).

The persistence of eelgrass meadows is also vulnerable to naturally-occurring changes to intertidal flats (e.g., channel migration)(Cornu et al. 2012).

The effects of summertime algae blooms (e.g., *Ulva spp*.) on eelgrass are a matter of some debate. Although some research suggests that sufficiently large algal mats in more freshwater habitats can have potentially toxic effects on seagrasses (Krause-Jensen et al. 1996, Hauxwell et al. 1998, Hessing-Lewis et al. 2011), it appears that these same interactions may result in neutral or even positive consequences in marine-dominated habitats (Hessing-Lewis et al. 2011). For example, because algal mats provide cover and retain moisture during periods of low tide exposure, algae have been shown to alleviate temperature stress in eelgrass, preventing plants from drying out (Boese et al. 2005).

**Background**

<u>Eelgrass</u>

Eelgrass is a marine “angiosperm” (i.e., flowering plant) that produces seeds in the summer months and new roots and rhizomes in the winter (Rumrill 2008). It differs from other aquatic plants because of its preference for submerged habitats, its ability to reproduce underwater, and its high salt tolerance (Cornu et al. 2012). Optimal eelgrass growth occurs in high salinity environments (i.e., 10-30), with seed germination occurring most frequently in brackish water (i.e., 5-10) (Phillips 1972, Phillips et al. 1983). Although it can tolerate periodic immersion in freshwater, it cannot persist in freshwater environments (Rumrill 2006).

Figure 8. Eelgrass meadows form canopies that provide habitat complexity for many estuarine animals. A sockeye salmon uses eelgrass as cover in a nearshore habitat in British Colombia's Flora Bank. Photo: indiegogo.com

Although eelgrass only grows sporadically in patches of 1-3m$^2$ in the brackish areas of the upper Coos estuary, it forms expansive meadows in the marine-dominated portions of the estuary. These meadows are important intertidal habitats that contribute organic matter to the estuarine food web (Rumrill 2006). They also serve many important ecological functions such as sediment stabilization, nutrient processing, trapping of detritus, and provision of important habitat for many species of estuarine animals (especially for juvenile finfish and shellfish) that are commercially, recreationally and ecologically valuable (Cornu et al. 2012, Phillips 1984, Rumrill 2006)(Figure 8). Due to the vital niche that eelgrass meadows fill in estuarine systems, the health of these communities is widely considered to be indicative the overall health of an estuary (Bricker et al. 1999, Cornu et al. 2012, Dennison et al. 1993).

Unfortunately, seagrasses are in decline in estuaries and coastal areas all over the world due to both human-induced and natural disturbances, including the following: coastal uplifting, coastal erosion, winter storms and hurricanes, grazing, naturally occurring sediment disturbances, disease, sediment and nutrient loading from human activity, mechanical damage from dredging and filling, aquaculture practices, commercial fish trawling and dragging, and contaminated sediments and water from heavy metals and/or other toxic compounds (Cornu et al. 2012, Short and Wyllie-Echeverria 1996).

In a review of over 200 seagrass studies, Waycott et al. (2009) found that the decline of seagrasses has been documented as early as 1879. They estimate that nearly a third of all seagrass meadows across the globe have been lost, with rates of decline accelerating markedly since 1990. They add that seagrass meadows are among the most threated ecosystems on earth. The alarming rate of their global decline is comparable to some of the most extensive habitat losses worldwide (e.g., mangroves, coral reefs, and tropical rainforests).

Seaweeds and Algae

The seaweeds and algae found along the Pacific coast are commonly divided into three groups: red, green, and brown algae (Dreuhl 2000)(Figure 9). Although algae share many of the basic characteristics of plants (e.g., photosynthesis, cell walls that provide rigidity, and generally not overtly sensitive to external stimuli), they lack some of the more advanced features (e.g., flowers, cones or enclosed reproductive systems, extraction of nutrients through roots, and protective bark or waxy coverings)(Dreuhl 2000).

Algae constitute a major portion of primary production and an important food source for filter-feeders and deposit-feeders on the tideflats of Pacific Northwest estuaries (Simenstad 1983). In addition to their importance to intertidal benthic communities, estuarine algae have been shown to provide nursery habitat for organisms that use the lower estuary during only a portion of their life cycle (e.g., salmon and other fishes)(Aitkin 1998, Nordby 1982, Emmett et al. 1991, Dreuhl 2000). Dead


Figure 9. The term "seaweed" is a colloquialism describing a diverse assemblage of algae species with unique taxonomies (Druehl 2000). Algae are commonly classified into three broad phyla, which are often referred to by the color of their pigments (red, green, and brown). Three algae from each group commonly found on the Oregon coast are pictured above.

Photos:
A) Turkish Washcloth (*Chondracanthus spp.*), Phylum: *Rhodophyta* (red algae)
photo credit: buzzmarinelife.blogspot.com

B) Sugar Kelp (*Laminaria saccharina.*), Phylum: *Phaeophyta* (brown algae)
photo credit: pendiva.com

C) Sea Lettuce(*Ulva spp.*), Phylum: *Chlorophyta* (green algae)
photo credit: U. Elaya Perumal

algae adrift in the open ocean are known to be food sources for marine organisms, and, as a consequence, the production of algae in estuaries affects the function of marine ecosystems (Valtysson n.d.). In addition to serving an important ecological function, algae are used as food for human consumption, industrial chemicals, fertilizers, livestock feed supplements, and in pharmaceuticals (Dreuhl 2000).

Similar to eelgrass, algae are considered "bio-indicators," because algal blooms can indicate "eutrophication" in estuaries, a condition caused by excessive nutrients that may result in decreased light availability, low oxygen in estuarine waters and sediments, and reduced growth of submerged aquatic vegetation such as eelgrass (Lee II and Brown 2009, Rumrill 2006, Cornu et al. 2012). The presence of algae alone, however, is not necessarily indicative of eutrophication. Rumrill (2006) explains that the chronic summertime persistence of green algae in the Coos estuary suggests that these species are simply established members of a healthy and functioning tidal flat community.

**References**

Aitkin, Kevin J. 1998. The Importance of Estuarine Habitats to Anadromous Salmonids of the Pacific Northwest: A Literature Review. [Technical report for the United States Fish and Wildlife Service]. Accessed 16 April 2015 from http://www.fws.gov/wafwo/fisheries/Publications/FP005.pdf

Boese, B. L., B. D. Robbins, and G. Thursby. 2005. Desiccation is a limiting factor for eelgrass (*Zostera marina L.*) distribution in the intertidal zone of a northeastern (USA) estuary. Botanica Marina 48:274-283.

Bricker, S. B., C. G. Clement, D. E. Pirhalla, S. P. Orlando, and D. R. G. Farrow. 1999. National Estuarine Eutrophication Assessment: Effects of Nutrient Enrichment in the Nation's Estuaries. 71 pp. NOAA, National Ocean Service, Special Projects Office and the National Centers for Coastal Ocean Science, Silver Spring, MD.

Clinton, P. J., D. R. Young, D. T. Specht, and H. Lee. 2007, A Guide to Mapping Intertidal Eelgrass and Nonvegetated Habitats in Estuaries of the Pacific Northwest USA, U.S. Environmental Protection Agency, Washington, D.C., EPA/600/R-07/062, 2007

Cornu, C.E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watershed. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Associations. 225 pp.

Dennison, W. C., R. J. Orth, K. A. Moore, J. C. Stevenson, V. Carter, S. Kollar, P. W. Bergstrom, and R. A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation. BioScience 43(2):86-94.

Druehl, L. 2000. Pacific Seaweeds. Madiera Park, British Columbia: Habour Publishing.

Emmett, R. L., S. A. Hinton, S. L. Stone, and M. E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in west coast estuaries Volume II. Species life history summaries. ELMR Report No. 8. National Oceanic and Atmospheric Administration, National Ocean Service, Rockville, MD. 329 pp.

Estevez, E. D. 2000. Matching salinity metrics to estuarine seagrasses for freshwater inflow management. pp. 295-308 In S.A. Bortone (ed.) Seagrasses: Monitoring, Ecology, Physiology, and Management. CRC Press. Boca Raton, FL

Everett, R., G. Ruiz, and J. Carlton. 1995. Effect of oyster mariculture on submerged aquatic vegetation: an experimental test in a Pacific Northwest estuary. Marine Ecology Progress Series 125: 205-221.

Hauxwell, J., J. McClelland, P. J. Behr, and I. Valiela. 1998. Relative importance of grazing and nutrient controls of macroalgal biomass in three temperate shallow estuaries. Estuaries 21(2):347-360.

Hessing-Lewis, Margot L., Sally D. Hacker, Bruce A. Menge, and Steve S. Rumrill. 2011. Context-Dependent Eelgrass-Macroalgae Interactions Along an Estuarine Gradient in the Pacific Northwest, USA. Estuaries and Coasts 34:1169-1181.

Hodder, J. 1986. Production biology of an estuarine population of the green alga, *Ulva spp*. in Coos Bay, Oregon. Ph.D. thesis, University of Oregon. 106 pp.

Krause-Jenson, D., K. Glathery, S. Rysgaard, and P. B. Christense. 1996. Production within dense mats of the filamentous macroalga *Chaetomorpha linum* in relation to light and nutrient availability. Marine Ecology Progress Series 134: 207-216.

Lee II, H. and C. A. Brown. (eds.) 2009. Classification of Regional Patterns of Environmental Drivers and Benthic Habitats in Pacific Northwest Estuaries. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. EPA/600/R-09/140.

National Geophysical Data Center of the National Oceanic and Atmospheric Administration (NGDC). 2014. National Multi-beam Bathymetry Survey Shapefiles. Accessed 14 April 2015 from http://www.arcgis.com/home/item.html?id=70a5eba1fcff49b682590288d340b38e

Nelson, Walter G., Henry Lee II, Janet O. Lamberson, Faith A. Cole, Christine L. Weiloefer, and Patrick J. Clinton. 2007. The Condition of Tidal Wetlands of Washington, Oregon, and California – 2002. Office of Research and Development, National Health and Environmental Effects Research Laboratory, EPA/620/R-07/002.

Nordby, C. S. 1982. The comparative ecology of ichthyoplankton within Tijuana estuary and its adjacent nearshore waters. Master's thesis, San Diego State University. 101 pp.

Phillips, R. C. 1972. Ecological life history of *Zostera marina L.* (eelgrass) in Puget Sound, WA. Ph.D. thesis, University of Washington. 154 pp.

Phillips, R. C., C. McMillan, and K. W. Bridges. 1983. Phenology of eelgrass, *Zostera marina L.*, along latitudinal gradients in North America. Aquatic Botany 15: 145-156.

Phillips, R. C. 1984. The ecology of eelgrass meadows in the Pacific Northwest: a community profile. U.S. Fish Wildlife Service FWS/OBS-84/24. 85 pp.

Pregnall, A. M. 1983. Production ecology of green macroalgal mats (*Enteromorpha spp.*) in the Coos Bay, Oregon estuary. Ph.D. thesis, University of Oregon. 145 p.

Pregnall, M. M. 1993. Regrowth and recruitment of eelgrass (*Zostera marina*) and recovery of benthic community structure in areas disturbed by commercial oyster culture in the South Slough National Estuarine Research Reserve, Oregon. Master's thesis, Bard College. 90 pp.

Rumrill, S. S. 2006. The Ecology of the South Slough Estuary: Site Profile of the South Slough National Estuarine Research Reserve. Salem, Oregon: NOAA, Oregon Department of State Lands Technical Report, 238p.

Rumrill, S. 2008. Ecology of the South Slough Estuary-- Site profile of the South Slough National Estuarine Research Reserve.

Rumrill, Steven S. and Derek C. Sowers. 2008. Concurrent Assessment of Eelgrass Beds (*Zostera marina*) and Salt Marsh Communities along the Estuarine Gradient of the South Slough, Oregon. Journal of Coastal Research. 55: 121-134.

Sanborn, E. I. and M. S. Doty. 1944. The marine algae of the Coos Bay – Cape Arago region of Oregon. Corvallis, OR: Oregon State University (Collection Records). 23 pp.

Short, F. T. and S. Wyllie-Echeverria. 1996. Natural and human-induced disturbance of seagrasses. Environmental conservation, 23(01), 17-27.

Simenstad, C. A. 1983. The ecology of estuarine channels of the Pacific Northwest coast: a community profile. U.S. Fish and Wildlife Service FWS/OBS-83/05. 181 pp.

South Slough National Estuarine Research Reserve (SSNERR). 2015. SeagrassNet eelgrass Monitoring Raw Data. [Unpublished data]. Accessed at the Estuarine and Coastal Sciences Laboratory of SSNERR 15 April 2015.

Valtysson, Hreidar Por. n.d. Benthic Algae. [Unpublished article of the Information center of the Icelandic Ministry of Fisheries and Agriculture]. Accessed 16 April 2015 from http://www.fisheries.is/ecosystem/marine-life/benthic-algae/

Waycott, M., C. M. Duarte, T. J. Carruthers, R. J. Orth, W. C. Dennison, S. Olyarnik, and S. L. Williams. 2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences, 106(30), 12377-12381.

Wyllie-Echeverria, S. and J. D. Ackerman. 2003. The seagrasses of the Pacific Coast of North America. pp. 199-206. In E.P. Green and F.T. Short (eds.) World Atlas of Seagrasses: present status and future conservation. Prepared by the UNEP World Conservation Monitoring Centre. University of California Press, Berkley, CA. 298 p.

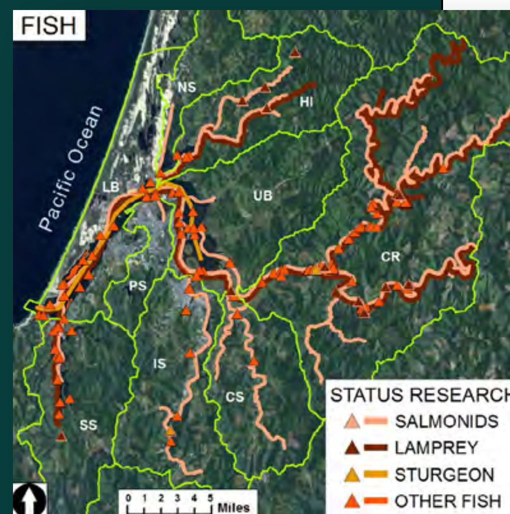
# Chapter 13: Fish in the Lower Coos Watershed

***Salmonids:*** *The status of Chinook salmon and cutthroat trout populations is generally good; the status of Coho salmon and steelhead trout populations is variable, depending on stream system.*

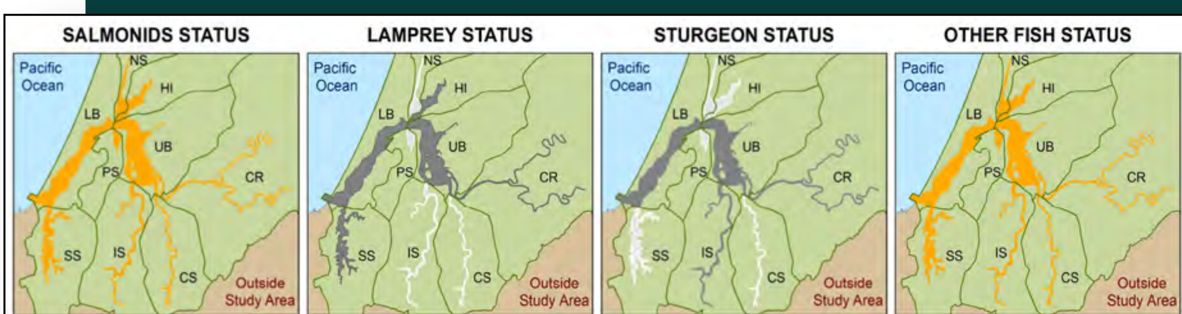
***Lamprey:*** *More data are needed to understand the status and distribution of the two lamprey species native to the Coos watershed, which appear to be declining in abundance in Oregon.*

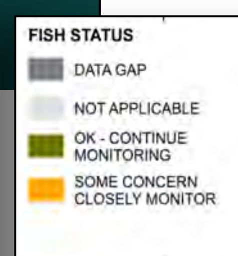
***Sturgeon:*** *Little is known about the status of the two sturgeon species found in the Coos system.*

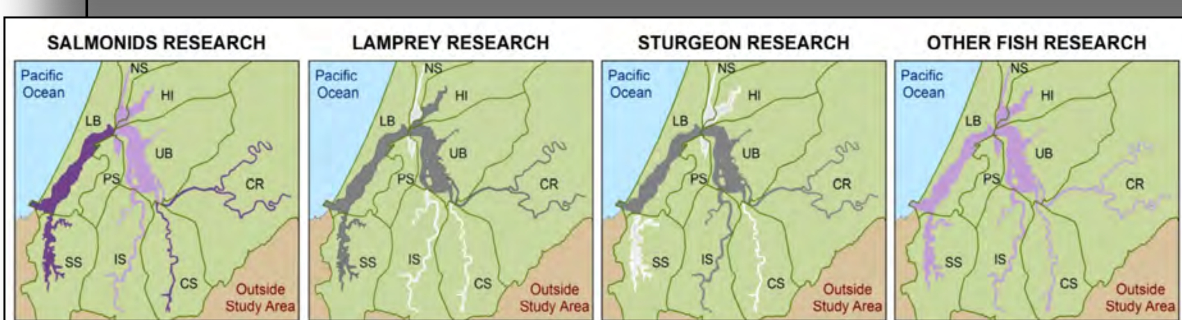
***Other Fish:*** *The Coos estuary supports more than 70 fish species but more information is needed to understand their populations and life histories.*




Subsystems: CR- Coos River CS- Catching Slough HI- Haynes Inlet IS- Isthmus Slough LB- Lower Bay NS- North Slough PS- Pony Slough SS- South Slough UB- Upper Bay




## Chapter 13: Fish in the Lower Coos Watershed

*This section includes the following data summaries: **Salmonids, Lamprey, Sturgeon, and Other Fishes**— which describe the status and trends (where the data allow) of fish in the Coos estuary and major freshwater tributaries in the lower Coos watershed.*

Salmonids: Data detailing the status of salmonid species in the Coos watershed were provided by the Oregon Plan for Salmon and Watersheds (Oregon Plan), which includes four Oregon Department of Fish and Wildlife (ODFW) fish monitoring projects: 1) Western Oregon Rearing Project (juveniles); 2) Aquatic Inventories Project (habitat); 3) Oregon Adult Salmonid Inventory and Sampling project (OASIS)(adults); and 4) Salmonid Life-Cycle Monitoring Project (survival)(ODFW 2013b). Oregon Plan data were supplemented by ODFW spawning survey data and the Oregon Native Fish Status Report (ODFW 2002, 2003, 2004, 2005c, 2005d, 2006, 2007, 2008, 2009, 2010, 2011, 2012, & 2013d).

The data presented in this chapter cover fish abundance and distribution at both the watershed and subsystem scales. At the watershed scale, the OASIS project provided abundance and distribution data for both adult Coho salmon and adult winter steelhead trout (ODFW 2013e; ODFW 2013f; Suring and Lewis 2008; Suring et al. 2008; Brown and Lewis 2009 & 2010; Brown et al. 2011, & 2012; Jacobsen et al. 2013). OASIS data were collected at 24 Oregon coast sites for Coho salmon and 13 sites for steelhead. The most recent OASIS data are from 2012, but the project also provides historic data for both Coho salmon and steelhead trout, dating back to 1990 and 2003 respectively. Adult Chinook abundance data were provided by ODFW spawning survey summaries, with the most recent data coming from 2013 (ODFW 2002, 2003, 2004, 2005d, 2006, 2007, 2008, 2009, 2010, 2011, 2012, & 2013d). An unpublished manuscript of ODFW's 2014 Coastal Multi-Species Conservation Management Plan was also referenced (ODFW 2014). Historic adult Chinook data (1974-2002) came from the 2005 Oregon Native Fish Status Report (ODFW 2005c).

At the subsystem-level, the most robust data are available from the Coos River and Haynes Inlet subsystems. In these basins, Coos Watershed Association (CoosWA) spawning surveys provided recent data (up to 2011) for Coho salmon (CoosWA 2011). Data for the South Slough subsystem are available from the Life Cycle Monitoring Program (Suring et al. 2012). These data were collected most recently in 2012.

Lamprey: The Lamprey data summary is based largely on incidental catch records from ODFW's Coho life-cycle monitoring project which reports, but does not analyze, lamprey counts (Suring et al. 2012). Likewise, unpublished raw lamprey data from CoosWA's Coho life-cycle monitoring project were used in the summary (CoosWA 2012). Counts of lamprey stream bed gravel nests, called “redds”, were also obtained from several reports (e.g., Kostow 2002). However, the redds data are a less accurate estimate of lamprey abundance because they are difficult to distinguish from steelhead redds (Kavanagh et al. 2005, Gunckel et al. 2006).

Sturgeon: Information about the status of sturgeon in the Coos system was primarily provided by ODFW’s Coos River Bain Fish Management Plan (Wagoner et al. 1990). Additional information is available in reports by Monaco and Emmett 1990; ODFW 2005a; ODFW 2005b; ORBIC 2013; ODFW 2013c and in unpublished data (ODFW 2013a).

Other Fish: Most of the information for the “Other Fish” data summary is from agency reports (e.g., Monaco and Emmett 1990), and was supplemented by theses (e.g. Kruse 1984) and peer-reviewed articles (e.g., Miller and Shanks 2004). While many of these data sources provided historic information, recent unpublished species distribution data were obtained from ODFW (ODFW 2013a) and the Oregon Institute of Marine Biology (OIMB 2013).

**Data Gaps and Limitations**

Salmonids: There are several imitations to the data describing the status of salmonids. For example, the location of annual spawning surveys conducted by ODFW and CoosWA varies from year to year, because these organizations have limited resources which preclude surveying every stream reach every year. These changes in survey location create gaps in the yearly fish data for some sites.

The use of multiple metrics to estimate salmonid abundance is another limitation. Among the estimation methods are: mark-recapture surveys, area-under-the-curve (AUC) modeling, redd counts, and density based on fish observed per mile of river at peak count. Time series comparisons are possible when the data are sufficiently robust and survey/modeling methods are consistent between years. Comparisons of data collected by different organizations are possible if surveying methods have been standardized. In addition, comparisons based on different abundance metrics have been made with caution, to avoid misleading or inaccurate interpretations. Some metrics can be converted to facilitate comparison. For example, peak count data (number of fish observed) can be converted to density data (fish per mile) by dividing the count at a site by the length of the associated survey section. When conversion is not possible, separate presentations of the data were warranted.

Aggregation of salmonid data also prohibits certain analyses. For example, the Coos River was grouped with the Tenmile, Coquille, Floras, and Sixes Rivers for a regional abundance estimate in ODFW’s 2013 OASIS Winter Steelhead Assessment Report (Jacobsen et al. 2013). Although regional aggregations are useful for statewide comparisons they may overestimate salmonid abundance in the Coos watershed alone.

Lamprey: There are no historic or current abundance estimates to determine status or trends for either lamprey species in the state of Oregon. Distribution information is also lacking for both lamprey species due to the difficulty in identifying ammocoetes (juveniles) by species (ODFW 2005c). Moreover, there is little life history information for either species in the Coos estuary. Detailed life history information for western brook lamprey is especially limited (ODFW 2005c).

Sturgeon: Information about abundance, distribution, and life histories of both white and green sturgeon in the Coos watershed is sparse. Neither past nor present abundance data for coastal white sturgeon exist. (ODFW 2005b). Similarly, very little is known about the status of green sturgeon populations, and the available abundance data are inconclusive (ODFW 2005a). More research is needed to alleviate these gaps (Wagoner et al. 1990).

Other Fish: Large data gaps exist for evaluating status and trends of "Other Fish" populations. The most complete assessment of life history data comes from a report by Monaco and Emmett (1990) describing annual distribution and abundance changes by age classes for 36 fish species in 32 West Coast estuaries. The distribution of each species in a particular estuary is based on salinity zones. However, a major limitation of this report is that the quality and quantity of data vary by species with some data derived from considerable field sampling and some based on best professional judgment. This report is also over 20 years old.

Another report from that time period is the Coos River Basin Fish Management Plan by Wagoner et al. (1990). Although this report focused on the Coos system, it primarily highlighted the lack of sampling data for non-salmonid populations. The objectives of the report were to prioritize the issues affecting the Coos system and to assess funding for fish research and monitoring. For example, one of the highest priorities was collecting baseline information on endemic Millicoma dace (*Rhinichthys cataractae ssp.*), but research and monitoring funds were lacking.

Our summary of Other Fish was mostly developed from raw data in two research projects– one by the Oregon Institute of Marine Biology (OIMB 2013), and a long term monitoring project by the Oregon Department of Fish and Wildlife (ODFW 2013a). The OIMB dataset was limited in scope (i.e., data only from summer 2013) but included accurate fish identifications. Although the ODFW dataset is from an on-going project and includes extensive data dating back to 1965, the project goals and sampling methods have shifted over time, thereby limiting its utility for quantifying fish populations. Some of the inconsistencies include: relocated sampling stations, varying confidence in fish identification between surveyors, estimates in population numbers, and differing seining dates between years.

**References**

Brown, E. and M. Lewis. 2009. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2009. [Monitoring Program Report Number OPSW-ODFW-2009-09]. Oregon Department of Fish and Wildlife. Salem, OR.

Brown, E. and M. Lewis. 2010. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2010. [Monitoring Program Report Number OPSW-ODFW-2010-09.] Oregon Department of Fish and Wildlife. Salem, OR.

Brown, E., J. Nott, and M. Lewis. 2011. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2011. [Monitoring Program Report Number OPSW-ODFW-2011-09]. Oregon Department of Fish and Wildlife. Salem, OR.

Brown, E., M. Weeber, M. Lewis, E. Hughes, R. Jacobsen, and J. Nott. 2012. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2012. [Monitoring Program Report Number OPSWODFW- 2012-09]. Oregon Department of Fish and Wildlife. Salem, OR.

Coos Watershed Association (CoosWA). 2011. Spawning Survey Form Data. [Unpublished data].

Coos Watershed Association (CoosWA). 2012. Coho life-cycle monitoring program. [Unpublished raw data].

Gunckel, S. L., K. K. Jones, and S. E. Jacobs. 2006. Spawning distribution and habitat use of adult Pacific and western brook lamprey in Smith River, Oregon. Oregon Department of Fish and Wildlife. Corvallis, OR.

Jacobsen R., J. Nott, E. Brown, M. Weeber, M. Lewis, and E. Hughes. 2013. Assessment of Western Oregon Adult Winter Steelhead – Redd Surveys 2013. [Monitoring Program Report Number OPSW-ODFW-2013-09.] Oregon Department of Fish and Wildlife. Salem, OR.

Kavanagh, P., K. Jones, C. Stein, and P. Jacobsen. 2005. Fish Habitat Assessment in the Oregon Department of Forestry Elliott Study Area. Oregon Department of Fish and Wildlife. Corvallis, OR.

Kostow, K. 2002. Oregon lampreys natural history, status, and problem analysis. Oregon Department of Fish and Wildlife. Salem OR.

Kruse, G. H. 1984. A simulation model of English sole (*Parophrys vetulus*) recruitment mechanisms. [PhD Thesis]. Oregon State University.

Miller, J. A. and A. L. Shanks. 2004. Ocean-estuary coupling in the Oregon upwelling region: abundance and transport of juvenile fish and of crab megalopae. Marine Ecology Progress Series 271: 267-279.

Monaco, M. E. and R. L. Emmett. 1990. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volumes 1 and 2. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Rockville, MD.

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Institute for Natural Resources, Portland State University. Portland, OR.

Oregon Department of Fish and Wildlife (ODFW). 2002. Summary of Standard Chinook Spawners Surveys: 2002 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2003. Standard Chinook Coastal Spawning Fish Survey Summary: 2003 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2004. Standard Chinook Coastal Spawning Fish Survey Summary: 2004 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2005a. Oregon Native Fish Status Report: Southern and Northern Green Sturgeon. Accessed 22 January 2014. Available online http://www.dfw.state.or.us/fish/onfsr/docs/final/11-other/methods-green-sturgeon.pdf

Oregon Department of Fish and Wildlife (ODFW). 2005b. Oregon Native Fish Status Report: Oregon White Sturgeon. Accessed 22 January 2014. Available online http://www.dfw.state.or.us/fish/onfsr/docs/final/11-other/methods-oregon-white-sturg.pdf

Oregon Department of Fish and Wildlife (ODFW). 2005c. Oregon Native Fish Status Report - Volume II. Available online http://www.dfw.state.or.us/fish/onfsr/report.asp

Oregon Department of Fish and Wildlife (ODFW). 2005d. Standard Chinook Coastal Spawning Fish Survey Summary: 2005 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2006. Standard Chinook Coastal Spawning Fish Survey Summary: 2006 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2007. Standard Chinook Coastal Spawning Fish Survey Summary: 2007 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2008. Standard Chinook Coastal Spawning Fish Survey Summary: 2008 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2009. Standard Chinook Coastal Spawning Fish Survey Summary: 2009 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2010. Standard Chinook Coastal Spawning Fish Survey Summary: 2010 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2011. Standard Chinook Coastal Spawning Fish Survey Summary: 2011 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2012. Standard Chinook Coastal Spawning Fish Survey Summary: 2012 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2013a. Coos fish monitoring seine program. [Unpublished raw data].

Oregon Department of Fish and Wildlife (ODFW). 2013b. Salmon Spawning Survey Procedures Manual. Accessed 23 January 2014. Available online http://oregonstate.edu/dept/ODFW/spawn/pdf%20files/reports/2013_CohoSSManualFinal.pdf

Oregon Department of Fish and Wildlife. (ODFW) 2013c. Sport Catch Statistics: Salmon, Steelhead, & Sturgeon. Accessed 22 January 2014. Available online http://www.dfw.state.or.us/resources/fishing/sportcatch.asp

Oregon Department of Fish and Wildlife (ODFW). 2013d. Standard Chinook Coastal Spawning Fish Survey Summary: 2013 Spawning Season. Estuarine and Coastal Sciences Laboratory of South Slough NERR. Accessed 24 January 2014.

Oregon Department of Fish and Wildlife (ODFW). 2013e. Oregon Coast Coho ESU Adult Spawning Abundance by Strata and Population (1990 – 2003). Accessed 20 December 2013. Available online http://oregonstate.edu/dept/ODFW/spawn/cohoabund.htm

Oregon Department of Fish and Wildlife (ODFW). 2013f. Oregon Coast Coho ESU Adult Spawning Abundance by Stata and Population (2004 – 2012). Accessed 20 December 2013. Available online http://oregonstate.edu/dept/ODFW/spawn/cohoabund.htm

Oregon Department of Fish and Wildlife (ODFW). 2014. Coastal Multi-Species Conservation and Management Plan. [Unpublished Manuscript].

Oregon Institute of Marine Biology (OIMB). 2013. Fish class seining and trawling data. [Unpublished raw data].

Suring E., E. Brown and M. Lewis. 2008. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2008. [Monitoring Program Report Number OPSW-ODFW-2008-09]. Oregon Department of Fish and Wildlife. Salem, OR.

Suring E. and M. Lewis. 2008. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2007. [Monitoring Program Report Number OPSW-ODFW-2007-09.] Oregon Department of Fish and Wildlife. Salem, OR.

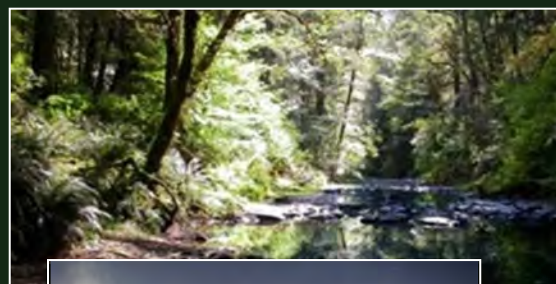
Suring, E., R. J. Constable, C. M. Lorion, B. A. Miller, and D. J. Wiley. 2012. Salmonid Life Cycle Monitoring in Western Oregon streams, 2009-2011. [Monitoring Program Report Number OPSW-ODFW-2012-2]. Oregon Department of Fish and Wildlife. Salem, OR.

Wagoner, L. J., K. K. Jones, R. E. Bender, J. A. Butler, D. E. Demory, T. F. Gaumer, J. A. Hurtado, W. G. Mullarky, P. E. Reimers, N. T. Richmond, and T. J. Rumreich. 1990. Coos River Basin Fish Management Plan. Oregon Department of Fish and Wildlife. Salem, OR.

# Effects of Climate Change on Local Marine, Estuarine, and Riverine Fishes

*Several climate-related changes have the potential to affect critical fish habitat as well as abundance and distribution of fish on the Oregon coast.*

- *Changes to marine habitats may reduce biodiversity and alter the distribution of fishes.*
- *Degradation and loss of estuarine habitats may jeopardize the reproductive success of local fish.*
- *Alterations to stream hydrology may result in critical habitat loss for cold water species.*



Salmon spawning habitat Photo: Umpqua Watersheds

Pacific storm
Photo: Partnership for Coastal Watersheds

Climate-related changes such as sea level rise (SLR), ocean acidification, and increasing ocean temperature are expected to affect marine and estuarine fish habitats. Other changes, such as altered precipitation patterns and increased frequency and severity of flood and drought, are expected to affect freshwater fish habitats. Fish that inhabit a variety of environments at different life stages, such as anadromous (migratory spawning) salmonids, are likely to be affected by all climate-related changes that affect both marine and estuarine habitats as well as freshwater habitats.

**Sea Level Rise (SLR)**

Many fish species use estuarine and near-shore ocean habitats at various parts of their life stages. Pacific herring (*Clupea pallasii*), require eelgrass beds, rocky shorelines or other substrates on which to attach their eggs during breeding season (Monaco and Emmett 1990). Many foraging fish species vital to the marine food web, such as surf smelt (*Hypomesus pretiosus*) and sand lance (*Ammodytes hexapterus*), use estuaries as breeding areas (Glick et al. 2007). Estuaries are vital to anadromous species by providing rearing habitats, the availability and quality of which affects ocean survival (Miller and Simenstad

***Sea Level Rise***

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, according to the National Research Council (NRC), predicted SLR rates for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary), are reported as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100.*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

1997).

The availability of high quality estuarine habitats may be threatened by SLR. Scientists have not yet determined whether sand flat and mudflat elevations relative to tidal levels will be able to keep pace with SLR. In other words, sedimentation rates may adjust with sea level rise so sand and mud flats remain about the same elevation relative to tidal levels as they are now, resulting in very little change in fish habitat availability. However, it is unlikely that coastal communities will allow intertidal habitats to migrate inland where high value real estate exists (Glick et al. 2007; Yamanaka et al. 2013). As SLR threatens rocky, intertidal habitats, the availability of hard substrate for egg deposition may decline. Species diversity and distribution may be affected by SLR in instances where salt water encroaches on brackish and freshwater habitats. Glick et al. 2007 note that since aquatic animals have specific salinity tolerances, SLR-driven salinity changes will be beneficial for some species and unfavorable for others. They also suggest SLR may still affect fishes less sensitive to these changes because their food sources may be affected by changing salinity regimes even if they are not.

**Ocean Acidification (OA)**

Few studies have been conducted investigating the effect of OA on fish in temperate marine ecosystems (Ishimatsu et al. 2004). However, a growing body of research suggests that OA causes a wide range of deleterious physiological responses in marine fishes. Ishimatsu et al. (2004) explain that elevated levels of ambient CO2 are associated with a condition in fish known as "hypercapnia," which causes disturbances that limit the function of the respiratory, circulatory, and nervous systems in fish. They suggest that the long-term effects of hypercapnia may inhibit important life functions by reducing growth, reproduction, and calcification.

Scientists who are studying tropical ecosystems report that OA may have significant effects on tropical fish. Dixson et al. (2010), Devine et al. (2012) and Munday et al. (2009) found significant effects of OA on the development of sensory mechanisms in tropical fish, and report that exposure to acidified seawater may impair the ability of these fish to recognize olfactory clues necessary for predator avoidance in tropical reefs.

Studies have shown that the effects of exposure to elevated CO2 levels are greatest in fish eggs, larvae, and juveniles, suggesting that fish in early developmental stages may be the most vulnerable to the impacts of ocean acidification (Kikkawa et al. 2003; Ishimatsu et al. 2004).

Other studies suggest that OA may change important fish habitats. Palacios and Zimmerman (2007) found that higher CO2 concentrations are positively correlated with reproductive output, below-ground biomass, and vegetative proliferation in eelgrass (Zostera marina). However, they note that this response is not necessarily beneficial to fish that are associated with eelgrass meadows, because other characteristics of CO2-rich environments (e.g., prolific algae growth and diminished water quality) are likely to overwhelm the positive effects of increased eelgrass productivity.

Although the precise effect of acidification on local fish populations is uncertain, it's likely that ocean acidification would reduce marine biodiversity through the loss of pH- and CO2-sensitive species and the likely reduction of habitat complexity (Widdicombe and Spicer 2008).

***Ocean Acidification***

*Since the late 18th century, the average open ocean surface pH levels worldwide have decreased by about 0.1 pH units, a decrease of pH from about 8.2 before the industrial revolution to about 8.1 today. A 0.1 change in pH is significant since it represents about a 30 percent increase in ocean acidity (the pH scale is logarithmic, meaning that for every one point change in pH, the actual concentration changes by a factor of ten). Scientists estimate that by 2100 ocean waters could be nearly 150% more acidic than they are now, resulting in ocean acidity not experienced on earth in 20 million years. The best Pacific Northwest ocean acidification data we have so far are from the Puget Sound area, where pH has decreased about as much as the worldwide average (a decrease ranging from 0.05 to 0.15 units).*

*Sources: Feely et al. 2010, NOAA PMEL Carbon Program 2013*

### *Increasing Ocean Temperatures*

*Worldwide, ocean temperatures rose at an average rate of 0.07° C (0.13° F) per decade between 1901 and 2012. Since 1880, when reliable ocean temperature observations first began, there have been no periods with higher ocean temperatures than those during the period from 1982 – 2012. The periods between 1910 and 1940 (after a cooling period between 1880 and 1910), and 1970 and the present are the times within which ocean temperatures have mainly increased.*

*Describing how the worldwide trend translates to trends off the Oregon coast is a complicated matter. Sea surface temperatures are highly variable due to coastal upwelling processes and other climatic events that occur in irregular cycles (e.g., El Niño events). We do have 27 years (1967-1994) of water temperature data collected from near the mouth of the Coos estuary that indicate through preliminary analyses a very weak trend towards warming water temperatures. Fifteen years (1995-2010) of data from multiple stations further up the South Slough estuary show very little water temperature change.*

*Sources: USEPA 2013, SSNERR 2013, Cornu et al. 2012*

**Increasing Ocean Temperature**

Increasing ocean temperatures may affect the distribution of marine and estuarine fish, with warmer temperatures creating more favorable habitats closer to the poles and nearer to the bottom of the ocean (Perry et al. 2005). Radovich (1961) has documented this phenomenon on the Pacific coast of North America by correlating unusually warm sea-surface temperatures with an increased number of anomalous fish landings between 1957 and 1959. He cites several instances of warm-water species being caught north of their expected ranges including the following: Pacific bonito (*Sarda chiliensis*) in Eureka, California, skipjack tuna (*Katsuwonus pelamis*) off Cape Blanco in Oregon, swordfish (*Xiphias gladius*) in Monterey Bay, and dolphinfishes (*Coryphaena spp.*) as far north as Grays Harbor, Washington.

Perry et al. (2005) note that fish with slower developmental rates or more complex life histories are less capable of adjusting to warming temperatures through rapid demographic responses like movement towards the poles. They anticipate that fish with these characteristics are more likely to be affected by rising ocean temperatures due to their inability to rapidly respond to unfavorable habitat changes.

In addition to distributional responses, increased temperatures may affect fish by encumbering basic life functions. The amount of energy allocated toward growth and reproduction in fish usually declines as

> **Local Effects of Changing Ocean Conditions**
>
> *The physical conditions of an estuary are sensitive to changes in long-term oceanographic fluctuations. O'Higgins and Rumrill have studied the physical response of the South Slough to changes in the Pacific Decadal Oscillation (PDO) index by monitoring water quality in the South Slough estuary from 2000 to 2006. Their data show a positive and statistically significant relationship between temperature and the PDO index. They also found a negative and statistically significant relationship between dissolved oxygen and the PDO index. This suggests that local estuaries are both anomalously warm and less oxygenated during the warmer (positive) phases of the PDO. Similarly, Hamilton has studied the relationship between the physical conditions of local waters and El Niño Southern Oscillation (ENSO) events between 2004 and 2010. Her data demonstrate a positive and statistically significant relationship between temperature and a multivariate ENSO index at stations in Charleston, South Slough's Valino Island, and South Slough's Winchester Creek.*
>
> *Sources: O'Higgins and Rumrill 2007, Hamilton 2011*

temperatures approach the extreme ends of species-specific tolerance ranges (Roessig et al. 2004). This is demonstrated in the English sole, which exhibits significantly slower growth in temperatures above 17.5° C (63.5° F) and is likely to experience reduced growth in extreme estuarine temperatures (Yoklavich 1982; Rooper et al. 2003). Similarly, studies of sand lances (*Ammodytes spp.*) indicate that water temperature plays an important role in spawning timing and affects both recruitment and growth rates (Monaco and Emmett 1990).

Increased water temperatures also compromise habitat quality for cold water species. According to the Oregon Department of Fish and Wildlife (ODFW 2014), higher water temperatures may accelerate the loss of areas that provide important cool water refugia and resting habitats for anadromous salmonid species.

**Marine and Estuarine Hypoxia**

Most of the climate-related alterations to fish habitats suggest increased likelihood of secondary effects. For example, the potential loss of tidal marshes can lead to reduced water quality in estuaries, because tidal marshes regulate nutrients and filter pollutants (Glick et al. 2007). High nutrient levels combined with increasing ocean temperatures and adequate light provide the ideal conditions for explosive algae growth. The overproduction of algae can damage aquatic ecosystems by blocking sunlight and reducing oxygen levels in the water column (USEPA 2013a). Hypoxia, low levels of dissolved oxygen in water, has deleterious effects on fish. Hypoxic conditions are linked to limited reproductive function in several species of marine and estuarine fish (Giorgi and Congleton 1984; Landry et al. 2007; Thomas et al. 2007). In extreme circumstances, low oxygen levels have caused mass mortalities (Pacific Fishery Management Council 1983).

**Changing Ocean Conditions**

Climate change is likely to cause changes in a variety of ocean conditions that will affect fish:

- Climate change will likely affect ocean circulation and have some effect on Pacific coast upwelling patterns (Hayward 1997, Bakun 1990).
- Research suggests a correlation between ocean temperature and increased severity and frequency of storms (Knutson et al. 2010, Webster et al. 2005, McGabe et al. 2001).
- The oceanographic effects of climate change may directly affect the abundance and distribution of marine fishes by affecting the availability of food resources. For example, Monaco and Emmett (1990) found that food availability for larval northern anchovy (*Engraulis mordaxis*) is reduced by storms or strong upwell-

***Pacific Decadal Oscillation and El Niño Southern Oscillation***

*The Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO) are cyclical climatic patterns that affect weather and ocean currents in and around the Pacific ocean. PDO is a pattern of oceanic conditions that shift every few decades. During a cold (negative) phase, the west Pacific warms, and the east Pacific cools; the opposite is true of a warm (positive) phase. ENSO is a climatic event that tends to occur every two to seven years and is characterized by anomalous warming of tropical Pacific waters. Locally, this warming is associated with drier conditions, warmer temperatures, and lower precipitation and streamflow, although it can also result in greater winter "storminess" and flooding.*

*Source: Mysak 1986*

that storms increase food abundance for adults.

ing conditions. However, they also find that storms increase food abundance for adults.

- ODFW (2014) suggests that rising temperature may be cause for increased ocean stratification, a trend which has previously been associated with poor foraging conditions for salmonids.

In addition to the effects of climate change, Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO) are cyclical patterns of climate variability (see sidebar) that influence ocean conditions, as well as fish abundance and distribution. The ecological response to shifts in PDO first affects primary producers and consumers before working to higher level consumers such as salmon. Warm PDO periods may be associated with decreased primary productivity in local waters due to the increased stratification of the California Current off the Oregon coast (Mantua et al. 1997; Hare et al. 1999). These events are likely to affect salmon marine survival rates (Hare el a. 1999).

Changing ocean conditions may affect fish populations through abiotic mechanisms such as modifications to critical habitats. Changes in precipitation regimes associated with the El Niño Southern Oscillation (ENSO), for example, may limit access to spawning grounds, and systems located near the southern end of salmon distribution ranges may reach critical levels as waters warm (Naiman et al. 2002).

**Stream Hydrology**

Many aspects of climate change are expected to alter the water cycle. The anticipated changes include increased and earlier peak stream flows and reduced summer stream flows (Defenders of Wildlife and ODFW 2008). ODFW (2014) suggests that these changes are likely to compound existing factors that are already limiting the suitability of fish habitats. They recognize the following as factors that are currently affecting critical fish habitats:

- Loss of peripheral stream connections
- Degradation of in-stream structures
- Unfavorable changes to water temperature, sedimentation regimes, barriers to upstream passage, and availability of gravel.

Increased water temperatures may limit the reproductive function of riverine fish that are already vulnerable. The white sturgeon (*Acipenser transmontanus*), for example, has been shown to have substantial egg mortality in water temperatures above 18° C (64° F) (Wagoner et al. 1990). Additionally, warmer waters may accelerate habitat loss by effectively eliminating cool backwaters and other areas that provide important refugia and resting habitats for salmon species (ODFW 2014; Defenders of Wildlife and ODFW 2008).

Warmer air temperatures and altered patterns of precipitation are a likely to directly influence the frequency, magnitude, and extent of extreme weather including flooding and drought (Reiman and Isaak 2010; Defenders of Wildlife and ODFW 2008). In instances where these extreme weather events compromise riparian habitats, the effects of climate change on fish may be accelerated by reductions in shading, bank stabilization, food availability, and nutrient and chemical mediation (ODFW 2014).

**References**

Bakun, A. 1990. Global climate change and intensification of coastal ocean upwelling. Science 247(4939): 198-201.

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. [Report prepared for the Partnership for Coastal Watersheds Steering Committee]. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Defenders of Wildlife and Oregon Department of Fish and Wildlife (ODFW). 2008. Preparing Oregon's Fish, Wildlife, and Habitats for Future Climate Change: A Guide for State Adaption Efforts. Accessed 15 January 2014. Available online http://www.oregon.gov/ENERGY/GBLWRM/docs/f-w_adaptation_guide.pdf

Devine, B. M., P. L. Munday, and G. P. Jones. 2012. Homing ability of adult cardinalfish is affected by elevated carbon dioxide. Oecologia 168(1): 269-276.

Dixson, D. L., P. L. Munday, and G. P. Jones. 2010. Ocean acidification disrupts the innate ability of fish to detect predator olfactory cues. Ecology Letters 13(1): 68-75.

Feely, R. A., S. R. Alin, J. Newton, C. L. Sabine, M. Warner, A. Devol, C. Krembs, and C. Maloy. 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. Estuarine, Coastal and Shelf Science 88(4): 442-449.

Giorgi, A. E. and J. L. Congleton. 1984. Effects of current velocity on development and survival of lingcod, Ophiodon elongatus, embryos. Environmental Biology of Fishes 19(1/2): 15-27.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-level Rise and Coastal Habitat in the Pacific Northwest: An analysis for Pudget Sound, Southwester Washington, and Northwestern Oregon. National Wildlife Federation. Accessed 15 January 2014. Available online http://www.nwf.org/pdf/Wildlife/PacificNW-SeaLevelRise.pdf

Hamilton, J. 2011. SWMP Bio-monitoring: Final Report (2004-2010). South Slough National Estuarine Research Reserve. Charleston, OR.

Hare, S. R., N. J. Mantua, and R. C. Francis. 1999. Inverse production regimes: Alaska and west coast Pacific salmon. Fisheries 24(1): 6-14.

Hayward, T. L. 1997. Pacific Ocean climate change: atmospheric forcing, ocean circulation and ecosystem response. Trends in ecology & evolution 12(4): 150-154.

Ishimatsu, A., T. Kikkawa, M. Hayashi, K. S. Lee, and J. Kita. 2004. Effects of CO2 on marine fish: larvae and adults. Journal of oceanography 60(4): 731-741.

Kikkawa, T., A. Ishimatsu, and J. Kita. 2003. Acute CO2 tolerance during the early developmental stages of four marine teleosts. Environmental Toxicology 18(6): 375-382.

Knutson, T. R., J. L. McBride, J. Chan, K. Emanuel, G. Holland, C. Landsea, I. Held, J. P. Kossin, A. K. Srivastava, and M. Sugi. 2010. Tropical Cyclones and Climate Change. Nature Geoscience 3(3): 1-37.

Landry, C. A., S. L. Steele, S. Manning, and A. O. Cheek. 2007. Long Term Hypoxia Suppresses Reproductive Capacity in the Estuarine Fish, Fundulu granadis. Comparative Biochemistry and Physiology 148: 317-232.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6): 1069-1079

McCabe, G. J., M. P. Clark, and M. C. Serreze. 2001. Trends in Northern Hemisphere surface cyclone frequency and intensity. Journal of Climate 14: 2763–2768.

Miller, J. A. and C. A. Simenstad. 1997. A comparative assessment of a natural and created estuarine slough as rearing habitat for juvenile Chinook and Coho salmon. Estuaries 20(4): 792-806.

Monaco, M. E. and R. L. Emmett. 1990. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volumes 1 and 2. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Rockville, MD.

Munday, P. L., D. L. Dixson, J. M. Donelson, G. P. Jones, M. S. Pratchett, G. V. Devitsina, and K. B. Døving. 2009. Ocean acidification impairs olfactory discrimination and homing ability of a marine fish. Proceedings of the National Academy of Sciences 106(6): 1848-1852.

Mysak, L. A. 1986. El Niño, interannual variability, and fisheries in the Northeast Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences 43: 464–97.

Naiman, R. J., R. E. Bilby, D. E. Schindler, and J. M. Helfield. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems 5(4): 399-417.

National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory (PMEL) Carbon Program. 2013. What is Ocean Acidification? Available online http://www.pmel.noaa.gov/co2/story/What+is+-Ocean+Acidification%3F

National Oceanic and Atmospheric Administration Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Available online http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Washington, DC: The National Academies Press. 201 pp.

O'Higgins, T. and S. S. Rumrill. 2007. Tidal and Watershed Forcing of Nutrients and Dissolved Oxygen Stress Within Four Pacific Coast Estuaries: Analysis of Time-Series Data Collected by the National Estuarine Research Reserve System-Wide Monitoring Program (2000-2006) Within Padilla Bay (WA), South Slough (OR), Elkhorn Slough (CA), and the Tijuana River Estuary (CA). [Final Report Submitted to the NOAA/University of New Hampshire Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)].

Oregon Department of Fish and Wildlife (ODFW). 2014. Coastal Multi-Species Conservation and Management Plan. [Unpublished Manuscript].

Pacific Fishery Management Council. 1983. Northern anchovy fishery management plan, fourth draft revision. Pacific Fishery Management Council. Portland, OR.

Palacios, S. L. and R. C. Zimmerman. 2007. Response of ellgrass Zostera marina to CO2 enrichment: possible impacts of climate change and potential for remediation of coastal habitats. Marine Ecology Progress Series 344: 1-13.

Perry, A. L, P. J. Low, J. R. Ellis, and J. D. Reynolds. 2005. Climate Change and Distribution Shifts in Marine Fishes. Science 308(5730): 1912-1915.

Radovich, J. 1961. Relationships of some marine organisms of the northeast Pacific to water temperatures, particularly during 1957 through 1959. Fish Bulletin 112(62): 18-30.

Rieman, B. E. and D. Isaak. 2010. Climate change, aquatic ecosystems, and fishes in the Rocky Mountain West: implications and alternatives for management. [General Technical Report RMRS-GTR-250]. United States Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO. 46 p.

Roessig, J. M., C. M. Woodley, J. J. Cech Jr, and L. J. Hansen. 2004. Effects of global climate change on marine and estuarine fishes and fisheries. Reviews in Fish Biology and Fisheries 14(2): 251-275.

Rooper, C. N., D. R. Gunderson, and D. A. Armstrong. 2003. Patterns in Use of Estuarine Habitat by Juvenile English Sole (Pleuronectes vetulus) in Four Eastern North Pacific Estuaries. Estuaries 26(4): 1142-1154.

South Slough National Estuarine Research Reserve (SSNERR). 2013. [Unpublished raw data]. System-Wide Monitoring Program (SWMP). Available online http://cdmo.baruch.sc.edu/

Thomas, P., M. S. Rahman, I. A. Khan, and J. A. Kummer. 2007. Widespread endocrine disruption and reproductive impairment in an estuarine fish population exposed to seasonal hypoxia. Proceedings of the Royal Society B: Biological Sciences 274(1626): 2693-2702.

United States Environmental Protection Agency (USEPA) Office of Water. 2013a. Impacts of Climate Change on the Occurrence of Harmful Algal Blooms. Accessed 4 December 2013. Available online http://www2.epa.gov/sites/production/files/documents/climatehabs.pdf

United States Environmental Protection Agency (USEPA). 2013b. Climate change indicators in the United States. Available online http://www.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html

Wagoner, L. J., K. K. Jones, R. E. Bender, J. A. Butler, D. E. Demory, T. F. Gaumer, J. A. Hurtado, W. G. Mullarky, P. E. Reimers, N. T. Richmond, and T. J. Rumreich. 1990. Coos River Basin Fish Management Plant. Oregon Department of Fish and Wildlife. Salem, OR.

Webster, P. J., G. J. Holland, J. A. Curry, and H. R. Chang. 2005. Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science 309: 1844-1846.

Widdicombe, S. and J. I. Spicer. 2008. Predicting the impact of ocean acidification on benthic biodiversity: what can animal physiology tell us? Journal of Experimental Marine Biology and Ecology 366(1): 187-197.

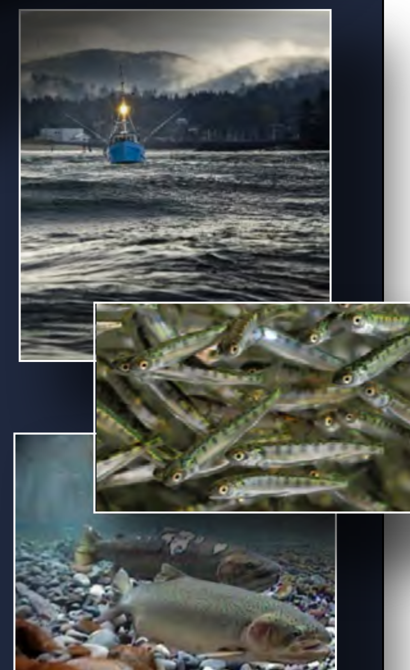
Yamanaka, T., D. Raffaelli, and P. White. 2013. Non-linear interactions determine the impact of sea-level rise on estuarine benthic biodiversity and ecosystem processes. PLoS ONE 8(7): 1-8.

Yoklavich, M. M. 1982. Energy Requirements of the English Sole (Parophrys vetulus). [MS Thesis]. San Francisco State University. San Francisco, CA.

# Salmonids in the Lower Coos Watershed

*Summary:*


- *Wild Coho salmon returns have marginally increased in the Coos River over the past 20 years but have recently declined in streams associated with Haynes Inlet and South Slough.*
- *Fall Chinook runs in the Coos River basin have been strong over the past 30 years.*
- *Winter steelhead abundance has declined; hatchery fish may comprise an increasingly large share of the population in the mid-south coast monitoring area.*
- *Substantial numbers of hatchery-raised fish have been released in the Coos River. The long-term effectiveness of these programs is a matter of on-going debate.*

**Evaluation**

Status of fall Chinook and cutthroat trout appear strong. These populations should continue to be monitored.

**Evaluation**

Status of coho and steelhead is of concern. Some indictors appear strong, while others are deteriorating.

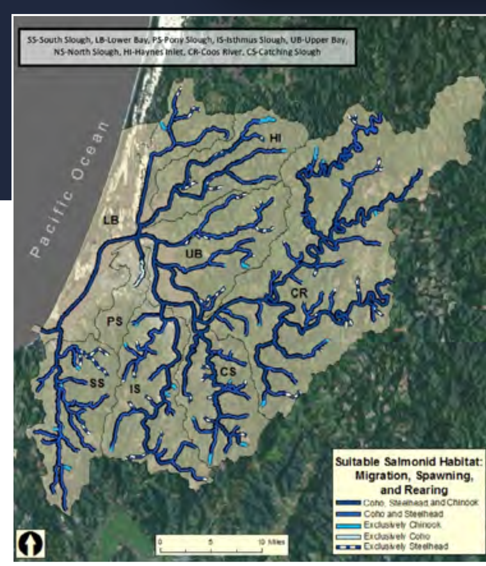



Figure 1. The spatial extent of habitat in the study area considered suitable for Coho and Chinook salmon, and for winter Steelhead migration, spawning, or rearing sometime during the past five reproductive cycles (ODFW 2013f).

**What's happening?**

Populations of salmonids in the lower Coos watershed primarily consist of Coho salmon (*Oncorhynchus kisutch*), winter steelhead (*Oncorhynchus mykiss irideus*), fall Chinook salmon (Oncorhynchus tshawytscha), and coastal cutthroat trout (*Oncorhynchus clarki clarki*). These fish use the waters of the Coos system for important life history functions such as migration, spawning, and rearing.

This document summarizes available information to describe the current abundance and distribution of juvenile and adult Coho, Chinook, steelhead, and other salmonids. It presents habitat maps and reports trends in abundance, as well as factors affecting their abundance such as hatchery production, predation, and the local effects of climate change.

Informationfor this summary was largely derived from activities supporting the Oregon Plan for Salmon and Watersheds (Oregon Plan). For example, adult Coho and winter steelhead abundance data are available through the Oregon Adult Salmonid Inventory and Sampling Project (OASIS), a component of the Oregon Plan (ODFW 2013d; ODFW 2013e; Suring and Lewis 2008; Suring et al. 2008; Brown and Lewis 2009 & 2010; Brown et al. 2011 & 2012; Jacobsen et al. 2013). Data for marine survival of Coho in the lower Coos watershed are published in the Life Cycle Monitoring Program (LCM) of the Oregon Plan (Suring et al. 2012). Spawning surveys for fall Chinook in the Coos River Basin contribute to the OASIS project and provided adult abundance data for this document (ODFW 2002, 2003b, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2011, 2012b, & 2013g). Information from the Oregon Plan is supplemented by other reports and unpublished, raw data from the Coos Watershed Association (ODFW 2014a; ODFW 2005a; CoosWA 2013a).

<u>Salmonid Species Distribution</u>
This assessment, like all the assessments in the Inventory, divides the project area into nine subsystems: South Slough, Pony Slough, Lower Bay, Upper Bay, Isthmus Slough, Catching Slough, Haynes Inlet, North Slough, and Coos River (see Figure 1). Coho salmon spawning occurs primarily in the Coos River, Upper Bay, and Haynes Inlet subsystems. Spawning occurs to a lesser extent in the North Slough, Catching Slough, Isthmus Slough, and South Slough subsystems. There is Coho migration and rearing habitat in all

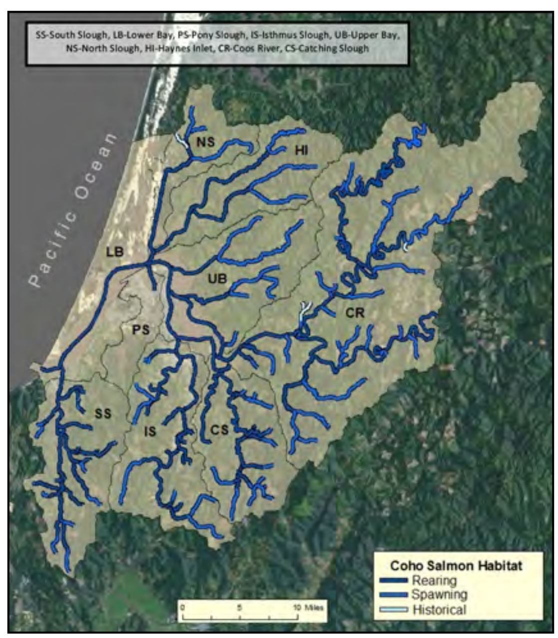



Figure 2. The spatial extent of coho salmon. Data: ODFW 2013b

nine subsystems (Figure 2). The spatial extent of winter steelhead closely corresponds with Coho salmon (Figure 3). Although fall Chinook salmon depend on habitats in all subsystems for some life cycle stages, their distribution is more limited than Coho and steelhead.

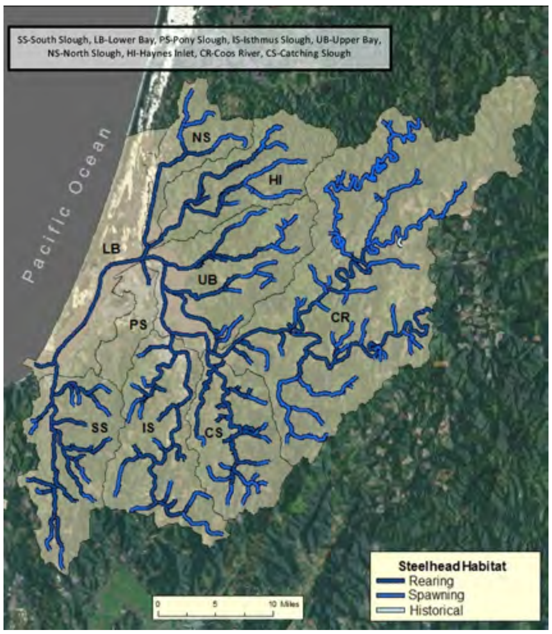



Figure 3. The spatial extent of winter steelhead. Data: ODFW 2013b

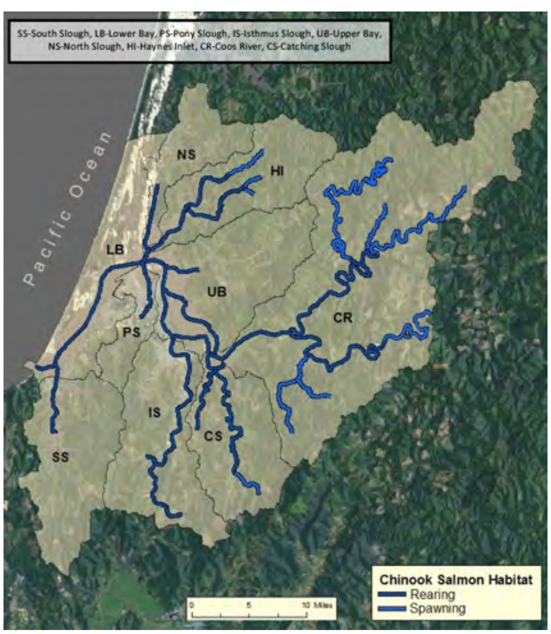



Figure 4. Spatial extent of Chinook salmon. Data: ODFW 2013b

Chinook spawning occurs primarily in the Coos River subsystem, with very limited spawning also in the Haynes Inlet, Catching Slough, Isthmus Slough, and South Slough subsystems (Figure 4).

Status and Trends: Adult Coho Salmon

OASIS monitors 24 adult Coho salmon populations at over 500 sites on the Oregon coast. Generally, wild Coho abundance on the Oregon coast has increased since 1990 while hatchery Coho abundance has decreased (Figure 5).

For the entire coast, the greatest increases in wild Coho abundance occurred in the late 2000s (Figure 5). The wild Coho population decreased from 2003-2007 then recovered during 2007-2011. The Oregon Department of Fish and Wildlife estimates that 99,094 wild Coho spawned on the Oregon coast in 2012, which represents a 380% increase from 1990 but a 72% decrease from the peak in 2011 (ODFW 2013d and 2013e).

The abundance of hatchery Coho salmon has been declining since 1990 (Figure 5). There was a sharp decline in the late 1990s and another period of steady decline between the early 2000s to 2012 (ODFW 2013d and 2013e).

Approximately 9,414 adult wild Coho spawned in the Coos River in 2012, which represents a 320% increase from 1990 and a 72% decrease from the 2001 peak level (Figure 5)(ODFW 2013d and 2013e).

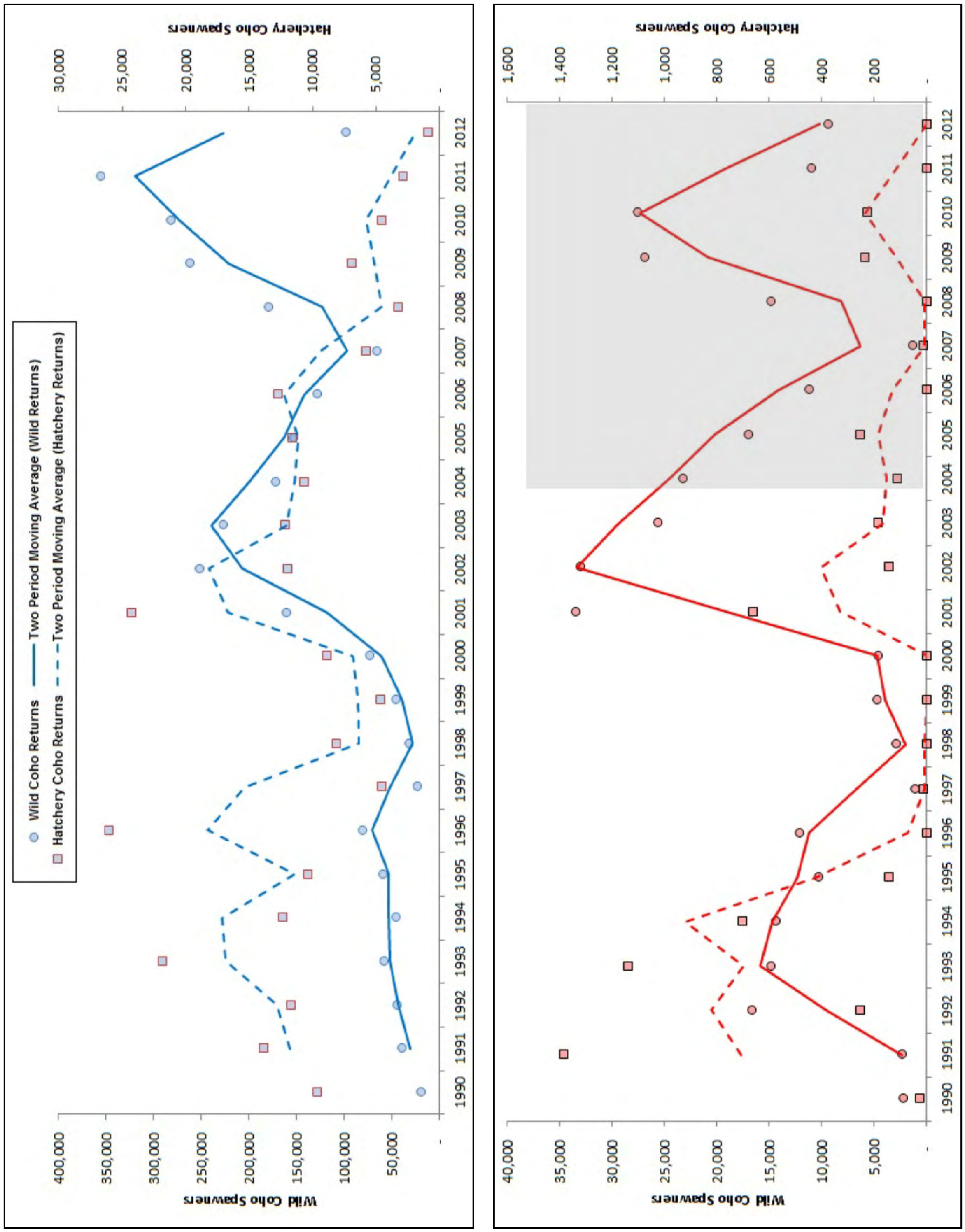



Figure 5. Adult Coho abundance estimates for the Oregon coast (blue) and the Coos River (red). Shaded area represents salmon returns to the Coos system after Coho hatchery programs were eliminated in 2004. Data: ODFW 2013d and 2013e

| OASIS Site | Returning Adults (2012) | Twenty-year Avg. (1990-2012) | Min | Max | Std error |
|---|---|---|---|---|---|
| **Coos River** | **9,414** | **14,011** | **1,112** | **33,595** | **2,129** |
| Umpqua River | 20,948 | 27,111 | 3,334 | 94,655 | 4,657 |
| Tillamook | 1,686 | 4,790 | 80 | 19,250 | 1,266 |
| Yaquina | 6,268 | 5,799 | 317 | 23,800 | 1,352 |
| Siuslaw | 11,946 | 12,393 | 501 | 55,445 | 2,795 |
| Coquille | 5,911 | 12,754 | 2,033 | 55,667 | 2,580 |
| All Oregon Coast Sites | 99,094 | 125,092 | 20,652 | 356,243 | 20,105 |

Table 1. Abundance of wild Coho salmon at OASIS sites. The Umpqua River data aggregate four OASIS sites including the Lower Umpqua, Middle Umpqua, North Umpqua, and South Umpqua. Data: ODFW 2013d and 2013e

The abundance of hatchery Coho in the Coos River has sharply declined since the 1990s (Figure 5). Hatchery Coho abundance in the Coos River peaked in the early 1990s, but since then, there have been several years with zero estimated hatchery fish on natural spawning grounds. The last hatchery Coho smolt release in the Coos basin was made in 2004 (G. Vonderohe, pers. comm., April 21, 2014). Summary statistics describing 20-year trends in the status of Coho salmon at several OASIS sites are presented in Table 1. Adult and juvenile Coho salmon populations in South Slough's Winchester Creek have also been tracked annually by the Oregon Plan's LCM since 1999 (Figure 6).

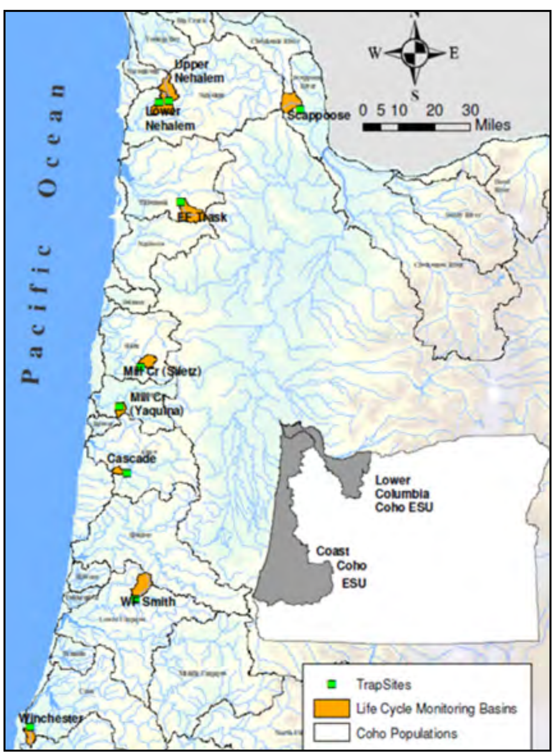



Figure 6. The locations of all eight life cycle monitoring basins. Graphic: Suring et al. 2012.

Although there are no clear trends in abundance for wild adults in LCM basins, the data do exhibit a weak pattern of cyclical returns in some basins (e.g., Siletz Mill Creek and Smith River in Figures 7b and 7c). In Winchester Creek, adult wild Coho returns are decreasing, and marine survival rates are low compared to other sites (Figure 7d).

Between 2000 and 2011, the marine survival rate for Coho salmon in Winchester Creek averaged approximately 4%, with the highest rate (approximately 10%) in 2001 and lowest (less than one percent) in 2008. The Winchester Creek site averaged 121 spawning Coho returning annually, with a lower bound of only five adults returning in 2000 and an upper bound of 374 adults in 2004 (Table 2).

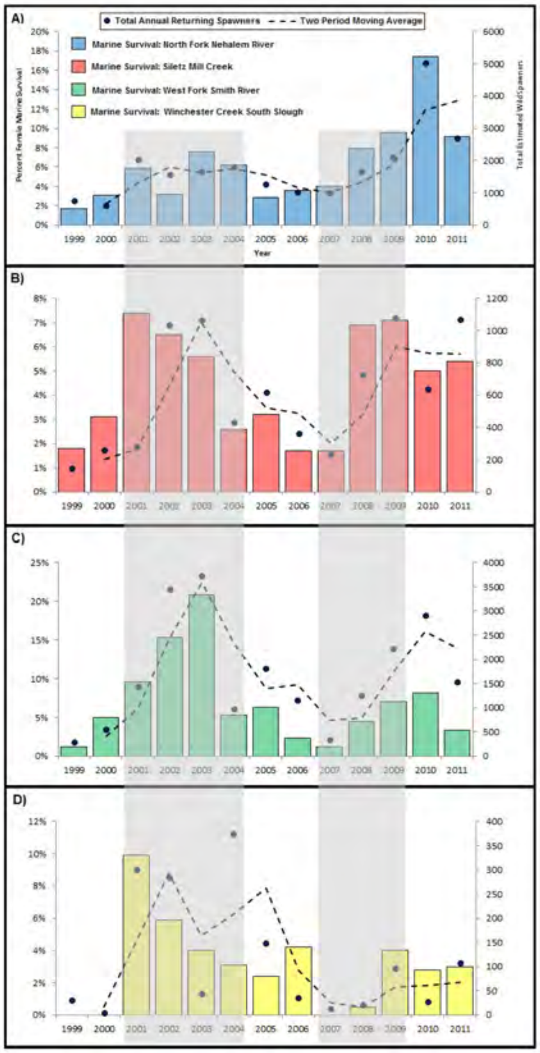



Figure 7. Trends in Coho salmon marine survival rates (bar graph) and returning wild spawning adult numbers (line graph) for four of the eight LCM basins. Generalized areas of high return rates (2001-2004) and low return rates (2007-2009) have been highlighted in grey. Data: Suring et al. 2012, ODFW 2012a.

The standard error measures the statistical variance from year to year, thus the small standard errors in the Winchester Creek data suggest that annual Coho runs are consistently small and marine survival is consistently low. This observation is supported by a general decline in adult wild Coho returning to Winchester Creek since the early 2000s (Figure 7).

**Summary Statistics: Marine Survival Rate in Four LCM Basins (2000-2011)**

| | Mean | Min | Max | Std Error |
|---|---|---|---|---|
| NF Nehalem River | 6.7% | 2.9% | 17.4% | 1.2% |
| Siletz Mill Creek | 4.7% | 1.7% | 7.4% | 0.6% |
| WF Smith River | 7.4% | 1.2% | 20.9% | 1.6% |
| Winchester Creek | 4.0% | 0.5% | 9.9% | 0.8% |

**Summary Statistics: Returning Adult Coho for Spawning in Four LCM Basins (2000-2011)**

| | Mean | Min | Max | Std Error |
|---|---|---|---|---|
| NF Nehalem River | 1,879 | 612 | 5,026 | 329 |
| Siletz Mill Creek | 652 | 237 | 1,104 | 100 |
| WF Smith River | 1,783 | 335 | 3,730 | 315 |
| Winchester Creek | 121 | 5 | 374 | 37 |

Table 2. The summary statistics for marine survival and number of returning adult Coho for spawning. Data: Suring et al. 2012, ODFW 2012a

To put the Winchester Creek LCM data in perspective, the second lowest marine survival rates were observed in Siletz Mill Creek (4.7% on average) between 2000 and 2011, with a peak of 7.4% in 2001 and a low of 1.7% in 2006 and 2007. Trends for LCM basin sites are summarized in Figure 7 and Table 2.

Time series analyses of population status are also performed for other subsystems where the data are sufficiently robust. The Coos Watershed Association (CoosWA) has conducted stream surveys in the salmon-bearing waterways of the Haynes Inlet subsystem since the early 2000s.

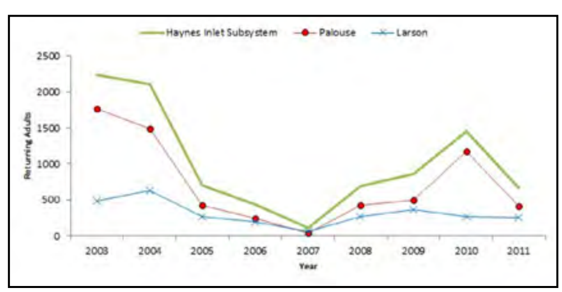



Figure 8. Trends in adult Coho returns to the Haynes Inlet subsystem. Data: CoosWA 2013a

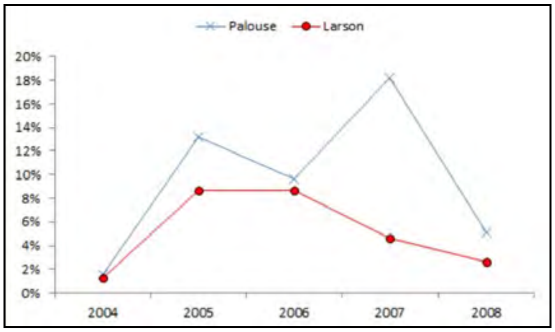


Figure 9. Marine survival is the proportion of Coho smolts that return to the Haynes Inlet Subsystem to spawn as adults. Data and caption: CoosWA 2013a

According to CoosWA (2013a), Coho returns to the Haynes Inlet subsystem trended downward in the early 2000s, but recovered from 2007-2010 (Figure 8). In 2011, CoosWA estimated 671 returns to the Haynes Inlet Subsystem, which was a decrease from 2010-levels and below the eight-year average (1,015 annual returns).

CoosWA (2013a) also estimated marine survival rates of adults returning to Palouse and Larson creeks in the Haynes Inlet subsystem for 2004-2008 (Figure 9). Survival rates in Palouse Creek were consistently higher than at Larson Creek. In general, marine survival rates increased from 2004-2006, except for a decrease in Palouse Creek returns in 2006. From 2006-2008, marine survival declined except for an increase at Palouse Creek in 2007.

Status and Trends: Juvenile Coho Salmon

Since 1998, ODFW has monitored juvenile Coho distribution and abundance as part of the Western Oregon Rearing Project (WORP) (Rodgers 2000, 2001, 2002; Jepsen and Rodgers 2004; Jepsen 2006; Jepsen and Leader 2007a, 2007b, 2008; Suring and Constable 2009, 2010; Constable and Suring 2010, 2012, 2013). WORP investigates juvenile distribution and reports pool occupancy rates (percent of pools with juveniles present) and abundance (fish per m2), which is measured by average density of juveniles in pools.

WORP is divided into regional “monitoring areas” that are grouped into larger “evolutionarily significant units” (ESU) and “distinct population segments” (DPS)(Figure 10). The Coos estuary is part of the mid-south coast monitoring area, which includes the Tenmile, Coos, Coquille, Floras, and Sixes River basins.

Juvenile abundance is a “coincident indicator” of adult abundance, meaning that current trends in juvenile abundance reflect current trends in the abundance of the adults that

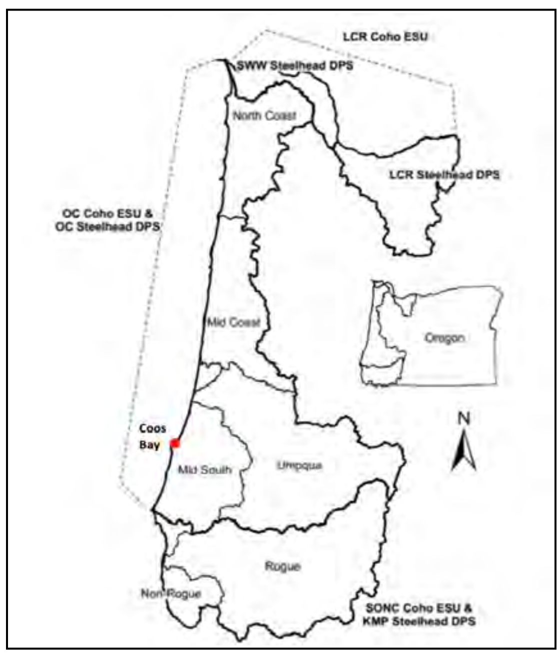


Figure 10. The spatial extent of Coho and steelhead monitoring areas, evolutionarily significant units (ESU), and distinct population segments (DPS) Graphic: Constable and Suring 2013; Codes: LCR- Lower Columbia River, SWW- Southwest Washington, OC- Oregon Coast, SONC- Southern Oregon Northern California, KMP- Klamath Mountain Province

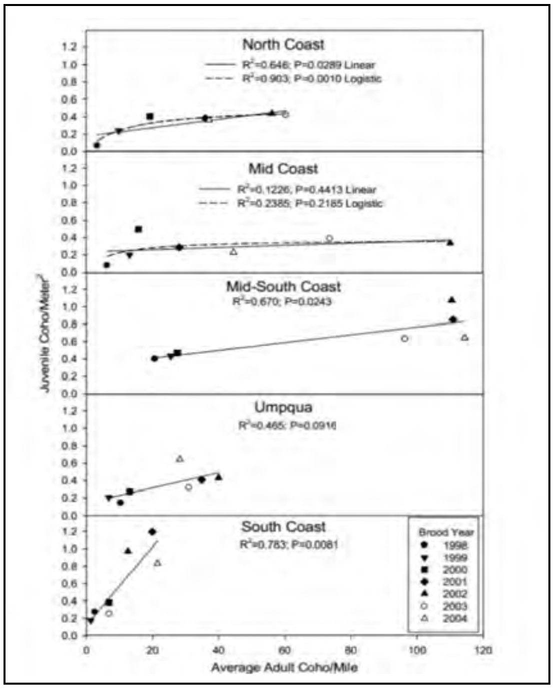



Figure 11. The relationship between juvenile abundance (fish/m2) and the average density (fish/mile) of the adults that produced them. $R^2$ is the percent of variation in adult abundance explained by juvenile abundance. Graphic: Jepsen and Leader 2007a

produced them. Jepsen and Leader (2007a) estimate with a high degree of confidence ($p<0.05$) that 67% of the variation in adult abundance is explained by variation in juvenile abundance in the mid-south coast (R2=0.67)(Figure 11).

Juvenile pool occupancy in the mid-south coast monitoring area has increased since 1998 (Figure 12). In 2011, juveniles were present in 79% of the area's pools (an 18% increase from 1998 levels). However, juvenile density was more variable: 12-year low (0.17 fish/m2) in 1998 and maximum density (1.07 fish/m2) in 2003. Overall, pool occupancy has shown a statistically significant ($p < 0.01$) annual increase since 1998, while the annual change in pool density ($p > 0.05$) is not statistically different from zero (i.e., neither increasing nor decreasing).

CoosWA (2013a) has also monitored juvenile Coho abundance in the Haynes Inlet Subsystem from 2006-2012 (Figure 13). The number of out-migrating smolts from the Haynes Inlet Subsystem increased from 2006 to 2011 but declined in 2012.

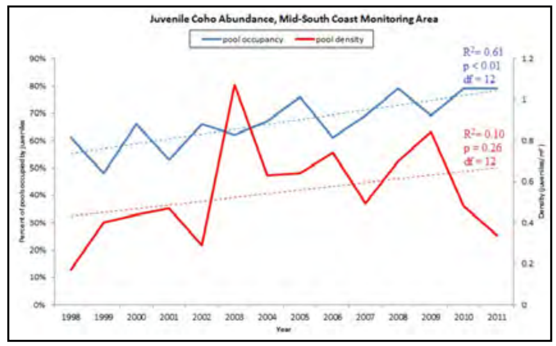



Figure 12. Juvenile Coho abundance in first through third order ("wadeable") streams in the mid-south coast monitoring area. Data: Rodgers 2000, 2001, 2002; Jepsen and Rodgers 2004; Jepsen 2006; Jepsen and Leader 2007a, 2007b, 2008; Suring and Constable 2009, 2010; Constable and Suring 2010, 2012, 2013

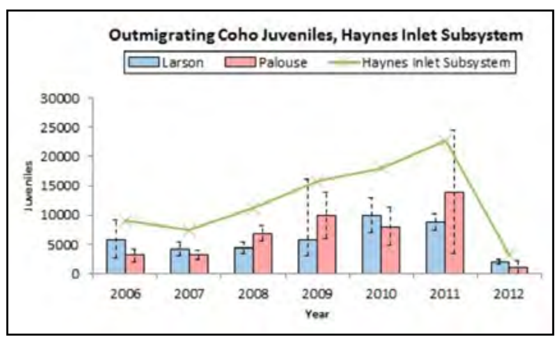



Figure 13. Juvenile Coho abundance in Larson and Palouse Creeks. Large confidence intervals are a reflection of low trap efficiency. Mean abundance in the Haynes Inlet Subsystem (green line) is represented by the sum of the annual means for Larson and Palouse Creeks Data: CoosWA 2013a

Status and Trends: Chinook Salmon

The Oregon Native Fish Status Report (ONSFR) provided historic data for Chinook salmon stocks in the Coos River basin (ODFW 2005a). To evaluate the status of Chinook salmon populations, the ONFSR uses six criteria established by the Native Fish Conservation Policy in 2003. These guidelines are referred to as "interim criteria" because they provide temporary guidance prior to the completion of conservation plans (ODFW 2005a; ODFW 2003a)(Table 3).

**Six Native Fish Conservation Policy Evaluation Criteria for the ONFSR**

**Existence:** "No more than 20% of the historical populations within the species management unit (SMU) have become extinct and no natural population within the SMU ...shall be lost in the future..."

**Distribution:** "Naturally produced members of a population must occupy at least 50% of a population's historic habitat."

**Abundance:** "The number of naturally produced spawners must be greater than 25% of the average abundance of naturally produced spawners over the most recent 30 year time period."

**Productivity:** "In years when total spawner abundance is less than the average abundance of naturally produced spawners over the past 30 years, then the rate of population increase shall be at least 1.2 adult offspring per parent..."

**Reproductive Independence:** "At least 90% of the spawners within a population must be naturally produced and not hatchery produced fish..."

**Hybridization:** "The occurrence of individuals that are the product of deleterious hybridization with species that are non-native to the basin in which they are found must be rare or nonexistent."

Table 3. Excerpts of ONFSR evaluation criteria.
Source: ODFW 2003a

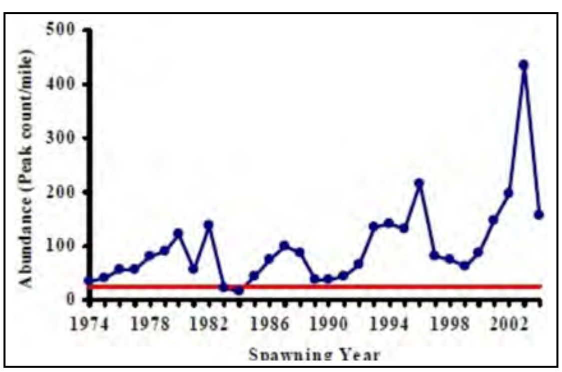



Figure 14. Historic abundance of adult fall Chinook salmon in the Coos River in number of observed fish (both live and dead) per mile at peak count. Benchmark necessary to pass ONFSR abundance criteria is highlighted in red. Graph: ODFW 2005a

The Coos River fall Chinook population met five of the six ONFSR criteria, meaning that the near-term sustainability (5 -10 years) of native Coos River fall Chinook at levels that provide "ecological, economic, recreational, and aesthetic benefits to present and future generations" may potentially be at risk (ODFW 2005a). It should be noted that Chinook salmon hatchery production between 1995 and 2005 greatly affected ODFW's ability to determine the status of wild Coos River Chinook salmon populations.

The data (ODFW 2005a) suggest that while the fall Chinook abundance in the Coos River varied considerably, it generally increased between 1974 and 2004, reaching a peak in 2003 (Figure 14).

The abundance of Fall Chinook in the Coos River has remained relatively large compared to most Oregon coast sites. ODFW's estimated 30-year average density for Coos River fall Chinook (101 fish per mile) is only exceeded by Chinook abundance in five of the remaining fifteen sampled estuaries on the Oregon coast (Table 4).

More recent Chinook abundance data were provided by ODFW spawning survey summaries (ODFW 2002, 2003b, 2004, 2005b, 2006,

| Species Mgmt. Unit | 30 Year Average | Abundance by Return Year (peak count per mile) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
| **Coos** | **101** | **--** | **87** | **148** | **195** | **434** | **155** |
| Necanicum | 7 | 2 | 4 | 10 | 11 | 21 | -- |
| Nehalem | 67 | -- | 53 | 89 | 156 | 86 | 78 |
| Tillamook | 63 | -- | 17 | 65 | 74 | 61 | 66 |
| Nestucca | 181 | -- | 80 | 132 | 310 | 68 | 190 |
| Salmon | 1748 | 1208 | 1245 | 1273 | 1196 | 3302 | -- |
| Siletz | 52 | -- | 54 | 103 | 145 | 101 | 34 |
| Yaquina | 34 | -- | 1 | 26 | 28 | 31 | 26 |
| Alsea | 69 | -- | 80 | 203 | 188 | 193 | 160 |
| Yachats | 90 | 135 | 128 | 109 | 149 | 197 | -- |
| Siuslaw | 186 | -- | 138 | 349 | 423 | 604 | 476 |
| North Umpqua | 166 | -- | 202 | 247 | 154 | 581 | 267 |
| Upper Umpqua | 4344 | 1979 | 2591 | 5402 | 7621 | 10158 | -- |
| Lower Umpqua | *Insufficient Data* | 20 | 57.1 | 60.5 | 156 | 241 | -- |
| Coquille | 78 | -- | 73 | 93 | 137 | 187 | 142 |
| Floras | 71 | -- | 42 | 128 | 173 | 170 | 62 |
| Sixes | 60 | -- | 2 | 67 | 57 | 51 | 153 |

Table 4. Fall Chinook abundance data for 16 Oregon coast species management units. Table: ODFW 2005a

| Survey Area | 2013 Abundance | Eleven Yr. Avg. (2002-2013) | Min | Max | Std. error |
|---|---|---|---|---|---|
| S. Fk. Coos | 143 | 233 | 50 | 532 | 37 |
| E Fk. Millicoma | 224 | 219 | 36 | 650 | 55 |
| W. Fk. Millicoma | 312 | 110 | 14 | 418 | 34 |
| Williams | 53 | 78 | 23 | 167 | 13 |

Table 5. Fall Chinook abundance data (fish per mile) for four Coos River species management units. Table: ODFW 2002, 2003b, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2011, 2012b, & 2013g

2007, 2008, 2009, 2010, 2011, 2012b, & 2013g). These data indicate that fall Chinook abundance in the Coos watershed decreased in the mid-2000s but recovered with peak abundances in 2010 for the Coos River and in 2011 for the Millicoma River (Figure 15). Although abundance declined after the highs of 2010/2011, adult Chinook peak counts are again increasing , with both the Coos and Millicoma Rivers exceeding the 30-year average in 2013 (Table 5). Currently, ODFW considers Coos fall Chinook a viable population with a low probability of extinction (ODFW 2014a).

<u>Status and Trends: Adult Winter Steelhead</u>

In 2003, OASIS initiated monitoring efforts to assess trends in the abundance of winter steelhead populations in coastal areas (Jacobsen et al. 2013). The Tenmile, Coos, Coquille, Floras, and Sixes River basins represent the mid-south coast monitoring area (Figure 16).

The OASIS project estimates Steelhead abundance by surveying “redds” (gravel “nests” in

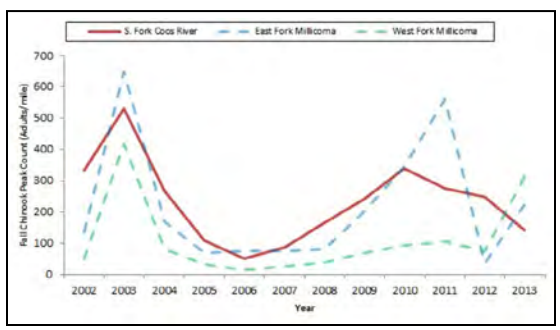



Figure 15. Abundance for fall Chinook in three local rivers. Millicoma peak count data (dashed) are subject to more variability than South Fork Coos data (solid), because Millicoma survey results are more dependent on river flow conditions (G. Vonderohe, pers. comm., April 21, 2014). Data: ODFW 2002, 2003b, 2004, 2005b, 2006, 2007, 2008, 2009, 2010, 2011, 2012b, and 2013g

stream bottoms where fish lay their eggs- see Background). Redd abundance in the Oregon Coast Distinct Population Segment (DPS) declined from 2003 to 2009, with a period of marginal increase in 2007. It again increased from 2009 to 2013, except for a decline in 2011, and reached a ten-year high in 2013 (Figure 17). ODFW notes that ideal survey conditions, including low flow and high water clarity in 2013 may have caused the unusually high rate of redd observation (Jacobsen et al. 2013).

For the mid-south coast monitoring area (MSCMA), which includes mainly the Coos


Figure 16. OASIS map of monitoring areas for winter steelhead. Monitoring areas are divided between two Oregon Coast Distinct Population Segments (DPS). The Oregon Coast DPS is shaded above in yellow, and the Klamath Mountain Province DPS is in pink. Graphic: Jacobsen et al. 2013

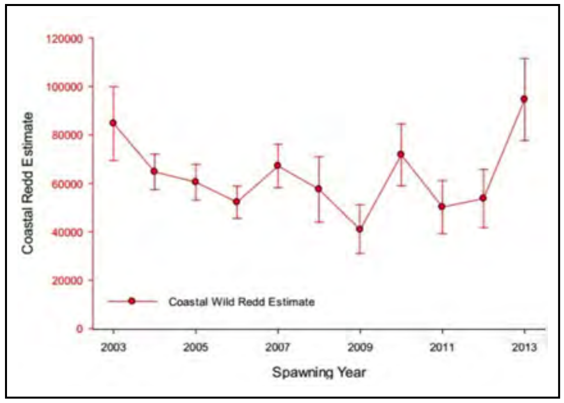



Figure 17. Redd abundance in the Oregon Coast DPS Data: Jacobsen et al. 2013

and Coquille watersheds, the number of redds observed in 2013 were 25% fewer compared with peak levels in 2007 (Table 6). Redd abundance declined from 2007-2012, but has recovered in2013 (Figure 18).

Hatchery steelhead accounted for approximately 21% of all spawning steelhead in the MSCMA. The proportion of hatchery origin spawners (pHOS) in 2013 was larger in the MSCMA than any other monitoring area on the Oregon coast (Jacobsen et al. 2013). However, data for the Coos and Millicoma Rivers indicate that local pHOS may be substantially lower than 21% (ODFW 2014b). In addition, pHOS in the MSCMA generally increased slightly over the past seven years but leveled off recently (Figure 19), although ODFW (2014b) data indicate that Coos and Millicoma River populations may not exhibit the same trend. Due to a high pHOS, the winter steelhead population in the Coos River basin failed to meet ODFW's reproductive independence criterion (Table 3)(ODFW 2005a).

| Monitoring Area | 2013 Redd Abundance | Seven-Year Avg. (2007-2013) | Min | Max | Std. error |
|---|---|---|---|---|---|
| **Mid-south coast** | **19,476** | **17,612** | **8,403** | **26,048** | **2,547** |
| North coast | 30,144 | 19,279 | 9,961 | 30,144 | 2,792 |
| Mid coast | 31,030 | 22,575 | 13,987 | 31,030 | 2,023 |
| Umpqua | 22,807 | 15,243 | 9,282 | 22,807 | 1,899 |
| South coast | 8,961 | 6,937 | 1,808 | 14,268 | 1,719 |

Table 6. Winter steelhead abundance data in terms of redd abundance from 2007 to 2013. Data: Suring and Lewis 2008; Suring et al. 2008; Brown and Lewis 2009 and 2010; Brown et al. 2011 and 2012; Jacobsen et al. 2013

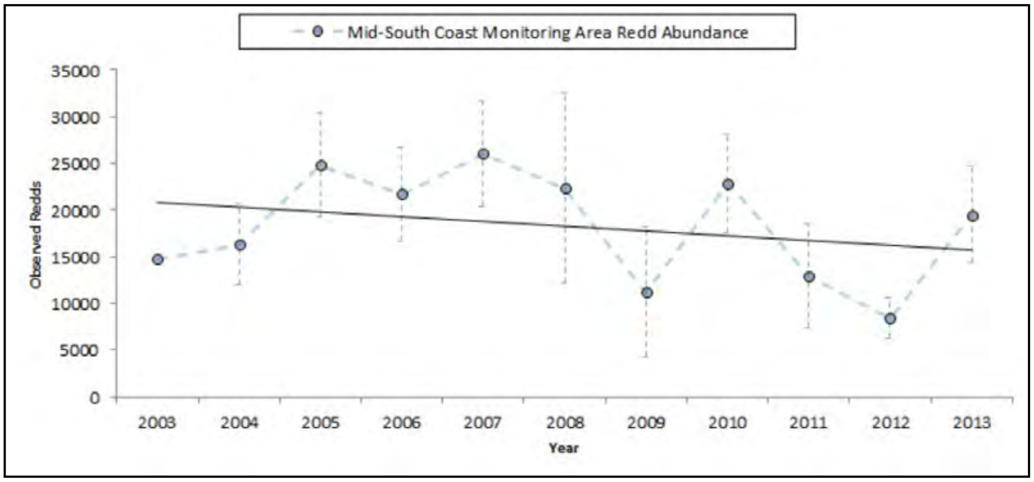



Figure 18. Trends in winter steelhead abundance in terms of number of redd observations over time (blue). Linear regression model (black) suggests a marginal decrease over time ($R^2$=0.08). However, this decrease is not statistically different from zero (p = 0.39). Data: Jacobsen et al. 2013

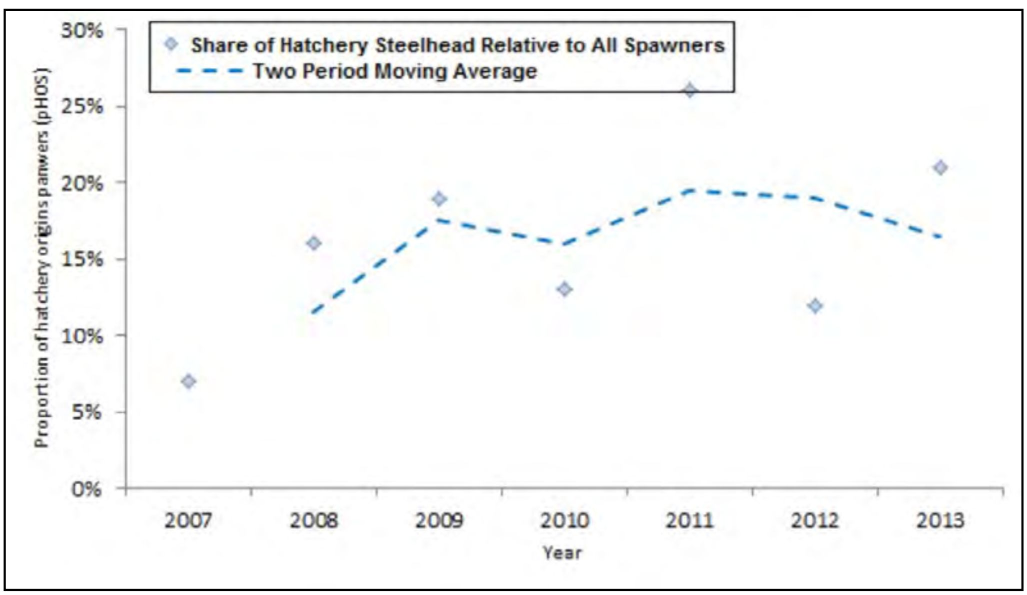



Figure 19. Proportion of hatchery origin spawners (pHOS) for the 2007 to the 2013 spawning seasons in the MSCMA. Data: Suring and Lewis 2008; Suring et al. 2008; Brown and Lewis 2009 and 2010; Brown et al. 2011 and 2012; Jacobsen et al. 2013

Overall, however, steelhead trout are classified as a viable population with a low probability of extinction in the MSCMA (ODFW 2014a).

<u>Status and Trends: Juvenile Winter Steelhead</u>

As part of the Western Oregon Rearing Project (WORP), ODFW has monitored juvenile steelhead distribution and abundance since 2002 (Jepsen and Rodgers 2004; Jepsen 2006; Jepsen and Leader 2007a, 2007b, 2008; Suring and Constable 2009, 2010; Constable and Suring 2010, 2012, 2013). The project studies juvenile distribution by recording pool occupancy rates (percent of pools with juveniles present) and abundance (fish per m2) as measured by average density of juveniles in pools. See "Status and Trends: Juvenile Coho Salmon" for an explanation of WORP structure and the importance of juvenile abundance.

Juvenile steelhead pool occupancy was variable between 2002 and 2007 (Figure 20). However, occupancy increased steadily from 2007-2011, reaching a 9-year high (44%) in 2011 (the most recent data available). The density data do not indicate a clear trend. In the early 2000s, density first decreased, then reached its 9-year high in 2005 (0.05 fish/m2) and then rose and fell after 2005. In 2011, density was 0.026 fish/m2 (a 13% decrease from 2002 and 48% lower than the 2005 peak).

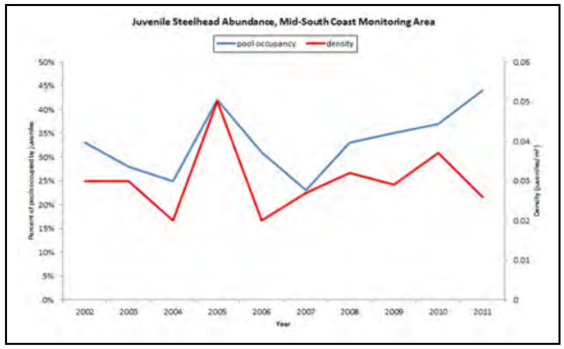



Figure 20. Juvenile steelhead abundance in first through third order ("wadeable") streams in the mid-south coast monitoring area. Data: Jepsen and Rodgers 2004; Jepsen 2006; Jepsen and Leader 2007a, 2007b, 2008; Suring and Constable 2009, 2010; Constable and Suring 2010, 2012

<u>Status and Trends: Other Salmonid Species</u>

**Coastal cutthroat trout** (*Oncorhynchus clarki clarki*) occupy almost all available stream habitats along the Oregon coast (at least seasonally), with the exception of streams with barriers to fish passage near the ocean (ODFW 2005a). Between 1998 and 2003, ODFW surveys found coastal cutthroat trout in the headwaters of most perennial streams and many seasonal streams. Their densities in Oregon coast waters are high and stable, therefore all stocking of cutthroat trout ended in 1996 with many programs being discontinued prior to that. Coastal cutthroat trout are able to respond quickly to changes in habitat quality and quantity; they can also persist in isolated populations or when interacting with other salmonid and non-salmonid species. Furthermore, this species is at low risk for failing the reproductive independence criterion established by the Native Fish Conservation Policy because hatchery releases were discontinued (ODFW 2005a).

Data describing local cutthroat trends are available for the Haynes Inlet subsystem. CoosWA has reported cutthroat captures as part of their juvenile fish trap (rotary screw trap) monitoring program on Larson and Palouse Creeks since 2005 (CoosWA 2013b).

Cutthroat trout captures in the Haynes Inlet subsystem generally rose from 2005-2011, with the greatest increase occurring in Larson Creek between 2009 and 2011 (Figure 21). However, captures in 2012 were well below 2011 levels due to a sharp decline in Larson Creek captures and the continued decline in Palouse captures from 2009 to 2012.

**Chum salmon** (*Oncorhynchus keta*) are at the very southern end of their range along the Oregon coast. Historic abundance and distribution information is limited. However, ODFW identified the Coos River basin as one of thirteen statewide historic chum salmon populations based on records for commercial landings. Although ODFW-sponsored surveys periodically report chum sightings in the Coos watershed, their frequency and number suggest that the population is effectively extinct in local waters (ODFW 2005a).

Commercial landing records were also used to help identify historic populations of **spring Chinook salmon.** However, since commercial landings were concurrent with hatchery releases, quantifying historic spring Chinook populations is difficult. The Coos River population of spring Chinook is classified by ODFW as extinct (ODFW 2005a).

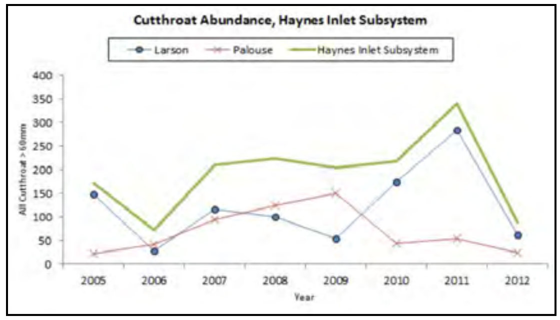



Figure 21. Cutthroat abundance in the Haynes Inlet Subsystem. These data have not been adjusted for trap efficiency. Data: CoosWA 2013b

**Why is it happening?**

Many environmental and human-related factors influence migration timing and the distribution and abundance of salmonid species in the Coos watershed. Among those factors are: 1) the condition and availability of spawning and rearing habitat, 2) commercial and recreational fish harvests, and 3) the effect of hatchery fish in wild fish populations. Salmon with limited spawning habitat availability (e.g., South Slough Coho) may be particularly vulnerable to these factors (P. Burns, pers. comm., April 23, 2014).

Oceanographic and climatic conditions may partially explain variations in salmon migration behavior and population levels. For example, the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO) are large-scale climate patterns that affect both marine and terrestrial biological communities throughout the western hemisphere. The PDO is a cyclical change in ocean conditions that generally shift every few decades from cold (negative) phases to warm (positive) phases. During a cold phase, the western part of the Pacific warms while the eastern part cools, with the opposite happening in a warm phase (Figure 22). In Oregon, a PDO cold phase is characterized by anomalously cool and oxygen-saturated waters; a warm phase is associated with usually warm and less oxygenated waters (O'Higgins and Rumrill 2007). The PDO phase was negative (cold) throughout 2013 and is expected to transition to near-neutral conditions in early 2014 (NOAA Northwest Fisheries Science Center 2014).

Mysak (1986) describes ENSO as a climatic event that tends to occur every two to seven years and is characterized by an unusual warming of tropical Pacific waters. In Oregon, the ENSO generally produces warmer, drier climatic conditions, and is frequently associated with lower precipitation and streamflow. However, ENSO events are sometimes unpredictable and can result in a higher frequency of winter storms and flooding. The presence or absence of ENSO conditions has been tracked using the Oceanic Niño Index, or ONI, since 1955 (Figure 23).

The PDO and ENSO are not completely independent, because ENSO events generally occur more frequently during the warm phase of the PDO (Hare et al. 1999).

These climatic oscillations are likely to have direct and important effects on salmon populations in both marine and freshwater environments (Naiman et al. 2002). Mantua et al. (1997) explains that PDO conditions first affect primary producers and consumers which in turn affect the higher level consumers such as salmon. Hare et al. (1999) suggest that these events are likely to affect salmon abundance through marine survival rates. Their research indicates that a 20-year warm PDO from the late 1970s to the late 1990s in the Pacific Northwest was marked by low primary productivity due to increased stratification in the California Current and poor foraging conditions for Pacific salmon.

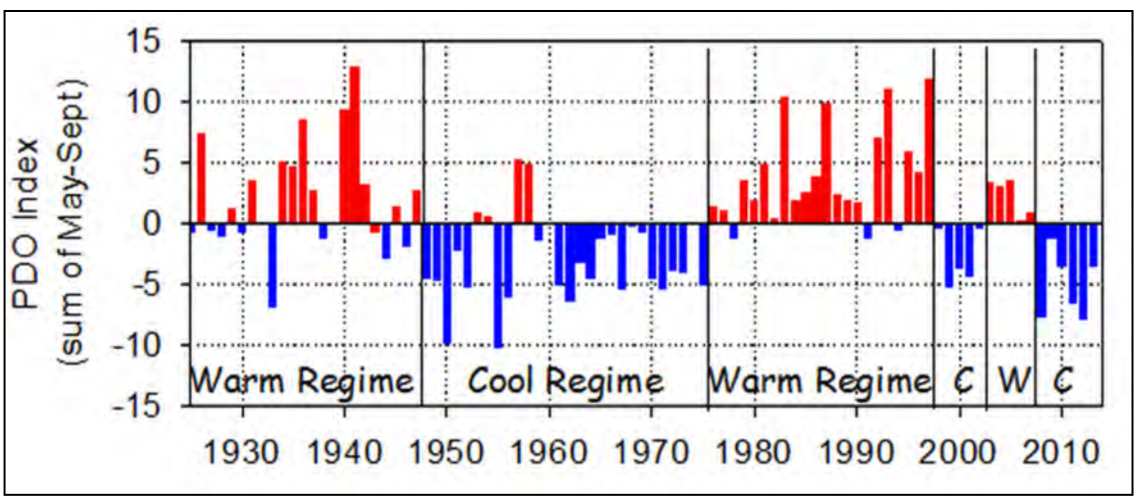



Figure 22. Time series of shifts in signs of the Pacific Decadal Oscillation (PDO), 1925 to present. Values are averaged over the months of May through September. Red bars indicate positive (warm) years; blue bars negative (cool) years. Graphic and caption: NOAA Northwest Fisheries Science Center 2014

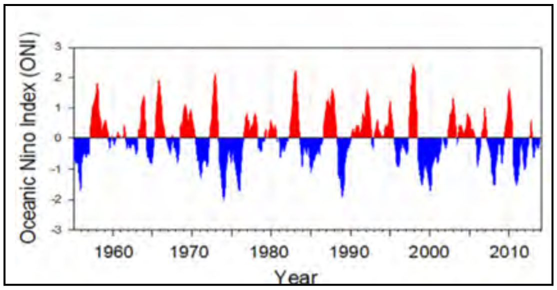



Figure 23. Values of the ONI, 1955 - present. Red bars indicate warm conditions in the equatorial Pacific, blue bars indicate cool conditions in equatorial waters. Large and prolonged El Niño events are indicated by large, positive values of the index. Graphic and caption: NOAA Northwest Fisheries Science Center 2014

Climatic events may also influence salmon abundance through abiotic factors. For example, changes in precipitation regimes may limit access to spawning grounds and stream temperatures may reach uninhabitable levels in locations near the southern end of salmon distribution ranges (Naiman et al. 2002). It's important to note that discrete climatic effects on salmon populations may be masked or overwhelmed by human-related influences such as hatchery production (Mantua et al. 1997).

**Background**

Salmonids are fish belonging to the family Salmonidae which includes Coho, Chinook, and chum salmon, steelhead and cutthroat trout and others. In many cases, these fish are anadromous, meaning they migrate from the sea to inland rivers and streams to spawn. The life cycle of anadromous fish begins with egg deposition and fertilization in the gravel of freshwater streams (Figure 24). Juvenile salmon emerge two to four months after fertilization and spend the next year or more in stream and upper estuarine habitats. Upon sufficient development they undergo smoltification, a physiological process that allows the young fish to migrate to the ocean and live in salt water.

Salmonids grow rapidly while in the ocean because food supplies are abundant. After living in the ocean for as long as five years, adult salmonids return to their home streams to spawn, relying on the fat reserves they've accumulated at sea to complete the migration. When a mature female is ready to spawn, she digs a nest (called a redd) in stream-bottom gravel, and deposits her eggs for fertilization by the male. Many salmonid species are "semelparous", which means they die after spawning. However, some species like steelhead and anadromous cutthroat trout have the ability to spawn repeatedly (Bowers et al. 1999, Cederholm et al. 1999).

Salmonid species provide crucial ecosystem services in the Coos watershed. Because most species of Pacific salmon (Oncorhynchus spp.) are semelparous, a sizeable spawning run will produce numerous salmon carcasses, which are an important food source for terrestrial animals and a critical means of transporting marine-derived nutrients back to land (Cederholm et al. 1999). Nutrients provided by salmon carcasses sustain the productivity of riparian ecosystems, a process that is sometimes referred to as stream "fertilization". Salmon have been identified as keystone species due to their ecological importance (Wilson and Halupka 1995).

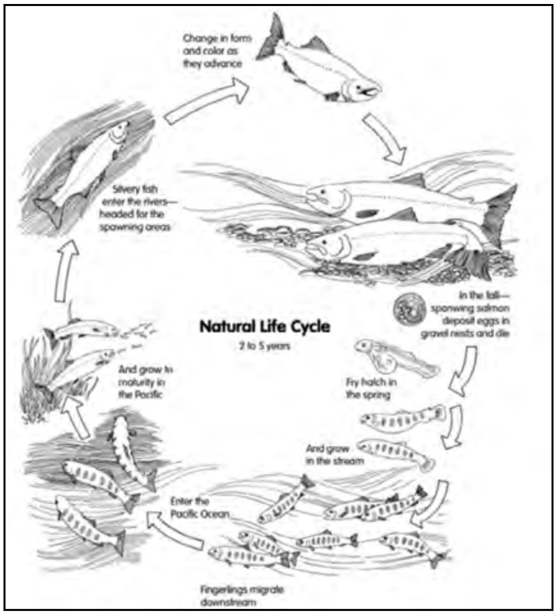



Figure 24. The life cycle of anadromous salmonids.
Graphic: Bowers et al. 1999

**Fish Hatcheries**

In an effort to supplement wild stocks of fish in Oregon waters, ODFW manages several fish hatchery and rearing programs along the coast. The Coos basin has ODFW hatchery programs on the Isthmus Slough and the Coos and Millicoma Rivers, with additional acclimation sites for both fall Chinook (two sites) and Winter Steelhead (four sites). Hatchery programs are coordinated by the Salmon and Trout Enhancement Program (STEP)(Figure 25). The goals of these local programs include: a) producing fish that are ecologically and genetically similar to wild populations, and b) educating students and the public through STEP (ODFW 2013a). In addition to live fish production, hatchery programs are a substantial source of salmon carcasses for stream fertilization (see Background).

The long-term effectiveness of hatchery programs is controversial due to genetic and ecological concerns. Research suggests that declines in wild populations, coupled with increases in hatchery production, may accelerate genetic changes in Pacific salmon species (*Oncorhynchus spp*.). These changes could compromise the long-term fitness of some species by reducing genetic variability and essentially eliminating locally adaptive gene complexes (Waples and Teel 1990; Christie et al. 2012). Furthermore, when hatchery and wild fish interbreed over several generations, the genetic effect of captive breeding practices may have a cumulative, negative influence on the reproductive fitness of wild stocks. As a result, it can take many years for wild stocks to recover after hatchery practices are terminated (Araki et al. 2009).

The production and release of fish bred in captivity may also be associated with ecological impairment. For example, competition is often cited as a harmful ecological interaction

Figure 25. A STEP volunteer helps to monitor fall Chinook populations at the Dellwood static trap, an ODFW installation on the South Coos River.

between hatchery and wild fish (Weber and Fausch 2003).

The long-term competitive abilities of fish may be affected by their genetic traits as well as behavioral, morphological, and physiological characteristics developed under different environmental conditions. Captive breeding is often associated with high densities, low current velocities, low selective pressures, and confined feeding. (Weber and Fausch 2003).

Some of these differences may result in higher competitive abilities for hatchery fish while some will result in lower competitive abilities. For example, several studies have found that hatchery fish are usually larger and grow faster than their wild counterparts (Fleming et al. 2002; Rhodes and Quinn 1999; Fleming and Einum 1997) which would presumably help them compete in the wild. Research also suggests that captive bred fish are generally less fit to avoid predation than wild fish (Johnsson et al. 1996; Berejikian 1995; Johnsson and Abrahams 1991). It's difficult to determine the full ecological consequence of these differences, because many of them have yet to be quantified (Weber and Fausch 2003).

Although the local risk of competition between hatchery and wild fish is thought to be minimized by the relatively large size of Coos Bay and surrounding estuaries, some concern still exists (ODFW 2014a). ODFW has outlined a set of best management practices for Coos watershed hatchery operations in a series of Hatchery and Genetic Management Plans (ODFW 2013c).

**Predation**

Pacific salmon species are vulnerable to predation by seals and sea lions (pinnipeds) and by sea birds.

Particularly in areas with struggling salmon populations, seal and sea lion population growth has caused heightened concern about the pinnipeds' salmonid consumption (Orr et al. 2004).

Pacific harbor seal (*Phoca vitulina richardsi*) populations have grown in response to increased protection under the Marine Mammal Protection Act of 1972 (Wright et al. 2007; Brown et al. 2005; Orr et al. 2004). According to Orr et al. (2004), Oregon harbor seal populations increased by an average of 6-7% annually from 1978-1988, but their numbers have since leveled off to about 8,000 individuals. This estimate is corroborated by Brown et al. (2005), who suggest that Oregon harbor seal populations have experienced rapid growth over the past few decades and are currently at or near carrying capacity (Figure 26).

Research suggests that salmonids compose anywhere from 1-30% of the harbor seal diet, depending on the area, season, and sampling methods (Orr et al. 2004; National Marine Fisheries Service 1997). Wright et al. (2007) studied seal predation in the Alsea River estuary by observing feeding rates, analyzing scat content, and tracking seal movement to infer foraging behavior. They estimate that pinnipeds consumed 1,161 adult salmonids over the course of three months in fall 2002.

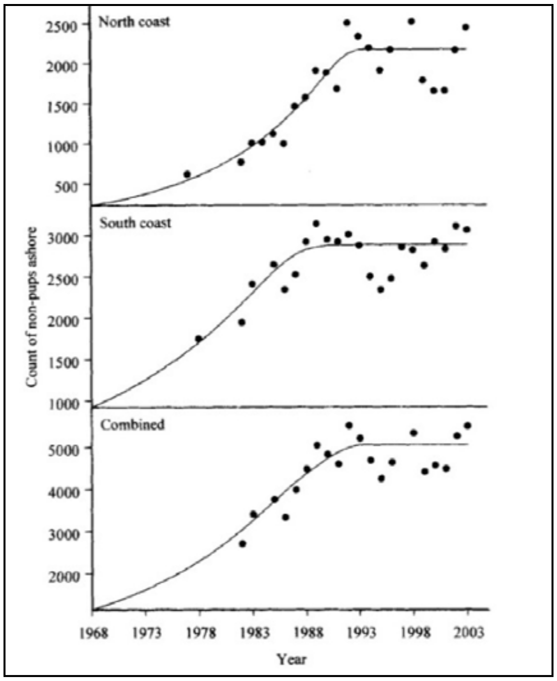



Figure 26. Average (black dots) and predicted (line) counts of non-pup harbor seals ashore in two survey regions in Oregon. The combined total represents the sum of the regional average and predicted values. Graphic and Caption: Brown et al. 2005

| Common Name | Taxon | Percentage of samples |
|---|---|---|
| **Salmonid spp. (adult)** | ***Oncorhynchus* spp.** | **9.4%** |
| **Salmonid spp. (juvenile)** | ***Oncorhynchus* spp.** | **0.8%** |
| Pacific herring | *Culpea pallasii* | 41.9% |
| English sole | *Parophrys vetulus* | 36.8% |
| Rex sole | *Glyptocephalus zachirus* | 19.7% |
| Dover sole | *Microstomus pacificus* | 15.4% |
| Pacific sand lance | *Ammodytes hexapterus* | 14.5% |
| Pacific tomcod | *Microgadus proximus* | 12.8% |
| Flatfish | Pleuronectidae | 11.1% |
| Sanddab spp. | *Citharichthys* spp. | 11.1% |
| Smelt spp. | Osmeridae | 11.1% |
| Butter sole | *Isopsetta isolepis* | 10.3% |
| Sculpin spp. | Cottidae | 9.4% |
| Pacific hake | *Merluccius productus* | 8.5% |
| Flatfish order | Pleuronectiformes | 7.7% |
| Northern anchovy | *Engraulis mordax* | 6.8% |
| Herring/shad | Clupeidae | 5.1% |
| Rockfish spp. | Sebastidae | 4.3% |
| Shiner perch | *Cymatogaster aggregate* | 4.3% |
| Unidentified fish | ----- | 4.1% |
| Octopus spp. | Octopodidae | 3.4 |
| Pacific staghorn sculpin | *Leptocottus armatus* | 3.4% |
| Surfperch spp. | Embiotocidae | 3.4% |
| Slender sole | *Lyopestta exillis* | 2.6% |
| Lingcod of greenling | Psettichthys melanostictus | 1.7% |
| Skate spp. | Hexagrammidae | 1.7% |
| Lamprey spp. | Rajidae | 1.7% |
| Codfishes | *Lampetra* spp. | 1.7% |
| Lingcod | Gadidae | 0.8% |
| Pacific sandfish | *Ophiodon elongatus* | 0.8% |
| Irish lord spp. | *Trichodon trichodon* | 0.8% |
| Pacific sardine | *Hemilepido tus* spp. | 0.8% |
| Cephalopod | Cephalopoda | 0.8% |
| Eelpout spp. | Zoarcidae | 0.8% |
| Poacher spp. | Agonidae | 0.8% |
| Gunnel spp. | Pholidae | 0.8% |

Table 7. Scat content analysis of the harbor seal. Source: Wright et al. 2007

Scat content analyses indicate that salmonids comprise a relatively small share of the pinniped diet (Table 7). Coho was the most commonly salmonid consumed, and harbor seal predation accounted for approximately 21% of the total Alsea Coho run in 2002. Tracking suggest that only a small proportion of seals (12.5%) exhibit foraging behavior that is consistent with specialization in salmonid predation.

In addition to pinniped predation, juvenile salmonids are also vulnerable to predation by sea birds. Public concern is often voiced about juvenile salmonid predation by the double-crested cormorant (*Phalacrocorax auritus*, DCCO), a species that is known to prey on more than 250 species of freshwater and marine fishes (Adkins and Roby, 2010).

In April and May 2012, ODFW conducted a diet study to assess DCCO predation on juvenile salmonids in Tillamook Bay (Adrean 2013). ODFW estimates that DCCOs consumed approximately 8,000 juvenile Coho (about 4% of all outmigrating Coho smolts) over two months (Adrean 2013).Their data indicate that the salmonid component of their diet was significantly higher in April than in May (Figure 27). Steelhead (47%) and Coho (21%) comprised the largest proportion of

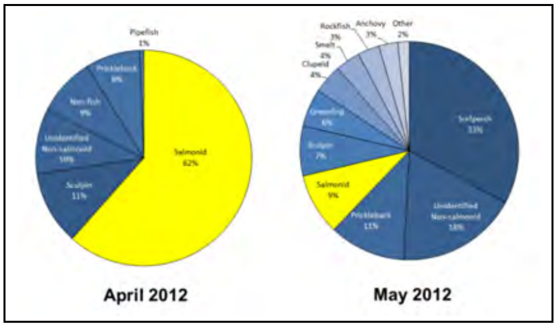



Figure 27. The composition of the double-crested cormorant diet during a two-month study period at Tillamook Bay in spring 2012. Data: Adrean 2013

| Salmonid Species | Proportion of All Salmonids Consumed |
|---|---|
| Steelhead | 47% |
| Coho | 21% |
| Cutthroat | 16% |
| Chum | 11% |
| Unidentified | 5% |

Table 8. Salmonid component of the double-crested cormorant diet in Tillamook Data: Adrean 2013

salmonids consumed (Table 8).

In 2013, the ODFW expanded the DCCO predation study to include two additional estuaries. Their preliminary results indicate that salmonids comprise about 6, 11, and 7% of the DCCO diet in the Tillamook, Umpqua, and Rogue systems, respectively. Almost all salmonids detected in the 2013 DCCO predation study were juvenile Coho salmon (J. Lawonn, pers. comm., April 21, 2014).

This analysis corroborates the research that was done by Oregon State University and the United States Geological survey on the Columbia River (Bird Research Northwest 2009). Their findings suggest that juvenile salmonids comprise approximately 10% of the DCCO diet on average, with data ranging from 2-25% of diet composition. They also support previous studies indicating that sand lance (*Ammodytes hexapterus*), clupeids (herrings and sardines), cottids (sculpins), embiotocids (surf perches), engraulids (anchovies), pholids (gunnels), and stichaeids (pricklebacks) are important prey items for DCCO populations in western North America (Adkins and Roby 2010).

In 2012, there were an estimated 1,260 breeding DCCO pairs on the Oregon coast (Adrean 2013). Statewide, DCCO populations have decreased from 2009 levels, which had about 2,384 breeding pairs (Adkins and Roby 2010). The DCCO breeding populations in the Coos estuary (at Coos Head and Cape Arago) may have decreased throughout the mid-2000s, but have since recovered (USFWS 2014). The U.S. Fish and Wildife Service estimates that there were 326 DCCO breeding pairs in the Coos Bay area in 2013 (down 15% from 2003).

**References**

Adkins, Jessica Y. and Daniel D. Roby. 2010. The Status Assessment of the Double-Crested Cormorant (*Phalacrocorax auritus*) in Western North America: 1998-2009. [Final report prepared for the U.S. Army Corps of Engineers]. Accessed 2 February 2014. Available online http://farallones.noaa.gov/eco/seabird/pdf/articles/monitoringandstatus/adkinsroby2010.pdf

Adrean, Lindsay. 2013. Avian Predation Program 2012 Final Report. Oregon Fish and Wildlife. Accessed 2 February, 2014. Available online http://www.dfw.state.or.us/conservationstrategy/avian_predation_mgmt.asp

Araki, Hitoshi, Becky Cooper, and Michael S. Blouin. 2009. Carry-over Effect of Captive Breeding Reduces Reproductive Fitness of Wild-Born Descendants in the Wild. Biology Letters, 5, 621-624.

Berejikian, B. A. 1995. The effects of hatchery and wild ancestry and experience on the relative ability of steelhead trout fry (*Oncorhynchus mykiss*) to avoid a benthic predator. Canadian Journal of Fisheries and Aquatic Sciences, 52(11), 2476-2482.

Bird Research Northwest (BRNW). 2009. Caspian Tern Research on the Lower Columbia River: 2008 Final Season Summary. Real Time Research, Bend, OR and Oregon State University, Corvallis, OR. Accessed 7 May 2014. Available http://www.birdresearchnw.org/project-info/project-background/caspian-terns/columbia-river-estuary/

Bowers, Patty, D. Wolf, B. Hastie, & Shann Weston. 1999. The Stream Scene: Watersheds, Wildlife, and People (2nd ed.). Portland, OR: Aquatic Education Program Publication distributed by Oregon Department of Fish & Wildlife.

Brown, E. and M. Lewis. 2009. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2009. Monitoring Program Report Number OPSW-ODFW-2009-09. Oregon Department of Fish and Wildlife, Salem, Oregon.

Brown, E. and M. Lewis. 2010. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2010. Monitoring Program Report Number OPSW-ODFW-2010-09. Salem, Oregon.

Brown, E., J. Nott and M. Lewis. 2011. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2011. Monitoring Program Report Number OPSW-ODFW-2011-09. Oregon Department of Fish and Wildlife, Salem, Oregon.

Brown, E., M. Weeber, M. Lewis, E. Hughes, R Jacobsen, and J. Nott. 2012. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2012. Monitoring Program Report Number OPSWODFW- 2012-09. Oregon Department of Fish and Wildlife, Salem, Oregon.

Brown, R. F., Wright, B. E., Riemer, S. D., & Laake, J. 2005. Trends in abundance and current status of harbor seals in Oregon: 1977–2003. Marine Mammal Science, 21(4), 657-670.

Cederholm, Jeff C., M.D. Kunze, T. Murota, & A. Sibatani. 1999. Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems. Fisheries, 24(10), 6-15.

Christie, M.R., M.L. Marine, R.A. French, R.S. Waples, and M.S. Blouin. 2012. Effective Size of a Wild Population in Greatly Reduced by Hatchery Supplementation. Heredity, 109, 254-260.

Constable, R. J. Jr. and E. Suring. 2010. Abundance Monitoring of Juvenile Salmonids in Coastal Oregon and Lower Columbia Streams, 2010. Monitoring Program Report Number OPSW-ODFW-2010-1, Oregon Department of Fish and Wildlife, Salem.

Constable, R. J. Jr. and E. Suring. 2012. Abundance Monitoring of Juvenile Salmonids in Coastal Oregon and Lower Columbia Streams, 2011. Monitoring Program Report Number OPSW-ODFW-2011-1, Oregon Department of Fish and Wildlife, Salem.

Constable, R. J. Jr. and E. Suring. 2013. Abundance Monitoring of Juvenile Salmonids in Coastal Oregon and Lower Columbia Streams, 2012. Monitoring Program Report Number OPSW-ODFW-2011-1, Oregon Department of Fish and Wildlife, Salem.

Coos Watershed Association (CoosWA). 2013a. Coho Life History in Tide Gated Lowland Streams Project Completion Report. OWEB Grant 210-2071. Accessed 12 February, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Coos Watershed Association (CoosWA). 2013b. [Scraw Trap Survey Form]. Unpublished raw data.

Fleming, I.A. and S. Einum. 1997. Experimental Tests of Genetic Divergence of Farmed from Wild Atlantic Salmon due to Domestication. ICESS Journal of Marine Sciences, 58, 1051-1063.

Fleming, Ian A., T. Agustsson, B. Finstad, JI Johnsson, and Bjön Thrandur Björnsson. 2002. Effects of Domestication on Growth Physiology and Endocrinology of Atlantic Salmon (Salmo salar). Canadian Journal of Fisheries and Aquatic Sciences, 58(9), 1323-1330.

Hare, S. R., Mantua, N. J., & Francis, R. C. 1999. Inverse production regimes: Alaska and west coast Pacific salmon. Fisheries, 24(1), 6-14.

Jacobsen R., J. Nott, E. Brown, M. Weeber, M. Lewis, and E. Hughes. 2013. Assessment of Western Oregon Adult Winter Steelhead – Redd Surveys 2013. Monitoring Program Report Number OPSW-ODFW-2013-09. Oregon Department of Fish and Wildlife, Salem, Oregon.

Jepsen, D.B. and Rodgers, J.D. 2004. Abundance Monitoring of Juvenile Salmonids in Oregon Coastal Streams, 2002-2003. Monitoring Program Report Number OPSW-ODFW-2003-1, Oregon Department of Fish and Wildlife, Portland.

Jepsen, D. B. 2006. Abundance Monitoring of Juvenile Salmonids in Oregon Coastal Streams, 2004. Monitoring Program Report Number OPSW-ODFW-2006-1, Oregon Department of Fish and Wildlife, Salem.

Jepsen, D. B., and K. Leader. 2007a. Abundance Monitoring of Juvenile Salmonids in Oregon Coastal Streams, 2005. Monitoring Program Report Number OPSW-ODFW-2007-1, Oregon Department of Fish and Wildlife, Salem.

Jepsen, D. B., and K. Leader. 2007b. Abundance Monitoring of Juvenile Salmonids in Oregon Coastal Streams, 2006. Monitoring Program Report Number OPSW-ODFW-2007-1, Oregon Department of Fish and Wildlife, Salem.

Jepsen, D. B., and K. Leader. 2008. Abundance Monitoring of Juvenile Salmonids in Oregon Coastal and Lower Columbia Streams, 2007. Monitoring Program Report Number OPSW-ODFW-2008-1, Oregon Department of Fish and Wildlife, Salem.

Johnsson, J. I., & Abrahams, M. V. 1991. Interbreeding with domestic strain increases foraging under threat of predation in juvenile steelhead trout (*Oncorhynchus mykiss*): an experimental study. Canadian Journal of Fisheries and Aquatic Sciences, 48(2), 243-247.

Johnsson, J.I., E. Petersson, E. Jönsson, B. Björnsson, and Torbjön, Järvi. 1996. Domestication and Growth Hormone Alter Antipredator Behaviour and Growth Patterns in Juvenile Brown Trout, *Salmo trutta*. Canadian Journal of Fisheries and Aquatic Sciences, 53(7), 1546-1554.

Mantua, N. J., Hare, S. R., Zhang, Y., Wallace, J. M., & Francis, R. C. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society, 78(6), 1069-1079

Mysak LA. 1986. El Niño, interannual variability, and fisheries in the Northeast Pacific Ocean. Can J Fish Aquatic Sci 43:464–97.

Naiman, R. J., Bilby, R. E., Schindler, D. E., & Helfield, J. M. 2002. Pacific salmon, nutrients, and the dynamics of freshwater and riparian ecosystems. Ecosystems, 5(4), 399-417.

National Marine Fisheries Service (NMFS). 1997. Investigation of scientific information on the impacts of California sea lions and Pacific harbor seals on salmonids and on the coastal ecosystem of Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-28. Accessed 18 February, 2014. Available online http://www.krisweb.com/biblio/gen_nmfs_nmfs_1997_tm28.pdf

NOAA Northwest Fisheries Science Center. 2014. 2013: Annual summary of ocean ecosystem indicators and pre-season outlook for 2014. Accessed online from: http://www.nwfsc.noaa.gov/research/divisions/fe/estuarine/oeip/b-latest-updates.cfm

O'Higgins, Timothy and Steven S. Rumrill. 2007. Tidal and Watershed Forcing of Nutrients and Dissolved Oxygen Stress Within Four Pacific Coast Estuaries: Analysis of Time-Series Data Collected by the National Estuarine Research Reserve System-Wide Monitoring Program (2000-2006) Within Padilla Bay (WA), South Slough (OR), Elkhorn Slough (CA), and the Tijuana River Estuary (CA). Final Report Submitted to the NOAA/Univ. of New Hampshire Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET). 28 September, 2007.

Oregon Department of Fish and Wildlife (ODFW). 2002. Summary of Standard Chinook Spawners Surveys: 2002 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2003a. Native Fish Conservation Policy. Accessed 23 January, 2014. Available online http://dfw.state.or.us/fish/CRP/nfcp.asp

Oregon Department of Fish and Wildlife (ODFW). 2003b. Standard Chinook Coastal Spawning Fish Survey Summary: 2003 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2004. Standard Chinook Coastal Spawning Fish Survey Summary: 2004 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2005a. Oregon Native Fish Status Report Volume II. Accessed 30 December, 2013. Available online http://www.dfw.state.or.us/fish/ONFSR/

Oregon Department of Fish and Wildlife (ODFW). 2005b. Standard Chinook Coastal Spawning Fish Survey Summary: 2005 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2006. Standard Chinook Coastal Spawning Fish Survey Summary: 2006 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2007. Standard Chinook Coastal Spawning Fish Survey Summary: 2007 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2008. Standard Chinook Coastal Spawning Fish Survey Summary: 2008 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2009. Standard Chinook Coastal Spawning Fish Survey Summary: 2009 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2010. Standard Chinook Coastal Spawning Fish Survey Summary: 2010 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2011. Standard Chinook Coastal Spawning Fish Survey Summary: 2011 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2012a. Latest Summary Data, Life Cycle Monitoring Program. Accessed 24 January, 2014. Available online https://nrimp.dfw.state.or.us/CRL/default.aspx?p=430

Oregon Department of Fish and Wildlife (ODFW). 2012b. Standard Chinook Coastal Spawning Fish Survey Summary: 2012 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2013a. Bandon Hatchery Operations Plan. Accessed 3 January, 2014. Available online http://www.dfw.state.or.us/fish/HOP/Bandon%20HOP.pdf

Oregon Department of Fish and Wildlife (ODFW) 2013b. Natural Resources Information Management Program. Fish Distribution Data shapefile. Accessed 18 December, 2013. Available online http://www.oregon.gov/DAS/CIO/GEO/pages/alphalist.aspx

Oregon Department of Fish and Wildlife (ODFW). 2013c. Hatchery Genetic management Plans (HGMP). Accessed 3 January, 2014. Available online http://www.dfw.state.or.us/fish/HGMP/final.asp

Oregon Department of Fish and Wildlife (ODFW). 2013d. Oregon Coast Coho ESU Adult Spawning Abundance by Stata and Population (1990 – 2003). Accessed 20 December 2013. Available online http://oregonstate.edu/dept/ODFW/spawn/cohoabund.htm

Oregon Department of Fish and Wildlife (ODFW). 2013e. Oregon Coast Coho ESU Adult Spawning Abundance by Stata and Population (2004 – 2012). Accessed 20 December 2013. Available online http://oregonstate.edu/dept/ODFW/spawn/cohoabund.htm

Oregon Department of Fish and Wildlife (ODFW). 2013f. Oregon Fish Habitat Distribution- Current and Historical. Accessed 20 December 2013. Available online https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&XMLname=1002.xml

Oregon Department of Fish and Wildlife (ODFW). 2013g. Standard Chinook Coastal Spawning Fish Survey Summary: 2013 Spawning Season. Accessed 24 January, 2014 at the Estuarine and Coastal Sciences Laboratory of South Slough NERR.

Oregon Department of Fish and Wildlife (ODFW). 2014a. Coastal Multi-Species Conservation and Management Plan. Unpublished Manuscript

Oregon Department of Fish and Wildlife (ODFW). 2014b. Steelhead Spawner Survey Summary Data (2003-2013). Unpublished data.

Orr, A. J., A. S. Banks, S. Mellman, H. R. Huber, and R. L. DeLong. 2004. Examination of the foraging habits of Pacific harbor seal (Phoca vitulina richardsi) to describe their use of the Umpqua River, Oregon and their predation on salmonids. Fishery Bulletin 102:108–117.

Rhodes, Justin S. and Thomas P. Quinn. 1999. Comparative Performance of Genetically Similar Hatchery and Naturally Reared Juvenile Coho Salmon in Streams. North American Journal of Fisheries Management, 19, 670-677.

Rodgers, J.D. 2000. Abundance of Juvenile Coho Salmon in Oregon Coastal Streams, 1998 and 1999. Monitoring Program Report Number OPSW-ODFW-2000-1, Oregon Department of Fish and Wildlife, Portland.

Rodgers, J.D. 2001. Monitoring of the Abundance of Juvenile Salmonids in Oregon Coastal Streams, 2001. Monitoring Program Report Number OPSW-ODFW-2001-1, Oregon Department of Fish and Wildlife, Portland.

Rodgers, J.D. 2002. Abundance Monitoring of Juvenile Salmonids in Oregon Coastal Streams, 2001. Monitoring Program Report Number OPSW-ODFW-2002-1, Oregon Department of Fish and Wildlife, Portland.

Suring E. and M. Lewis. 2008. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2007. Monitoring Program Report Number OPSW-ODFW-2007-09. Oregon Department of Fish and Wildlife, Salem, Oregon

Suring E., E. Brown and M. Lewis. 2008. Assessment of Oregon Coastal Adult Winter Steelhead – Redd Surveys 2008. Monitoring Program Report Number OPSW-ODFW-2008-09. Oregon Department of Fish and Wildlife, Salem, Oregon.

Suring, E., and R. J. Constable, Jr. 2009. Abundance Monitoring of Juvenile Salmonids in Coastal Oregon and Lower Columbia Streams, 2008. Monitoring Program Report Number OPSW-ODFW-2009-1, Oregon Department of Fish and Wildlife, Salem.

Suring, E., and R. J. Constable, Jr. 2010. Abundance Monitoring of Juvenile Salmonids in Coastal Oregon and Lower Columbia Streams, 2009. Monitoring Program Report Number OPSW-ODFW-2010-1, Oregon Department of Fish and Wildlife, Salem.

Suring, E., R.J. Constable, C.M. Lorion, B.A. Miller, D.J. Wiley. 2012. Salmonid Life Cycle Monitoring in Western Oregon streams, 2009-2011. Monitoring Program Report Number OPSW-ODFW-2012-2, Oregon Department of Fish and Wildlife, Salem.

United States Fish & Wildlife Service (USFWS). 2014. [Catalog of Oregon Seabird Colonies]. Unpublished data.

Waples, Robin S. and David J. Teel. 1990. Conservation Genetics of Pacific Salmon I. Temporal Changes in Allele Frequency. Conservation Biology, 4(2), 144-156.

Weber, Edward D. and Kurt D. Fausch. 2003. Interactions between Hatchery and Wild Salmonids in Streams: Difference in Biology and Evidence for Competition. Canadian Journal of Fisheries and Aquatic Sciences, 60(8), 1018-1036

Wilson, Mary F. & Karl C. Halupka. 1995. Anadromous Fish and Keystone Species in Vertebrate Communities. Conservation Biology, 9(3), 489-497.

Wright, B. E., Riemer, S. D., Brown, R. F., Ougzin, A. M., & Bucklin, K. A. 2007. Assessment of harbor seal predation on adult salmonids in a Pacific Northwest estuary. Ecological Applications, 17(2), 338-351

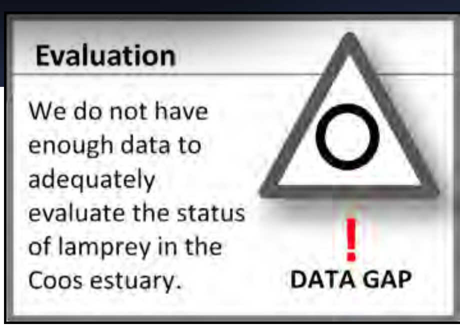
# Lamprey in the Lower Coos Watershed

*Summary:*

- *Two lamprey species are native to the Coos system, yet very little is known about their abundance, distribution, or life history.*

Photo above: Western brook lamprey
Source: Gary Susak, ODFW

Pacific lamprey
Photo: www.critfc.org





Spatial extent of Pacific Lamprey. Data: ODFW 2012

**What's happening?**

Two lamprey species, the western brook lamprey (*Lampetra richardsoni*) and Pacific lamprey (*Entosphenus tridentatus* formerly *Lampetra tridenta*), are native to the Coos estuary. Like most non- commercial species, the status and distribution of lampreys have not been the focus of research in the Coos estuary. Therefore, all available information comes from incidental catch data obtained during investigations of other fish species.

Although data have not been collected specifically to quantify Coos estuary lamprey populations, anecdotal evidence suggests a decline in Pacific lamprey abundance along the entire Oregon coast during the past 30-40 years (ODFW 2005).

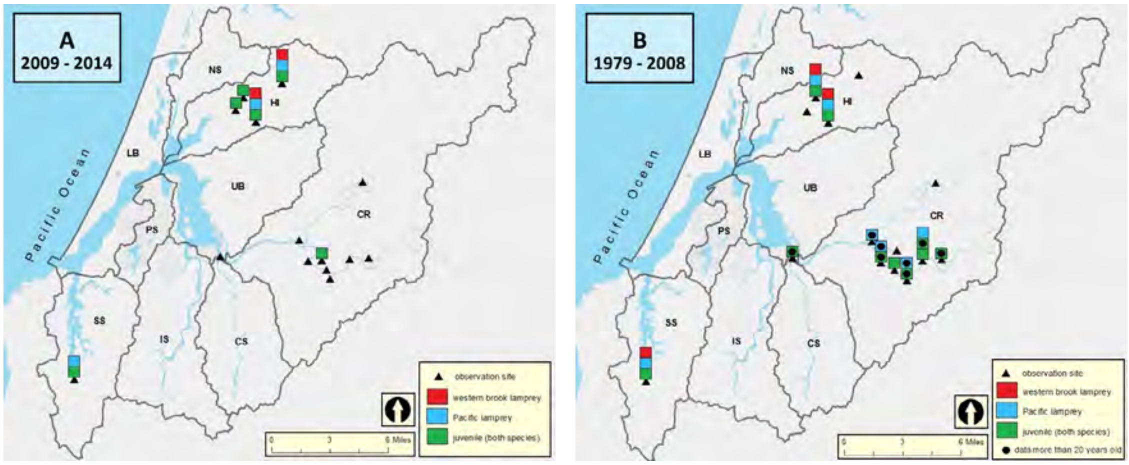



Figure 1. Current (A) and historical (B) lamprey observations of Pacific (blue), brook (red), and juvenile (green) lampreys. Observations that were made prior to 1994 are represented by dots. Sites that have recorded multiple historical observations of the same species (e.g., Pacific lamprey) both prior to 1994 and again from 1995-2008 are represented by two boxes of the same color (e.g., green) both with and without a dot. Data: ODFW 2013; CoosWA 2012; Suring et al. 2012. SS-South Slough, LB-Lower Bay, PS-Pony Slough, IS-Isthmus Slough, UB-Upper Bay, NS-North Slough, HI-Haynes Inlet, CR-Coos River, CS-Catching Slough

Since 2002, Pacific lamprey presence has been documented by the Oregon Department of Fish and Wildlife (ODFW) while conducting salmonid population research in the South Slough's Winchester Creek. They counted 43 adults in 2002 but only one in 2006 and 2007 (Suring et al. 2012)(Figure 1). ODFW also caught hundreds of ammocoetes (juveniles) each year from 2002-2007. However the counts did not differentiate between the Pacific and western brook lamprey. Eyed lamprey, the life stage between juvenile and adult, were also recorded, with a range of over 1,500 individuals in 2006 to a low of two in 2010.

Pacific lamprey have also been found during ODFW's annual steelhead surveys in other areas of the Coos estuary system. Kavanagh et al. (2005) examined fisheries information for the Elliot State Forest study area and reported no lampreys or lamprey redds (gravel "nests") during winter surveys in 2003. In 2004, however, one adult and 9.2 redds per mile were documented in Palouse Creek. Three adults per mile were also recorded for the West Fork Millicoma River, along with 43 redds per mile. However, redds are a poor indicator of lamprey abundance, because lampreys create redds during courtship that are never used, and Pacific lamprey redds are easily confused with steelhead redds (Kostow 2002, Gunckel et al. 2006).

Incidental catches of adult and ammocoete Pacific lamprey were recorded in Larson and Palouse Creeks (Haynes Inlet drainage basin) by Coos Watershed Association (CoosWA) researchers during annual salmon life cycle monitoring, which began in 2005 (Figure 1). Roughly 1-5 adult Pacific lamprey were found in Larson Creek most years, but were only occasionally found in Palouse Creek. Ammocoetes were more abundant in the Larson system

and not differentiated by species.
CoosWA also found other ammocoetes and adult western brook lamprey in Larson and Palouse Creeks during the same Coho lifecycle monitoring surveys (Figure 1)(CoosWA 2012). Western brook lamprey adults were found in moderate numbers (~50) in the Larson system and low numbers (~5) in Palouse Creek. Pacific lamprey ammocoete and adult counts were combined, and ammocoetes were captured in higher numbers in the Larson system.

Western brook lamprey have also been found in low densities in the South Slough watershed, and are often associated with beaver ponds (Rumrill 2002).

In the Coos River, annual ODFW seining has collected Pacific lamprey adults and ammocoetes as recently as 2011 (Figure 1)(ODFW 2013).

In nearby basins:

- Data from the Winchester Dam on the North Umpqua River show lamprey abundance began declining rapidly in the early 1970's and remained low (Kostow 2002).
- Gunckel et al. (2006) noted that Pacific lamprey only occupied large mainstem reaches of the Smith River. The same distribution was observed by Brumo (2006) in the Coquille River.
- A short-term study in the nearby Tenmile Creek estimated approximately 6,500 Pacific lamprey migrated to the ocean in 1994 and about 3,500 in 1995, indicating a healthy but highly variable population (van de Wetering 1998).

In the Umpqua watershed's Smith River, Gunckel et al. (2006) found that western brook lamprey were widespread in smaller-order tributaries, an analysis based partly on redd surveys. However, as with Pacific lamprey, population estimates for western brook lamprey based on redds are less accurate than counts because:

- redds are sometimes too close together to distinguish;
- redds can be confused with elk tracks, therefore should not be counted unless adults are also present; and
- western brook lamprey sometimes spawn in redds already created by Pacific lamprey (Gunckel et al. 2006).

Despite the lack of quantitative western brook lamprey population data, ODFW (2005) speculates that their numbers and distribution are declining, most likely due to habitat loss and pollution.

**Background**

<u>Pacific lamprey</u>
An anadromous species, adult Pacific lamprey require freshwater creeks with sand and gravel bottoms for spawning while juveniles require low velocity freshwater side channels with soft sediments for burrowing (Kavanagh et al. 2005). Juveniles remain burrowed four to seven years before emerging and migrating to the ocean, where they spend another two to three years as parasitic adults before returning to their natal streams to spawn (Close et al. 2002).

Pacific lamprey are federally listed as a "Species of Concern", and state listed as "Imperiled in Oregon" (ORBIC 2013; ODFW 2006).

Pacific lamprey are harvested as a subsistence food by Native Americans and have high cultural value for several Oregon Tribes. In fact, the Coquille Tribe name may mean "eel", a reference to lampreys (Byram 2002).

Western Brook Lamprey

In contrast with Pacific lamprey, western brook lamprey spend their entire lives in fresh water and probably remain close to their natal streams (ODFW 2005). Western brook lamprey ammocoetes spend up to 6 years burrowing in the fine sediments of slow-moving streams. Upon emergence, they are sexually mature and stop feeding; about 6 months later they spawn and die (Gunckel et al. 2006; Kostow 2002).

Western brook lamprey are currently ranked by NaturServe as globally "apparently secure" but in Oregon they are considered a species at risk (Santos et al. 2014). ODFW lists them as "Sensitive or vulnerable" (ORBIC 2013; ODFW 2006).

**Why is it happening?**

Degradation of spawning and ammocoete habitats is likely the main cause of declining lamprey populations. Degradation can include: dewatering of stream reaches, which strands burrowing ammocoetes in exposed substrates; impediments to passage (e.g., incorrectly installed culverts); reduced water quality (e.g., higher water temperatures); stream bottom dredging (e.g., mining activities); and predation by non-indigenous species (e.g., striped bass)(USFWS 2010). Ammocoetes are particularly vulnerable to these habitat changes.

**References**

Brumo, A. F. 2006. Spawning, larval recruitment, and early life survival of Pacific lampreys in the South Fork Coquille River, Oregon. [MS Thesis]. Oregon State University.

Byram, R. S. 2002. Scoquel, Coquelle, and Coquille. In Ivy, D. B. and R. S. Byram (eds.). Changing landscapes: sustaining traditions. [Proceedings of the 5th and 6th Annual Coquille Cultural Preservation Conferences]. Coquille Indian Tribe. North Bend, OR: 121–138.

Close, D. A., M. S. Fitzpatrick, and H. W. Li. 2002. The Ecological and Cultural Importance of a Species at Risk of Extinction, Pacific Lamprey. Fisheries 27(7): 19-25.

Coos Watershed Association (CoosWA). 2012. Coho life-cycle monitoring program. [Unpublished raw data].

Gunckel, S. L., K. K. Jones, and S. E. Jacobs. 2006. Spawning distribution and habitat use of adult Pacific and western brook lamprey in Smith River, Oregon. Oregon Department of Fish and Wildlife. Corvallis, OR.

Kavanagh, P., K. Jones, C. Stein, P. Jacobsen. 2005. Fish Habitat Assessment in the Oregon Department of Forestry Elliott Study Area. Oregon Department of Fish and Wildlife. Corvallis, OR.

Kostow, K. 2002. Oregon lampreys natural history, status, and problem analysis. Oregon Department of Fish and Wildlife. Salem, OR.

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Institute for Natural Resources, Portland State University. Portland, OR.

Oregon Department of Fish and Wildlife (ODFW). 2005. Oregon Native Fish Status Report - Volume II: 530-536. Available online http://www.dfw.state.or.us/fish/onfsr/report.asp

Oregon Department of Fish and Wildlife (ODFW). 2006. The Oregon Conservation Strategy. Oregon Department of Fish and Wildlife. Salem, OR. Available online http://www.dfw.state.or.us/conservationstrategy/contents.asp#spec

Oregon Department of Fish and Wildlife (ODFW). 2012. Oregon Fish Habitat Distribution, Pacific Lamprey Shapefile. Accessed 28 January 2014. Available online https://nrimp.dfw.state.or.us/nrimp/default.aspx?pn=fishdistdata

Oregon Department of Fish and Wildlife (ODFW). 2013. Coos fish monitoring seine program. [Unpublished raw data].

Rumrill, S. 2002. The Ecology of South Slough Estuary: Site Profile of the South Slough National Estuarine Research Reserve. National Oceanic and Atmospheric Administration. Charleston, OR.

Santos, N. R., J. Katz, P. B. Moyle, and J. H. Viers. 2014. A Programmable Information System for Management and Analysis of Aquatic Species Range Data in California. Environmental Modelling and Software 53: 13-16. Available online http://pisces.ucdavis.edu/content/lampetra-richardsoni

Suring, E., R. J. Constable, C. M. Lorion, B. A. Miller, and D. J. Wiley. 2012. Salmonid Life Cycle Monitoring in Western Oregon streams, 2009-2011. [Monitoring Program Report Number OPSW-ODFW-2012-2]. Oregon Department of Fish and Wildlife. Salem, OR.

United States Fish and Wildlife Service (USFWS). 2010. Best Management Practices to Minimize Adverse Effects to Pacific Lamprey (*Entosphenus tridentatus*). Available online http://www.fws.gov/pacific/Fisheries/sphabcon/Lamprey/pdf/Best%20Management%20Practices%20for%20Pacific%20Lamprey%20April%202010%20Version.pdf

van de Wetering, S. J. 1998. Aspects of life history characteristics and physiological processes in smolting Pacific Lamprey, *Lampetra tridentata*, in a central Oregon coast stream. [MS Thesis]. Oregon State University.

# Sturgeon in the Lower Coos Watershed

*Summary:*

- *Little is known about the current and historic distribution, abundance, and life history of sturgeon in the Coos watershed.*
- *Green sturgeon is federally listed as a threatened species.*
- *The longevity, slow growth, and delayed maturation of sturgeon species make them particularly vulnerable to overexploitation.*

White sturgeon
Image: Idaho Dept. of Fish and Game

Green sturgeon
Image: Duane Raver, International Game Fish Assn.

**Evaluation**

We do not have enough data to evaluate with confidence the status of sturgeon in the Coos estuary.

**DATA GAP**

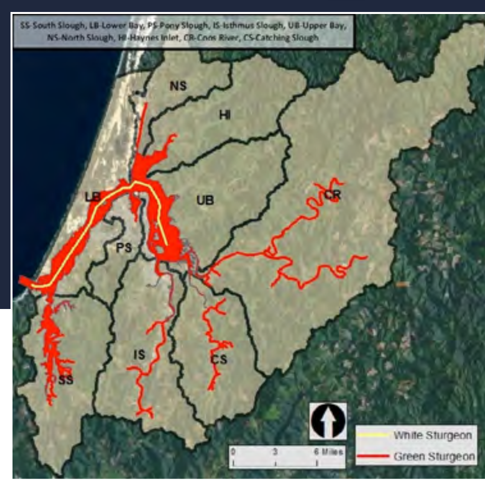



Figure 1. Spatial extent of sturgeon species. White sturgeon extent based on record of fish distribution and activity (ODFW 2007). Green sturgeon extent based on federally designated critical habitat (NOAA 2009).

**What's happening?**

Very little is known about the abundance and distribution of both white and green sturgeon (*Acipenser transmontanus* and *A. medirostris*) in the Coos estuary. White sturgeon is thought by Monaco and Emmett (1990) to be present in the Lower Bay and Upper Bay subsystems of the project area (Figure 1). They report that white sturgeon can be found year round in both the brackish (0.5-25) and marine-dominated (>25) zones of the Coos estuary. According to Wagoner et al. (1990), white sturgeon are not known to reproduce in the Coos estuary.

According to the Oregon Department of Fish and Wildlife (ODFW 2005b), the current and historical abundance of coastal white sturgeon stocks are unknown. They go on to explain that, due to highly migratory behavior, the current distribution of white sturgeon may not reflect its historic distribution. However, on the assumption that the lower Columbia River is primarily responsible for the production of coastal stocks, ODFW suggested in 2005 that the abundance of coastal white sturgeon was at low risk for failing below at least 25 percent of the historic abundance levels.

Though not abundant in any Pacific coast estuary, a small population of green sturgeon is thought to exist in the Coos estuary (Monaco and Emmett 1990, Wagoner et al. 1990, ODFW 2005a). ODFW reports that green sturgeon have been observed on rare ocassion at the forks of the South Coos and Millicoma Rivers, as well as in Isthmus Slough during their seining surveys. The National Oceanic and Atmospheric Administration (NOAA 2009) has designated critical habitat areas for green sturgeon in each of the nine subsystems. Green sturgeon are not know to reproduce in the Coos watershed (Monaco and Emmett 1990; Wagoner et al. 1990).

The available data on current and historic green sturgeon abundance are inconclusive (ODFW 2005a). The Oregon Biodiversity Information Center (ORBIC 2013) lists two distinct populations of green sturgeon (Figure 2). Currently, the northern green sturgeon population is is federally listed as a species of


Figure 2. Northern (green) and southern (red) distinct population segments for the green sturgeon. Data: NOAA 2009

concern, and the southern population is listed as threatened.

**Why is it happening?**

Information about abundance, distribution, and ecology of both white and green sturgeon in the Coos watershed is sparse, and more research and monitoring are needed to address this data gap (Wagoner et al. 1990). However, the status of local sturgeon populations is likely the product of several environmental and anthropogenic influences.

The longevity, slow growth, and delayed maturation of sturgeon species make them particularly vulnerable to overexploitation. Excessive harvest in the Colombia River has caused the collapse of sturgeon stocks in the past (Devore et al. 1995). Prior to 1990, the recreational harvest of white sturgeon in the Coos watershed was small but increasing (Wagoner et al. 1990). Harvest numbers increased in the Coos Bay and Coos River in the mid and late 90s, but have since followed a decreasing trend (Figure 3). Green sturgeon is incidentally caught while fishing for other species, most notably in the salmon and white sturgeon fisheries of the Columbia River (Monaco and Emmett 1990; ODFW 2005a). ODFW (2013) reports that some green sturgeons were caught in the Coos estuary by recreational anglers in the late 90s and early 2000s. This trend peaked in 1998 with a reported catch of 33 fish, and has since decreased. The most recent green sturgeon landing by a recreational angler in the Coos watershed was reported in 2003.

Hydroelectric development in critical sturgeon habitat has affected sturgeon abundance in Oregon waters. The installation of hydroelectric facilities may be a significant factor in the loss of sturgeon habitat, and development on the main stem of the Columbia River may have reduced white sturgeon productivity (Devore et al. 1995). Parsley et al. (1993) explain that development on the Columbia River may have isolated historically migratory populations of sturgeon by altering the hydrology of the river, though they also suggest that the precise effects of Columbia River alterations remain speculative since existing knowledge about habitat use of sturgeon species is limited. Similarly, research suggests that spawning populations of green

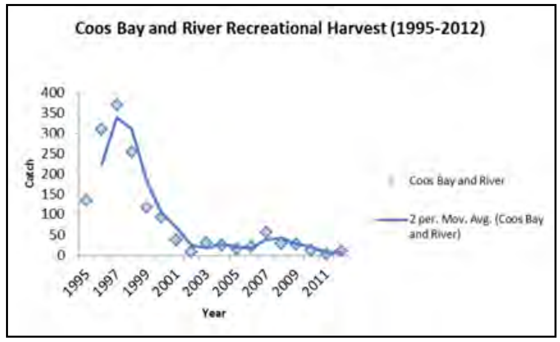



Figure 3. Time series trends for the recreational harvest of white sturgeon in Coos Bay and on the Coos River from 1995 to 2012. Data: ODFW 2013

sturgeon in the Rogue River may be negatively impacted by the artificial flow manipulation either directly through egg and larval development issues or indirectly through a reduction in the forage base (Erickson et al. 2002). The impacts of altered stream hydrology in the Rogue River is of particular concern, because green sturgeon spawning on the west coast has been confirmed only in the Rogue (Oregon), Sacramento and Klamath Rivers (California)(Moyle et al. 1995).

**Background**

White sturgeon are anadromous fish that spend the majority of their life in estuaries but return to freshwater to spawn, sometimes migrating distances of hundreds of kilometers (100 kilometer = 62 miles) across different estuarine and riverine systems (UC Davis 2014). The spawning timing of these species is highly variable (Bemis and Kynard 1997). However, Monaco and Emmett (1990) suggest that white sturgeon move upstream to spawning grounds in late winter and spring, and green sturgeon move into the estuary for spawning in spring and early summer. These species spawn in freshwater, and are able to spawn repeatedly, but most females do not spawn every year (Bemis and Kynard 1997). White sturgeon take 12-15 years to reach sexual maturity (Monacco and Emmett 1990) and have a long life span that may exceeded 100 years (UC Davis 2014; ODFW 2005a).

Distribution and habitat information for both white and green sturgeon:

- The distribution of white sturgeon is a function of age and salinity tolerance, with younger fish favoring the upstream or freshwater end of estuaries and older fish inhabiting the more marine-dominated regions closer to the Ocean (UC Davis 2014).
- Green sturgeon adults spend most of their time in nearshore ocean habitats (ODFW 2005a).
- Estuarine habitat requirements for green sturgeon include cobble for spawning and clean sand for juvenile and adults.
- White sturgeon adults can inhabit fresh, estuarine or marine waters over a variety of substrates, from sandy-mud to cobble (Monaco and Emmett 1990).

**References**

Bemis, W. E. and B. Kynard. 1997. Sturgeon rivers: an introduction to acipenseriform biogeography and life history. Environmental Biology of Fishes,48(1-4), 167-183.

Devore, J. D., James, B. W., Tracy, C. A., and Hale, D. A. 1995. Dynamics and potential production of white sturgeon in the unimpounded lower Columbia River. Transactions of the American Fisheries Society, 124(6), 845-856.

Erickson, D. L., North, J. A., Hightower, J. E., Weber, J., and Lauck, L. 2002. Movement and habitat use of green sturgeon Acipenser medirostris in the Rogue River, Oregon, USA. Journal of Applied Ichthyology, 18(4-6), 565-569.

Monaco, Mark E., and Robert L. Emmett. 1990. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volumes 1 and 2. Rockville, MD: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Moyle, P.B., R.M. Yoshiyama, J.E. Williams, and E.D. Wikramanayake. 1995. Fish Species of Special Concern in California. 2nd edition. California Department of Fish and Game, Sacramento, CA.

National Oceanic and Atmospheric Administration (NOAA). 2009. Fisheries Data: Critical Habitat. Green Sturgeon, Southern Distinct Population Segment Shapefile. Accessed 27 January, 2014. Available online http://www.nmfs.noaa.gov/gis/data/critical.htm

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Oregon Biodiversity Information Center Institute for Natural Resources, Portland State University, Portland, OR.

Oregon Department of Fish and Wildlife (ODFW). 2005a. Oregon Native Fish Status Report: Southern and Northern Green Sturgeon. Accessed 22 January, 2014. Available online http://www.dfw.state.or.us/fish/onfsr/docs/final/11-other/methods-green-sturgeon.pdf

Oregon Department of Fish and Wildlife (ODFW). 2005b. Oregon Native Fish Status Report: Oregon White Sturgeon. Accessed 22 January, 2014. Available online http://www.dfw.state.or.us/fish/onfsr/docs/final/11-other/methods-oregon-white-sturg.pdf

Oregon Department of Fish and Wildlife (ODFW). 2007. White Sturgeon Distribution Shapefile. Accessed 27 January, 2014. Available online http://spatialdata.oregonexplorer.info/geoportal/catalog/search/resource/details.page?uuid=%7B69EEB059-1DB7-48DB-BB3D-0B56114F9236%7D

Oregon Department of Fish and Wildlife (ODFW). 2013. Sport Catch Statistics: Salmon, Steelhead, & Sturgeon. Accessed 22 January, 2014. Available online http://www.dfw.state.or.us/resources/fishing/sportcatch.asp

Parsley, M. J., Beckman, L. G., & McCabe Jr, G. T. (1993). Spawning and rearing habitat use by white sturgeons in the Columbia River downstream from McNary Dam. Transactions of the American Fisheries Society, 122(2), 217-227.

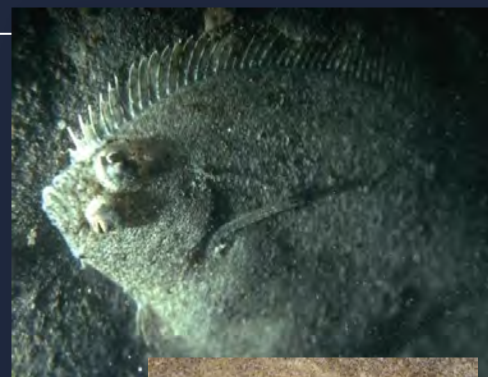
University of California at Davis (UC Davis). 2014. California Fish Species. Accessed 22 January, 2014. Available online http://calfish.ucdavis.edu/species/?ds=241&uid=113

Wagoner, L.J., K.K. Jones, R.E. Bender, J.A. Butler, D.E. Demory, T.F. Gaumer, J.A. Hurtado, W.G. Mullarky, P.E. Reimers, N.T. Richmond and T.J. Rumreich. 1990. Coos River Basin Fish Management Plan. Oregon Department of Fish and Wildlife, Salem, OR.

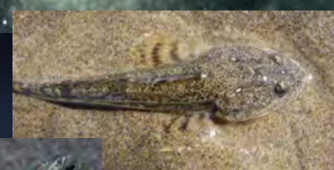
# Other Fishes in the Coos Estuary


*Summary:*

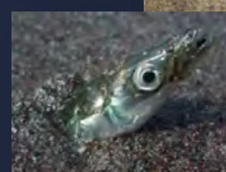
- *Over 70 species of non-salmonid fish use the Coos system at some point in their lives, including one endemic species (Millicoma dace), yet surprisingly little is known about the ecology, population or distribution of these fishes.*
- *The Coos system appears to provide a variety of habitat types that support high fish species richness.*

Speckled sanddab
Photo: U of OR



Pacific Staghorn sculpin
Photo: the outershores.com



Pacific sand lance
Photo: NOAA

**Evaluation**

We do not have enough data to fully evaluate the status of other fishes found in the Coos estuary.

**DATA GAP**

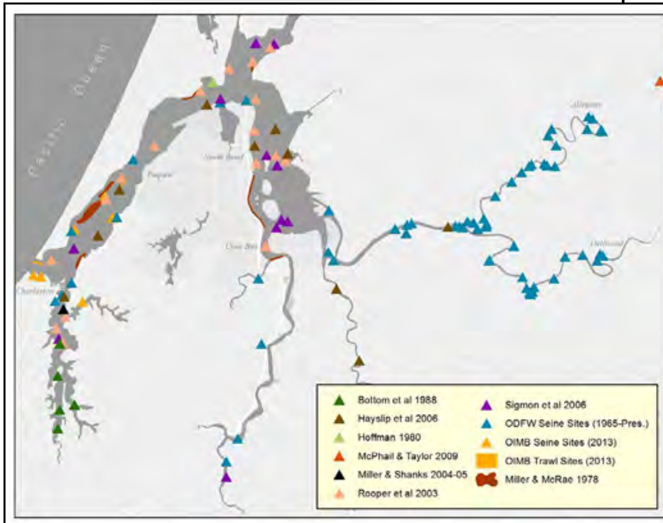



Figure 1. Study locations where Other Fish data were collected.

**What's happening?**

At least 70 non-salmonid fish species ("other fishes") inhabit the Coos estuary and associated rivers at some point in their life cycle (see Table 1 for a list of those documented in the last 5 years). "Other" fishes use the estuary and its tributaries variously: some marine fishes may live in the lower, more saline reaches of the estuary as adults (e.g., Cabazon and lingcod inhabiting the waters around rock jetties); some live most of their adult life in the ocean, but come into the estuary to spawn (e.g. Pacific herring or topsmelt);

some spawn in the ocean as adults, but their larvae or juveniles enter the estuary to take advantage of productive nursery habitat (e.g. rockfish living in eelgrass beds). Other fishes live in the brackish waters (e.g. shiner perch) or fresh waters (e.g. stickleback, longnose dace) of the Coos estuary through all stages of their life cycles.

Unfortunately, distribution and abundance of Other Fish species in the Coos estuary are poorly understood since these species have not, for the most part, been the subject of targeted studies.

This document summarizes available information describing the distribution, abundance and conservation status of Other Fish species found in the Coos estuary. Brief Other Fishes summaries, organized in alphabetical order by species common name, are divided into the three sections corresponding to adult phase habitats: Marine Fishes, Estuary Fishes, and Freshwater Fishes. The final summary, Infrequently Encountered Fishes, details available information about fishes who appear to be only occasional Coos estuary residents.

The presence and distribution information in these summaries rely primarily on the findings of the Oregon Department of Fish and Wildlife's long-term seining program (1965-present)(ODFW 2013b) and fish seining conducted by scientists and students at the Oregon Institute of Marine Biology in 2013 (OIMB 2013)(Figure 1). ODFW's long-term seining program initially sampled all fishes in the Coos system but ultimately shifted to monitoring only Chinook salmon. Other Fishes are still identified and counted during Chinook sampling, but large numbers of non-salmonid species are estimated. There are additional limitations to the data in the sampling methods used. Seining methods have remained standard over the years, but fish identification varies by staff abilities

| Common name | Scientific name | Year (most recent) |
|---|---|---|
| American shad | *Alosa sapidissima* | 2008 |
| Black rockfish | *Sebastes melanops* | 2013 |
| Brown Irish lord | *Hemilepidotus spinosus* | 2013 |
| Buffalo sculpin | *Enophrys bison* | 2013 |
| Butter sole | *Isopsetta isolepis* | 2013 |
| Cabezon | *Scorpaenichthys marmoratus* | 2013 |
| Chinook salmon | *Oncorhynchus tshawytscha* | 2013 |
| coastrange sculpin | *Cottus aleuticus* | 2010 |
| Coho salmon | *Oncorhynchus kisutch* | 2013 |
| Copper rockfish | *Sebastes caurinus* | 2013 |
| Cutthroat trout | *Oncorhynchus clarki* | 2013 |
| English sole | *Parophrys vetulus* | 2013 |
| Fluffy sculpin | *Oligocottus snyderi* | 2010 |
| Greenling sp. | *Hexagrammos sp.* | 2013 |
| Gunnel sp. | *Pholis spp.* | 2013 |
| Kelp greenling | *Hexagrammos decagrammus* | 2013 |
| Large scale sucker | *Catostomus macrocheilus* | 2009 |
| Lingcod | *Ophiodon elongatus* | 2013 |
| Longnose dace | *Rhinichthys cataractae* | 2008 |
| Northern anchovy | *Engraulis mordax* | 2012 |
| Pacific herring | *Clupea pallasii* | 2013 |
| Pacific lamprey | *Lampetra tridentata* | 2011 |
| Pacific sand lance | *Ammodytes hexapterus* | 2013 |
| Pacific staghorn sculpin | *Leptocottus armatus* | 2013 |
| Penpoint gunnel | *Apodichthys flavidus* | 2013 |
| Prickly sculpin | *Cottus asper* | 2011 |
| Redside shiner | *Richardsonius balteatus* | 2010 |
| Redtail surf perch | *Amphistichus rhodoterus* | 2010 |
| Rock greenling | *Hexagrammos lagocephalus* | 2010 |
| Rockfish sp. | *Sebastes sp.* | 2013 |
| Saddleback gunnel | *Pholis ornata* | 2013 |
| Sand sole | *Psettichthys melanostictus* | 2013 |
| Sardine, Pacific | *Sardinops sagax caerulea* | 2010 |
| Sharpnose sculpin | *Clinocottus acuticeps* | 2010 |
| Shiner surfperch | *Cymatogaster aggregata* | 2013 |
| Silver spotted sculpin | *Blepsias cirrhosus* | 2013 |
| Snake prickleback | *Lumpenus sagitta* | 2013 |
| Speckled dace | *Rhinichthys osculus* | 2010 |
| Speckled sanddab | *Citharichthys stigmaeus* | 2013 |
| Starry flounder | *Platichthys stellatus* | 2013 |
| Steelhead | *Oncorhynchus mykiss* | 2013 |
| Striped seaperch | *Embiotoca lateralis* | 2013 |
| Surf smelt | *Hypomesus pretiosus* | 2013 |
| Threespine stickleback | *Gasterosteus aculeatus* | 2011 |
| Tidepool sculpin | *Oligocottus maculosus* | 2013 |
| Tidepool snailfish | *Liparis florae* | 2010 |
| Topsmelt | *Atherinops affinis* | 2012 |
| Tube-snout | *Aulorhynchus flavidus* | 2010 |
| Walleye perch | *Hyperprosopon argenteum* | 2013 |
| White sturgeon | *Acipenser transmontanus* | 2012 |
| Bay pipefish | *Syngnathus leptorhynchus* | 2013 |

Table 1. List of documented fish species in the Coos system in the past 5 years (2008-2013). Compiled from: ODFW 2013a, ODFW 2013b, ODFW 2012, OIMB 2013, McPhail and Taylor 2009, G. Vonderohe, pers. comm., 2014.

and species are typically not verified using keys. Identification of rare fishes is especially questionable. In addition, the seining effort was not identical in all years (some sites were missed— especially after the sampling focus shifted to Chinook) and during some years sampling was skipped altogether. Finally, seining methods may have inadvertently introduced bias into the sampling since seining is not effective at capturing all fish (e.g., larger more mobile fish species).

Oregon Institute of Marine Biology's (OIMB) fish data were collected during day and nighttime trawls at two locations in the lower Coos estuary (Figure 1) during summer 2013 as part of its Biology of Fishes class. OIMB scientists and students also seined at six locations in the lower estuary (Figure 1). The goal of the study was to examine the diversity of fish species in a variety of habitats. Identification of fish to the species level was an important component of the class. Species identification was attempted in the field by students and in most cases a specimen was brought back to the lab for confirmation by keying out fish using the following guides: Miller and Lea 1972; Hart and Clemens 1973; Eschmeyer and Herald 1983; Kramer et al. 1995. In all cases, final confirmation of species identification was provided by Biology of Fishes Professor, Wade Smith, a specialist in marine fishes.

The Other Fish life history information reported in these summaries relies primarily on the work of Monaco and Emmett, specifically Volume II of their two-part series describing fishes and invertebrates in US west coast estuaries (Monaco and Emmett 1990).

The Other Fishes summaries are followed by a section describing researchers' most recent understanding of how Other Fishes are using the Coos estuary.

**Marine Fishes in the Coos Estuary** (see Figure 2 and Table 2)

American shad (*Alosa sapidissima*) is a non-native anadromous fish species and is described with other non-native species in Chapter 18: Non-Indigenous and Invasive Species.

Brown Irish lord (*Hemilepidotus spinosus*) were found most recently near Clam Island in the lower Coos estuary in 2013 (OIMB 2013) and have been caught infrequently in the lower estuary by ODFW (ODFW 2013b).

Butter sole (*Pleuronectes isolepis*), one of two dominant flatfishes found off the Oregon Coast (the other being English sole- see below) and considered common in the Coos estuary (W. Smith, pers. comm., 2014), were found in 2013 near Clam Island in the lower estuary (OIMB 2013). Over 20 individuals were netted and released. Butter sole have a relatively short spawning period (February-May)(Richardson et al. 1980). No other data on species abundance or distribution are available.

Cabezon (*Scorpaenichthys marmoratus*), a species of sculpin, have been regularly found as juveniles in the lower estuary by ODFW (ODFW 2013b), and near Clam Island, also in the lower estuary, by OIMB (OIMB 2013). Over the course of a 2+ year study, Schlosser and Bloeser (2006) found Cabazon to be

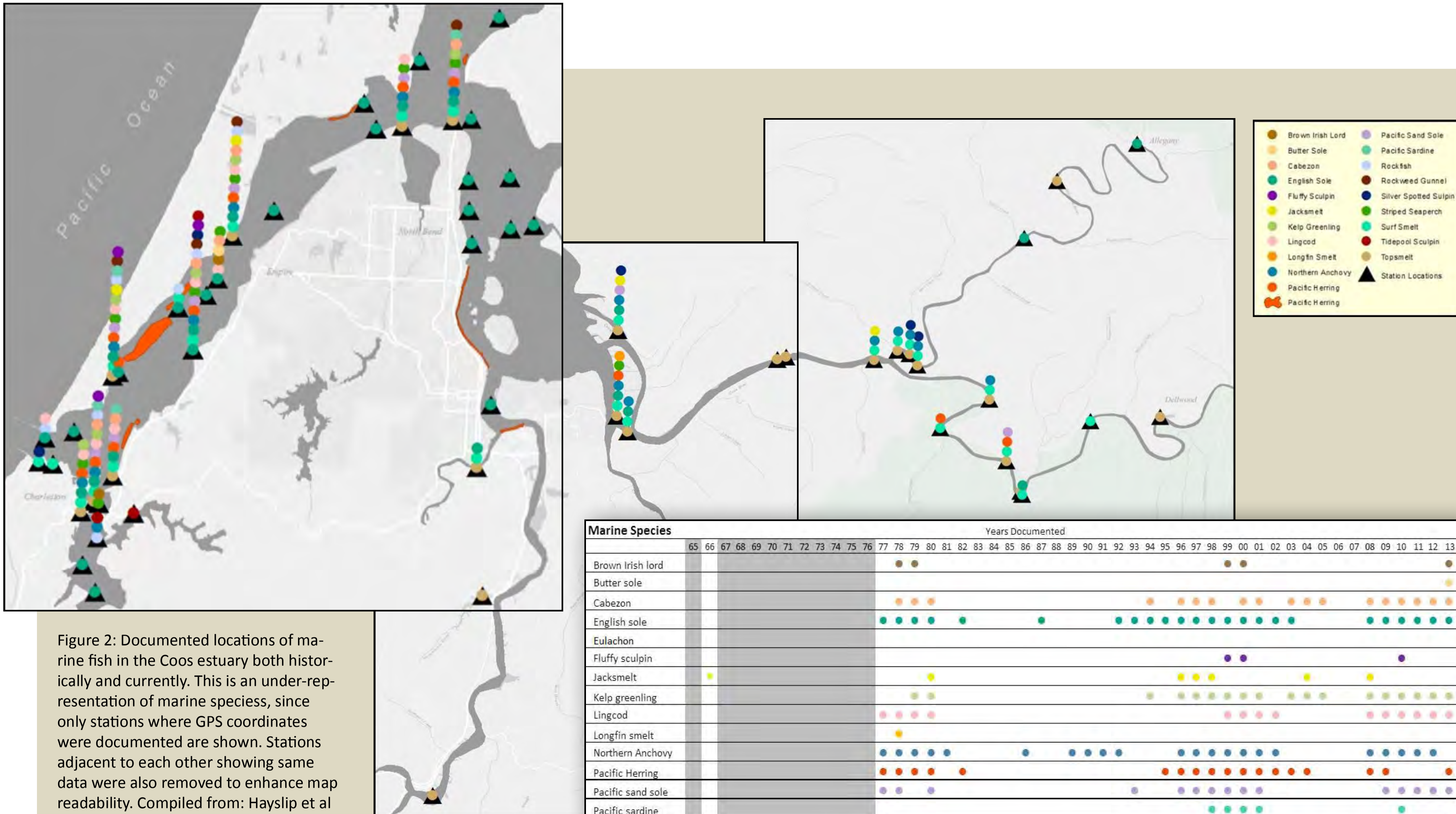



Figure 2: Documented locations of marine fish in the Coos estuary both historically and currently. This is an under-representation of marine speciess, since only stations where GPS coordinates were documented are shown. Stations adjacent to each other showing same data were also removed to enhance map readability. Compiled from: Hayslip et al 2006; Miller and McRae 1978; Miller and Shanks 2004 and 2005; ODFW 2013b, OIMB 2013; Rooper et al 2003.

Years Documented

| Marine Species | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brown Irish lord | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | • |
| Butter sole | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • |
| Cabezon | | | | | | | | | | | | | | • | • | • | | | | | | | | | | | | | | • | | • | • | • | | • | • | | • | • | • | | | • | • | • | • | • | • |
| English sole | | | | | | | | | | | | | • | • | • | • | | • | | | | | • | | | | | • | • | • | • | • | • | • | • | • | • | • | • | | | | | • | • | • | • | • | • |
| Eulachon | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fluffy sculpin | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | | | | | | | | | | • | | | |
| Jacksmelt | | • | | | | | | | | | | | | | | • | | | | | | | | | | | | | | | | • | • | • | | | | | | • | | | | • | | | | | |
| Kelp greenling | | | | | | | | | | | | | | | • | • | | | | | | | | | | | | | | • | | • | • | • | • | • | • | | • | • | • | | | • | • | • | • | • | • |
| Lingcod | | | | | | | | | | | | | • | • | • | • | | | | | | | | | | | | | | | | | | | • | • | • | • | | | | | | • | • | • | • | • | • |
| Longfin smelt | | | | | | | | | | | | | | • | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Northern Anchovy | | | | | | | | | | | | | • | • | • | • | • | | | | | • | | | • | • | • | • | | | | • | • | • | • | • | • | • | | | | | | • | • | • | • | • | |
| Pacific Herring | | | | | | | | | | | | | • | • | • | • | | • | | | | | | | | | | | | | • | • | • | • | • | • | • | • | • | • | | | | • | • | | | | • |
| Pacific sand sole | | | | | | | | | | | | | • | • | | • | | | | | | | | | | | | | • | | | • | • | • | • | • | • | | | | | | | | • | • | • | • | • |
| Pacific sardine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | • | • | • | | | | | | | | | • | | | |
| Pacific Tomcod | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Red Irish lord | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Rockfish | | | | | | | | | | | | | • | • | • | | | | | | | | | | | | | | | | | • | | • | • | • | • | • | • | • | • | | | • | • | • | | | • |
| Rockweed gunnel | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | • | | | | | | | | | | | | | |
| Silver spotted sculpin | | | | | | | | | | | | | | | • | • | | | | • | | | | • | • | | | | | | | | | | | | | | | | | | | | • | | | | • |
| Striped seaperch | | | | | | | | | | | | | | • | • | • | | | | | | | | | | | | | | • | | • | • | • | • | • | • | | | | | | | • | • | • | • | | • |
| Surf smelt | | | | | | | | | | | | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | | | | • | • | • | • | • | • |
| Tidepool sculpin | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | | | | | | | | | | | • |
| Tidepool snailfish | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | • | | | |
| Topsmelt | | | | | | | | | | | | | • | • | • | • | • | • | • | • | | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | | | • | • | • | • | • | |
| Wolf eel | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| White seaperch | | | | | | | | | | | | | | • | • | • | | | | | | | | | | | | | | | | • | • | | • | • | | | | • | | | | | | | | | |

• Species present

Table 2: Years marine fish were documented in the Coos estuary. Grayed out portions coincide with years no seining took place for the ODFW seining project. Compiled from: Hayslip et al 2006; Miller and McRae 1978; Miller and Shanks 2004 and 2005; ODFW 2013b, OIMB 2013; Rooper et al 2003.

nearly as abundant as black rockfish during the course of their study (Figure 3), and most abundant near mud and sandy substrates associated with drift algae.

English sole (*Pleuronectes vetulus*) juveniles were found on multiple sampling runs by ODFW in the Coos River system, and have been consistently captured in the lower estuary and South Slough systems, sometimes by the hundreds (ODFW 2013b). Numerous English sole juveniles were caught in 2013 near Clam Island and near the North Jetty by OIMB (OIMB 2013). For the west coast as a whole, English sole harvests, subject to both regulatory and market-driven fluctuations, were at near historic lows at the time of a National Marine Fisheries Service report by Stewart (2005). The same report shows English sole spawning biomass increased from 1995 to 2005.

While English sole adults are rarely found in estuaries, juveniles are common in estuarine habitats which function as juvenile fish nurseries (Lassuy 1989a). Not surprisingly, in the Coos system, juveniles can be found year-round in the estuary, most abundantly April to November (Monaco and Emmett 1990).

Rooper et al. (2003) studied habitat types in multiple estuaries along the west coast and determined the highest density of juvenile English soles were found in "Lower Side Channel" habitat, which in the Coos system they designated as the South Slough. They also found the average English sole juvenile density decreased with decreasing salinities; smaller juveniles appeared to be more sensitive to salinity changes. English sole juveniles were also highly correlated with bottom habitat, preferring medium or fine grain sand.

In a species profile by Lassuy (1989a), English sole juveniles were said to aggregate in estuary nursery areas for about a year before moving towards progressively deeper waters and ultimately leaving the estuary as 5 ½" to 6" (140-150mm) juveniles. Additionally, Lassuy (1989a) and Kruse (1984) describe how females of this commercially important species are harvested in higher numbers (90% of total catch) in commercial fisheries since males rarely reach harvestable size.

English sole is also an important fish for understanding water and sediment pollution levels since the fish are prone to accumulating contaminants in their flesh, which can form visible cancerous lesions or tumors (Sigmon et al. 2006).

Eulachon (*Thaleichthys pacificus*), a small anadromous fish, is a federally listed threatened species (Oregon Biodiversity Information Center 2013). They are found only rarely in the Coos estuary (Monaco and Emmett 1990).

Fluffy sculpin (*Oligocottus snyderi*) is a very small fish that has only been documented several times in the lower estuary by ODFW. The last time it was found by ODFW was in 2010 (ODFW 2013b). Smith notes that fluffy sculpin are likely to be poorly sampled by seines (W. Smith, pers. comm., 2014)

Jacksmelt (*Atherinopsis californiensis*) schools have been documented inside the estuary on several occasions by ODFW, most recently in 1998 (ODFW 2013b).

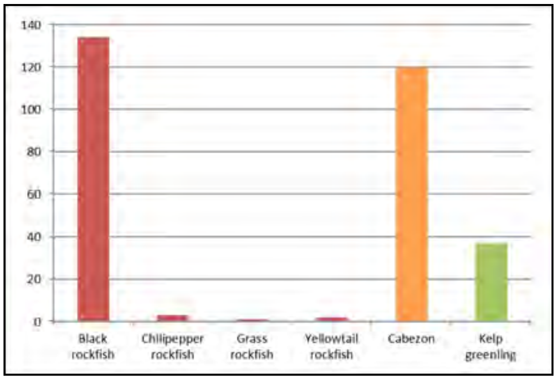


Figure 3: Counts of each species combined for all sampling events at Coos Bay from June 2003 to December 2005. Red bars represent rockfish species, the orange bar is cabezon and green is kelp greenling. Data: Schlosser and Bloeser 2006.

Kelp greenling (*Hexagrammos decagrammus*) were found by Schlosser and Bloeser (2006) to inhabit kelp beds with mud bottoms in the Coos estuary, being the third most abundant catch during their study, behind black rockfish and Cabezon (Figure 3). Wagoner et al. (1990) reported that Kelp greenling are often found in lower portions of the Coos estuary. They've also been documented on numerous occasions in the lower estuary and mouth of South Slough by ODFW, who last caught kelp greenling in 2013 (ODFW 2013b). Recently, a greenling was caught near the North Jetty in the lower estuary by OIMB (OIMB 2013).

Lingcod (*Ophiodon elongatus*) adults have infrequently been found by ODFW in the lower estuary; they last documented several in 2013 (ODFW 2013b). Juvenile lingcod were found near Clam Island and near the North Jetty by OIMB in 2013 (OIMB 2013). Lingcod are rarely found in the Coos estuary as adults, although larvae and juveniles are found fairly regularly— generally in January and February (larvae); or April through August (juveniles) (Monaco and Emmett 1990). Wagoner et al. (1990) described the data gaps in scientists' understanding of lingcod stocks but noted the existence of a recreational fishery off the rock jetties in lower portions of the Coos estuary.

Longfin smelt (*Sprinchus thaleichthys*) are small anadromous fish found only once (in 1978) by ODFW in the Coos estuary (ODFW 2013b). Longfin smelt life stages all occur within the estuary (Monaco and Emmett 1990): in the fall, juveniles and adults use the upper tidal freshwater reaches of the estuary; during the winter, adults spawn in these regions and then die; in the spring and summer, juveniles move to the marine-dominated lower portions of the estuary (Monaco and Emmett 1990).

Northern anchovy (*Engraulis mordax*) have been found by ODFW on numerous occasions in both the Coos estuary and Coos River, most recently in 2012 (ODFW 2013b). ODFW reports having sometimes caught Northern Anchovy in the hundreds. Adults and juveniles migrate into the Coos estuary during summer months. Adults are found most abundantly June through November and juveniles April through November (Monaco and Emmett 1990). Northern anchovy are a commercially important bait fish as well as important prey for many birds species, including the California brown pelican (Monaco and Emmett 1990).

Pacific herring (*Clupea pallasii*) is a schooling fish that returns to its natal estuary to spawn. Adults can be found in the Coos estuary January through September, but are most abundant at spawning times – January through April (Monaco and Emmett 1990). The Coos estuary is one of the Oregon coast's major herring spawning destinations (Lassuy 1989b).

Juvenile Pacific herring can be found in the estuary April through November, but are most abundant June through September (Monaco and Emmett 1990). During a spawning event, eggs are attached to solid substrates such as eelgrass or rocks. Juveniles remain in inshore waters for the first few months before moving offshore, although some populations remain in estuarine waters (Stevenson 1962). The most recent information on distribution, time of spawning, and egg biomass in the Coos estuary was quantified by Miller and McRae in 1978. They found that the most extensively used spawning habitats were the eelgrass beds in the lower parts of estuary, while the densest spawning occurred on cargo docks in mid and upper parts of estuary. They noted that the rocky substrate at Fossil Pt. accounted for about one quarter of all spawning biomass in the Coos estuary (Figure 4) during the 1977-78 spawning season, which totaled an estimated 144.5 tons of eggs. This estimate should be considered minimal due to bird predation prior to sampling (e.g., Black Brant goose), eliminating as much as 90% of the eggs in the first week after spawning. ODFW reported finding juvenile Pacific herring mainly in the lower regions of the estuary often in extremely high numbers (>1,000 individuals per seine on multiple occurrences)(ODFW 2013b). Most recently (2013) ODFW again documented very high numbers estimated at about 1,000 individuals during two separate seining events. Pacific herring were also fund


Figure 4: Site locations of Miller and McRae study on Pacific herring, including location of the Fossil Pt. station. Data: Miller and McRae 1978.

near Stacey Beach by OIMB in 2013 (OIMB 2013).

<u>Pacific sand sole (*Psettichthys melanostictus*)</u> is a native flat fish that ODFW has frequently found during fish seining (ODFW 2013b). Pacific sand sole were found almost exclusively in the lower estuary and South Slough, sometimes in moderately large numbers (20-75 individuals).

<u>Pacific sardine (*Sardinops sagax*)</u> is a schooling pelagic fish considered a keystone species due to the dozens of marine birds and mammals that depend on them as a major food source. Miller and Shanks (2004) found that Pacific sardine juveniles rearing in the Coos estuary were significantly larger than those from an adjacent outer coast site (Sunset Bay), though they were found less frequently

in the estuary. The most recent stock assessment (2012) for the northern subpopulation of this species (which includes Oregon) concludes that they are not being overfished (Hill et al. 2012), though there is preliminary evidence from 2013/2014 landings that populations have declined since this report (Barboza 2014; Dillman 2013), possibly due to this species' naturally fluctuating populations (e.g., effects of cold phase Pacific decadal oscillation). ODFW found Pacific sardines in the Coos estuary in 2010 but have not collected any since (ODFW 2013b).

Pacific tomcod (*Microgadus proximus*) is a schooling marine species often found as adults and juveniles in estuaries during May through August, mostly in the mixed and seawater zones (salinity > 0.5) of the Coos estuary (Monaco and Emmett 1990). Pacific tomcod have been found three times in the lower estuary by ODFW, most recently in 1999 (ODFW 2013b).

Red Irish lord (*Hemilepidotus hemilepidotus*) is a fish in the sculpin family noted by Wagoner et al. (1990) to be found in lower portions of the Coos estuary, although population data are unavailable for this species. ODFW has found them twice in the lower estuary, most recently in 2000 (ODFW 2013b).

Rockfish (*Sebastes spp.*), such as black and copper rockfish (*Sebastes melanops* and *S. caurinus*), are generally only found in the Coos estuary as juveniles. Miller and Shanks (2004) found more juvenile Pacific rockfish inside the Coos estuary than at an adjacent coastal site (Sunset Bay). Schlosser and Bloeser (2006) trapped juvenile rockfish, Cabazon and greenlings monthly from 2003-2005 at multiple estuaries and found that rockfish preferred eelgrass or sand bottom associated with drift algae habitat in the Coos estuary. Black rockfish were by far the most common rockfish found in the Coos estuary during their study (Figure 3). OIMB found black rockfish near the North Jetty in the lower Coos estuary (OIMB 2013). Multiple rockfish of unknown species were also collected during a seining event near Clam Island by the same group. ODFW has frequently found copper and black rockfish juveniles in their seining and has also occasionally found brown rockfish (*Sebastes auriculatus*), blue rockfish (*Sebastes mystinus*), and bocaccio rockfish (*Sebastes paucispinis*)(ODFW 2013b).

Rockweed gunnel (*Apodichthys fucorum*) have only occasionally been documented inside the lower Coos estuary, most recently in 2000 by ODFW (ODFW 2013b).

Silver spotted sculpin (*Blepsias cirrhosis*) have been found by OIMB at Tunnel Beach in the lower Coos Bay in 2013 (OIMB 2013). ODFW has documented silver spotted sculpin a handful of times, most recently in 2009 (ODFW 2013b).

Striped bass (*Morone saxatilis*) are an introduced sport fish and as such will be discussed in the Chapter 18: Non-Indigenous and Invasive Species.

Striped seaperch (*Embiotoca lateralis*), known to occur and spawn in the Coos estuary, were found near the North Jetty in the lower estuary by OIMB in 2013 (OIMB 2013). ODFW has generally found these fish at lower estuary sites, most recently in 2011 (ODFW 2013b).

Surf smelt (*Hypomesus pretiosus*) is an important recreational fish as well as a valuable prey species for many birds and mammals. Surf smelts are abundant year-round in the Coos estuary as juveniles (especially April through October) while adults are generally only found in high numbers from June through August (Monaco and Emmett 1990). Larvae can also be found in the Coos estuary, but only in high salinity regions (>25)(Monaco and Emmett 1990). Juvenile and adult surf smelts were found in large numbers (~580 individuals) at Coast Guard Cove in the lower estuary, and in smaller numbers at Tunnel Beach and Sitka Dock by OIMB in 2013 (OIMB 2013). ODFW has found surf smelts in lower regions of the estuary, but occasionally high numbers appeared in the Coos River systems (ODFW 2013b). In 2013, ODFW found high numbers of both adults and juvenile surf smelt (estimated >1,000 individuals per seine on multiple occurrences), most recently in lower Coos estuary sampling sites.

Tidepool sculpin (*Oligocottus maculosus*) were found by OIMB in 2013 in several seines in the Joe Ney Slough (OIMB 2013). ODFW also found these fish in 2000 at their Sitka dock site in the lower estuary (ODFW 2013b). Miller and Shanks (2005) found several tidepoll sculpin individuals near the entrance to Joe Ney Slough in 2000.

Tidepool snailfish (*Liparis florae*) were found by ODFW in the lower Coos estuary at the Empire boat ramp in 2010 (ODFW 2013b).

Topsmelt (*Atherinops affinis*) is a schooling marine fish that spends much of its life in the marine-dominated (salinity >25) parts of estuaries (Monaco and Emmett 1990). All topsmelt age classes are highly abundant in the Coos estuary, especially during times of peak spawning (May through July), where eggs are laid primarily on eelgrass or tideflat algae in the estuary (Monaco and Emmett 1990). ODFW found topsmelt in the upper and lower portions of the estuary, as well as the Coos River; most recently in 2012 (ODFW 2013b).

Wolf Eel (*Anarrhichthys ocellatus*) can be found around jetties in the lower estuary, or at Fossil Pt., although information on abundance and life history in the Coos estuary is lacking for this species (Wagoner et al. 1990).

**Estuarine Fishes in the Coos Estuary** (see Figure 5 and Table 3)

Arrow goby (*Clevelandia ios*) is an estuary-dependent fish whose life stages all occur in the estuary (Monaco and Emmett 1990). Frequently associated with ghost shrimp burrows (*Callianasa californiensis*), in the Coos estuary arrow gobies have been found using (mainly unoccupied) ghost shrimp burrows at Jordan Cove (Hoffman 1980). They're found in intertidal areas in spring and summer and in subtidal channels during fall and winter (Monaco and Emmett 1990; Hoffman 1980). ODFW has found arrow gobies mainly in the upper estuary as recently as 1997 (ODFW 2013b).

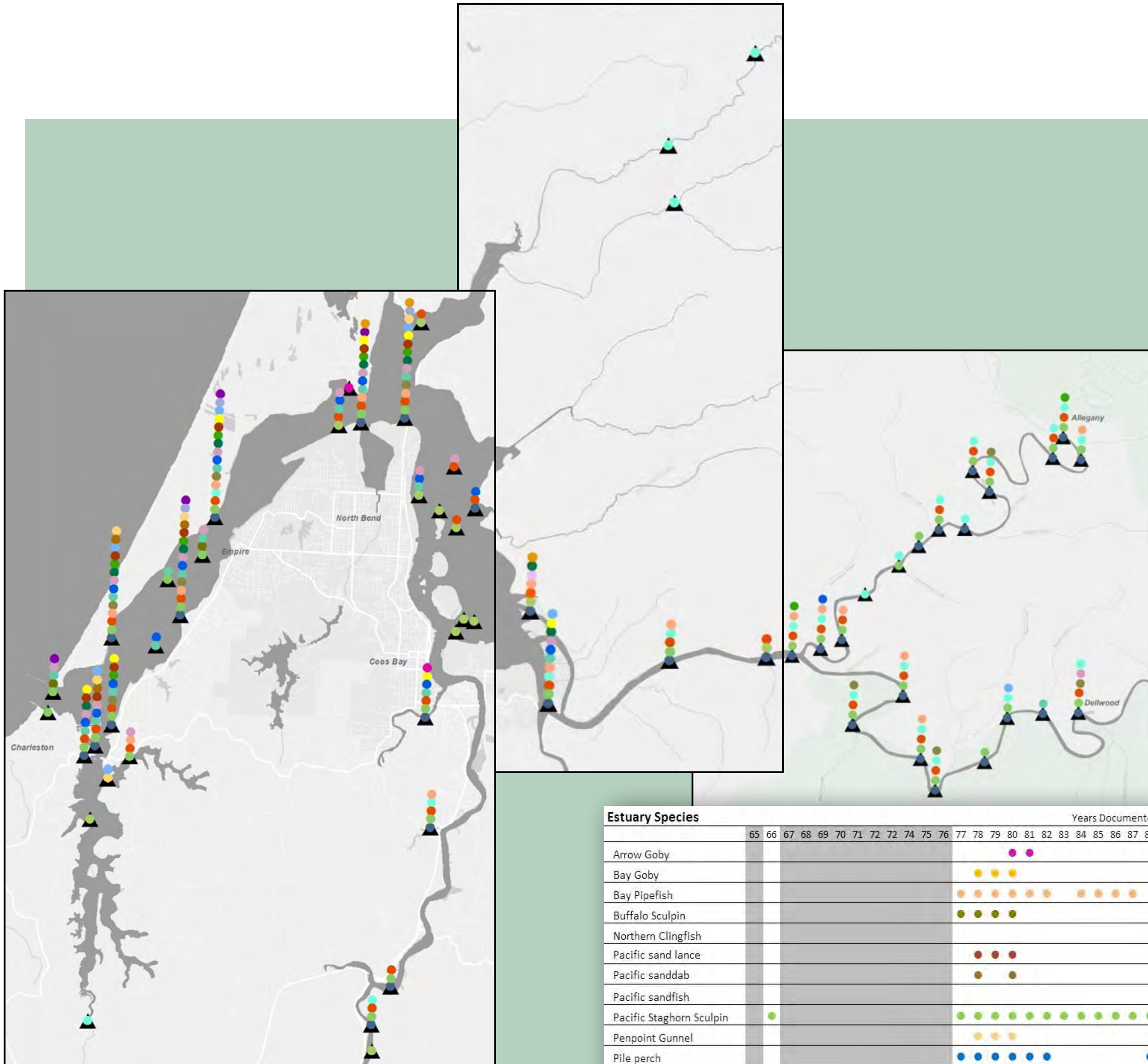



Figure 5: Documented locations of estuarine fishes in the Coos system both historically and currently. This is an under-representation of estuary species, since only stations where GPS coordinates were documented are shown. Compiled from: ODFW 2013b, OIMB 2013; Hayslip et al 2006; Sigmon et al 2006; Miller and Shanks 2005; Hoffman 1980.


Table 3: Years estuary fish were documented in the Coos estuary. Grayed out portions coincide with years no seining took place for the ODFW seining project. Compiled from: ODFW 2013b, OIMB 2013; Hayslip et al 2006; Sigmon et al 2006; Miller and Shanks 2005; Hoffman 1980.

| Estuary Species | Years Documented | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 72 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |
| Arrow Goby | | | | | | | | | | | | | | | | ● | ● | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | |
| Bay Goby | | | | | | | | | | | | | | ● | ● | ● | | | | | | | | | | | | | | | | ● | ● | ● | | ● | | | | | | | | | | | | | |
| Bay Pipefish | | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | | | ● | | ● | | ● | ● | ● | ● | ● | ● |
| Buffalo Sculpin | | | | | | | | | | | | | ● | ● | ● | ● | | | | | | | | | ● | ● | | | | | | ● | ● | | ● | ● | | | | ● | | | | ● | ● | | ● | ● | ● |
| Northern Clingfish | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pacific sand lance | | | | | | | | | | | | | | ● | ● | ● | | | | | | | | | | | | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | | | | | ● | ● | ● | ● | ● | ● |
| Pacific sanddab | | | | | | | | | | | | | | ● | | ● | | | | | | | | | | | | | | | | | ● | | ● | ● | | | ● | | | | | | | | | | |
| Pacific sandfish | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pacific Staghorn Sculpin | | ● | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Penpoint Gunnel | | | | | | | | | | | | | | ● | ● | ● | | | | | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | | | | | | | ● | ● | | | | ● |
| Pile perch | | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | | | | | | ● | | | | | | ● | | ● | ● | | ● | | | ● | | | | | | ● | | | | | |
| Redtail surfperch | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | |
| Saddleback Gunnel | | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | | ● | | ● | ● | | | | | | | | | ● | ● | ● | ● | ● | ● | | | | | | | ● | ● | ● | ● | ● | ● |
| Shiner perch | | ● | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | ● | | ● | ● | ● | ● | ● | ● |
| Silver surfperch | | | | | | | | | | | | | ● | ● | ● | ● | | ● | | | | | | | | | | | | | | ● | | ● | | | | | | | | | | | ● | | | | |
| Snake Prickleback | | | | | | | | | | | | | ● | ● | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | ● |
| Speckled Sanddab | | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | | | | | | | | | | | | | | ● | ● | | ● | ● | | | | | | | | | ● | ● | | ● | ● |
| Starry Flounder | | ● | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Threespine Stickleback | | ● | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | ● | ● | ● | | ● | ● | ● | ● | | |
| Tubenose Poacher | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | |
| Tubesnout | | | | | | | | | | | | | | ● | ● | | ● | | | | | | | | ● | | | | | | | ● | ● | ● | ● | ● | ● | | | | | | | ● | | ● | | | |
| Walleye surfperch | | | | | | | | | | | | | ● | ● | ● | ● | | | | | | | ● | | | | | | | | | ● | ● | ● | ● | ● | | | | | | | | ● | | ● | ● | | ● |
| White seaperch | | | | | | | | | | | | | | ● | ● | ● | | | | | | | | | | | | | | | | ● | ● | | ● | ● | | | | ● | | | | | | | | | |

● Species present

Bay Goby (*Lepidogobius lepidus*) also use ghost shrimp burrows in intertidal flats as well as eelgrass beds. They can be found throughout the length of the Coos estuary, although specific data on their population are lacking (Wagoner et al. 1990). In a long term monitoring program by ODFW (1965-present), bay goby were found on multiple occasions in upper and lower regions of the estuary, most recently in 2000 (ODFW 2013b).

Bay Pipefish (*Syngnathus leptorhynchus*) are frequently found in estuarine habitats, especially eelgrass beds (Wagoner et al. 1990). ODFW has consistently found both adult and juvenile bay pipefish throughout the Coos estuary, as far up as the confluence of the Millicoma and South Fork Coos Rivers (ODFW 2013b). They were found by OIMB in 2013 in Joe Ney Slough (OIMB 2013).

Buffalo Sculpin (*Enophrys bison*) are often found in intertidal eelgrass beds in the lower Coos estuary (Wagoner et al. 1990). ODFW has regularly found small numbers of buffalo sculpin in the lower estuary, most recently in 2012 (ODFW 2013b). OIMB found several buffalo sculpin near Clam Island and the North Jetty in the lower estuary in 2013 (OIMB 2013).

Northern Clingfish (*Gobiesox maeandricus*) can be found in waters near rock jetties in the lower estuary, or at Fossil Pt. (Wagoner et al. 1990).

Pacific sand lance (*Ammodytes hexapterus*) are a slender schooling fish that have the unique habit of burrowing into sand – a behavior mainly exhibited during non-reproductive periods in the late fall to early spring, as well as at night during the rest of the year (Hiss 1985). In the Coos estuary, they're most commonly found in seawater zones (salinity >25) April through October (Monaco and Emmett 1990). ODFW has found Pacific sand lance in the lower Coos estuary as recently as 2013, frequently in exceedingly high numbers of both adults and juveniles (multiple seines greater than 500 individuals)(ODFW 2013). The presence of both age classes supports the idea that Pacific sand lance is not a migratory species (Hiss 1985). Pacific sand lance require clean sandy areas in which to burrow, generally in high flow areas in order to maintain good oxygenation. This habitat is often found at the mouths of estuaries (Monaco and Emmett 1990). Pacific sand lance are important prey for many bird species, as well as many fish species, including juvenile salmonids.

Pacific sanddab (*Citharichthys sordidus*) are a medium flatfish that have been found only occasionally in the Coos estuary (lower estuary or mouth of South Slough) by ODFW, most recently in 2000 (ODFW 2013b).

Pacific sandfish (*Trichodon trichodon*) are mainly found in sandy habitat in lower reaches of the Coos estuary (Wagoner et al. 1990).

Pacific Staghorn sculpin (*Leptocottus armatus*) are found in great abundance year-round in all parts of the estuary mostly in sandy habitats (Monaco and Emmett 1990). ODFW has routinely found abundant numbers of both juvenile and adult staghorn sculpin near Dellwood on the South Fork Coos River, near Allegany on the Millicoma River, past Shinglehouse Slough in Isthmus Slough, and throughout the Coos estuary (ODFW 2013b)(Figure 5). OIMB found Pacific staghorn sculpin near Clam Island and near the North Jetty in the lower estuary in 2013 (OIMB 2013). Multiple individuals were also found by OIMB at Tunnel Beach, Stacey Beach and Joe Ney Slough.

Penpoint Gunnel (*Apodichtys flavidus*) are often found in eelgrass beds in the lower estuary (Wagoner et al. 1990). ODFW has found penpoint gunnel infrequently, generally between the McCullough bridge and the mouth of the Coos estuary, as recently as 2013 (ODFW 2013b). Miller and Shanks (2005) found penpoint gunnel each year (1998-2001) near the entrance to South Slough in numbers as high as 578 (1999).

Pile perch (*Damalichthys vacca*) have been found as both juveniles and adults at the mouth of South Slough and in lower and upper portions of the estuary on numerous occasions by ODFW, most recently in 2002 (ODFW 2013b).

Redtail surfperch (*Amphistichus rhodoterus*) have been found in both lower and upper portions of the Coos estuary by ODFW as recently as 2013 (ODFW 2013b).

Saddleback Gunnel (*Pholis ornate*) are often found in eelgrass beds in the lower Coos estuary (Wagoner et al. 1990). ODFW has found saddleback gunnel on numerous occasions in the lower estuary, most recently in 2013 (ODFW 2013b). OIMB found several near Clam Island and the North Jetty in the lower Coos estuary and in Joe Ney Slough in 2013 (OIMB 2013).

Shiner perch (*Cymatogaster aggregata*) are commonly found in all parts of the Coos estuary and are known to spawn here (Wagoner et al. 1990). Both adult and juvenile shiner perch are commonly found by ODFW throughout the Coos estuary and the Coos and Millicoma River sampling areas in high numbers (>1,000 individuals per seine on multiple occurrences)(ODFW 2013). Numerous shiner perch were also captured at Joe Ney Slough by OIMB in 2013 (OIMB 2013). Although no recent studies have specifically investigated the population and distribution of this species, Wagoner et al. (1990) noted that shiner perch historically contributed to the majority of fishes retained by anglers – they cite that 58% of total fish caught in Coos Bay in 1971 were from the surfperch family. Monaco and Emmett (1990) describe shiner perch as highly abundant in the Coos estuary with highest numbers found between May and August. They also reported that July is the peak month of parturition (shiners give birth to live young), which means that juvenile shiner perch are most abundant July through October. Shiner perch are commonly associated with aquatic vegetation, docks or pilings – on sand or muddy bottoms (Bane 1968).

Silver surfperch (*Hyperprosopon ellipticum*) have been found by ODFW on numerous occasions (primarily juveniles), most recently in 2009 (ODFW 2013b). No information on habitat use in the Coos estuary is available.

Snake Prickleback (*Lumpenus sagittal*) are often found in eelgrass beds in the lower estuary (Wagoner et al. 1990). ODFW has occasionally found snake prickleback (primarily in the lower estuary), as recently as 2013 (ODFW 2013b). OIMB found one individual near Clam Island in 2013 (OIMB 2013).

Speckled Sanddab (*Citharichthys stigmaeus*) are mainly found in lower Coos estuary sandy habitats (Wagoner et al. 1990). ODFW found speckled sanddab in the lower estuary as recently as 2013 (ODFW 2013b). OIMB found numerous speckled sanddabs near Clam Island and near the North Jetty in the lower estuary in 2013 (OIMB 2013).

Starry flounder (*Platichthys stellatus*, formerly *Pleuronectes stellatus*) are flatfish found in all parts of the estuary as far up as the heads of tide. ODFW found juvenile starry flounder near Dellwood on the South Fork Coos River, near Allegany on the Millicoma River, past Shinglehouse Slough in Isthmus Slough, and in the main part of the Coos estuary, as recently as 2013 (ODFW 2013b). Wagoner et al. (1990) report that starry flounder abundance has been down since the early 1970's. Monaco and Emmett (1990) report that starry flounder adults and juveniles can be found in low numbers year-round in the Coos estuary in both mixed and marine-dominated zones (salinity > 0.5). They also report that juveniles are most abundant during May - August. Preferred habitat for starry flounder is sand or mud soft bottoms.

Three-spined stickleback (*Gasterosteus aculeatus*) are found year-round throughout the Coos estuary and into freshwater rivers and streams, in slow moving waters with soft mud or sand bottoms. Juveniles and adults form loose schools and are most abundant in the Coos estuary during August - October (Monaco and Emmett 1990). ODFW has found three-spined stickleback frequently and in large numbers (100's of individuals on multiple occasions) almost exclusively in the Coos River system, most recently in 2011 (ODFW 2013b).

Coos Watershed Association (CoosWA) has found this species at Larson and Palouse Creeks in the Haynes Inlet drainage, during their annual Coho life-cycle monitoring project. They were caught all years in both creeks (2005 – present), and in higher numbers in Palouse Creek (>100 + most years)(CoosWA 2012).

Three-spined stickleback have been documented during ODFW's Coho life-cycle monitoring project in the Winchester Creek of South Slough, again often by the hundreds annually (Suring et al. 2012)

Tubenose Poacher (*Pallasina barbata*) is mainly found in lower reaches of the Coos estuary, in sandy bottom habitat or eelgrass beds (Wagoner et al. 1990).

Tubesnout (*Aulorhynchus flavidus*) are often found in eelgrass beds in the lower estuary (Wagoner et al. 1990). ODFW (2013b) and Miller and Shanks (2005) found tubesnout in both the lower and upper portions of the Coos estuary, as recently as 2010.

Walleye surfperch (*Hyperprosopon argenteum*) were found as recently as 2013 by ODFW from the lower Coos estuary to the mouth of the Coos River (ODFW 2013b).

White seaperch (*Phanerodon furcatus*) were found as recently as 2004 by ODFW in most

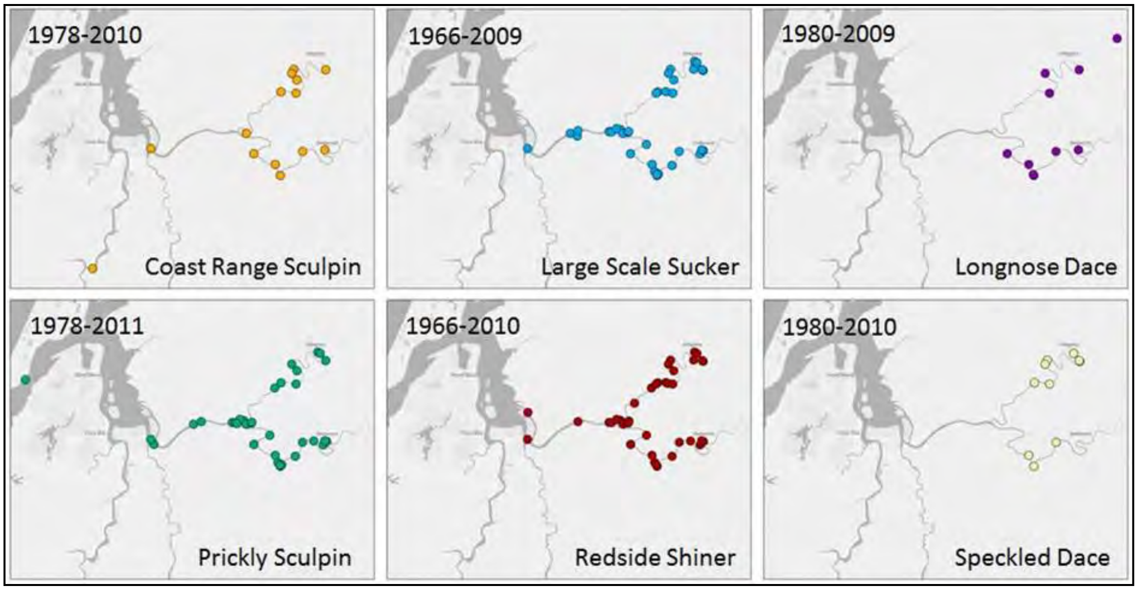



Figure 6: Location of freshwater fish species documented in the Coos River system, historically and currently (date ranges shown top left of each map). This is an under-representation, since only stations where GPS coordinates were documented are shown. Compiled from: ODFW 2013b, McPhail and Taylor 2009.

Years Documented

| Freshwater Species | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coastrange Sculpin | | | | | | | | | | | | | | ● | ● | ● | | ● | | | | ● | | ● | |
| Large Scale Sucker | | ● | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Longnose (Millicoma) Dace | | | | | | | | | | | | | | | | ● | | ● | | | | | | | |
| Prickly Sculpin | | | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Redside Shiner | | ● | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Reticulate Sculpin | | | | | | | | | | | | | | | | | | | | | | | | | |
| Speckled dace | | | | | | | | | | | | | | | | ● | | ● | | | | | | | |

| Freshwater Species | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coastrange Sculpin | ● | ● | | ● | ● | | ● | | | ● | | | | | | | | | | | ● | | | |
| Large Scale Sucker | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | ● | | ● | | | ● | | | | |
| Longnose (Millicoma) Dace | | | | | | | ● | ● | | ● | ● | | | | | | | | | | | | | |
| Prickly Sculpin | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | ● | | ● | | | | ● | ● | | |
| Redside Shiner | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | | ● | ● | ● | ● | | ● | ● | | | |
| Reticulate Sculpin | | | | | | | | | | | | | | | | | | | | | | | | |
| Speckled dace | | | ● | | | | | ● | ● | ● | | | ● | | ● | | ● | | | ● | ● | | | |

■ Species present

Table 4: Years freshwater fish were documented in the Coos estuary. Grayed out portions coincide with years no seining took place for the ODFW seining project. Compiled from: ODFW 2013b, McPhail and Taylor 2009.

sections of the estuary and in the Coos River (ODFW 2013b).

**Freshwater Fishes in the Coos Estuary** (see Figure 6 and Table 4)

Coastrange Sculpin (*Cottus aleuticus*) is a small sculpin which lives in riffles and glides of freshwater streams and is fished recreationally (mostly as a bait species)(Wagoner et al. 1990). ODFW has found coastrange sculpin in both the Millicoma and South Fork Coos Rivers as recently as 2010 (ODFW 2013b).

Large Scale Sucker (*Catostomus macrocheilus*) is native to the Coos River system and fished recreationally (mostly as a bait species) (Wagoner et al. 1990). ODFW has caught large scale suckers only on several occasions, exclusively in the Coos and Millicoma River systems, sometimes by the hundreds, and most recently in 2009 (ODFW 2013b).

Longnose dace (*Rhinichthys cataractae*) are small freshwater minnows that live in fast-flowing streams among gravel substrates.

They are important prey for larger fishes including salmonids (Bisson and Reimers 1977). Locally, this species is known as the Millicoma dace and is recognized as a separate race, if not a separate subspecies, endemic to the Coos River system (ORBIC 2013; ODFW 2006; Kavanagh et al. 2005). McPhail and Taylor (2009) used DNA techniques to conclude that the Millicoma dace are unique enough to warrant their own species designation. ODFW found dace only infrequently, most recently in 2000, where substrate varied between sand and gravel to mud (ODFW 2013b). The Millicoma dace is federally listed as a species of concern (ORBIC 2013) and state rankings say it is "imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction or extirpation" (ODFW 2006). It has been found on both the West and East forks of the Millicoma River as well as the South Fork Coos River (Kavanagh et al. 2005).

Prickly Sculpin (*Cottus asper*) are native to the Coos River system and are fished recreationally (mostly as a bait species)(Wagoner et al. 1990). ODFW found prickly sculpin in relatively large numbers (20+ individuals) on numerous occasions in both the Millicoma and Coos River systems, and found them most recently in 2011 near Dellwood (ODFW 2013b).

Redside shiner (*Richardsonius balteatus*) is native to the Coos River system and recreationally fished (mostly as a bait species) (Wagoner et al. 1990). ODFW found redside shiners numerous times, almost exclusively in the Coos and Millicoma River systems. They have frequently been found by the hundreds as both juveniles and adults, most recently in 2010 (ODFW 2013b).

Reticulate Sculpin (*Cottus perplexus*) live in rubble or gravel substrate of streams, often in riffles. They are a native fish in the Coos River system and are recreationally fished (mostly as a bait species)(Wagoner et al. 1990).

Speckled dace (*Rhinichthys osculus*) are native to the Coos River system and recreationally fished (mostly as a bait species)(Wagoner et al. 1990). ODFW have found speckled dace on numerous occasions in the Millicoma and South Fork Coos, most recently in 2010 (ODFW 2013b).

**Infrequently Encountered Fishes in the Coos Estuary** (see Figure 7 and Table 5)

Several fish species have been found very infrequently by ODFW during their long-term fish sampling program. These fish are either rare visitors to the Coos estuary, inhabit deeper parts of the estuary (so not typically captured by the beach seining techniques used by ODFW), or are not readily caught in seine nets. These fish include the following marine species: C-O sole (*Pleuronichthys coenosus*) caught once in 1996; Crescent gunnel (*Pholis laeta*) seen once in 1997; Curlfin turbot (*Pleuronichthys decurrens*) found in two different years, most recently 1996; the eel-like high cockscomb (*Anoplarchus purpurescens*) found twice, last in 1999; Padded sculpin (*Artedius fenestrlis*) last found in 1979; Rainbow seaperch (*Hypsurus caryi*) last documented in 1977; Rex sole (*Glyptocephalus zachirus*) found once in 1997;

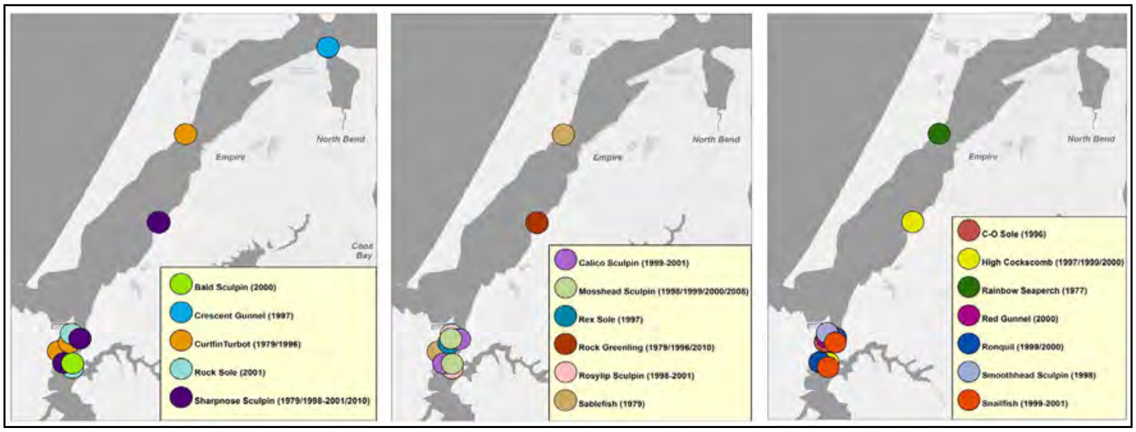



Figure 7:Locations of fish species infrequently encountered in the Coos estuary during ODFW's long term seining program. This is an under-representation of Infrequent Visitors, since only stations where GPS coordinates were documented are shown. Dates each species was found are shown next to each name. Data from: ODFW 2013b.

Years Documented

| Infrequent Species | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bald sculpin |||||||||||||||||||||||||||||||||||●||||||||||||||
| C-O sole |||||||||||||||||||||||||||||||●|||||||||||||||||||
| Calico sculpin ||||||||||||||||||||||||||||||||||●|●|●||||||||||||
| Crescent gunnel ||||||||||||||||||||||||||||||||●||||||||||||||||||
| Curlfin turbot ||||||||||||||●||||||||||||||||●|||||||||||||||||||
| High cockscomb ||||||||||||||||||||||||||||||||●||●|●|||||||||||||
| Mosshead sculpin |||||||||||||||||||||||||||||||||●||●|●||||||||●|||||
| Padded sculpin ||||||||||||||●||||||||||||||||||||||||||||||||||||
| Plainfin midshipman |||||||||||||||||||||||||||||||||||||||||||●|||||
| Rainbow seaperch ||||||||||||●||||||||||||||||||||||||||||||||||||||
| Red gunnel |||||||||||||||||||||||||||||||||||●||||||||||||||
| Rex sole ||||||||||||||||||||||||||||||||●||||||●|||||||||||
| Rock greenling ||||||||||||||●||||||||||||||||●||||||||||||||●|||
| Rock Sole ||||||||||||||||||||||||||||||||||||●|||||||||||||
| Ronquil ||||||||||||||||||||||||||||||||||●|●||||||||||||||
| Rosylip sculpin |||||||||||||||||||||||||||||||||●|●|●|●||||||||||||
| Sablefish ||||||||||||||●||||||||||||||||||||||||||||||||||||
| Sharpnose sculpin ||||||||||||||●|||||||||||||||||||●|●|●|●|||||||||●|||
| Smoothhead sculpin |||||||||||||||||||||||||||||||||●|||||||||||||||||
| Snailfish ||||||||||||||||||||||||||||||||||●|●|●||||||||||||

● Species present

Table 5: Years infrequently encountered fish were documented in the Coos estuary. Grayed out portions coincide with years no seining took place for the ODFW seining project. Compiled from: ODFW 2013b; Hayslip et al 2006; Miller and Shanks 2005.

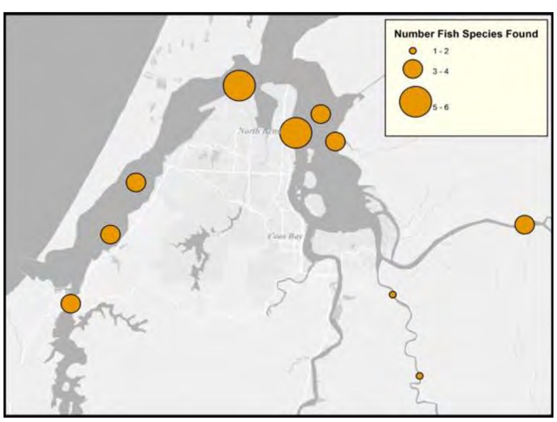



Figure 8: EMAP/CEMAP station locations. Size of symbol is proportional to the number of species found at each station during the 1999 survey. Data: Hayslip et al 2006; Sigmon et al 2006.

Rock greenling (*Hexagrammos lagocephalus*) documented in three different years, most recently in 2010; sablefish (*Anoplopoma fimbria*) documented at several stations in 1979; and sharpnose sculpin (*Clinocottus acuticeps*) found by Miller and Shanks (2005) each year (1998-2001) near the entrance to South Slough (highest numbers caught: 18 in 1999; caught most recently in 2010). In addition, Miller and Shanks found the following larvae or juvenile fishes in very small amounts (<5/ year on average) except where otherwise noted: Bald sculpin (*Clinocottus recalvus* ) in 2000; Calico sculpin (*Clinocottus embryum*) in 1999-2001 (caught in variable numbers- maximum was 13 individuals in 2000); Mosshead sculpin (*Clinocottus globiceps*) in 1998, 2000, 2001 (caught in variable numbers- maximum was 14 individuals in 1998); Red Gunnel (*Pholis schultzi*) in 2000; Rock sole (*Lepidopsetta bilineata*) in 2001; Ronquil (*Ronquilus jordani* ) in 1999; Rosylip sculpin (*Ascelichthys rhodorus*) in 1998-2001 in relatively large quantities (241 in 1999); Smoothhead sculpin (*Artedius lateralis*) in 1998; Snailfish (*Liparis sp.*) in 1999-2001.

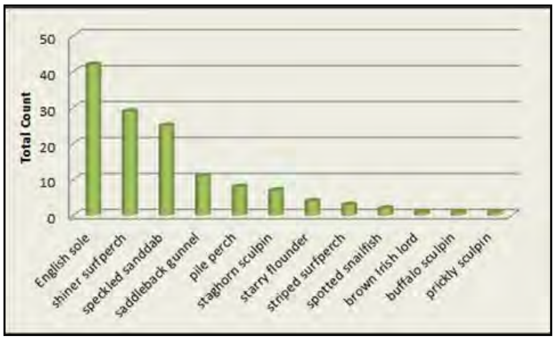



Figure 9: Combined counts of all species found in all trawls for all Coos Bay stations during the 1999 sampling season. Data: Hayslip et al 2006; Sigmon et al 2006.

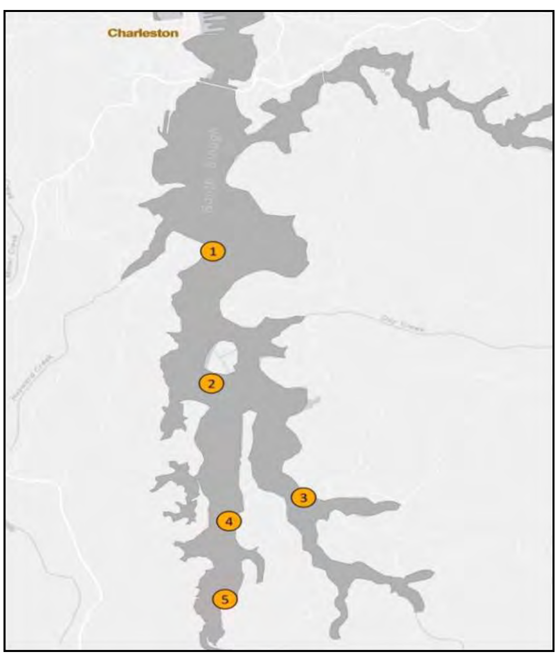



Figure 10: Sampling stations used by Bottom et al 1988

**Fish Diversity in the Coos Estuary**

Despite scientists' limited understanding of the populations and distribution of many native fish populations, a joint study by the United States Environmental Protection Agency (USEPA) and the Oregon Department of Environmental Quality (ODEQ) demonstrated the high diversity of species that exists in the Coos estuary. The project, called EMAP by USEPA (Hayslip et al. 2006), and CEMAP by ODEQ (Sigmon et al. 2006), measured fish abundance, species richness, and diversity in small estuaries from San Francisco to Puget Sound. Coos Bay sampling stations in 1999 produced a high of six species per trawl and nine out of 11 stations netted more than two species per trawl. In contrast, half of all stations in all estuaries sampled in the same year produced only one or two species per trawl, suggesting relatively high fish species diversity in the Coos estuary (Figure 8). Fish species found in the 1999 Coos estuary trawls are shown in Figure 9.

Bottom et al. (1988) described the multiple habitats fishes use in estuaries by examining fish community structure in South Slough. They seined five locations on four occasions, choosing the dry season (April-early Oct), so marine fishes using the estuary would be included in the study (Figure 10). For all but one station, they seined over mud flats near fringing marshes at high tide, and in tidal channels at low tide. One station was only sampled at low tide.

Bottom et al. found that species richness was consistently higher in low tide channel habitats than in high tide tideflat habitats and that species richness decreased along a gradient from the mouth of South Slough, directly correlated with decreasing salinity. Species richness in the entire system was highest in July, while total abundance of fishes in the system peaked in June (Figure 11). Figure 12 shows abundance of each fish species found in this study.

Habitat played an important role in determining fish community structure. Most of the transient marine or anadromous species were found in tidal channels (e.g., rockfish or northern anchovy), while the upper slough appeared to be an important spawning and nursery ground for marine fishes (e.g., Pacific herring and English sole, respectively). Adult white surfperch, adult walleye surfperch, adult topsmelt and adult pile perch represented the oldest and largest fishes found and were almost exclusively found in tidal channels closest to the mouth of South Slough. In contrast, important habitat for rearing juveniles of many species are located in the upper estuary and were the first nursery areas in the estuary to be occupied (generally by shiner surfperch and staghorn sculpin). Of all stations, the upper estuary sampling station (5) produced the highest densities of juvenile fishes by far.

Data from ODFW's long term seining program appear to agree with some of the findings from Bottom et al. Specifically, these data show differences in species richness in lower estuary sampling sites (more species per seine/higher salinity) compared with Coos River stations (fewer species per seine/lower salinity)(derived from unpublished data ODFW2013b). The logical explanation is that large numbers of marine species use the higher salinity portions of the estuary, compared with the relatively smaller numbers of fresh water fish species.

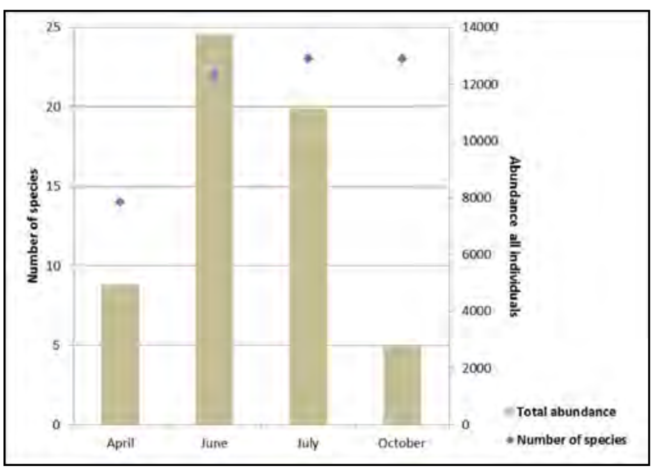
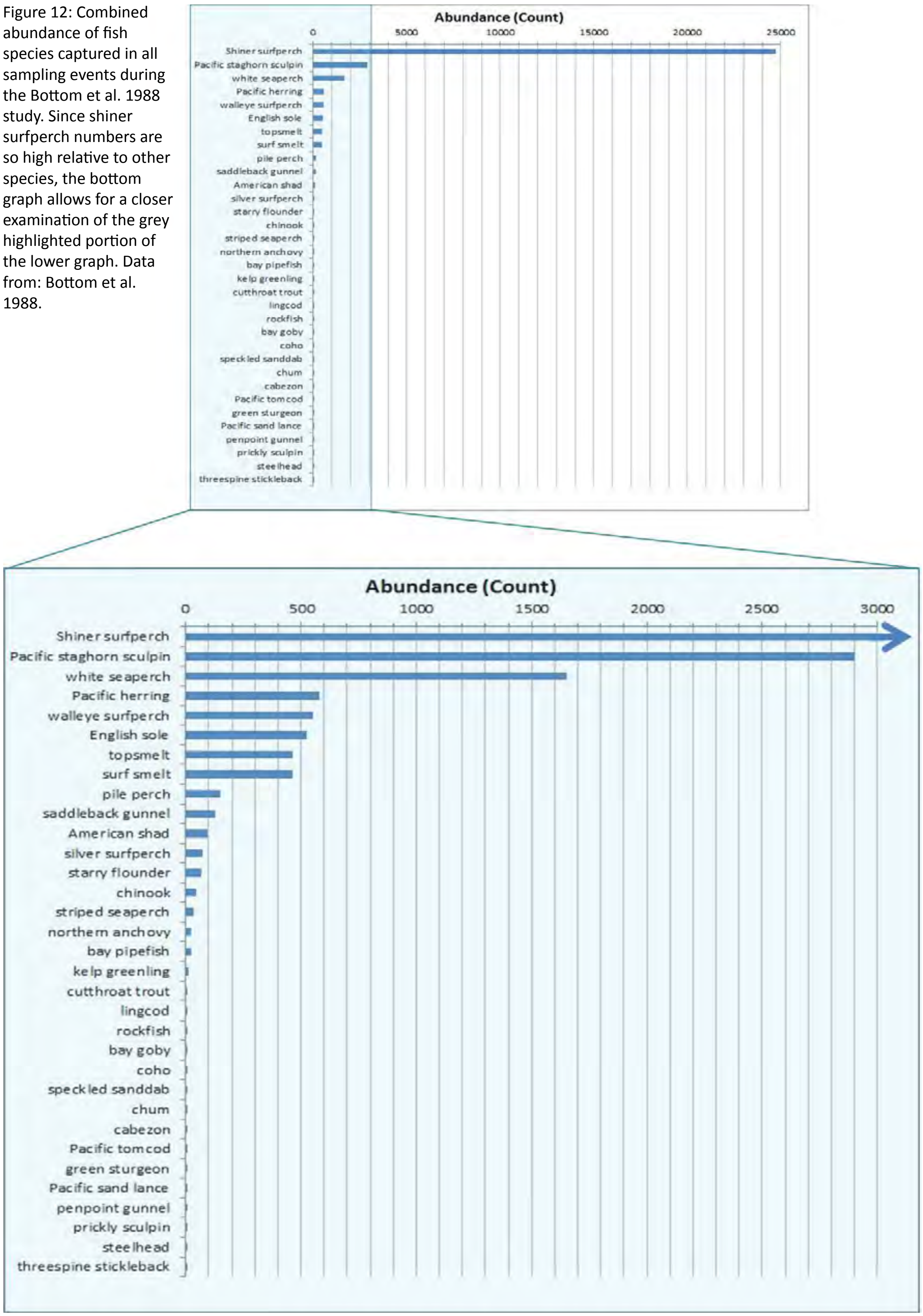



Figure 11: Combined species diversity from 5 stations in the South Slough (shown as blue diamonds with left axis) and combined fish counts at all stations (shown as beige bars with right axis) over the course of 4 seining events (months shown). Data: Bottom et al. 1988

Figure 12: Combined abundance of fish species captured in all sampling events during the Bottom et al. 1988 study. Since shiner surfperch numbers are so high relative to other species, the bottom graph allows for a closer examination of the grey highlighted portion of the lower graph. Data from: Bottom et al. 1988.



**References**

Bane, G. W. 1968. Fishes of the upper Newport Bay. University of California at Irvine Res. Ser.3:1-114.

Barboza, T. West Coast Sardine Crash Could Radiate Throughout Ecosystem. Los Angeles Times. January 5, 2014. Retrieved from: http://www.latimes.com/science/la-me-sardine-crash-20140106,0,3689464.story?page=1#axzz2re06eWnH

Bisson, P. A., and P. E. Reimers. 1977. Geographic Variation among Pacific Northwest Populations of Longnose Dace, *Rhinichthys cataractae*. Copeia. 1977 (3): 518-522.

Bottom, D. L., K. K. Jones, and J. D. Rodgers. 1988. Fish community structure, standing crop, and production in upper South Slough (Coos Bay), Oregon. Charleston, Or: South Slough National Estuarine Research Reserve.

Coos Watershed Association (CoosWA) 2012. [Coho life-cycle monitoring program]. Unpublished raw data.

Dillman, T. 2013. Fishery Managers Scale Back Sardine Harvest. Fishermen's News. December 1, 2013. Retrieved from: http://www.fishermensnews.com/story/2013/12/01/features/fishery-managers-scale-back-sardine-harvest/225.html

Eschmeyer, W.N., and E. S. Herald. 1983. A field guide to Pacific Coast fishes of North America: from the Gulf of Alaska to Baja, California. Boston: Houghton Mifflin.

Hart, J. L., and W. A. Clemens. 1973. Pacific fishes of Canada. Ottawa: Fisheries Research Board of Canada.Hayslip, G., L. Edmond, V. Partridge, W. Nelson, H. Lee, F. Cole, J. Lamberson , and L. Caton. 2006. Ecological Condition of the Estuaries of Oregon and Washington.

Hayslip, G., L. Edmond, V. Partridge, W. Nelson, H. Lee, F. Cole, J. Lamberson , and L. Caton. 2006. Ecological Condition of the Estuaries of Oregon and Washington. EPA 910-R-06-001. U.S. Environmental Protection Agency, Office of Environmental Assessment, Region 10, Seattle, Washington.

Hill, K.T., P. R. Crone, N. C.H. Lo, D. A. Demer, J.P. Zwolinski, B. J. Macewicz. 2012. Assessment of the Pacific Sardine Resource in 2012 for U.S. Management in 2013. NOAA National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA.

Hiss, J.M. 1985. Summary of the Life History of Pacific Sand Lance (*Ammodytes hexapterus*) and its Distribution in Relation to Protection Island National Wildlife Refuge. U.S. Fish and Wildlife Service, Olympia, WA.

Hoffman, Carol Jane. 1980. Associative behavior of the arrow goby, *Clevelandia ios* (Jordan and Gilbert) and the ghost shrimp, *Callianassa californiensis* Dana. Thesis (M.S.)--University of Oregon.

Kavanagh, P., K. Jones, C. Stein, P. Jacobsen. 2005. Fish Habitat Assessment in the Oregon Department of Forestry Elliott Study Area. Oregon Department of Fish and Wildlife, Corvallis, OR.

Kramer, D. E., W. H. Barss, B. C. Paust and B. E. Bracken. 1995. Guide to Northeast Pacific flatfishes: families Bothidae, Cynoglossidae, and Pleuronectidae. Fairbanks, Alaska: Alaska Sea Grant College Program, University of Alaska, Fairbanks.

Kruse, G. H. 1984. A simulation model of English sole (*Parophrys vetulus*) recruitment mechanisms. Thesis (PhD) – Oregon State University.

Lassuy, D. R. 1989a. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- English sole. U.S. Fish Wildlife Service Biolical Report: 82(11.101). U.S. Army Corps of Engineers, TR EL-82-4. 17 pp.

Lassuy, D. R. 1989b. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) – Pacific herring. U.S. Fish Wildlife Service Biolical Report: 82(11.126). U.S. Army Corps of Engineers, TR EL-82-4. 18 pp.

McPhail, J. D., and E. B. Taylor. 2009. Phylogeography of the longnose dace (*Rhinichthys cataractae*) species group in northwestern North America - the origin and evolution of the Umpqua and Millicoma dace. Canadian Journal of Zoology. 87 (6).

Miller, B. and E. McRae. 1978. Herring spawn survey, Coos Bay, Oregon: winter 1977-78. Oregon Department of Fish and Wildlife.

Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. [Sacramento]: State of California, Dept. of Fish and Game.

Miller, J.A., and A.L. Shanks. 2004. Ocean-estuary coupling in the Oregon upwelling region: abundance and transport of juvenile fish and of crab megalopae. Marine Ecology Progress Series. 271: 267-279.

Miller, J. A. and A. L. Shanks. 2005. Abundance and distribution of larval and juvenile fish in Coos Bay, Oregon: a time-series analysis based on light trap collections. Marine Ecology Progress Series 305:177-191.

Monaco, Mark E., and Robert L. Emmett. 1990. Distribution and abundance of fishes and invertebrates in West Coast estuaries. V1 and v2. Rockville, Md: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Oregon Biodiversity Information Center Institute for Natural Resources, Portland State University, Portland, OR.

Oregon Department of Fish and Wildlife (ODFW). 2006. The Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, OR. Retrieved from: http://www.dfw.state.or.us/conservationstrategy/contents.asp#spec

Oregon Department of Fish and Wildlife (ODWF). 2012. Sport Fishing Catch Statistics. Retrieved from: http://www.dfw.state.or.us/resources/fishing/sportcatch.asp

Oregon Department of Fish and Wildlife (ODFW). 2013a. Oregon Adult Salmonid Inventory & Sampling Project (OASIS). Retrieved from: http://oregonstate.edu/dept/ODFW/spawn/cohoabund.htm

Oregon Department of Fish and Wildlife (ODFW). 2013b. [Coos fish monitoring seine program]. Unpublished raw data.

Oregon Institute of Marine Biology (OIMB). 2013. [Fish class seining and trawling data]. Unpublished raw data.

Richardson, S. L., J. R. Dunn, and N. H. Naplin. 1980. Eggs and larvae of butter sole, I*sopsetta isolepis*, (Pleuronectidae), off Oregon and Washington. Fish. Bull. 78:401–417.

Rooper, Christopher N., Donald R. Gunderson, and David A. Armstrong. 2003. Patterns in Use of Estuarine Habitat by Juvenile English Sole (*Pleuronectes vetulus*) in Four Eastern North Pacific Estuaries. Estuaries. 26 (4): 1142-1154.

Schlosser, S. C. and J. Bloeser. 2006. The collaborative study of juvenile rockfish, cabezon, and kelp greenling habitat associations between Morro Bay, California and Newport, Oregon. UC San Diego: California Sea Grant College Program.

Sigmon C.L.T., Caton L., Coffeen G., Miller S., 2006. Coastal Environmental Monitoring and Assessment Program. The Condition of Oregon's Estuaries in 1999, a Statistical Summary. Oregon Department of Environmental Quality, Laboratory. DEQ04-LAB-0046-TR.

Stevenson J.C. 1962. Distribution and survival of herring larvae (*Clupea pallasi* Valenciennes) in British Columbia waters. Journal of the Fisheries Research Board of Canada. 19:735-810.

Stewart, I. J. 2005. Status of the U.S. English sole resource in 2005. National Marine Fisheries Service, Seattle, WA.

Suring, E., R.J. Constable, C.M. Lorion, B.A. Miller, D.J. Wiley. 2012. Salmonid Life Cycle Monitoring in Western Oregon streams, 2009-2011. Monitoring Program Report Number OPSW-ODFW-2012-2, Oregon Department of Fish and Wildlife, Salem.

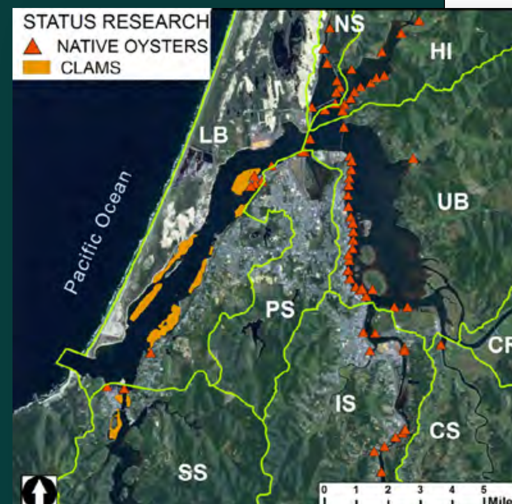
Wagoner, L.J., K.K. Jones, R.E. Bender, J.A. Butler, D.E. Demory, T.F. Gaumer, J.A. Hurtado, W.G. Mullarky, P.E. Reimers, N.T. Richmond and T.J. Rumreich. 1990. Coos River Basin Fish Management Plan. Oregon Department of Fish and Wildlife, Salem, OR.

# Chapter 14: Clams and Native Oysters in the Coos Estuary

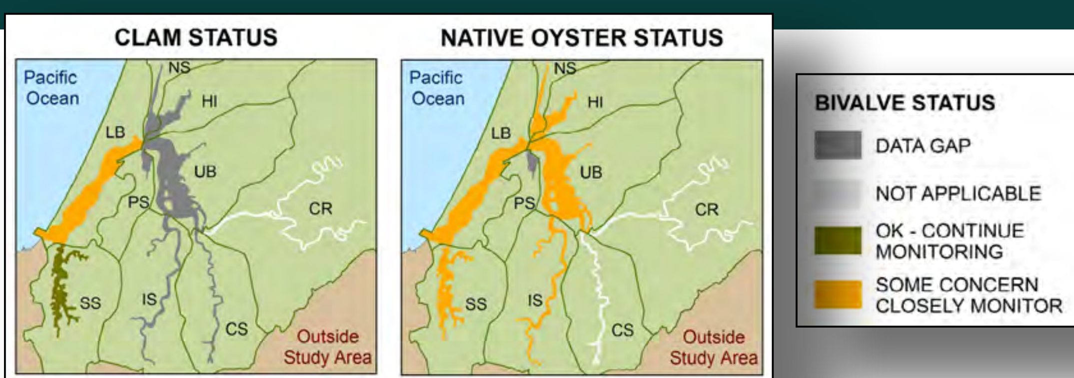
*Craig Cornu, Erik Larsen, Colleen Burch Johnson- South Slough NERR*

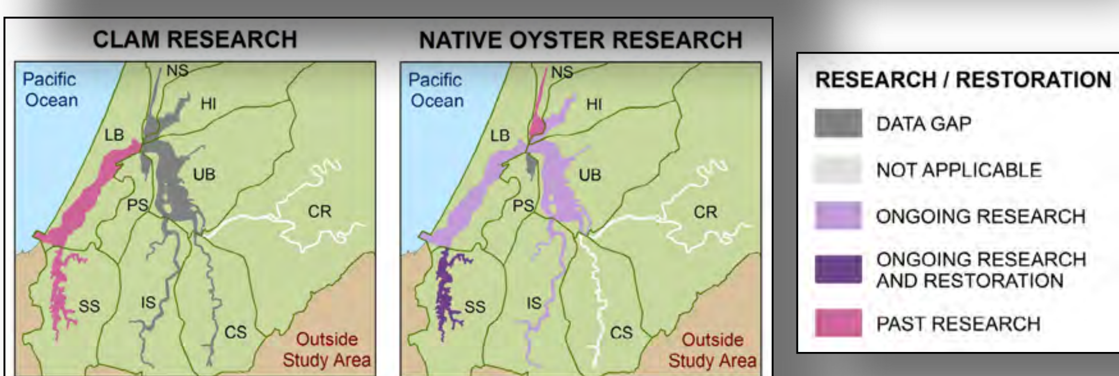
***Clams:*** *In ODFW study areas, the status of butter and gaper clams has improved since the last inventory (1979) while the status of native littleneck clams and cockles has declined.*

***Native Oysters:*** *Olympia oyster populations appear to be stable and even increasing. A 2006 survey shows native oysters present in multiple Coos estuary subsystems including particularly dense patches in the Upper Bay.*




Subsystems: CR- Coos River, CS- Catching Slough, HI- Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay



## Chapter 14: Clams and Native Oysters in the Coos Estuary

*This section includes two data summaries: **Recreational Clams** and **Native Oysters**— which describe the status and trends (where the data allow) of bivalve populations in the Coos estuary.*

Data detailing the status of recreational clams are available for two of the Coos estuary subsystems (South Slough and Lower Bay). The most recent data come from the Shellfish and Estuarine Assessment of Coastal Oregon (SEACOR) project, which was conducted by the Oregon Department of Fish and Wildlife (ODFW) in 2009.

Historic data describing the status of recreational clams from the 1920s to the 1970s are also available in published research documents, and collectively cover the remaining subsystems.

It should be noted that while these historic data are useful for providing insight into the status of recreational clams over time, they also present some challenges (see Data Gaps and Limitations). Some current data gaps will likely be filled when ODFW conducts more comprehensive clam monitoring in the Coos estuary again in 2014 or 2015.

Information about the status of native oysters is relatively complete for subsystems with oyster habitat (all except the Catching Slough and Coos River subsystems). Most of the native oyster data summarized in this chapter came from a cooperative project between the South Slough Reserve and ODFW which resulted in a published paper describing the presence of native oysters in the Coos estuary (Groth and Rumrill 2009). Research conducted by the Oregon Institute of Marine Biology (OIMB) in the South Slough, Lower Bay, Haynes Inlet, Upper Bay and Isthmus Slough subsystems was also used.

In addition, this chapter includes information about ongoing native oyster restoration efforts in the South Slough subsystem.

**Data Gaps and Limitations**

Recreational Clam Data: Assessing the status of recreational clams in Coos Bay is made difficult by gaps and limitations in the data. For example, published records detailing the status of clams are often geographically limited or outdated. The most recent data are from the SEACOR study, which focused on only two of the Coos estuary subsystems (McCrae 2009). Prior to the 2009 SEACOR project, the next most recent data for clams date back to 1979 (Bottom et al. 1979, Hancock 1979).

Additionally, methodological differences among the studies complicate status comparisons of clams in the Coos estuary. Direct comparisons are only possible where trends in the status of clams over time are clear and unrelated to methodological differences alone. The historical data provide general snapshots of clam populations at specific times in the past. The geographic and temporal spottiness of the clam data is understood and will be corrected when ODFW conducts more comprehensive SEACOR studies in the Coos estuary.

Native Oyster Data: An assessment of the status of native oysters in the Coos estuary is subject to its own set of limitations. Although status data from Groth and Rumrill (2009) are geographically comprehensive, the data are qualitative, thereby making quantitative analyses difficult. Furthermore, the status of native Olympia oysters in Coos Bay has been infrequently studied, though research is currently being conducted (e.g., 2012-13 OIMB Master theses) and will be included in this inventory when project results become available.

**Non-Indigenous Bivalves**

Non-indigenous and invasive clam and oyster species in the Coos estuary are not addressed in this chapter. For the status of non-native bivalve populations, including species such as the purple varnish clam (*Nuttallia obscurata*), see Chapter 18: Non-Indigenous and Invasive Species. The status and distribution of commercial oyster cultivation, including the non-indigenous Pacific oyster (*Crassostrea gigas*) is also discussed in Chapter 18.

**References**

Bottom, D. and B. Kreag, F. Ratti, C. Roye, R. Starr. 1979. Habitat classification and inventory methods for the management of Oregon estuaries. [Oregon Department of Fish and Wildlife final estuary inventory project report]. 84 pp.

Groth, S. and S. Rumrill. 2009. History of Olympia oysters (*Ostrea lurida* Carpenter 1864) in Oregon estuaries, and a description of recovering populations in Coos Bay. Journal of Shellfish Research 28(1): 51-58.

Hancock, D. R. 1979. Subtidal clam populations: distribution, abundance, and ecology. Oregon State University, Sea Grant College Program. Corvallis, OR.

McCrae, J. 2009. SEACOR Shellfish and Estuarine Assessment of Coastal Oregon. Oregon Department of Fish and Wildlife, Marine Resources Program. Newport, OR.

# How the Local Effects of Climate Change Could Affect Clams and Native Oysters

*There are several climate change-related effects expected on the Oregon coast that have the potential to affect the abundance, distribution and "consume-ability" of recreational clams and native oysters:*

- *Rising sea levels are expected to cause shifts in the distribution of clam and oyster beds*
- *Ocean acidification is expected to change the rate at which clams and oysters can form their shells*
- *Higher ocean temperatures are expected to result in more harmful algal blooms in estuaries and facilitate invasive species invasions*

Clam diggers near Charleston

Native oysters in South Slough

**Sea Level Rise**

Apart from the obvious effects on developed lowlands in the project area (residential, commercial, and industrial lands), sea level rise (SLR) has the potential to affect clam and oyster habitat. SLR could change the duration and frequency of tidal inundation and tidal current velocities in the sand flat, mud flat, and channel bank habitats favored by clams and oysters. Change in the quality of these habitats will unquestionably affect where clams and oysters will be able to survive. However, one very important unanswered question is how much change will actually occur as sea levels rise. Scientists have not yet determined whether sand flat and mudflat elevations relative to tidal levels will be able to keep pace with SLR. In other words, sedimentation rates may adjust with sea level rise so sand and mud flats remain about the same elevation relative to tidal levels as they are now, resulting in very little change in the abundance and species composition of current clam and oyster habitat in the Coos estuary. Determining the likelihood of these habitats to keep pace with SLR is the subject of several research proposals for which scientists are currently seeking funding.

***Sea Level Rise***

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, according to the National Research Council (NRC), predicted SLR rates for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary), are reported as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100.*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

Other changes to the physical characteristics of these habitats are likely to have a direct effect on the status of the benthic community. According to a recently published study by Yamanaka et al. (2013)(based on three estuaries in the United Kingdom), anticipated physical SLR-related changes to clam and oyster habitat include coarser sediment grain size; steeper channel bank, sand and mud flat slopes; higher salinities; and higher exposure to wave action. They also suggest changes may be further exacerbated by other characteristics often associated with climate change, such as increased frequency of storms.

Their study suggests that the effects of SLR on clam and oyster habitat are likely to be determined by the varied and complex interactions among all these physical habitat attributes rather than any one factor acting alone. They warn that accelerated sea level rise is likely to make estuarine intertidal areas less diverse and less productive through declines in species abundance, diversity, and "community metabolism" (a measure of the oxygen consumed by all individual invertebrates, used as an index of ecosystem function).

These negative effects are potentially intensified by coastal development pressures. As sea levels rise, it is unlikely that coastal communities will allow intertidal habitats to migrate inland where high value real estate exists. Consequently, intertidal estuarine organisms like clams and oysters may be at high risk for being squeezed between unfavorable changes to their environment and hard coastal defenses (Yamanaka et al. 2013).

**Ocean Acidification**

Clams and oysters, having shells made from calcium carbonate, are at particular risk from the lowering pH levels of ocean waters. According to researchers including Barton et al. (2012), the relative corrosiveness of seawater caused by lowering pH levels may cause adult and juvenile bivalves to have trouble forming and maintaining their shells. Because of changes in the carbonate chemistry of the increasingly acidic ocean waters, fewer carbonate ions are available for uptake by marine organisms. Carbonate ions are the primary

### *Ocean Acidification*

*Since the late 18th century, the average open ocean surface pH levels worldwide have decreased by about 0.1 pH units, a decrease of pH from about 8.2 before the industrial revolution to about 8.1 today. A 0.1 change in pH is significant since it represents about a 30 percent increase in ocean acidity (the pH scale is logarithmic, meaning that for every one point change in pH, the actual concentration changes by a factor of ten). Scientists estimate that by 2100 ocean waters could be nearly 150% more acidic than they are now, resulting in ocean acidity not experienced on earth in 20 million years. The best Pacific Northwest ocean acidification data we have so far are from the Puget Sound area, where pH has decreased about as much as the worldwide average (a decrease ranging from 0.05 to 0.15 units).*

*Sources: Feely et al. 2010, NOAA PMEL Carbon Program 2013*

building blocks for bivalve shells.

Shellfish hatcheries on the West Coast have been directly affected by ocean acidification. For example, in 2007, the Whiskey Creek Shellfish Hatchery in Netarts Bay, OR suffered losses in commercial Pacific oyster (*Crassostrea gigas*) larvae production. Oyster larvae were dying because they couldn't build their shells in the low pH seawater used at the hatchery; without shells, oyster larvae can't form feeding and swimming appendages (Barton et al. 2012).

Acidification may indirectly impact clams and oysters by limiting food availability. Research suggests that a reduction in carbonate ions may negatively affect "calcifying" plankton species that require specific water chemistry for maintaining external calcium carbonate skeletons (Orr et al. 2005; Fabry et al. 2008). Plankton species may also be impacted by a decrease in other critical nutrients. For example, Shi et al. (2010) have demonstrated that acidification has a harmful effect on marine phytoplankton by limiting the bioavailability of iron.

**Increasing Ocean Temperature**

Increasing ocean temperature is likely to affect clams and oysters by contributing to sea level rise (SLR) and by contributing to an increased frequency and duration of harmful algal blooms.

Research shows a strong correlation between increasing ocean temperature and sea-level rise (Rahmstorf 2007; Domingues 2008; Vermeer and Rahmstorf 2009). As ocean water temperature increases, it expands, filling larger volumes. Higher ocean temperatures also contribute to SLR by accelerating glacier and polar ice cap melting, by providing lubricating melt water, and by promoting the loss of buttressing ice shelves that support ice further inland (Rahmstorf 2007).

Rising sea levels will likely affect clam and oyster habitat as described previously in this overview.

Other ocean temperature-SLR feedback loops exist. For example, research suggests a positive correlation between ocean temperature and increased severity and frequency of storms (Knutson et al. 2010; Webster et al. 2005; McCabe et al. 2001). This is likely to worsen the anticipated impacts of sea level rise on bivalves (Yamanaka et al. 2013).

According to the United States Environmental Protection Service (USEPA), increasing ocean temperatures may also contribute to an increased frequency and intensity of harmful algal blooms (HABs). Combined with other climate-related changes including high nutrient levels, warm ocean waters provide the ideal conditions for explosive algae growth (USEPA 2013a). These overly abundant algal "blooms" can damage aquatic ecosystems by blocking sunlight and depleting the oxygen required by other organisms, including those that directly or indirectly contribute to clam and oyster food resources (USEPA 2013a).

One example of a potential algal bloom that produces toxins harmful to humans and animals is cyanobacteria (blue-green "algae"). Cyanobacteria are particularly well-suited for increased exposure to UV radiation, higher ocean temperatures, and low-oxygen environments, because they evolved in ancient oceans that had many of the same characteristics as climate-altered modern oceans (Paul 2008). The exposure of clams and oysters (as

*Increasing Ocean Temperatures*

*Worldwide, ocean temperatures rose at an average rate of 0.07° C (0.13° F) per decade between 1901 and 2012. Since 1880, when reliable ocean temperature observations first began, there have been no periods with higher ocean temperatures than those during the period from 1982 – 2012. The periods between 1910 and 1940 (after a cooling period between 1880 and 1910), and 1970 and the present are the times within which ocean temperatures have mainly increased.*

*Describing how the worldwide trend translates to trends off the Oregon coast is a complicated matter. Sea surface temperatures are highly variable due to coastal upwelling processes and other climatic events that occur in irregular cycles (e.g., El Niño events). We do have 27 years (1967-1994) of water temperature data collected from near the mouth of the Coos estuary that indicate through preliminary analyses a very weak trend towards warming water temperatures. Fifteen years (1995-2010) of data from multiple stations further up the South Slough estuary show very little water temperature change.*

*Sources: USEPA 2013b, SSNERR 2013, Cornu et al. 2012* well as other shellfish) to blooms of cyanobacteria and other HABs places these bivalves off-limits for human consumption. In communities with commercial clam, oyster, and other shellfish fisheries, HABs represent real potential costs to regional economies (Hoagland et al. 2002).

Warming ocean trends may also promote the establishment of invasive species in coastal and estuarine waters, potentially exacerbating HABs, disrupting clam and oyster food resources, and introducing new parasites to clam and oyster (and other shellfish) populations. Research suggests that warmer ocean temperatures may give introduced species a competitive edge by increasing the magnitude of growth and recruitment of exotic species relative to their native counterparts (Stachowicz et al. 2002).

Warmer ocean temperature regimes may alter the species composition of local biota by facilitating the movement of temperature-constrained marine and estuarine species towards areas formerly too cool for habitation. In the case of exotic species transported across oceans or continents by humans, warmer ocean waters may provide increasingly suitable habitats for purposefully or inadvertently introduced invasive species, creating additional threats to local clam and oyster populations (Stachowicz et al. 2002).

*Local Effects of Harmful Algal Blooms*

*On the Oregon coast, there are several plankton species that can have adverse ecological and socioeconomic effects through harmful algal blooms (HABs). Local diatoms and dinoflagellates (*Pseduo-nitzchia spp.*,* Alexandrium spp.*, and* Akashiwo sanguinea*) produce a neurotoxin that is associated with amnesic shellfish poisoning in humans. "Alexandrium blooms" appear to be primarily responsible for HABs and the closure of shellfisheries on the southern Oregon coast. Contamination of shellfish south of Cape Blanco is strongly correlated with late-summer upwelling, and the expected changes to upwelling patterns associated with climate change may significantly affect the frequency and distribution of HABs on the west coast.*

*Sources: OCCRI 2010, Tweddle et al. 2010, Bakun 1990, Schwing and Mendelssohn 1997*

## References

Bakun, A. 1990. Global climate change and intensification of coastal ocean upwelling. Science 247(4939): 198-201.

Barton A., B. Hales, G. G. Waldbusser, C. Langdon, and R. A. Feely. 2012. The Pacific oyster, *Crassostrea gigas*, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. Limnology and Oceanography 57(3): 698-710.

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. [Report prepared for the Partnership for Coastal Watersheds Steering Committee]. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Domingues, C. M., J. A. Church, N. J. White, P. J. Gleckler, S. E. Wijffels, P. M. Barker, and J. R. Dunn. 2008. Improved estimates of upper-ocean warming and multi-decadal sea-level rise. Nature 453: 1090-1094.

Fabry, V. J., B. A. Seibel, R. A. Feely, and J. C. Orr. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science: Journal du Conseil 65(3): 414-432.

Feely, R. A., S. R. Alin, J. Newton, C. L. Sabine, M. Warner, A. Devol, C. Krembs, and C. Maloy. 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. Estuarine, Coastal and Shelf Science 88(4): 442-449.

Hoagland, P., D. M. Anderson, Y. Kaoru, and A.W. White. 2002. The Economic Effects of Harmful Algal Blooms in the United States: Assessment Issues, and Information Needs. Estuaries 25: 819-837.

Knutson, T. R., J. L. McBride, J. Chan, K. Emanuel, G. Holland, C. Landsea, I. Held, J. P. Kossin, A. K. Srivastava, and M. Sugi. 2010. Tropical Cyclones and Climate Change. Nature Geoscience 3(3): 1-37.

McCabe, G. J., M. P. Clark, and M. C. Serreze. 2001. Trends in Northern Hemisphere surface cyclone frequency and intensity. Journal of Climate 14: 2763–2768.

National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory (PMEL) Carbon Program. 2013. What is Ocean Acidification? Available online http://www.pmel.noaa.gov/co2/story/What+is+-Ocean+Acidification%3F

National Oceanic and Atmospheric Administration Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Available online http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Washington, DC: The National Academies Press. 201 pp.

Oregon Climate Change Research Institute (OCCRI). 2010. Oregon Climate Assessment Report. Eds.: K. D. Dello and P. W. Mote. College of Oceanic and Atmospheric Sciences, Oregon State University. Corvallis, OR. Available online http://occri.net/wp-content/uploads/2011/01/OCAR2010_v1.2.pdf

Orr, J. C., V. J. Fabry, O. Aumont, L. Bopp, S. C. Doney, R. A. Feely, and A. Yool. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437(7059): 681-686.

Paul, V. J. 2008. Global warming and cyanobacterial harmful algal blooms. In: Hudnell, K. H. (ed.). Cyanobacterial Harmful Algal Blooms: State of the Science Research Needs. Advances in Experimental Medicine and Biology (619): 239-257.

Rahmstorf, S. 2007. A Semi-Empirical Approach to Projecting Future Sea-Level Rise. Science 317: 1866d.

Schwing, F. B. and R. Mendelssohn. 1997. Increased coastal upwelling in the California Current System. Journal of Geophysical Research: Oceans 102(C2): 3421-3438.

Shi, D., Y. Xu, B. M. Hopkinson, and F. M. Morel. 2010. Effect of ocean acidification on iron availability to marine phytoplankton. Science 327(5966): 676-679.

South Slough National Estuarine Research Reserve (SSNERR). 2013. [Unpublished raw data]. System-Wide Monitoring Program (SWMP). Available online http://cdmo.baruch.sc.edu/

Stachowicz, J. J., J. R. Terwin, R. B. Whitlatch, and R. W. Osman. 2002. Linking climate change and biological invasions: Ocean warming facilitates nonindigenous species invasions. Proceedings of the National Academy of Sciences 99(24): 15497-15500.

Tweddle, J. F., P. G. Strutton, D. G. Foley, L. O'Higgins, A. M. Wood, B. Scott, and Z. Forster. 2010. Relationships among upwelling, phytoplankton blooms, and phycotoxins in coastal Oregon shellfish. Marine Ecology Progress Series 405(April): 131-145.

United States Environmental Protection Agency (USEPA) Office of Water. 2013a. Impacts of Climate Change on the Occurrence of Harmful Algal Blooms. Accessed 4 December 2013. Available online http://www2.epa.gov/sites/production/files/documents/climatehabs.pdf

United States Environmental Protection Agency (USEPA). 2013b. Climate change indicators in the United States. Available online http://www.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html

Vermeer, M. and S. Rahmstorf. 2009. Global Sea Level Linked to Global Temperature. Proceedings of the National Academy of Sciences 106(51): 21527-21532.

Webster, P. J., G. J. Holland, J. A. Curry, and H. R. Chang. 2005. Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment. Science 309: 1844-1846.

Yamanaka, T., D. Raffaelli, and P. White. 2013. Non-linear interactions determine the impact of sea-level rise on estuarine benthic biodiversity and ecosystem processes. PLoS ONE 8(7): 1-8.

# Recreational Clams in the Coos Estuary



*Summary:*

- *Butter and gaper clam populations in some areas of lower Coos estuary and South Slough have increased since a similar assessment in the 1970s.*
- *Native littleneck clams and cockle populations have generally fallen since the 1970s in the areas sampled.*
- *Population shifts of any estuarine-dependant animals should be cause for further investigation to understand potential causes of change.*

*Source: ODFW 2014*



Figure 1. 2009 ODFW SEACOR study areas located in the South Slough (SS) and Lower Bay (LB) subsystems.

**Evaluation**

Status of gaper and butter clams appear to be improving. These populations should continue to be monitored.

**Evaluation**

Status of littleneck clams and cockles appear to be deteriorating. These populations should be closely monitored.

**What's happening?**

Recreational clamming is an important part of our area's quality of life. To improve understanding of clam population size and distribution in the Coos estuary, Oregon Department of Fish and Wildlife's (ODFW)

Shellfish and Estuarine Assessment of Coastal Oregon (SEACOR) project documented in 2008-09 the status of four recreationally important bay clam species in the lower Coos estuary- South Slough (SS) and Lower Bay (LB) subsystems (see Figure 1): gaper clams (*Tresus capax*); butter clams (*Saxidomus gigantea*); native littleneck clams (*Leukoma staminea*); and cockles (*Clinocardium nuttallii*).

Project scientists estimated the distribution and abundance of each species within the SEACOR study sites and described the habitat requirements for each. The results of this work are summarized in Table 1 (ODFW 2014). The ODFW report summarizes results from their detailed assessment

Table 1. Mean clam density data per meter squared for three SEACOR study areas in the lower Coos estuary. ODFW 2014.

| Study Area | Clam Species | Area Mean/m$^2$ |
|---|---|---|
| **Clam Island** | Butter | 4.6 |
| | Cockle | 0.3 |
| | Gaper | 19.9 |
| | Littleneck | 0.4 |
| **Pigeon Point** | Butter | 11.1 |
| | Cockle | 1.0 |
| | Gaper | 3.1 |
| | Littleneck | 1.4 |
| **South Slough** | Butter | 2.1 |
| | Cockle | 1.5 |
| | Gaper | 1.8 |
| | Littleneck | 0.3 |
| **All Regions** | Butter | 6.0 |
| | Cockle | 0.9 |
| | Gaper | 8.3 |
| | Littleneck | 0.7 |

method (DAM) at three study sites: South Slough, Clam Island and Pigeon Point. Rapid assessment method (RAM) data from other sites (Empire, Airport and North Spit) were deemed preliminary data only (see Background). Italicized text below indicates sections quoted directly from the ODFW (2014) report unless otherwise noted.

**SEACOR Study Results**

Clam beds were found in all areas studied by the SEACOR team. The greatest numbers of clam beds were found at the Clam Island and Pigeon Point study sites (both in the Lower Bay subsystem)(Figure 1). Overall, both gaper clams and butter clams were found in much greater densities than cockles and littleneck clams at all study sites (Table 1). Gaper clam densities were the highest at the Clam Island study site (Figure 2, Table 1) and butter clam densities were high at both Clam Island and Pigeon Point (Figure 3, Table 1), which are both located in the lower Coos estuary subsystem. Cockles were found in relatively high densities only in the South Slough study area (Figure 4, Table 1), while native littleneck clams were found only in low densities at all three sites, the most dense being Pigeon Point (Figure 5, Table 1).

The low densities of littleneck clams in the 2009 SEACOR study contrasts with earlier surveys conducted in the 1970s when native littleneck clams were found to be reasonably abundant in the Coos estuary.


Figure 2. Gaper clam abundance and distribution in SEACOR study areas Data from Empire, Airport and North Spit sites are considered preliminary only. Data: ODFW 2014.

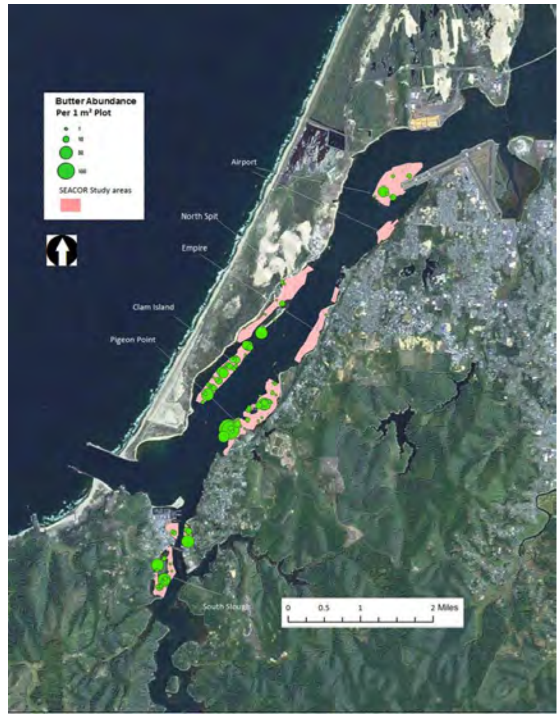



Figure 3. Butter clam abundance and distribution in SEACOR study areas. Data from Empire, Airport and North Spit sites are considered preliminary only. Data: ODFW 2014.

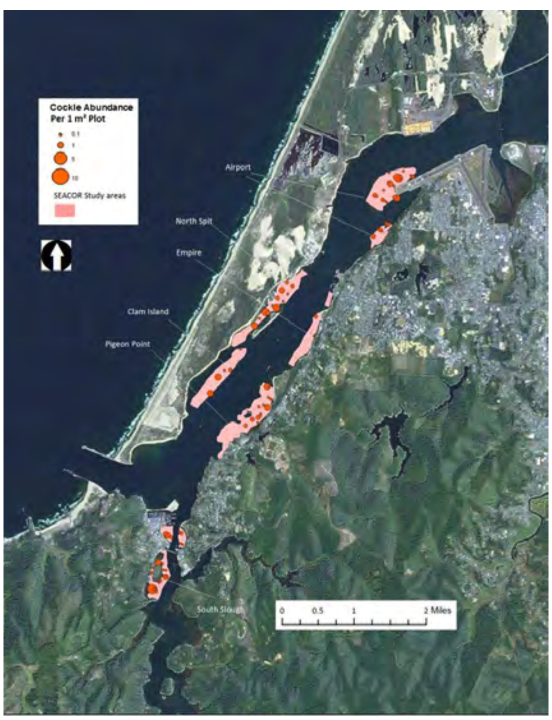



Figure 4. Cockle abundance and distribution in the SEACOR study areas. Data from Empire, Airport and North Spit sites are considered preliminary only. Data: ODFW 2014.


Figure 5. Littleneck clam abundance and distribution in the SEACOR study areas. Data from Empire, Airport and North Spit sites are considered preliminary only. Data: ODFW 2014.

Additional detail, organized by study sites, is found in ODFW's SEACOR final report (2014):

***Clam Island*** *supported high densities and diverse assemblages of bay clams (Figure 6). Butter clams were abundant across all tidal strata at Clam Island (site mean=4.6 clams/$m^2$). Cockles were least abundant at Clam Island, compared to the other tide flats surveyed by DAM, and were most abundant in the mid-intertidal (mean = 0.6 clams/$m^2$). Gaper clams exhibited the greatest densities at Clam Island (mean=19.9 clams/$m^2$) and were most dense in the low intertidal (mean=45.6 clams/$m^2$). Native littleneck clams exhibited low densities at all three sites (mean=0.7 clams/$m^2$), including Clam Island (mean=0.4 clams/$m^2$).*

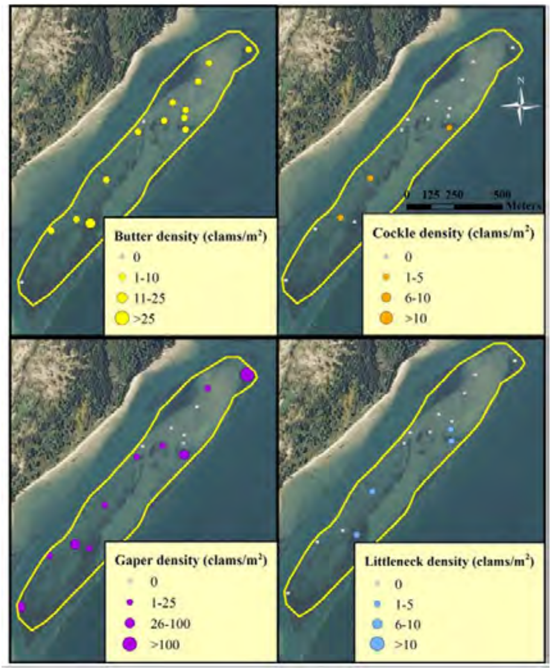


Figure 6. Clam distribution and abundance (clams/$m^2$) at the SEACOR Clam Island study site. Note the difference in scale for each clam species. Data are from DAM surveys only. Data and figure: ODFW 2014.

***Pigeon Point*** *exhibited the highest densities of butter clams (Figure 7), particularly at high tidal elevations (H, mean=15.0 clams/$m^2$) in sandy areas commonly referred to as "butter bars." Cockles were not very abundant at Pigeon Point (mean=1.0 clams/$m^2$), and were most prevalent in the mid tidal stratum at Pigeon Point (mean=2.2 clams/$m^2$). Gapers were less abundant at Pigeon Point compared to Clam Island (mean=3.1 clams/$m^2$). Low tidal elevations harbored the greatest densities of gapers across all sites (mean=19.3 clams/$m^2$) including Pigeon Point (mean 8.2 clams/$m^2$). Littleneck clams exhibited the highest densities at Pigeon Point (mean=1.4 clams/$m^2$), where they showed little difference in density among tidal strata.*

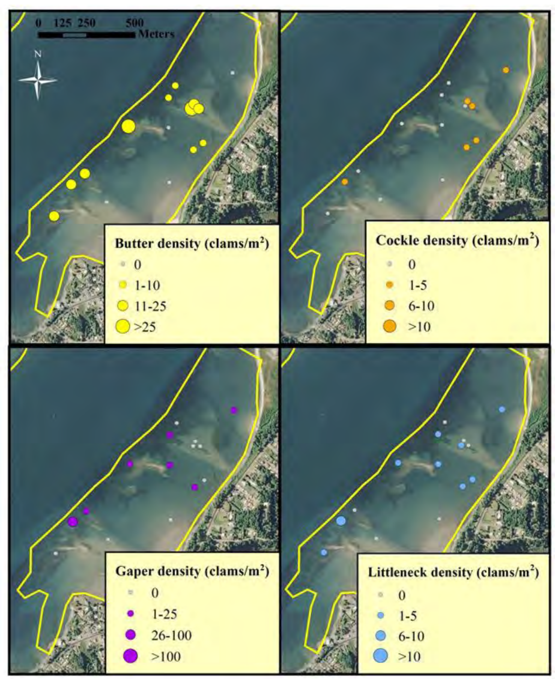


Figure 7. Clam distribution and abundance (clams/$m^2$) at the SEACOR Pigeon Point study site. Note the difference in scale for each clam species. Data are from DAM surveys only. Data and figure: ODFW 2014.

***South Slough*** *exhibited the lowest density of butter clams (mean=2.1 clams/m²), but they were still abundant compared to other clams such as cockles and littlenecks (Figure 8). The highest densities of cockles occurred at South Slough (mean=1.5 clams/m²), particularly in high and low tidal elevations (mean=2.0 clams/m² and 1.6 clams/m², respectively). The largest cockles were also collected at South Slough (mean shell length=70.2 mm). Gapers were least abundant at South Slough (mean=1.8 clams/m²) among the three sites sampled by DAM. Generally, gaper clam length increased with decreasing tidal stratum except at South Slough, which lacked smaller gaper clams. Littleneck clams were least abundant at South Slough (mean=0.3 clams/m²)(Figure 8) and were entirely absent at many waypoints surveyed by DAM.*

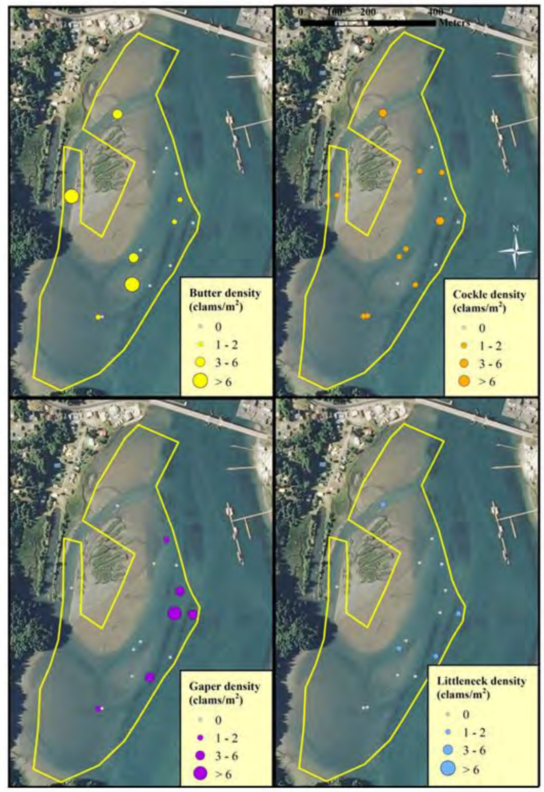



Figure 8. Clam distribution and abundance (clams/m²) at the SEACOR South Slough study site. The scale for each clam species is the same. Data are from DAM surveys only. Data and figure: ODFW 2014.

**Clam Bed Attributes**

Clam bed attributes including bed type, eelgrass cover, sediment type and intertidal elevation were measured by ODFW scientists and summarized for the Coos estuary in Figures 9-12. They determined through a series of regression analyses the following:

- The presensence of algae on clam beds was negatively correlated with the presnce of butter clams- these clams were almost always found in non-vegetated sand flats.
- The presensence of algae in clam beds was positively correlated with the presnce of cockles and with the presence of gaper clams.
- Cockles and littleneck clams were most frequently found in oxygenated clam bed sediments.
- The presence of gaper clams was negatively correlated with sediment temperature “at depth” (the depth in the sediment where those clams are normally found). So, the higher the sediment temperatures were, the fewer gaper clams were found. Gapers were found in greatest abundances in low intertidal flats.
- The presence of native eelgrass beds (*Zostera marina*) was positively correlated with the presence of littleneck clams (in the few areas they were found).


Figure 9. Intertidal bed type in the SEACOR study areas. Data: ODFW 2014.


Figure 10. Major sediment type in the SEACOR study areas. Data: ODFW 2014.


Figure 11. Eelgrass cover in the SEACOR study areas. Data: ODFW 2014.


Figure 12. Tideal height range in the SEACOR study areas. Data: ODFW 2014.

**Why is it happening?**

The status of clam populations is a function of a variety of environmental conditions including but not limited to bathymetry (shape of the estuary bottom), human activities (e.g., commercial oyster culture, dredging of the commercial shipping channel), and the health of other key benthic and pelagic communities such as eel grass beds and crustaceans (Carlton et al. 1991; Yocom and Edge 1929).

Furthermore, the status of local environmental conditions is determined by many changing elements associated with both natural and human-induced changes. For example, the effects of major storms or the establishment of an oyster culture system have the potential to change the bathymetry of an area via sedimentation or scouring of the estuary bottom. These same actions may also affect the health of nearby eelgrass communities (Carlton et al. 1991). Determining the effects of these activities is a complicated process requiring collection of quanitative data over multiple time periods.

**Past Studies**

Previously conducted clam research in the Coos estuary provides information that can be used to characterize trends in local clam populations. The research presented here represents 80 years of published clam survey data. The oldest study dates back to 1929 and the most recent study was completed in 2009. Figure 13 provides a geographic summary of the study areas for all previously published clam surveys in the Coos estuary.

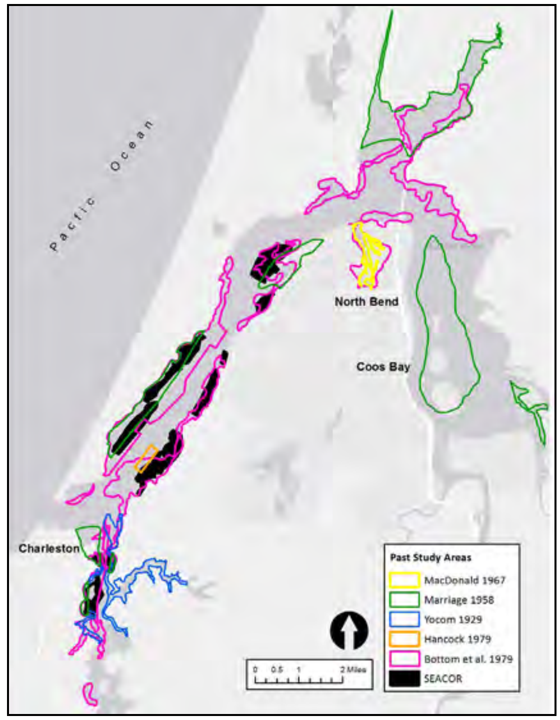



Figure 13. Locations of all previously conducted clam surveys in Coos Bay

Detailed comparisons between studies conducted during different time periods are made difficult by gaps in the data. For example, only two published clam surveys of Pony Slough have been completed, with the most recent data coming from the 1970s (Macdonald 1967; Bottom et al. 1979). Additionally, some areas such as the Upper Bay subsystem, for which the Marriage study (1958) represents the most current data, have not been surveyed for many years. Methodological differences between studies further complicate comparisons between data sets from different studies.

These difficulties notwithstanding, the available historic data are useful in that they provide a snapshot of the status of clams over time. Comparisons of historic data may be valuable in instances where methodological differences in and of themselves are unlikely to account for overwhelmingly clear trends over time.

Historically, clams have demonstrated a wide range of adaptations to the environmental conditions of the study area. In 1929, Yocom and Edge observed a total of forty-one bivalve species in the area between Sunset Bay and Fossil Point (Figure 14). Despite having surveyed a variety of substrata (e.g., rocks, sand, mud, mixed sand and mud, and driftwood) with diverse habitat characteristics

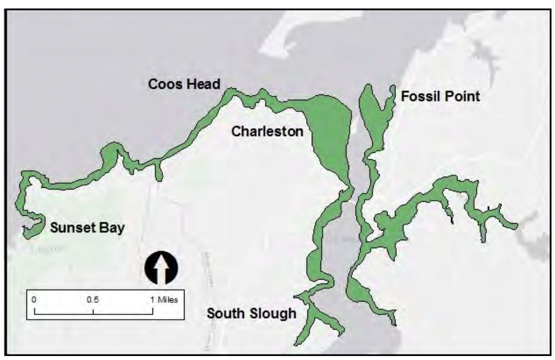



Figure 14. Survey area for Yocom and Edge (1929) is highlighted above in green.

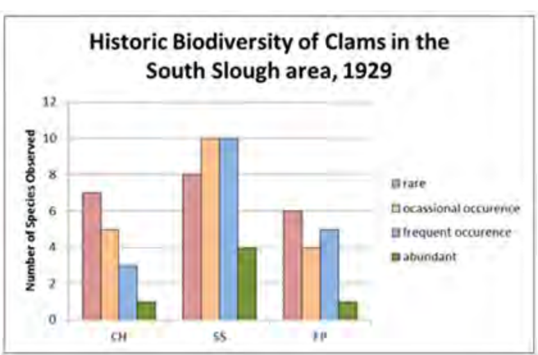



Figure 15. Relative diversity of clams in three inventory subregions. CH = Coos Head SS = South Slough FP = Fossil Point Data: Yocom and Edge 1929.

(e.g., exposure to ocean waves, varying levels of tidal current and sedimentation, etc.) each area studied exhibited high biodiversity, with twenty-seven different species of bivalves occurring between Coos Head and Fossil Point alone (Figure 15).

Some historic trends in local clam populations are apparent. The decline of soft shell clams (*Mya arenaria*) between the 1920s and the 1950s is apparent when comparing the findings of Yocom and Edge (1929) with those of Marriage (1958).

Yocam and Edge noted an abundance of soft shell clams in South Slough in 1929 while Marriage found no soft shelled clams in the same area nearly thirty years later.

Marriage also surveyed North Slough and Haynes Inlet, where soft shell clams were found in scattered beds. It should be noted that the North Slough and Haynes Inlet soft shell clam populations were much smaller than those of earlier years in the same areas, suggesting that the pattern of population decline may well have been characteristic of the greater Coos estuary during these years (Marriage 1958).

In the case of butter and gaper clams at Pigeon Point and Clam Island, the data suggest that the populations of these species may have decreased since the 1970s (Figures 16 and 17). This decline is due to a decrease in clam abundance on Clam Island; although the decline is partially offset by increases at Pigeon Point and may be subject to some variation in magnitude due to methodological differences across studies, it seems likely that the net effect is negative (ODFW Shellfish Program 2009).

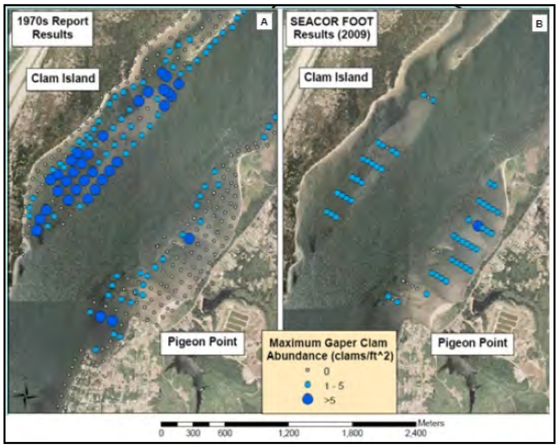



Figure 16. Gaper clam abundance data from a 1979 report (A) are compared to the same data from a study conducted in 2009 (B). Data: ODFW 2014.

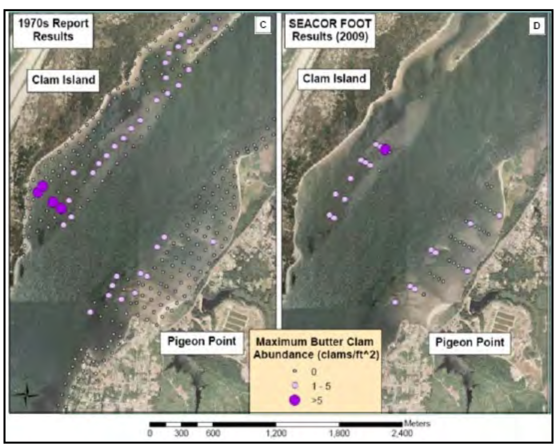



Figure 17. Butter clam abundance data from a 1979 report (C) are compared to the same data from a study conducted in 2009 (D). Data: ODFW 2014.

**Background**

SEACOR Study
From the SEACOR report summary (ODFW 2014, unless otherwise noted):

*SEACOR is funded by Oregon Department of Fish and Wildlife recreational shellfish license fees and captures a snapshot of the status of Oregon's estuarine resources for baseline data and for comparison to past (ODFW 1970's "raccoon" report: Bottom et al. 1979) and future studies. The SEACOR project initially targeted intertidal flats of the lower Coos Bay Estuary during 2008-2009. However, the state legislature has made the project permanent to allow future assessment of all of Oregon's estuaries following this general sampling strategy (ODFW Shellfish Program 2009).*

*Coos Bay was selected as SEACOR's pilot site because it is Oregon's largest outer coast estuary, has a long history of supporting recreational and commercial clam harvest, and has experienced increasing urbanization and industrialization since the late 1800s. Coos Bay is a proposed site for a large liquid natural gas facility which would require additional dredging of the channel, an activity that first occurred in 1927. The increasing importance of Coos Bay as a shipping port since its early colonization resulted in physiographic changes primarily from dredging and filling as well as community compositional changes from introductions and extractions. Updating our understanding of estuarine habitats and the distribution and size of Coos Bay bay clam populations was valuable and necessary in* *the face of these changes in habitat and community structure.*

*This 18-month study focused on six study sites which encompassed three tidal strata (low, mid, high)(Figure 1). These sites were identified by a "scouting" method not employed with the subsequent estuary studies. Scouting was accomplished using a team transect approach. Team members spaced 10 m apart recorded habitat information every 10 m along transects from shore to channel. The team was repositioned every 100-300 m along the shore of lower Coos Bay. Based on scouting, study sites were selected for sampling when the following criteria met: (1) the area was composed of unconsolidated sediment suitable for burrowing organisms, (2) the area was located in the marine-dominated region of the estuary (Davidson 2006), (3) the area was large enough to support a statistically viable number of samples, (4) the area was known to be or likely to be used by recreational shellfish harvesters, and (5) the area was likely to support clam species at some population level, based on previous studies. This last criterion highlights a key change made for future estuarine studies. Entire tidal flats were surveyed in Tillamook Bay instead of targeting clam bed areas as was done for the Coos Bay pilot study.*

The six study sites are described by ODFW (2014) as follows:

*The* ***Airport*** *study site is composed of several contiguous extensive tide flats that border the Southwest Oregon Regional Airport runway on three sides and a section of the shoreline that extends south. On the northern border of the Airport runway, there is an extensive, sandy, shrimp-dominated tide flat. To the west of the Airport, there is a heterogeneous and broad tide flat that forms a small peninsula. The peninsula is composed of soft mud close to the runway and to the east, sand at the western edge, a small terrestrial island in the center, and a mixed sediment eelgrass habitat to the far south.*

*The* ***Clam Island*** *study site is emergent only at lower tides and is entirely isolated from land by water during all tides. It is bordered by an unmaintained channel to the west (demarcated by pole markers at the north and south end of the island) and by the federally-maintained navigational channel to the east. The southern end is lower in tidal elevation than the northern end, and there is a depression at the southern end with abundant eelgrass. This study site is a popular target of recreational clammers, and the adjacent channels are popular for recreational crabbers, as well.*

*The* ***Empire*** *study site is a relatively narrow strip of two distinct tide flats partially separated by a small dune headland. The larger portion of this site is to the south and the entire site is bordered to the east by low-lying dunes and densely-urbanized variable neighborhood.*

*The* ***North Spit*** *study site is dominated by four cobble-dominated terrestrial islands, surrounded by areas of soft mud and other areas of sand. The western border is the sand* *peninsula that encloses Coos Bay. The dune area to the north of the study site was lightly-developed with industrial buildings, and is a natural area with limited public access (i.e. four-wheel drive on sand or boat access only). This lightly-developed industrial area to the north (Jordan Cove, specifically) is the proposed location of a new liquid natural gas facility.*

*The* ***Pigeon Point*** *study site is the most heterogeneous, with separate areas dominated by cobble, nearly pure sand, and nearly pure mud. There are several dredge spoil piles that are not emergent at standard high tides composed largely of cobble that form a barrier across the edge of the site; this separates the bulk of the exposed tide flat from the shipping channel. There are two permanent pools, one to the north that is shallow and is highly vegetated with eelgrass and algae and a second pool in the central area that is filled with soft mud and light vegetation. This site is named after "Pigeon Point," a highly-developed residential neighborhood that borders the south edge. The eastern edge is also highly-developed with residential buildings. In contrast, the northern border is a low-lying dune habitat situated on landfill. Access to this site is fairly easy, with paths leading down the bluff face at both the northern and southern ends.*

*The* ***South Slough*** *study site refers to an area that contains three discrete tide flats with the largest of the three locally called the "South Slough Flat". The "South Slough Flat" is bordered by the Charleston Bridge at its northern edge, the Metcalf Marsh at its western edge and by the lightly-developed forested bluff known as Collver Point, to the south. There is a large cluster of hummocks (raised areas), vegetated with salt marsh plants that are entirely submerged only at extreme high tides. There are also two major drainage channels from the Metcalf Marsh, one to the south and one to the north of the hummock cluster. There is abundant eelgrass (*Zostera marina*) in the lower intertidal areas. This site is a very popular area for clammers. It is also subject to harvest by small-scale commercial clammers harvesting cockle clams, and other fishermen harvesting burrowing shrimp for bait. The South Slough study site also includes the smaller "Charleston Triangle" and "Fisherman's Grotto" (a restaurant at the access point) tide flats, which were only sampled during RAM surveys. Both of these tide flats are located just north of the Charleston Bridge, are heavily used by clammers, and are adjacent to the marina and fish processing plants.*

*This study assessed 450 ha of tide flats of which 150 ha were surveyed by DAM. RAM surveys were conducted at all 6 study sites, whereas DAM surveys (n=45 sites) were only conducted in Clam Island, Pigeon Point, and South Slough. The SEACOR results focus on these three flats. All results are detailed in the SEACOR Coos Bay Final Report (in prep.).*

## References

Bottom, D., B. Kreag, F. Ratti, C. Roye, and R. Starr. 1979. Habitat classification and inventory methods for the management of Oregon estuaries. [Oregon Department of Fish and Wildlife final estuary inventory project report]. 84 pp.

Carlton, J. T., G. M. Ruiz, and R. A. Everett. 1991. The structure of benthic estuarine communities associated with dense suspended populations of the introduced Japanese oyster *Crassostrea gigas*: years 1 and 2. [South Slough National Estuarine Research Reserve final report]. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Office of Ocean and Coastal Resource Management, National Estuarine Research Reserve System. Washington, DC.

Davidson, T. M. 2006. The invasion of the Australasian burrowing isopod (*Sphaeroma quoianum*) in Coos Bay, Oregon. University of Oregon.

Hancock, D. R. 1979. Subtidal clam populations: distribution, abundance, and ecology. Oregon State University, Sea Grant College Program. Corvallis, OR.

MacDonald, K. B. 1967. Quantitative studies of salt marsh mollusc faunas from the North American Pacific Coast. [PhD Thesis]. University of California. San Diego, CA.

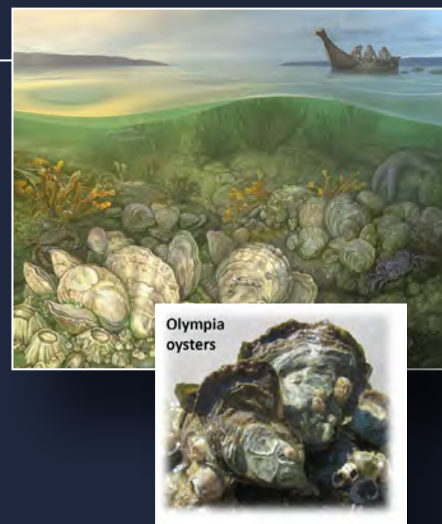
Marriage, L. D. 1958. The bay clams of Oregon; their identification, relative abundance, and general distribution. Fish Commission of Oregon. Portland, OR.

Oregon Department of Fish and Wildlife Shellfish Program. 2009. SEACOR Results. Available online http://www.dfw.state.or.us/mrp/shellfish/Seacor/results.asp

Oregon Department of Fish and Wildlife (ODFW). 2014. Status of Oregon bay clam fisheries, stock assessment, and research. [Information Report Series draft June 2014]. Oregon Department of Fish and Wildlife Marine Resources Program. 113 pp.

Yocom, H. B. and E. R. Edge. 1929. The ecological distribution of the Pelecypoda of the Coos Bay region of Oregon. Northwest Science: 65-71.

# Native Oysters in the Coos Estuary





*Summary:*

- *Olympia oyster populations appear to be stable and even increasing. A 2006 survey shows native oysters present in multiple Coos estuary subsystems including particularly dense patches in the Upper Bay.*
- *However, native oysters are present in much smaller numbers today than in the early 20th century.*
- *Researchers are re-introducing adult oysters in the Coos estuary and investigating the biology and ecology of naturally occurring Olympia oysters.*

*(Source: Groth and Rumrill 2009)*


**Evaluation**

Status of Native Oysters is stable and improving and should continue to be monitored.

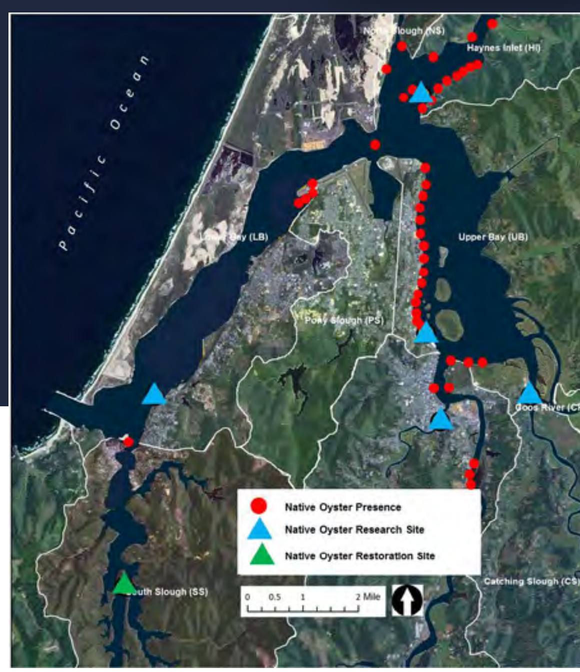



**Figure 1.** Status of native oysters in the Coos estuary in the South Slough, Lower Bay, North Slough, Haynes Inlet, Upper Bay and Isthmus Slough subsystems.

## What's happening?

The Olympia oyster (*Ostrea lurida*) is the only oyster native to the U.S. West Coast, and was once abundant in estuaries from Baja California to Sitka, Alaska. Interestingly, the oyster was not present in Coos Bay at the time Europeans settled in the area, but shells found in dredge spoils and shell middens indicate that they were present in the area historically and were harvested by Native Americans. One hypothesis is that a tsunami and/or fire caused a huge input of sediment into the bay, smothering the oyster population.

In the 1980s, Olympia oysters were discovered growing in Coos Bay once again. Genetic similarities between Olympia oysters in Coos Bay and those in Willapa Bay, WA suggest that the local reappearance of this species was likely the result of an introduction event from Willapa (Stick 2011). It is likely that they arrived as juveniles attached to the shells of (non-native) Pacific oysters grown commercially in Willapa Bay and transported to Coos Bay. These juvenile Olympia oysters may have then spawned and their larvae settled elsewhere in the bay, setting up a new population.

Presently, the Olympia oyster population here appears to be stable and even increasing. A 2006 survey shows the oyster to be present mainly in the upper part of the bay, with particularly dense patches along the waterfront of Coos Bay, North Bend, and Eastside (Figures 1 and 2). An increasing number of researchers have become interested in restoring Olympia oyster populations (Figure 3). Researchers at the South Slough Reserve are attempting to recreate an oyster population in the South Slough estuary. They are also partnering with the Oregon Institute of Marine Biology (OIMB) to conduct research into the biology and ecology of the oysters in Coos Bay (see below).

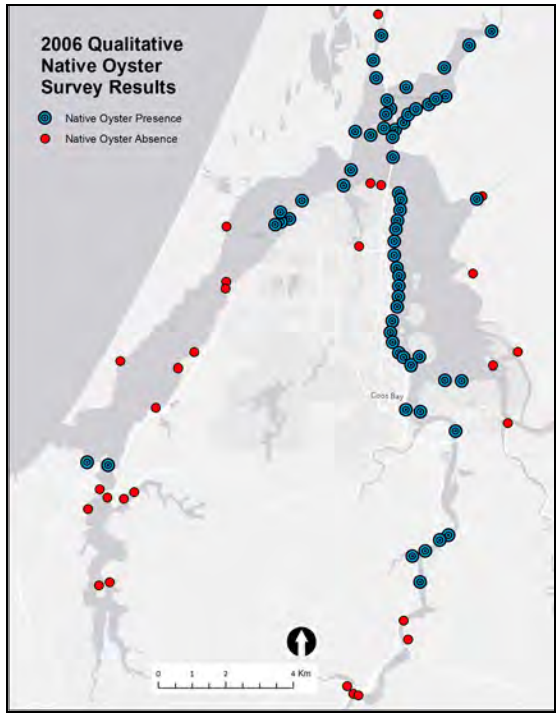



Figure 2. 2006 qualitative native oyster survey results Data: Groth and Rumrill (2009)

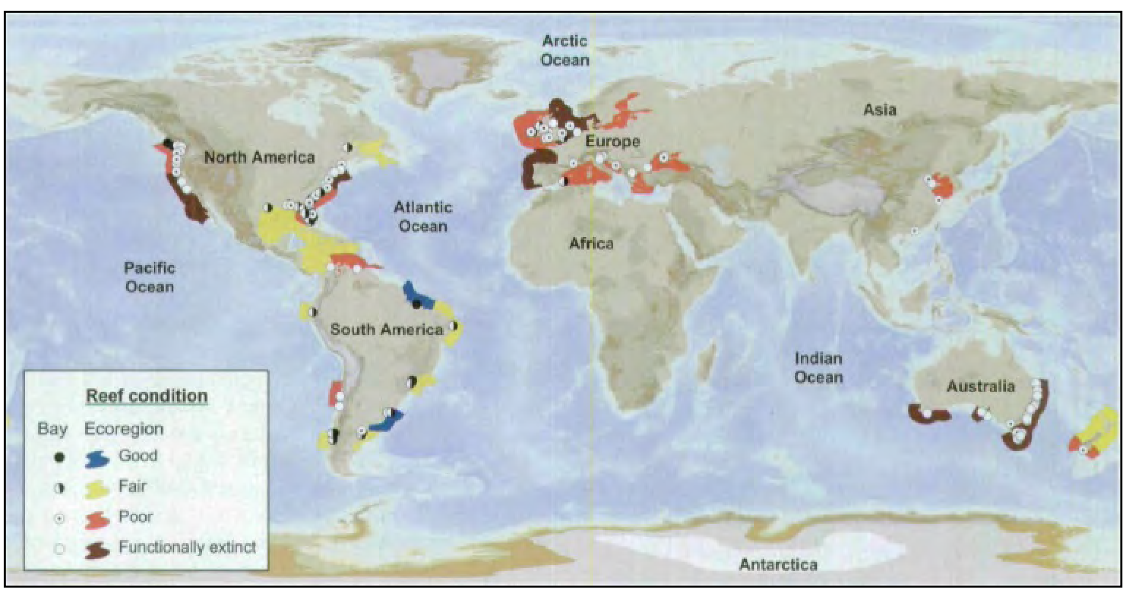
Figure 3. Volunteers aid in the restoration of native populations of Olympia oysters (*O. lurida*) in Coos Bay

### Why is it happening?

The disappearance of Olympia oysters in Coos Bay is most likely the result of a natural disaster. One hypothesis is that a tsunami and/or fire caused a huge input of sediment into the bay, smothering the local oyster population. In recent history, populations of Olympia oysters outside the Coos Bay area have also experienced a pattern of decline. Around the turn of the 20th century, Olympia oysters were heavily harvested along the West Coast, mainly for the San Francisco market. This overharvesting, as well as the increased development of estuarine areas, loss of hard substrate, sedimentation, and pollution caused the Olympia oyster population to decline dramatically.

The decline of oyster populations on the West Coast in the 20th century is indicative of a larger global trend (Figure 4). Several factors have contributed to the decline of oyster reefs across the globe. The extensive harvest of wild oyster populations has commonly led to the loss of reef structure, which exacerbates the impact of additional stresses such as anoxia, sedimentation, disease, and non-native species (Beck et al. 2011). Other anthropogenic influences including the modification of coastlines, changes to freshwater inflow regimes, sedimentation, nutrient loading, and pollution have further contributed to the decline of oysters across the globe (Beck et al. 2011; NRC 2004). A loss of 85 percent of the world's oyster reefs relative to historic abundance levels is estimated, and over a third (37 percent) of existing oyster reefs in bays across the globe are considered functionally extinct (Beck et. al. 2011).
The conservation of oysters on a global as well as local scale is important, because oysters provide many ecosystem services, including water filtration, shoreline stabilization, and habitat for many animals (e.g., fish, crabs, and birds)(Beck et al. 2011). There

Figure 4. Condition of the world's oyster reefs. < 50% lost = Good; 50% to 89% lost = Fair; 90% to 99% lost = Poor; > 99% lost = functionally extinct. GRAPHIC: Beck et al. (2011)



are also beneficial secondary effects that are associated with these ecosystem services. For example, water filtration can serve to remove excess nutrients, thereby reducing likelihood of harmful algal blooms that have many ecological as well as economic consequences (Beck et al. 2011). In order to protect these valuable ecosystem services and promote biodiversity in the Coos estuary, two main oyster restoration projects have been spearheaded. These projects are supported by NOAA's Community-based Restoration Program (CRP) and the National Estuarine Research Reserve System (NERRS) Science Collaborative program.

**What's being done?**

The CRP has supported several research projects investigating the biology and ecology of native oysters, many of which were led or assisted by community members and college student interns. One project involved collecting oyster juveniles, or spat, on shell bags in Coos Bay and then transferring these bags to South Slough (see Figure 3). Researchers then monitored the growth and survival of these juveniles for about a year. The juveniles survived well and grew, on average, about 10 mm between January and July.

Although the CRP projects were completed in 2009, South Slough Reserve science staff members continue to monitor these shell bags, and are currently in the process of moving them from their current location at Younker Point to a more suitable area near Long Island Point. Monitoring living adults in South Slough will provide data on the feasibility of restoring oysters to this area; the adults may also serve as local sources of natural occurring Olympia oyster larvae for use in future restoration efforts, if needed.

A thorough understanding of the reproductive development of Olympia oysters in Coos Bay is a critical component of the advancement of local restoration efforts. As a means towards that end, the South Slough Reserve and OIMB are partners in several Olympia oyster research projects supported by the NERRS Science Collaborative program. Graduate students at OIMB are currently investigating sexual development and timing of oyster larval brooding and release; mechanisms of oyster larval retention in the bay; oyster larval abundance vs. settlement throughout Coos Bay; and oyster growth and survival throughout the bay.

The results of this research have provided important insights into the life history of native oysters in the Bay. Oates (2013) found that intertidal oysters in Coos Bay have a reproductive period of approximately three to four months, and reproduction corresponds to water temperatures of approximately 15-19° C (59-66° F). These findings corroborate previously conducted research (Hori 1933; Hopkins 1937; Imai et al. 1954). In addition to temperature, brooding closely corresponds to high chlorophyll-a concentrations, suggesting a positive relationship between food availability and reproductive output of oysters (Oates 2013).

Temperature and chlorophyll-a concentrations alone, however, fail to completely explain the timing of reproductive events of native oysters in Coos Bay. Oysters exposed to low salinity regimes in Coalbank Slough experienced repressed levels of gametogenesis, suggesting that the reproductive success of native oysters in Coos Bay may be critically dependent on salinity parameters (Oates 2013). Further research suggests that other abiotic factors such as tidal mixing and changes in precipitation regimes may also affect recruitment patterns and larval distribution in juvenile Olympia oysters (Prichard 2013). More research is required in order to fully understand the effects of salinity and other ambient parameters (e.g., dissolved oxygen or pH) on the reproductive success of native oysters in Coos Bay.

Additional research provides restoration practitioners with guidelines concerning the settlement preferences of native juvenile oysters in Coos Bay. Sawyer (2011) found that juvenile Olympic oysters were generally non-selective in their settlement preference when provided with a variety of hard substrata, including both live and dead species of native Olympic oysters and non-native Pacific oysters (*Crassostrea giggas*). However, juveniles did demonstrate a clear preference for settlement on the bottom of shells.

These findings indicate that the type of substrate provided for settlement is unlikely to limit the success of local restoration efforts. They further indicate that restoration efforts may benefit by suspending settlement substrata in the water column in order to allow for easy access to bottom of shells. Interestingly, the non-selective settlement tendencies of Olympic oysters implies that the commercial harvest of Pacific oysters represents a potential “recruitment sink” in that juvenile Olympic oysters that have settled on mature Pacific oysters become, in effect, bycatch upon the harvest of these individuals (Sawyer 2011).

Restoration decisions involving the placement of settlement substrata relative to the location of existing adults will benefit from a further understanding of the spatial preferences of juvenile Olympia oysters. As a means to this end, Prichard (2013) has studied recruitment patterns and larval distributions in Coos Bay. Her research suggests that juvenile Olympia oysters tend to settle in close proximity to previously established populations of adults, suggesting that these oysters have relatively limited larval distributions. Research investigating the timing of settlement of Olympia oysters in Coos Bay is on-going, and restoration efforts will also benefit from a well-developed understanding of the temporal settlement preferences of these oysters (R. Rimler, pers. comm., Nov. 2013).

The genetic practices of restoration projects are likely to directly affect the degree to which native oysters may successfully reestablish themselves in Coos Bay. The genetic distance between populations of Olympia oysters is a function of the geographic distance between those populations; that is to say that Olympia oysters in California, for example, are genetically distinct from oysters of the same species in Coos Bay (Stick 2011). The marked exception to this finding is the population of Olympia oysters in Willapa Bay, WA, which is genetically very similar to the population of oysters in Coos Bay despite the geographic distance between these two sites (Stick 2011). As previously mentioned, this is likely the result of a previously occurring introduction event from Willapa Bay to Coos Bay. In order to assure the long-term viability of restoration efforts in Coos Bay, the implications of collecting broodstock from geographically distant sources should be carefully considered until it can be determined whether these populations are locally adapted (Stick 2011).

Work to further understand the status of contaminants in the Bay that may be harmful to native oyster stocks has also been undertaken by the Oregon Department of Environmental Quality (ODEQ). Butyltins, which are chemicals found in anti-fouling boat bottom paints, are of particular concern because they have been shown to cause shell deformities and decreased reproductive capacity in oysters (Wolniakowski et al. 1987). In the late 1980s, ODEQ documented high concentrations of Butyltins in the waters of Coos Bay as well as in the tissues of locally produced Pacific oysters (Wolniakowski et al. 1987). Research has documented steady declines in local Butyltin levels since the late 1980s, suggesting that the on-going management and regulation has been relatively effective in abating this pollutant in Coos Bay (Elgethun et al. 1999). The local distribution of detected Butyltins did not closely correspond to the locations of their origin, suggesting that concentration of Butyltins may be more a function of estuary bathymetry and tidal flushing patterns than proximity to point sources (Elgethun et al. 1999).

Peteiro and Shanks (2014) have studied migratory patterns in larval Olympia oysters. Their findings suggest that larval oysters in Coos Bay have some capacity to perform tidal-timed migrations, but their swimming ability is usually overcome by current speeds. These results indicate that the effectiveness of tidal-timed migrations in the estuary may be limited by local hydrology, and strategies for maximizing larval retention may benefit from detailed studies on local hydrodynamics.

**Background**

Oysters are bivalves, a type of mollusk characterized by two opposing shells, or valves. They are related to clams, mussels, and other commonly known and often edible mollusks. They feed by filtering small particles from seawater. Many oysters, like other bivalves, release sperm and eggs separately in the water, where they meet and fertilize to form

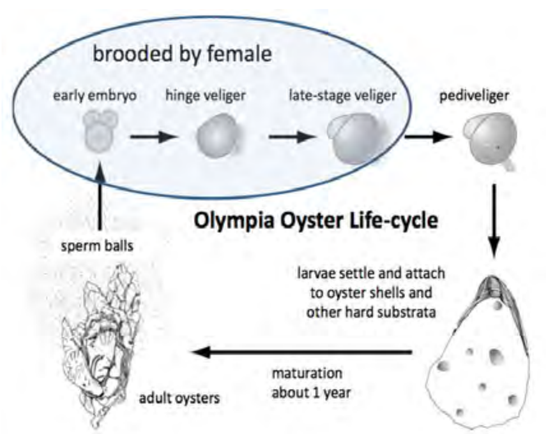



Figure 5. Life history of the Olympia oyster. GRAPHIC: Swanson n.d.

embryos outside the body of the mother. But Olympia oysters retain eggs within the mother's shell. They "brood" their embryos for several weeks before releasing the young, now called larvae, into the water column (see Figure 5).

All oysters and most bivalves produce larvae, which are generally less than a millimeter in length. The larvae swim, eat, and develop in the water for several weeks to several months. They then search for a hard surface on which to settle and metamorphose into a juvenile oyster.

Young oysters tend to settle near other oysters, forming large aggregations, or beds. These beds help stabilize the muddy bottom of the estuary and may improve habitat conditions for eelgrass, an important estuarine plant. Once settled, oysters are cemented to the substrate and remain attached to the substrate for the rest of their lives. The hard, complex surfaces provided by groups of oysters provide a unique habitat in which other estuarine animals can hide, settle, or lay eggs. In this way, a substantial oyster population could increase species diversity.

**References**

Beck, M. W., R. D. Brumbaugh, L. Airoldi, A. Carranza, L. D. Coen, C. Crawford, O. Defeo, G. J. Edgar, B. Hancock, M. C. Kay, H. S. Lenihan, M. W. Luckenbach, C. L. Toropova, G. Zhang, and X. Guo. 2011. Oyster Reefs at Risk and Recommendations for Conservatoin, Restoration, and Management. BioScience 61(2): 107-116.

Elgethun, K., C. Neumann, and P. Blake. 1999. Butyltins in shellfish, finfish, water, and sediment from the Coos Bay estuary (Oregon, USA). Chemosphere 41: 953-964.

Groth, S. and S. Rumrill. 2009. History of Olympia oysters (*Ostrea lurida* Carpenter 1864) in Oregon estuaries, and a description of recovering populations in Coos Bay. Journal of Shellfish Research 28(1): 51-58.

Hopkins, A. E. 1937. Experimental observations on spawning, larval development, and setting in the Olympia oyster *Ostrea lurida*. Bulletin of United States Bureau of Fisheries 48: 439-503.

Hori, J. 1933. On the development of the Olympia oyster, *Ostrea lurida* Carpenter, transplanted from the United States of Japan. Bulletin of the Japanese Society for Science and Fisheries 1(61): 269-276.

Imai T., S. Sakai. H. Okeda, and T. Yoshida. 1954. Breeding of the Olympia oyster in tanks and culture experiments in Japanese waters. Tohoku Journal of Agricultural Research 5(1): 13-25.

National Research Council (NRC). 2004. Non-native Oysters in the Chesapeake Bay. National Academy Press. Available online http://www.nap.edu/openbook.php?isbn=0309090520

Oates, M.S. 2013. Observations of Gonad Structure and Gametogenic Timing in a Recovering Population of *Ostrea lurida* (Carpenter 1864). (MS thesis). Department of Biology, University of Oregon.

Peteiro, L. G. and A. L. Shanks. 2014. Larval Dispersal Patterns of Olympia Oyster in Coos Bay, Oregon. [Unpublished manuscript]. South Slough National Estuarine Research Reserve. Accesed 27 January 2014.

Prichard, C. 2013. Distribution of Larval Bivalves in the Coos Estuary, Coos Bay, Oregon . [MS thesis]. Department of Biology, University of Oregon.

Sawyer, K. M. 2011. Settlement Preference and the Timing of Settlement of the Olympia Oyster, *Ostrea lurida*, in Coos Bay, Oregon. [MS thesis]. Department of Biology, University of Oregon.

Stick, D. A. 2011. Identification of Optimal Broodstock for Pacific Northwest Oysters. [PhD dissertation]. Oregon State University, Corvallis, OR.

Swanson, K. R. n.d. South Carolina Oyster Restoration and Enhancement Program. Available online http://score.dnr.sc.gov/deep.php?subject=2&topic=15

Wolniakowski, K. U., M. D. Stephenson, and G. S. Ichikawa. 1987. Tributyltin concentrations and pacific oyster deformations in Coos Bay, Oregon. Marine Technology Society. Washington, DC. Proceedings International Organotin Symposium 4: 1438-1442.

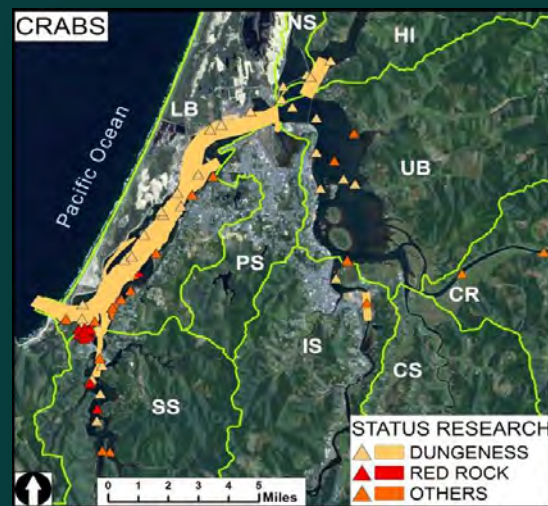
# **Chapter 15:** Crabs in the Coos Estuary

*Jenni Schmitt, Colleen Burch Johnson*
*- South Slough NERR*

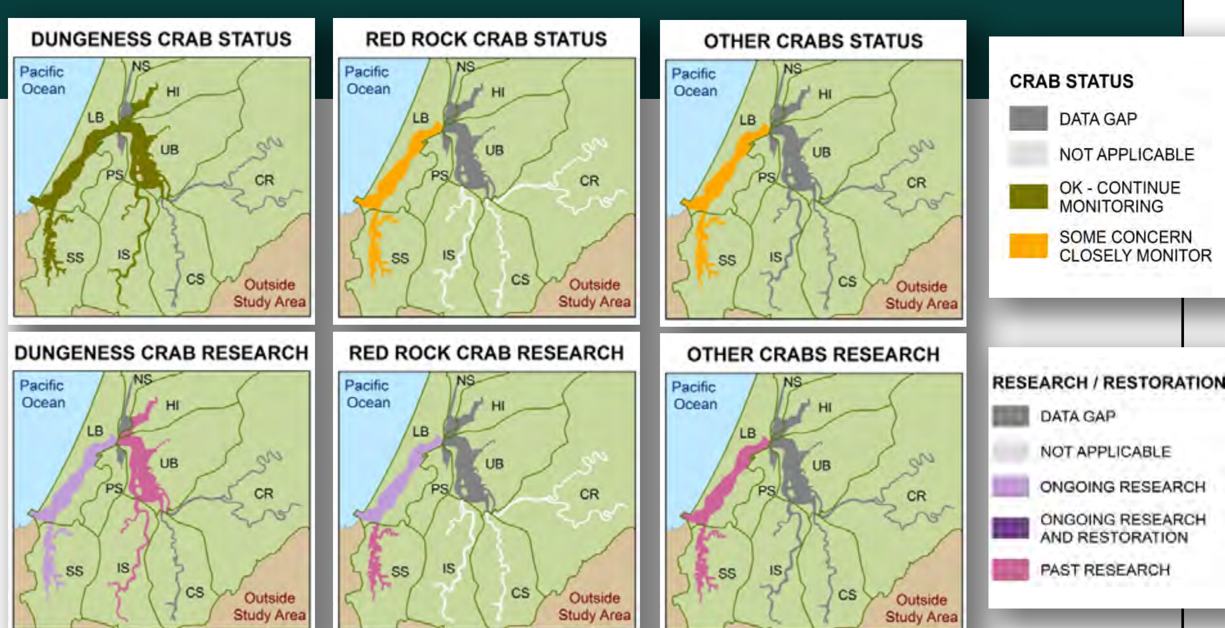
*<u>Dungeness Crabs</u>: The Dungeness crab fishery is sustainably managed, allowing for continued stable Dungeness populations on the west coast in general.*

*<u>Red Rock Crabs</u>: Red Rock crabs appear to have a healthy resident population in Coos Bay, although their populations are largely unstudied.*

*<u>Other Crabs</u>: More information is needed to properly assess these populations. Shore crabs appear abundant despite the introduction of the Atlantic mud crab. The status of subtidal crabs, pea crabs and kelp crabs has not been recently assessed.*




Subsystems: CR- Coos River, CS- Catching Slough, HI- Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay



## Chapter 15:
## Crabs in the Coos Estuary

*This chapter includes three data summaries: **Dungeness Crabs**, **Red Rock Crabs**, and **Other Crabs** – each describing the most current research on the status and trends (where the data allow) of crab populations in the Coos Estuary.*

The South Slough and Lower Bay are the two most studied subsystems for all crab populations and the only subsystems where information is reported for red rock crabs (*Cancer productus*). Although Dungeness crabs (*Cancer magister*) are mainly found in the Lower Bay and South Slough subsystems, Dungeness crab populations have been studied in all subsystems except Pony Slough, Coos River and Catching Slough. Information about "Other Crabs" comes mainly from studies focusing on South Slough and the Lower Bay, and from limited studies in the Upper Bay, Isthmus Slough and Coos River subsystems.

While all three crab-related data summaries include current and historical data, information for Dungeness and red rock crabs is by far the most current. For example, recent creel surveys have been conducted by the Oregon Department of Fish and Wildlife (ODFW) to help understand Dungeness crab population trends (Ainsworth et al. 2012), and a new, though preliminary ODFW study informs us of red rock population structure in the Coos estuary (Groth et al. 2013). Much of the information for the Other Crabs data summary is older, the most current being from deRivera et al. in 2005.

Information in crab data summaries was derived from a variety of sources including theses (e.g., Dunn 2011), agency reports (e.g., Ainsworth et al. 2012), peer review literature (e.g., Shanks 2013), and personal communications with various researchers.

**Data Gaps and Limitations**

Dungeness Crab Data: Due to their economic importance, Dungeness crabs are the most studied of the crab species. However, questions remain about how Dungeness crabs use estuaries.

For example, the migration of Dungeness between the estuary and the ocean is largely unstudied, although preliminary results from Groth et al. (2013) suggest seasonal movement of Dungeness crabs in and out of the Coos estuary.

Another Dungeness crab-related question Oregon State University is investigating (with ODFW), is the possibility of genetically different subpopulations of Dungeness crab –important for understanding how to keep the Dungeness crab fishery sustainable since harvesting selectively among crab subpopulations can affect genetic characteristics within a population and ultimately reduce the fisheries' productivity. (ODFW 2013).

An ongoing ODFW study samples Dungeness crabs in the Yaquina and Alsea estuaries, collecting data on carapace width, weight, sex, epifaunal growth on carapace, missing appendages, parasite presence, and evidence of pitting (injuries), thus providing important abundance and health information (ODFW 2013). A similar study in the Coos estuary could provide insight into the use of habitats by Dungeness crabs locally.

Red Rock Crab Data: Even though red rock crabs are recreationally harvested, this native crab has been largely unstudied. However, ODFW is now gathering much-needed information (e.g., growth rates) that may contribute to our understanding of how red rock crabs use the Coos estuary.

Other Crabs Data: More information is needed on other crabs in the Coos estuary. The most comprehensive targeted study is Queen's thesis from 1930 which provides an excellent historic baseline for other crabs in the Coos estuary but is obviously of limited use for understanding the status of current crab populations. Most needed is information characterizing the current distribution, productivity, and habitat usage by the large variety of non-Dungeness crabs that use the Coos estuary – especially subtidal crabs, pea crabs (*Pinnixa faba*), and kelp crabs (*Pugettia producta*), about which there is especially limited information.

**Non-Indigenous Crabs**

While there is mention in this chapter of a non-indigenous crab species (Atlantic mud crab— *Rhithropanopeus harrisi*), the status of non-native crab populations in the Coos estuary, including invasive species such as the European green crab (*Carcinus maenas*) are discussed in full in Chapter 18: Non-Indigenous and Invasive Species.

**References**

Ainsworth, J. C., M. Vance, M. V. Hunter, and E. Schindler. 2012. The Oregon recreational Dungeness crab fishery, 2007-2011. [Oregon Department of Fish and Wildlife Information Report 2012-04, Marine Resources Program]. Newport, OR.

deRivera, C. E., G. M. Ruiz, J. Crooks, K. Wasson, S. Lonhart, P. Fofonoff, B. Steves, S. Rumrill, M. S. Brancato, S. Pegau, D. Bulthuis, R. K. Preisler, C. Schoch, E. Bolwby, A. DeVogelaere, M. Crawford, S. Gittings, A. Hines, L. Takata, K. Larson, T. Huber, A. M. Leyman, E. Collinetti, T. Pascot, S. Shull, M. Anderson, and S. Powell. 2005. Broad-scale nonindigenous species monitoring along the West Coast in National Marine Sanctuaries and National Estuarine Research Reserves. [Report to National Fish & Wildlife Foundation]. 126 pp.

Dunn, P. H. 2011. Larval biology and estuarine ecology of the Nemertean egg predator *Carcinonemertes errans* on the Dungeness crab, *Cancer magister*. [PhD Thesis]. University of Oregon.

Groth, S., S. Yamada, E. Post, and J. Heinrich. 2013. Mark recapture of red rock crab, *Cancer productus*, in Coos Bay, OR. [Poster session presented at Towards an Estuarine Ethic: integrating science and stewardship]. 36th Annual Meeting of the Pacific Estuarine Research Society: 2013, April 4-7. Delta, BC.

Oregon Department of Fish and Wildlife (ODFW). 2013. Oregon Dungeness Crab Research and Monitoring Plan. Available online http://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/ODFW_Dungeness-CrabResearchMonitoringPlan2013.pdf

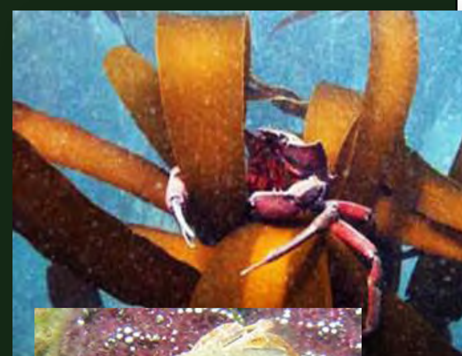
Queen, J. C. 1930. Marine decapod crustacea of the Coos Bay, Oregon district. [MS Thesis]. University of Oregon, Department of Biology.

Shanks A. L. 2013. Atmospheric forcing drives recruitment variation in the Dungeness crab (*Cancer magister*), revisited. Fisheries Oceanography 22(4): 263-272.

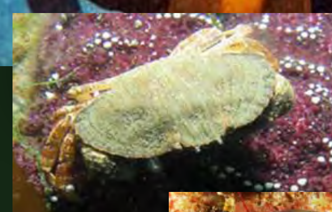
# How the Local Effects of Climate Change Could Affect Crabs in the Coos Estuary

*There are several climate-related changes expected on the Oregon coast that have the potential to affect crab populations in the Coos estuary:*

- *Ocean acidification is expected to cause a multitude of effects on crabs including low molt success rate and decreased larval survival.*
- *Warming oceans, sea level rise, and hypoxia events are all likely to stress crab populations, most likely causing a shift in range, distribution, and habitat use.*
- *Increasing ocean temperatures will also likely affect survivorship of multiple crab species.*
- *Changes in ocean currents are expected to affect recruitment of larvae to the estuary and alter nutrient availability.*



Kelp Crab
Photo:
Scott Groth



Juvenile Red
Rock Crab
Photo: ODFW

Porcelain Crab
Photo: UC Berkeley

With Oregon's Dungeness crab (*Cancer magister*) fishery certified sustainable by the Marine Stewardship Council, one naturally wonders whether the fishery can remain sustainable and robust should permanent climate-influenced changes take place in the Coos estuary and nearshore ocean. Scientists are also concerned about climate-related effects on habitats associated with the other estimated 30 species of crab living in our estuary. Climate-related changes will likely come from the increasing acidification and temperature of ocean and estuary waters, hypoxia (low dissolved oxygen levels) in ocean and estuary waters, sea level rise, and change in oceanographic conditions, each of which are discussed below.

### Ocean Acidification

Increasing acidic conditions in the ocean are expected to have major consequences for invertebrates with shells or exoskeletons, such as crabs. For example, adverse effects of ocean acidification were found in laboratory experiments by Long (2013) who found that only 25% of female red king crabs (*Paralithodes camtschaticus*) molting in acidified water were able to molt successfully, while 100% of those in the control group (standard ocean salinity) successfully molted.

Long also made the surprising observation that for many crab species — including Dungeness crab — calcium content in freshly molted crab exoskeletons is higher in acidified water than those molting in standard sea water. Long suggests this is most likely due to the ability of many crab species to increase their internal pH during a molt cycle; the increased pH range between their bodies and the more acidified water could lead to a higher calcium content in exoskeletons. However, this physiological process comes at a high energetic cost, seen in the drastic depletion of lipid reserves in molting adults, leaving them depleted of a major energy source required for proper growth. In further experiments, Long saw survival of red king crab larvae decrease by 13% in acidified water.

Intertidal crabs live in a constantly fluctuating environment as the relatively stable conditions of high tide give way to stressful low tide conditions. Changes in oxygen and pH can be drastic and occur very rapidly in shallow isolated tide pools, but these changes are temporary and only last until the next high tide. Ceballos-Osuna et al. 2013 found that the intertidal porcelain crab (*Petrolisthes cinctipes*) had 30% reduced survival of juveniles when continuously exposed to low pH

*Ocean Acidification*

*Since the late 18th century, the average open ocean surface pH levels worldwide have decreased by about 0.1 pH units, a decrease of pH from about 8.2 before the industrial revolution to about 8.1 today. A 0.1 change in pH is significant since it represents about a 30 percent increase in ocean acidity (the pH scale is logarithmic, meaning that for every one point change in pH, the actual concentration changes by a factor of ten). Scientists estimate that by 2100 ocean waters could be nearly 150% more acidic than they are now, resulting in ocean acidity not experienced on earth in 20 million years. The best Pacific Northwest ocean acidification data we have so far are from the Puget Sound area where pH has decreased about as much as the worldwide average (a decrease ranging from 0.05 to 0.15 units).*

*Sources: Feely et al. 2010, NOAA PMEL Carbon Program 2013* waters. Therefore, intertidal organisms that are presently tolerant to brief changes in pH could still be detrimentally affected by ocean acidification.

**Increasing Ocean Temperatures**

One consequence of a warming ocean may be decreased stability in ocean habitats, and thus decreased survivorship of multiple crab species. Brown and Terwilliger (1999) found that Dungeness crab megalopae and first instar juveniles are more temperature sensitive than older crabs, in part because they are spawned in stable ocean conditions before moving to the warmer and more fluctuating temperatures in estuaries during their adult stage. Destabilizing the ocean conditions would likely have deleterious effects on the crab's sensitive younger stages. Brown and Terwilliger also noted that survival at all larval stages decrease as water temperatures approach 20° C (68° F). To put this in perspective, ocean waters near Coos Bay ranged between 8.6° and 18.2° C (47.5° and 64.8° F) in 2011 (NOAA National Data Buoy Center n.d.), suggesting that further research is needed to understand how rising ocean temperatures over the next several decades could ultimately stress crab juveniles past their limit in the Coos estuary.

Others have documented temperature-related stresses on crab physiology and life histories. For example, Wild (1980) found that increases in water temperature decreased hatching success of Dungeness crab eggs, especially when temperatures over 13° C (55° F) were reached. On average, 685,000 eggs per

*<u>Increasing Ocean Temperatures</u>*

*Worldwide, ocean temperatures rose at an average rate of 0.07° C (0.13° F) per decade between 1901 and 2012. Since 1880, when reliable ocean temperature observations first began, there have been no periods with higher ocean temperatures than those during the period from 1982 – 2012. The periods between 1910 and 1940 (after a cooling period between 1880 and 1910), and 1970 and the present are the times within which ocean temperatures have mainly increased.*

*Describing how the worldwide trend translates to trends off the Oregon coast is a complicated matter. Sea surface temperatures are highly variable due to coastal upwelling processes and other climatic events that occur in irregular cycles (e.g., El Niño events). We do have 27 years (1967-1994) of water temperature data collected from near the mouth of the Coos estuary that indicate through preliminary analyses a very weak trend towards warming water temperatures. Fifteen years (1995-2010) of data from multiple stations further up the South Slough estuary show very little water temperature change.*

*Sources: USEPA 2013, SSNERR 2013, Cornu et al. 2012* crab hatched in 10° C (50° F) water, while only 14,000 per crab hatched at 16.7° C (62° F) (Wild 1980). Normal development from egg to larvae in Oregon takes place between 10° and 13.9° C (50° and 57° F)(Rasmuson 2013).

Stillman (2003) reported that thermal stress from global climate change may already be affecting intertidal species such as porcelain crabs (*Petrolisthes cinctipes*). This has been seen in Monterey, California with a decline in Porcelain crab abundance of over the past 60 years, corresponding to a rise in water temperature. Stillman suggests that those species that have evolved to survive high temperatures for short periods of time, such as intertidal crabs, are already near the limit of their maximal temperature and will therefore be particularly susceptible to sustained increases in water temperature.

Another likely outcome of warming oceans is a shift in the timing of larval development. This means that the evolutionarily established timing of crab larvae development may no longer remain in sync with the seasonal blooms of their planktonic food sources (Pörtner and Farrell 2008). Moreover, warmer ocean waters are expected to change the community composition of the nearshore ocean, including upper trophic food web organisms (e.g. salmonids), which rely on crab larvae as a main component of their diets (Pörtner and Farrell 2008).

A warming ocean is also likely to cause a shift towards the poles in all invertebrate species as well as a vertical shift towards deeper, cooler habitats, changing the population dynamics in the estuary and nearshore ocean (McConnaughey and Armstrong 1995). Especially apparent will be population changes in species where the Coos estuary is near the Northern or Southern extent of their range. (e.g., the pygmy rock crab, *Cancer oregonensis*).

*Sea Level Rise*

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, according to the National Research Council (2012), predicted SLR rates for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary), are reported as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100 .*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

**Hypoxia Events**

Hypoxic conditions can stress crabs, especially subtidal populations, which are not regularly exposed to low oxygen conditions. Increasing temperatures compound the effects of hypoxia. In turn, hypoxic events can reduce the thermal tolerance of some crabs. This problem will be particularly relevant to intertidal crabs, which are sometimes living near the limit of both their thermal and hypoxia tolerance (Metzger et al. 2007).

### Sea Level Rise

Drowned river valleys, such as the Coos estuary, provide valuable intertidal habitat to numerous crab species. If sedimentation rates do not allow intertidal marshes to keep pace with sea level rise, many of these areas may be lost due to rising sea levels, especially where no low elevation lands exist for the marshes to migrate to (McConnaughey and Armstrong 1995).

### Change in Oceanographic Conditions

Changes in oceanographic conditions, such as local wind patterns, ocean currents or other weather cycles, raise questions about how the local effects of long term climate change will affect the distribution of pelagic larvae, the timing of spring transition and the recruitment of crabs into the Coos estuary. It is unclear what exact effects these changes will have on the planktonic larval phase of crabs, but it is likely recruitment will be altered (McConnaughey and Armstrong 1995). Shifts in the timing or strength of spring transition will also alter nutrient availability for larvae, affecting their health and survival (McConnaughey and Armstrong 1995).

### References

Brown, A. C. and N. B. Terwilliger. 1999. Developmental changes in oxygen uptake in *Cancer magister* (Dana) in response to changes in salinity and temperature. Journal of Experimental Marine Biology and Ecology 241(2): 179-192.

Ceballos-Osuna L., H. A. Carter, N. A. Miller, and J. H. Stillman. 2013. Effects of ocean acidification on early life-history stages of the intertidal porcelain crab *Petrolisthes cinctipes*. Journal of Experimental Biology 216(8): 1405-1411.

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. [Report prepared for the Partnership for Coastal Watersheds Steering Committee]. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Feely, R. A., S. R. Alin, J. Newton, C. L. Sabine, M. Warner, A. Devol, C. Krembs, and C. Maloy. 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. Estuarine, Coastal and Shelf Science 88(4): 442-449.

Long, C. W., K. M. Swiney, and R. J. Foy. 2013. Effects of ocean acidification on the embryos and larvae of red king crab, *Paralithodes camtschaticus*. Marine Pollution Bulletin 69(1-2): 38-47.

McConnaughey, R. A., and D. A. Armstrong. 1995. Potential effects of global climate change on Dungeness crab (*Cancer magister*) populations in the northeastern Pacific Ocean. Canadian Special Publication of Fisheries and Aquatic Sciences 121: 291-306.

Metzger, R., F. J. Sartoris, M. Langenbuch, and H. O. Pörtner. 2007. Influence of elevated $CO_2$ concentrations on thermal tolerance of the edible crab *Cancer pagurus*. Journal of Thermal Biology 32(3): 144-151.

National Oceanic and Atmospheric Administration National Data Buoy Center. n.d. Umpqua Offshore, OR station 46229. Available online http://www.ndbc.noaa.gov/station_page.php?station=46229

National Oceanic and Atmospheric Administration Pacific Marine Environmental Laboratory (PMEL) Carbon Program. 2013. What is Ocean Acidification? Available online http://www.pmel.noaa.gov/co2/story/What+is+-Ocean+Acidification%3F

National Oceanic and Atmospheric Administration Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Available online http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council. 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Washington, DC: The National Academies Press. 201 pp.

Pörtner, H. O., and A. P. Farrell. 2008. Physiology and Climate Change. Science 322(5902): 690-692.

Rasmuson, L. K. 2013. The biology, ecology and fishery of the Dungeness crab, *Cancer magister*. Advances in Marine Biology 65: 95-148.

South Slough National Estuarine Research Reserve (SSNERR). 2013. [Unpublished raw data]. System-Wide Monitoring Program (SWMP). Available online http://cdmo.baruch.sc.edu/

Stillman, J. H. 2003. Acclimation Capacity Underlies Susceptibility to Climate Change. Science 301(5629): 65.

United States Environmental Protection Agency (USEPA). 2013. Climate change indicators in the United States. Available online http://www.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html

Wild, P. W. 1980. Effects of Seawater Temperature on Spawning, Egg Development, Hatching Success, and Population Fluctuations of the Dungeness Crab, *Cancer Magister*. CalCOFI Report 21: 115-120. Available online http://www.calcofi.org/publications/calcofireports/v21/Vol_21_Wild.pdf

# Dungeness Crabs in the Coos Estuary


*Summary:*

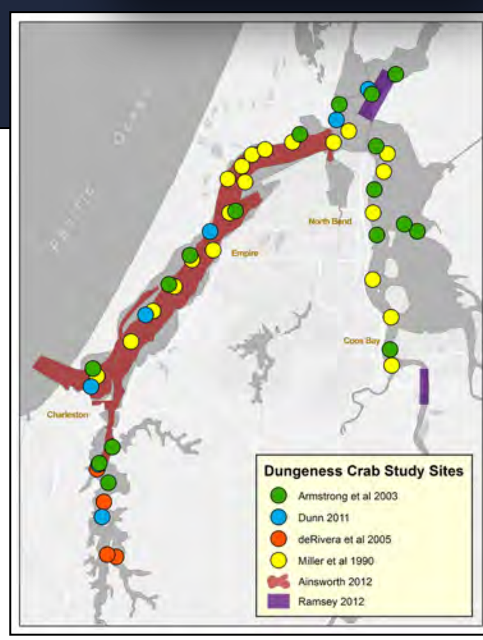
- *Despite 90% of the legal-sized male Dungeness crab population being taken by commercial crabbing each year, ODFW data indicate that the Dungeness crab fishery remains sustainable.*
- *Decadal variations in ocean currents along with the timing of spring upwelling conditions ultimately determine yearly adult Dungeness crab populations in the Coos estuary.*


*Adult Dungeness Crab*

*Dungeness Crab Megalope*

**Evaluation**

Continued healthy commercial landings of Dungeness crabs suggest crab populations remaining sufficient to support a sustainable fishery.




Recent Dungeness crab study locations.

### What's happening?

Oregon Department of Fish and Wildlife's commercial Dungeness crab (*Cancer magister*) landings data provide resource managers and scientists with a very reliable index of four year old adult Dungeness crab populations in Oregon estuaries (S. Groth and A. Shanks, pers. comm., April 2012). These data indicate that the Dungeness crab fishery has been healthy and robust for decades (Figure 1) despite the fact that commercial crabbers harvest about 90% of the commercially available male Dungeness crab population most years (Ainsworth et al. 2012).

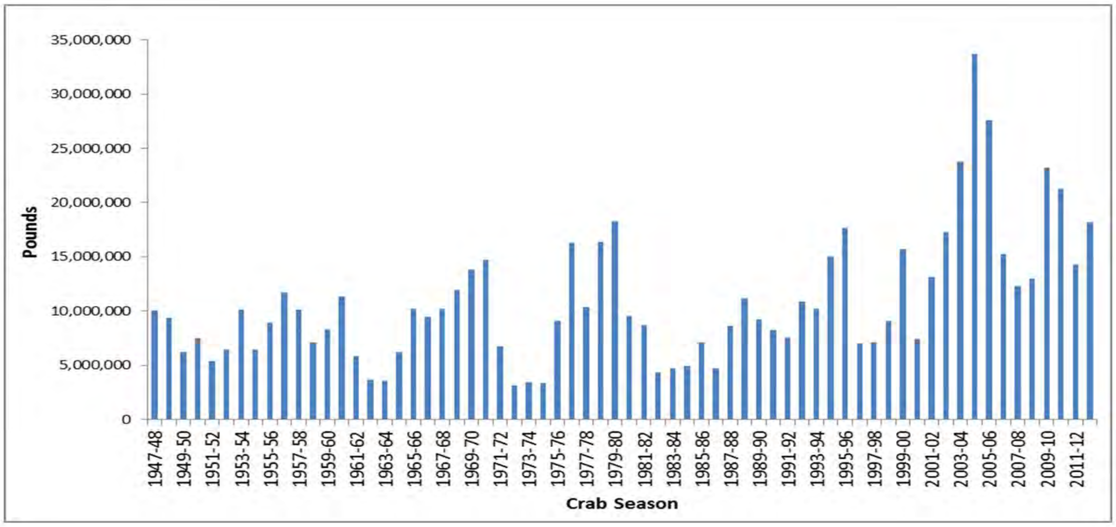



Figure 1. Oregon commercial Dungeness crab landings (millions of pounds) by season (1947-48 through 2012-13 crab seasons). Graph ODFW 2001.

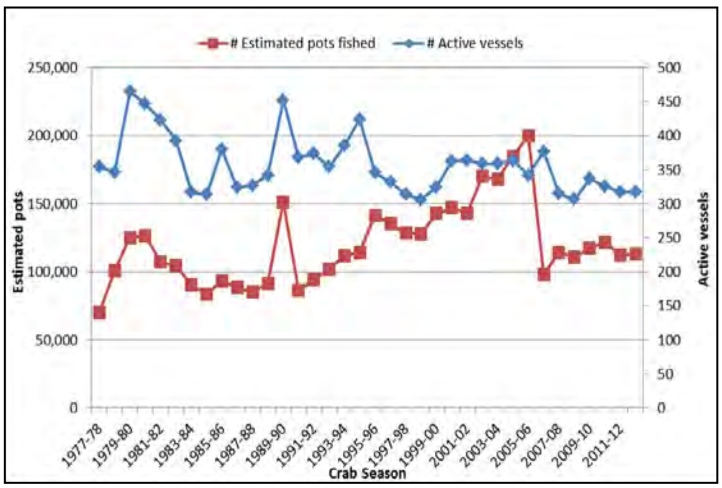



Figure 2. Number of active vessels and estimated number of pots used in Oregon's commercial Dungeness crab fishery from 1977-78 to 2012-13 crab seasons. Graph ODFW 2001.

Figure 2 shows the number of commercial crab pots and vessels engaged in crabbing in Oregon between 1977 and 2012, illustrating relatively recently established crab fishery management measures. Limited entry to the fishery (limited number of permits issued) began during the 1995-96 season; limits on the number of crab pots used by permit holders began during the 2006-07 season. These measures help maintain the sustainability of the commercial Dungeness crab fishery.

We should note that some of the recent increases in commercial landings may actually be due to long-term cyclical changes in North Pacific climate, the latest cycle of which happened to benefit crab populations (A. Shanks, pers. comm., April 2012; see more in Why is it happening?).

The recreational Dungeness crab fishery, another important element of the coastal Oregon economy, also appears to be stable. This is good news since according to Dean Runyan and Associates (2009), recreational shellfish harvests contribute $172 million to Oregon's

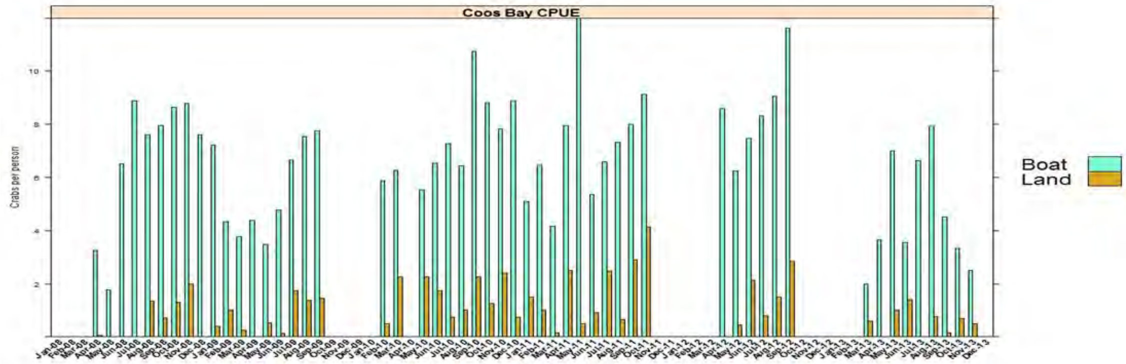


Figure 3. Recreational Dungeness crab catch per person in Coos Bay 2008-2013. Graph: ODFW 2001.

Figure 4. Most popular crabbing locations in the Coos estuary. Data: ODFW 2001.

economy. The Coos estuary is one of Oregon's most popular clamming and crabbing destinations. Recreational crabbing (mainly for Dungeness crabs) comprises a large percentage of the recreational crab harvest in Coos Bay.

Figure 3 shows the relative stability of the recreational crab catch in the Coos estuary in recent years and Figure 4 shows where over 98% of the recreational crabbing effort takes place in the Coos estuary (Ainsworth et al. 2012).

According to Ainsworth et al. (2012) in their survey of Oregon's Dungeness crab fishery for 2007-11, crabs harvested from the Coos estuary were among the largest of all bays surveyed (likely due to the greater ocean influence in the lower Coos estuary), with a mean weight of 643.5 g (1.42 lbs) averaged over four years of data. They note that while recreational crabbing effort has not changed significantly statewide since 1971, effort has actually decreased in Coos Bay. And despite that decrease in effort, Coos Bay's recreational crab harvests have increased. Over 40,000 crabs were caught in Coos Bay in 1971, while in more recent times (2007-2011) the recreational catch averaged between 86,000-136,000 crabs per year (likely due to improvements in fishing gear, changes in bait, and larger and more efficient boats).

Current Oregon Department of Fish and Wildlife (ODFW) commercial crabbing regulations protect recreational crabbers' share of the

Dungeness crab harvest (i. e., shorter seasons and larger size limit for commercial crabbers). Without this protection, the recreational fishery would be greatly affected by the commercial crabbing industry (Ainsworth et al. 2012).

**Why is it happening?**

Dungeness crabs inhabit estuaries and offshore waters from Alaska to Monterey Bay, California (Ricketts et al. 1985). In the Coos estuary, they're found in the South Slough, the lower and upper Coos estuary, and the Isthmus Slough (Figure 5)(Miller et al. 1990; deRivera et al. 2005; Ramsay 2012).

Like all crabs, young Dungeness crabs first live in the water column as "planktonic larvae," first as crab zoea (2.1 mm-10 mm, 0.08 in-0.4 in) and then as pea-sized megalopae. Ultimately, they develop into small juvenile crabs, settle out of the water column, and begin living on intertidal and subtidal channel bottoms, mudflats, and in eelgrass beds.

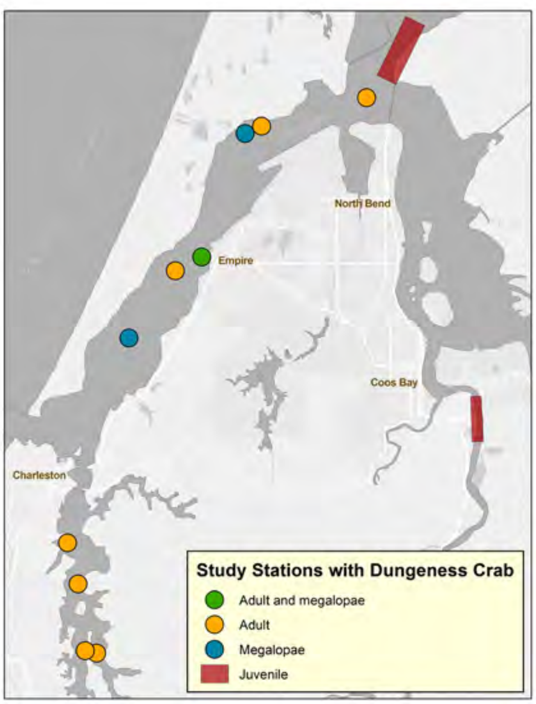



Figure 5. Study stations where Dungeness crabs were found during surveys . Data from deRivera et al. 2005, Ramsay 2012 and Miller et al. 1990.

Understanding both the larval and settled life stages of juvenile Dungeness crabs helps us understand the status and trends of adult crab populations. Research conducted locally by Shanks and Roegner (2007) linked the number of Dungeness crab megalopae settling in the Coos estuary with the number of adult crabs caught locally four years later (simplistically, more megalopae = more adults). Further, they determined that the number of Dungeness crab megalopae settling in the Coos estuary is correlated with the timing of the spring transition, when low productivity wintertime ocean conditions off the Oregon coast shifts to high productivity summertime ocean conditions (productivity determined by north wind-driven upwelling in the summer and south wind-driven downwelling in the winter). Shanks and Roegner report that early spring transitions result in greater the numbers of megalopae settling, and four years later, more adult crabs available for harvest.

Shanks (2013) has also described planktonic Dungeness crab larvae movement relative to Pacific Decadal Oscillation (PDO) patterns: patterns in which oceanic and ocean-related climate conditions shift every 20-30 years from cold phases to warm phases and back again.

A cold phase of the PDO, which our region has been experiencing locally since 1999 (NASA JPL 2000), strengthens the south-flowing California Current. This causes megalopae to accumulate along the Washington and Oregon coasts, and thus creates extraordinary high returns of megalopae to the Coos estuary and surrounding area. During a warm phase of the PDO, the opposite occurs. Adult Dungeness crab populations are reduced in Oregon waters as the California Current is weakened, allowing the stronger, north-flowing Gulf of Alaska Current to pick up the megalopae and move them northwards. Shanks showed that cold phase PDO, paired with early spring transition and constant spring upwelling, creates conditions for the highest crab megalopae returns to the Coos estuary system.

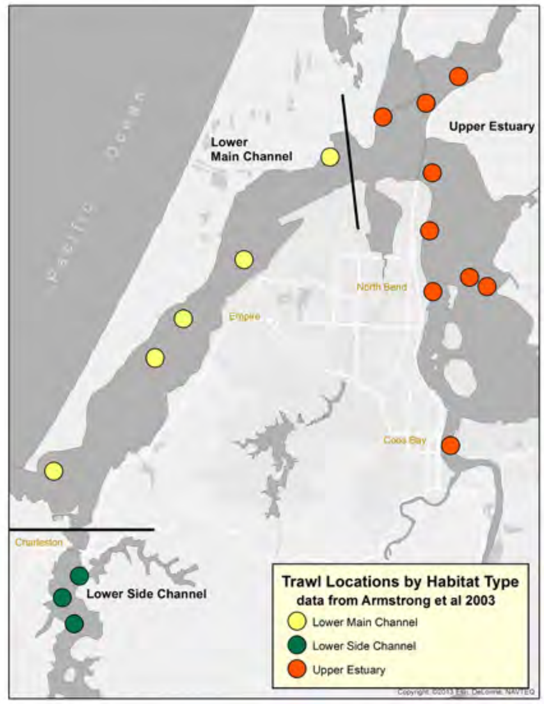



Figure 6. Trawl stations from Armstrong et al. 2003. Map shows partitioning of the Coos estuary into Lower Side Channel, Lower Main Channel and Upper Estuary habitat types.

The quality and type of habitat where crabs settle out of the water column also influences adult crab populations. Armstrong et al. (2003) determined juvenile Dungeness crab density and abundance by age class in several Oregon and Washington estuaries while also considering the influences of water temperature, salinity, sediment composition and habitat. They found the habitat with the highest juvenile crab density was what they called Lower Side Channel habitat, characterized by higher summer temperatures, shallow depths, extensive intertidal areas, and high shell and macroalgae cover. Other habitats called Lower Main Channel habitat and the Upper Estuary habitat were also described and were characterized as follows: Lower Main Channel was defined as being adjacent to the estuary mouth, with cold summer temperatures, high salinity, deep channels, little ground cover, and few intertidal zones; Upper Estuary is indicated by the warmest summer temperatures, low salinities, moderate amounts of intertidal habitat, and high amounts of cover (mainly from shell and woody debris).

In the Coos estuary, the Lower Side Channel habitat averaged a juvenile Dungeness crab density of about 1,300 crabs/ha, compared to the Lower Main Channel habitat (600 crabs/ha) and the Upper Estuary habitat (700 crabs/ha)(Figure 6). Although it contains the most productive (and thus most dense) habitat, the Lower Side Channel makes up only 11% of the estuary. Due to its small size this habitat supports the smallest overall Dungeness crab population in the Coos estuary, with a total summer abundance around 300,000 juvenile crabs. The Lower Main Channel represents 64% of the estuary and thus supports the biggest population with a total summer abundance around 850,000 juvenile crabs, while the Upper Bay supports nearly 500,000 juvenile crabs.

Another study by Ramsay (2012) shows the importance of oysters as habitat refuge for juvenile Dungeness crabs. Ramsay determined juvenile Dungeness crab densities in three habitat types: native oysters, non-native oysters, and eelgrass. At the Isthmus Slough study site (Figure 7), juvenile crabs used native oyster habitat (5 crab/$m^2$) far more than adjacent eelgrass habitat (0 crab/$m^2$). At the Haynes Inlet site, crab densities were higher in Japanese Oyster habitat (8.5 crab/$m^2$) than in adjacent eelgrass habitat (0.57 crab/$m^2$), though crab refuge provided by commercial oyster beds is thought to be temporary due to the frequent disturbances in those areas (S. Groth, pers. comm., 2014). Ramsay's study did not discern a significant difference in density by oyster species.

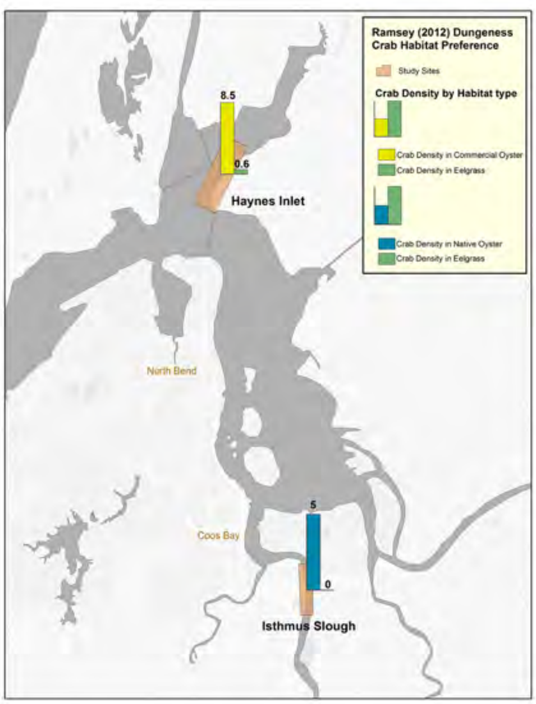



Figure 7. Study sites from Ramsay 2012, showing juvenile Dungeness crab density (per $m^2$) in eelgrass, native oyster and commercial oyster habitats. Numbers on bars represent average density in that habitat type

Adults also prefer specific habitats. Results from McMillan et al. (1995) found adult densities to be highest in habitats containing mixed sand and gravel along with macroalgae or eelgrass, while the lack of complexity in open sand habitats resulted in the fewest crabs. Intertidal zones are also important as they provide crucial foraging habitat for Dungeness crab adult, as seen in studies at Willapa Bay (Holsman et al. 2006).

Brooding female Dungeness crabs appear to require sandy habitat (Rasmuson 2013). Due to the large number of eggs they carry under their abdominal flap, female Dungeness bury themselves in sand up to 10 cm (4 in.) deep to hold the eggs in place, limiting their movement (Rasmuson 2013).

Estuaries not only provide excellent habitat for juvenile and adult Dungeness crabs, they also may provide refuge from some parasites that may otherwise threaten the health of adult Dungeness crab populations. Oregon Institute of Marine Biology researcher Paul Dunn (2011) examined the effects of the

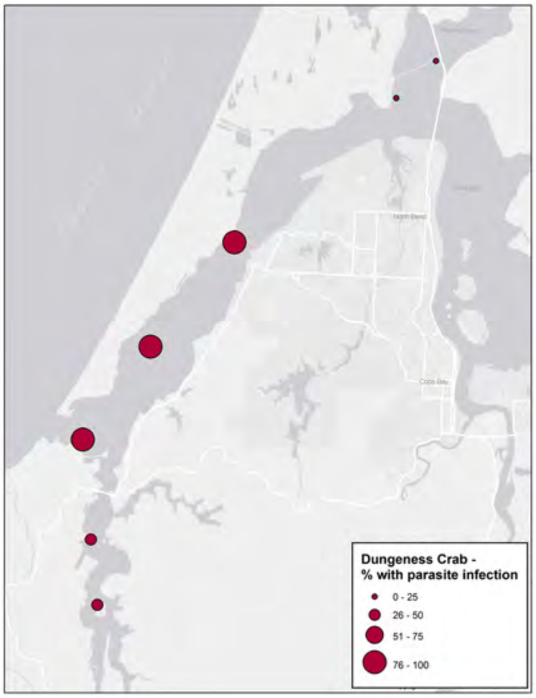



Figure 8. Study site locations from Dunn 2011, showing percentage of Dungeness crabs caught that were infected with the parasitic worm. Locations near the mouth of the estuary show higher infection rates.

parasitic worm (*Carcinonemertes errans*) on adult Dungeness crabs. Dunn documented parasitic feeding on the egg masses of female crabs, which caused potentially significant brood loss. Dunn investigated the relative abundance of this parasitic worm in the Dungeness crab population and found that crabs living closest to the mouth of the estuary were infected with greatest number of parasites (Figure 8), and that crabs sampled in nearshore ocean waters had more parasites than crabs sampled from estuarine waters.

This difference suggested that the parasite's salinity tolerances were different than those of their hosts, which means that estuarine waters may act as a refuge for crabs from *C. errans* parasites. In fact, Dunn reported that Dungeness crabs can tolerate salinities ranging from 11 to 35, preferring salinities over 20 (Cleaver 1949, Robinson & Potts 1979), and determined that only 50-70% of juvenile parasitic worm parasites survived 2 days at a salinity of 10.

These results suggest that there may be more to the story because reduced estuarine salinity explained some, but not all parasite loading. Dunn indicated that *C. errans* larvae prefer to settle on crabs already infected with juvenile worms, providing another piece to the puzzle.

ODFW's Ainsworth and Groth (pers. comm. 2014) report that egg-carrying female Dungeness crab have never been found in estuarine waters (only in the nearshore ocean), which confounds scientists' ability to conclusively decide whether estuarine waters provide refuge from the parasites for Dungeness crabs. Parasites documented on Dungeness crabs in estuarine waters have been found in relatively low numbers on male crabs (in clusters at the base of their walking legs). They report that the presence of these parasites on the male Dungeness crabs decreases in lower salinity waters in the upper estuary.

**References**

Ainsworth, J. C., M. Vance, M. V. Hunter, and E. Schindler. 2012. The Oregon recreational dungeness crab fishery, 2007-2011. [Oregon Department of Fish and Wildlife Information Report 2012-04]. Marine Resources Program. Newport, OR.

Armstrong, D. A., C. Rooper, and D. Gunderson. 2003. Estuarine Production of Juvenile Dungeness Crab (*Cancer magister*) and Contribution to the Oregon-Washington Coastal Fishery. Estuaries 26(4): 1174-1188.

Cleaver, F. C. 1949. Preliminary results of the coastal crab (*Cancer magister*) investigation. Biological Report 49A: 47-82.

Dean Runyan Associates. 2009. Fishing, Hunting, Wildlife Viewing, and Shellfishing in Oregon: 2008 State and County Expenditure Estimates. [Prepared for Oregon Department of Fish and Wildlife and Travel Oregon]. Dean Runyan Associates. Portland, OR. Available online http://www.dfw.state.or.us/agency/docs/Report_5_6_09--Final%20%282%29.pdf

deRivera, C. E., G. M. Ruiz, J. Crooks, K. Wasson, S. Lonhart, P. Fofonoff, B. Steves, S. Rumrill, M. S. Brancato, S. Pegau, D. Bulthuis, R. K. Preisler, C. Schoch, E. Bolwby, A. DeVogelaere, M. Crawford, S. Gittings, A. Hines, L. Takata, K. Larson, T. Huber, A. M. Leyman, E. Collinetti, T. Pascot, S. Shull, M. Anderson, and S. Powell. 2005. Broad-scale nonindigenous species monitoring along the West Coast in National Marine Sanctuaries and National Estuarine Research Reserves. [Report to National Fish & Wildlife Foundation]. 126 pp.

Dunn, P. H. 2011. Larval biology and estuarine ecology of the nemertean egg predator *Carcinonemertes errans* on the Dungeness crab, *Cancer magister*. [PhD Dissertation]. University of Oregon, Department of Biology.

Holsman, K. K., P. S. McDonald, and D. A. Armstrong. 2006. Intertidal migration and habitat use by subadult Dungeness crab *Cancer magister* in a NE Pacific estuary. Marine Ecology Progress Series 308: 183-195.

McMillan, R., D. Armstrong, and P. Dinnel. 1995. Comparison of intertidal habitat use and growth rates of two northern Puget Sound cohorts of 0+ age Dungeness crab, *Cancer magister*. Estuaries and Coasts 18(2): 390-398.

Miller, D. R., R. L. Emmett, and S. A. Hinton. 1990. A preliminary survey of benthic invertebrates in the vicinity of the Coos Bay, Oregon, navigation channel. Northwest and Alaska Fisheries Center, Coastal Zone and Estuarine Studies Division. Seattle, WA.

National Aeronautics and Space Administration Jet Propulsion Laboratory (JPL). 2000. La Niña's persistence may be part of larger climate pattern. Available online http://sealevel.jpl.nasa.gov/newsroom/pressreleases/index.cfm?FuseAction=ShowNews&NewsID=211

Oregon Department of Fish and Wildlife (ODFW). 2001. Oregon marine fisheries 2000 status report. Oregon Department of Fish and Wildlife Marine Resources Program. Newport, OR.

Ramsay, J. 2012. Ecosystem services provided by Olympia oyster (*Ostrea lurida*) habitat and Pacific oyster (*Crassostrea gigas*) habitat; Dungeness crab (*Metacarcinus magister*) production in Willapa Bay, WA. [MS Thesis]. Oregon State University.

Rasmuson, L. K. 2013. The biology, ecology and fishery of the Dungeness crab, *Cancer magister*. Advances in Marine Biology 65: 95-148.

Ricketts, E. F., J. Calvin, J. W. Hedgpeth, and D. W. Phillips. 1985. Between Pacific tides. Stanford, CA: Stanford University Press.

Robinson G. D., and W. T. W. Potts. 1979. Ion fluxes and diffusion potentials in the Dungeness crab, *Cancer magister*. Journal of Comparative Physiology B 131: 285-292.

Shanks A. L. and G. C. Roegner. 2007. Recruitment Limitation In Dungeness Crab Populations Is Driven By Variation In Atmospheric Forcing. Ecology 88(7): 1726–1737.

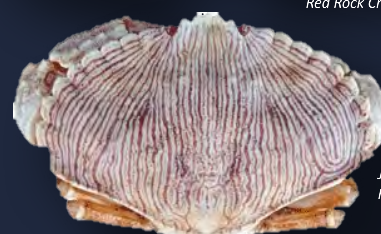
Shanks A. L. 2013. Atmospheric forcing drives recruitment variation in the Dungeness crab (*Cancer magister*), revisited. Fisheries Oceanography 22(4): 263-272.

# Red Rock Crab in the Coos Estuary

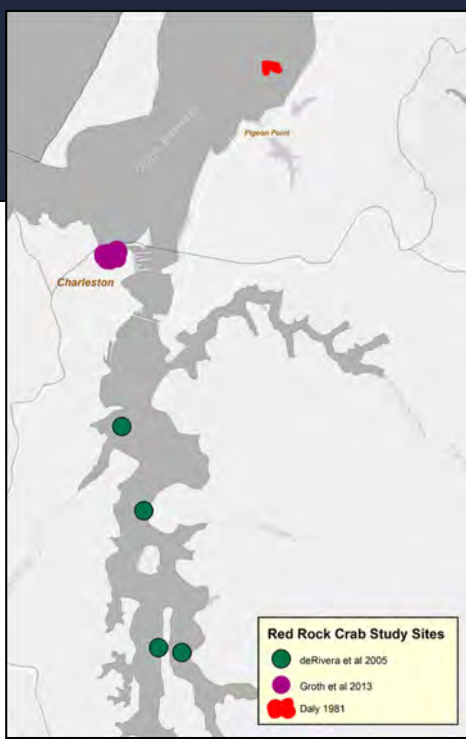

*Summary:*

- *The population of red rock crab appears stable in the Coos estuary but more data are needed to understand the population dynamics of this species.*


Adult Red Rock Crab



Juvenile Red Rock Crab




Location of red rock crab study sites.

**Evaluation**

Populations appear stable, although these crabs have been minimally studied in the Coos system.

DATA GAP

**What's happening?**

Oregon Department of Fish and Wildlife (ODFW) regulates the harvest of red rock crab (*Cancer productus*) less rigorously than Dungeness crab, allowing any size or sex to be taken and a limit of 24 crabs per person per day. Despite this, scientists think red rock crab populations may be relatively stable in the Coos estuary. Preliminary results from a crab tagging study by Groth et al. (2013) show relative stability in Coos Bay's red rock crab's size distributions compared with those of Dungeness crab, though Groth urges caution on this point because the results may simply be highlighting red rock crab's high site fidelity (S. Groth, pers. comm., 2014). He also found that all red rock crab age classes are found year round within the estuary, which differs from Dungeness crabs (larger crabs are found inside the estuary in the fall and smaller crabs in the spring and summer) (Figure 1). This work suggests, at minimum, the importance of the estuary as a year-round habitat for red rock crabs.

**Distribution in the Coos Estuary**

Red rock crab adults are found among rocks and hard bottom substrates. They're found mostly in estuarine habits and infrequently outside estuaries (e.g., nearshore ocean bottom, where Dungeness crabs are abundant) (S. Groth, pers. comm., 2013).

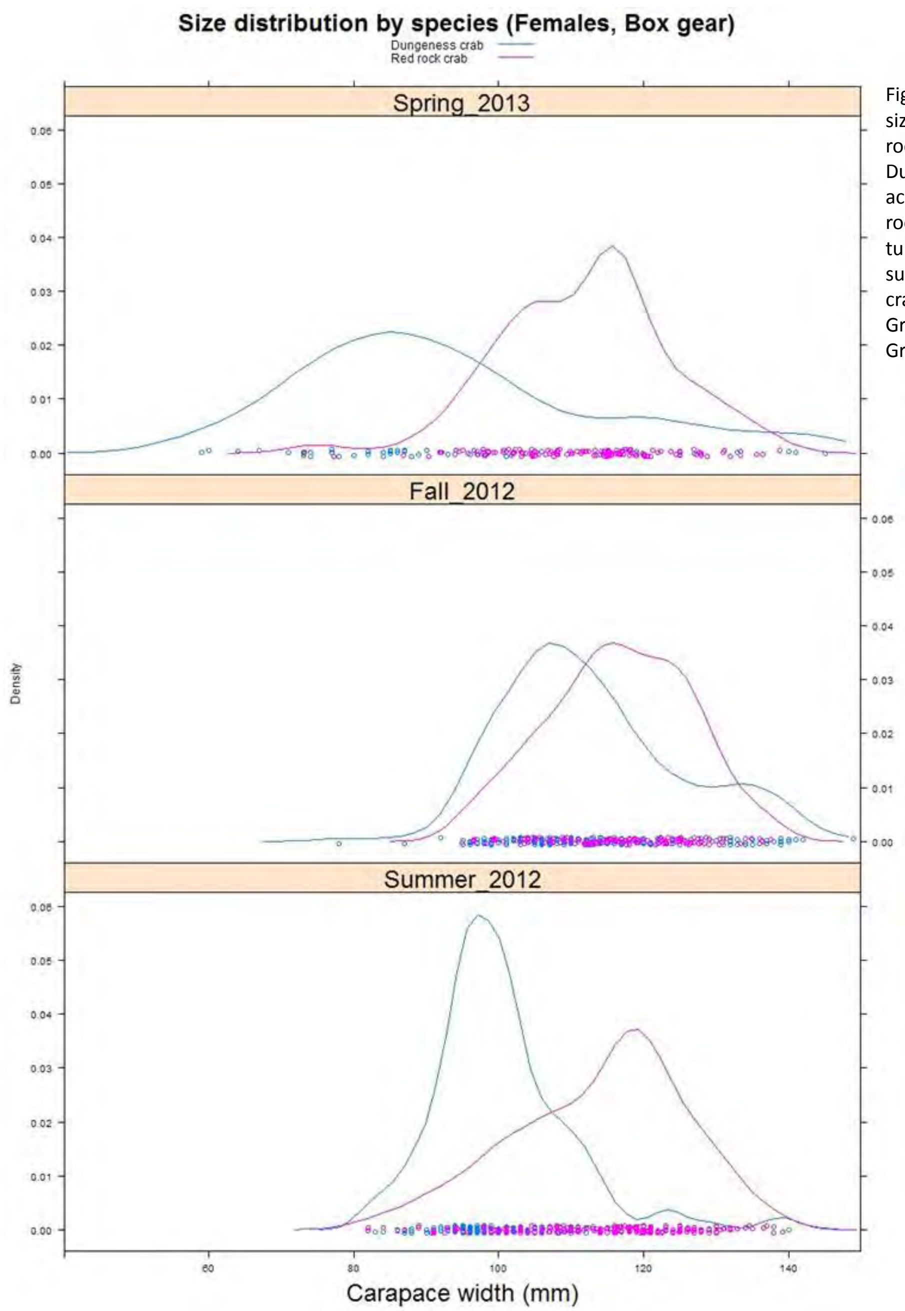



Figure 1. Density of different size classes of female red rock crab compared to Dungeness crab, shown across three seasons. Red rock crab population structure is similar spring, fall and summer, while Dungeness crab sizes shift seasonally. Graph (preliminary data): Groth et al. 2013.

Red rock crabs do not burrow and tend to avoid sandy substrates as they lack any straining apparatus for sand removal (Rudy et al. 2013). They have been found at Crown and Collver Points in South Slough (deRivera et al. 2005) as well as the inner boat basin in Charleston (S. Groth, pers. comm., 2013). deRivera et al. (2005) found the highest numbers of red rock crabs closest to the mouth of the South Slough and found them conspicuously absent at their Winchester Creek and Sengstacken Arm study sites in the upper South Slough estuary, possibly due to lack of suitable habitat (Figure 2).

Red rock crabs are often found at the rocky dredge spoils areas north of Pigeon Point, in the greater Coos bay (Daly 1981) and have been found as far up the Coos estuary as McCullough Bridge in North Bend, even in wintertime when they prefer to stay in the deeper, more saline water (S. Groth, pers. comm., 2013). Because red rock crabs are osmoconformers whose body fluids match surrounding sea water salinity, they cannot tolerate brackish or fresh water for any length of time (Carroll and Winn 1989). Consequently, red rock crab distribution is influenced by tidally-driven salt water concentrations and are thus more commonly found in lower regions of the bay in times of large freshwater input (i.e., winter) and further up the bay during dryer periods (Daly 1981). During periods of high salinity in the upper estuary, red rock crabs outcompete both *Hemigrapsus* shore crab species for prime intertidal habitat (Daly 1981).

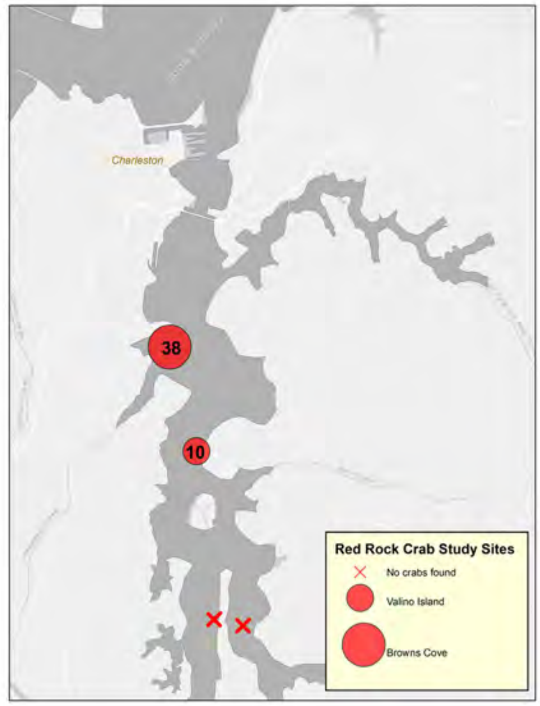



Figure 2. deRivera et al. (2005) study locations. Size of red circles represent relative abundance of red rock crab found. Numbers in symbols represent total number of red rock crabs caught at each site during a single trapping event.

An inventory of the abundance and spatial distribution of red rock crabs in the Coos estuary would be very useful to better understand this ecologically important species.

## References


Carroll, J. C. and R. N. Winn. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest)—brown rock crab, red rock crab, and yellow crab. [United States Fish and Wildlife Service Biological Report 82(11.117) and United States Army Corps of Engineers, TR EL-82-4]. 16 pp.

Daly, G. P. 1981. Competitive interactions among three crab species in the intertidal zone. [PhD Thesis]. University of Oregon.

deRivera, C. E., G. M. Ruiz, J. Crooks, K. Wasson, S. Lonhart, P. Fofonoff, B. Steves, S. Rumrill, M. S. Brancato, S. Pegau, D. Bulthuis, R. K. Preisler, C. Schoch, E. Bolwby, A. DeVogelaere, M. Crawford, S. Gittings, A. Hines, L. Takata, K. Larson, T. Huber, A. M. Leyman, E. Collinetti, T. Pascot, S. Shull, M. Anderson, and S. Powell. 2005. Broad-scale nonindigenous species monitoring along the West Coast in National Marine Sanctuaries and National Estuarine Research Reserves. [Report to National Fish & Wildlife Foundation]. 126 pp.

Groth, S., S. Yamada, E. Post, and J. Heinrich. 2013. Mark recapture of red rock crab, *Cancer productus*, in Coos Bay, OR. [Poster session presented at Towards an Estuarine Ethic: integrating science and stewardship]. 36th Annual Meeting of the Pacific Estuarine.

Rudy, P. Jr, L. H. Rudy, A. Shanks, and B. Butler. 2015. Oregon Estuarine Invertebrates, Third Edition. University of Oregon. Available online https://library.uoregon.edu/scilib/oimb/oei

# Other Crabs in the Coos Estuary


*Summary:*

- *As of 1981, the yellow shore crab and the purple shore crab were relatively abundant in rocky intertidal invertebrate communities in the Coos estuary (Daly 1981).*
- *More research is needed to evaluate status and trends for the numerous non-Dungeness crab species in the Coos estuary.*



**Evaluation**

We do not have enough data to evaluate the status of 30 native crab species historically found in our estuary. **DATA GAP**

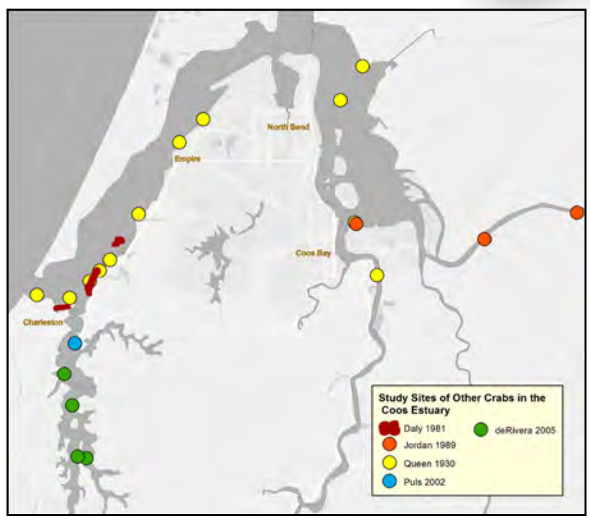



Figure 1. Location of other crabs study sites.

**What's happening?**

In addition to Dungeness (*Cancer magister*) and red rock (*Cancer productus*) crabs, there are at least 30 known crab species historically found in the Coos estuary. Surprisingly little is known about the status of these crab species or how they're using the estuary. Studies of these "other" crab species are either dated (e.g., Daly 1981) or included incidentally in other studies (e.g., deRivera et al. 2005) (Figure 1).

The most comprehensive study of other crabs is nearly 85 years old – a thesis from 1930 completed by John Queen. Queen exhaustively surveyed 12 stations throughout the Coos estuary, finding 30 species of crab regularly using various habitats in the estuary (Figure 2). While Queen's study provides an excellent historic baseline for other crabs in the Coos estuary, the data are obviously of limited use for understanding the status of current crab populations. It's worth noting that the Coos estuary has changed considerably since that study was completed, including major changes in bathymetry, hydrology and geography (e.g., in 1930 Pony Slough drained to the west, where the airport runway now is; there is now a jetty creating the Charleston inner boat basin; the main shipping channel has been dredged wider and deeper). As a result, crab habitats have also understandably changed dramatically, with some being augmented and some diminished.

Two introduced crabs (the Atlantic mud crab, *Rhithropanopeus harrisi* and the green crab, *Carcinus maenas*) were not documented in the 1930 study, but are relatively common now. Non-native and invasive crabs are discussed in Chapter 18: Non-Indigenous and Invasive Species.

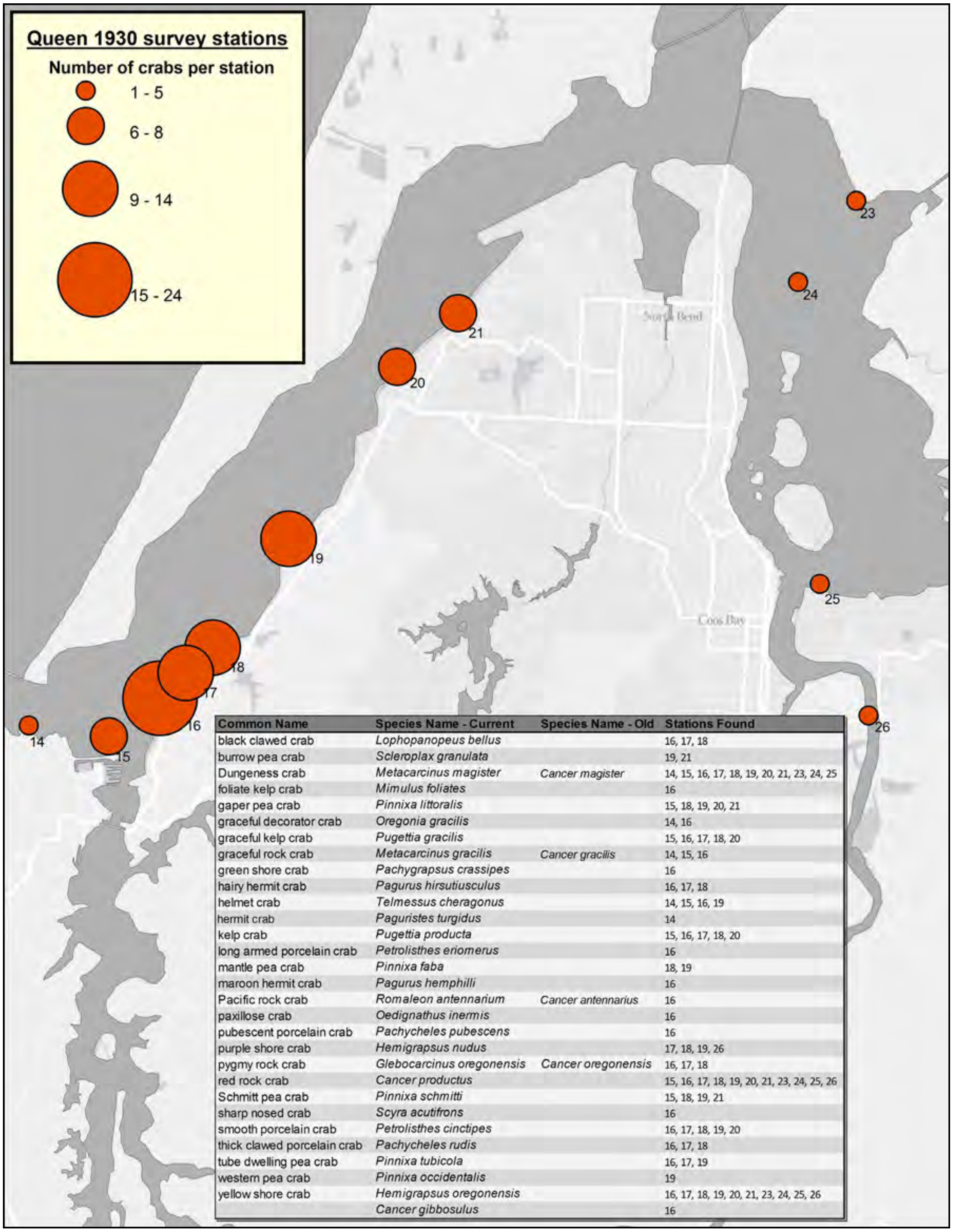
Several species (see below) have been studied since 1930, although none in the past few decades. We found no record of the remaining species having been studied since Queen's effort.

The following information summarizes our current understanding of how different species of non-Dungeness crabs are using the Coos estuary. To fill the considerable data gaps about the status and trends of "other" crab populations in the Coos estuary, further research and monitoring of these species should be considered.

**Yellow Shore Crab**: The yellow shore crab (*Hemigrapsus oregonensis*) is a native crab which, along with the purple shore crab (see following summary), dominates the invertebrate populations in the rocky intertidal areas of the Coos estuary (Daly 1981). Yellow shore crabs have been found in salinities as low as 3 in the Coos estuary, which overlaps with the salinity range of the non-native Atlantic mud crab (*Rhithropanopeus harrisi*). Anywhere their habitat ranges overlap, yellow shore crabs push juvenile Atlantic mud crabs into more freshwater habitats, effectively limiting the non-native crab's populations in the Coos estuary (Jordan 1989).

A more recent study in 2002 by Puls on the larval migration of the yellow shore crab provides some insights into the life history of this small crab. Puls captured over 43,000 yellow shore crab larvae in four plankton sampling sessions in South Slough and went on to describe how, over a four to five week period, newly spawned larvae are exported from the estuary to the ocean where they develop. They are then most likely imported back into the estuary as more mature crab "megalopae" before finally settling out in the estuary's rocky intertidal areas as adult crabs. However, little is known about returning megalopae numbers or abundance of adults in the estuary.

**Purple shore crab**: The purple shore crab (*Hemigrapsus nudus*), along with the yellow shore crab, represent a dominant portion of the macrofauna found in rocky intertidal areas in the Coos estuary, with densities exceeding 100/m$^2$ (Daly 1981). The purple




| Common Name | Species Name - Current | Species Name - Old | Stations Found |
|---|---|---|---|
| black clawed crab | *Lophopanopeus bellus* | | 16, 17, 18 |
| burrow pea crab | *Scleroplax granulata* | | 19, 21 |
| Dungeness crab | *Metacarcinus magister* | *Cancer magister* | 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25 |
| foliate kelp crab | *Mimulus foliates* | | 16 |
| gaper pea crab | *Pinnixa littoralis* | | 15, 18, 19, 20, 21 |
| graceful decorator crab | *Oregonia gracilis* | | 14, 16 |
| graceful kelp crab | *Pugettia gracilis* | | 15, 16, 17, 18, 20 |
| graceful rock crab | *Metacarcinus gracilis* | *Cancer gracilis* | 14, 15, 16 |
| green shore crab | *Pachygrapsus crassipes* | | 16 |
| hairy hermit crab | *Pagurus hirsutiusculus* | | 16, 17, 18 |
| helmet crab | *Telmessus cheragonus* | | 14, 15, 16, 19 |
| hermit crab | *Paguristes turgidus* | | 14 |
| kelp crab | *Pugettia producta* | | 15, 16, 17, 18, 20 |
| long armed porcelain crab | *Petrolisthes eriomerus* | | 16 |
| mantle pea crab | *Pinnixa faba* | | 18, 19 |
| maroon hermit crab | *Pagurus hemphilli* | | 16 |
| Pacific rock crab | *Romaleon antennarium* | *Cancer antennarius* | 16 |
| paxillose crab | *Oedignathus inermis* | | 16 |
| pubescent porcelain crab | *Pachycheles pubescens* | | 16 |
| purple shore crab | *Hemigrapsus nudus* | | 17, 18, 19, 26 |
| pygmy rock crab | *Glebocarcinus oregonensis* | *Cancer oregonensis* | 16, 17, 18 |
| red rock crab | *Cancer productus* | | 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26 |
| Schmitt pea crab | *Pinnixa schmitti* | | 15, 18, 19, 21 |
| sharp nosed crab | *Scyra acutifrons* | | 16 |
| smooth porcelain crab | *Petrolisthes cinctipes* | | 16, 17, 18, 19, 20 |
| thick clawed porcelain crab | *Pachycheles rudis* | | 16, 17, 18 |
| tube dwelling pea crab | *Pinnixa tubicola* | | 16, 17, 19 |
| western pea crab | *Pinnixa occidentalis* | | 19 |
| yellow shore crab | *Hemigrapsus oregonensis* | | 16, 17, 18, 19, 20, 21, 23, 24, 25, 26 |
| | *Cancer gibbosulus* | | 16 |

Figure 2. Location of Queen's 1930 study sites. Size of symbol over each station shows the proportional number of crab species found at that station. Also shown is a complete list of species and where they were found.

shore crab frequently out-competes the yellow shore crab for their preferred refuge of large rocks in the estuary's intertidal zone (Daly 1981). Rocks provide protection from predators and from desiccation and high temperatures during low tides. Large rocks are more stable from wave action and thus a highly valued resource for crabs.

**Striped shore crab**: Also known as green shore crab, the striped shore crab (*Pachygrapsus crassipes*) dominates the rocky high intertidal zone in the Coos estuary and can often be found crawling among jetty rocks (Daly 1981, Rudy et al. 2015). The northernmost range for this crab is near Newport, OR, probably determined by low winter temperatures (Hiatt 1948 as cited in Rudy et al. 2015). Puls (2002) investigated larval abundance of the striped shore crab and found low numbers present in South Slough (over 1,500 larvae counted over 3 sampling periods). This study speculated that the lack of suitable habitat for adult shore crabs in South Slough could account for the low crab larvae numbers there.

**Other crabs**: Numerous other crabs can be found in the lower estuary in higher salinity waters including the pygmy rock crab (*Cancer oregonensis*), found at Fossil Point and Pigeon Point in the rocky lower intertidal and rarely found south of Oregon (Rickets et al. 1985); the kelp crab (*Pugettia producta*), found in the South Slough hanging onto kelp, eelgrass or pilings; the porcelain crab (*Petrolisthes cinctipes*), found at Pigeon Point under rocks or in mussel beds; and the hairy hermit crab (*Pagurus hirsutiusculus*), found in the South Slough at Collver Point or Metcalf Preserve, often under algae or eelgrass (Rudy et al. 2015). The pea crab (*Pinnixa faba*) is a parasitic crab that primarily lives inside live gaper clams (*Tresus capax*), but can also be found in soft-shelled or bent-nosed clams (Rudy et al. 2015). Limited sampling by deRivera et al. (2005) did not find pygmy rock crab at any of four sampling sites in South Slough. Without additional research, the status of this species in the South Slough and other parts of the Coos estuary remains uncertain.

**References**

Daly, G. P. 1981. Competitive interactions among three crab species in the intertidal zone. [PhD Thesis]. University of Oregon.

deRivera, C. E., G. M. Ruiz, J. Crooks, K. Wasson, S. Lonhart, P. Fofonoff, B. Steves, S. Rumrill, M. S. Brancato, S. Pegau, D. Bulthuis, R. K. Preisler, C. Schoch, E. Bolwby, A. DeVogelaere, M. Crawford, S. Gittings, A. Hines, L. Takata, K. Larson, T. Huber, A. M. Leyman, E. Collinetti, T. Pascot, S. Shull, M. Anderson, and S. Powell. 2005. Broad-scale nonindigenous species monitoring along the West Coast in National Marine Sanctuaries and National Estuarine Research Reserves. [Report to National Fish & Wildlife Foundation]. 126 pp.

Hiatt, R. W. 1948. The biology of the lined shore crab, *Pachygrapsus crassipes* Randall. Pacific Science 2: 135-213.

Jordan, J. R. 1989. Interspecific interactions between the introduced Atlantic crab *Rhithropanopeus harrisii* and the native estuarine crab *Hemigrapsus oregonensis* in Coos Bay, Oregon. [MS Thesis]. University of Oregon. Available online https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/9809/jordan009.pdf?sequence=1

Puls, A. L. 2002. Transport of zooplankton in South Slough, Oregon. [MS Thesis]. University of Oregon.

Queen, J. C. 1930. Marine decapod crustacea of the Coos Bay, Oregon district. [MS Thesis]. University of Oregon, Department of Biology.

Ricketts, E. F., J. Calvin, J. W. Hedgpeth, and D. W. Phillips. 1985. Between Pacific tides. Stanford: Stanford University Press.

Rudy, P. Jr, L. H. Rudy, A. Shanks, and B. Butler. 2015. Oregon Estuarine Invertebrates, Third Edition. University of Oregon. Available online https://library.uoregon.edu/scilib/oimb/oei

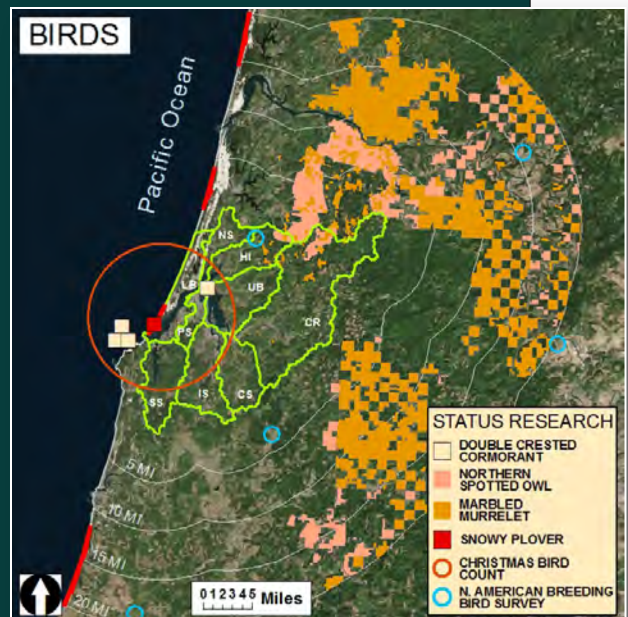
# **Chapter 16:** Birds in the Lower Coos Watershed

*Erik Larsen, Colleen Burch Johnson, Max Beeken - South Slough NERR*

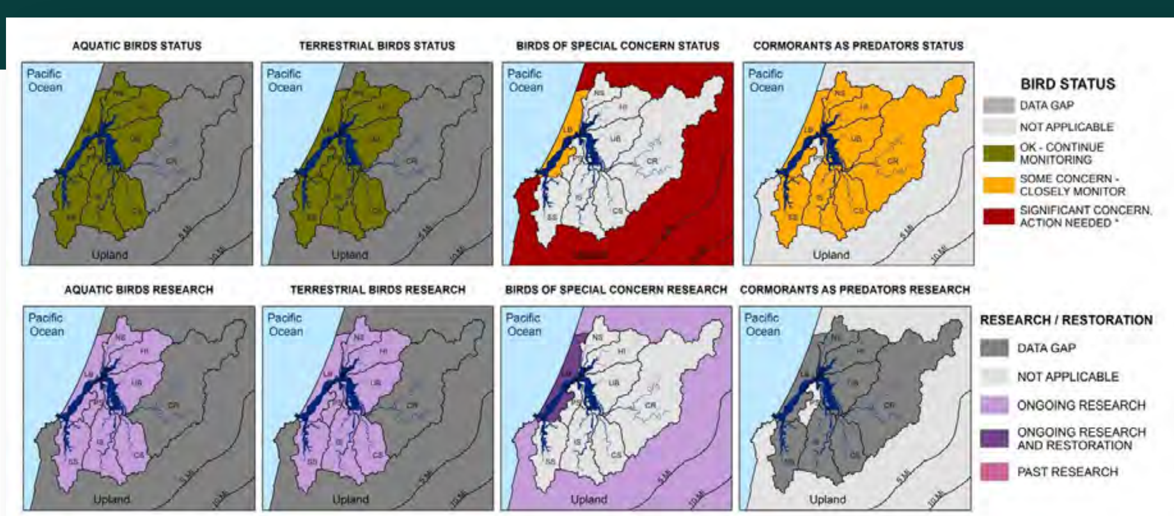
***Aquatic Birds:*** *Waterfowl populations have generally increased while wading bird, shorebird, and seabird populations have remained generally stable.*

***Terrestrial Birds:*** *Most terrestrial bird populations don't exhibit clear trends, suggesting generally stable populations.*

***Birds of Special Concern:*** *Western snowy plover populations have recovered from low 1990-levels; Coos Bay's North Spit appears to be one of the most productive snowy plover nesting habitats statewide. Both the marbled murrelet and northern spotted owl are declining throughout their range, but the rate of local decline appears to be slow relative to other areas in the Pacific Northwest.*




Subsystems: CR- Coos River, CS- Catching Slough, HI- Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay



## Chapter 16: Birds in the Lower Coos Watershed

*This chapter includes three data summaries: **Aquatic Birds, Terrestrial Birds,** and **Birds of Special Concern**— which describe the status and trends (where the data allow) of birds in the Coos estuary and associated uplands.*

### Aquatic Birds

The Aquatic Birds data summary focuses on birds primarily associated with aquatic habitats, including waterfowl, wading birds, seabirds, and shorebirds. Many aquatic bird species also depend on terrestrial resources.

Where possible, information about the status and trends of aquatic bird species is presented at several scales, including: Pacific Flyway (including several states); Oregon (statewide); Western Oregon (several counties); and Project Area (several subsystems).

For waterfowl, regional status and trends data (i.e., data for the entire Pacific Flyway) came from the United States Fish and Wildlife Service (USFWS) 2014 Pacific Flyway Data Book (Olson 2014). This source provides estimates for both historic and current waterfowl abundance in the Pacific Flyway, with information dating back to as far as 1955 in some cases.

The Pacific Flyway Data Book was supplemented by USFWS Online data query tools, which contains information about waterfowl in both Oregon and western Oregon (USFWS 2014a). This tool provided data for both historic (as old as 1965) and current (2014) midwinter population estimates. USFWS data at the statewide level are presented along with results from the United States Geological Survey's North American Breeding Bird Survey (BBS), which details statewide abundance trends (1966-2014) at 144 sites in Oregon (USGS 2014).

Within the project area, data characterizing waterfowl abundance came from the Audubon Christmas Bird Count (CBC), conducted by the Cape Arago chapter of the National Audubon Society (Figure 1)(Audubon 2014). The local CBC has been conducted regularly since 1972. However, data gaps occur in years when the CBC was not conducted (i.e., 2010, 2014) and when the data were not entered into the Audubon web site (1987-1989). For the Aquatic Birds data summary, a 33-year CBC data range (1980-2013) was analyzed. CBC data from 1972 and 1974-1979 were excluded due to data formatting issues. Addressing those issues was beyond the scope of this project.

For wading birds, seabirds, and shorebirds, data are available at both the statewide level and the local level. Similar to waterfowl, data at these scales came from the BBS and CBC, respectively (USGS 2014; Audubon 2014).

Local data were supplemented by personal communications with local bird experts and unpublished manuscripts (Rodenkirk 2012; T. Rodenkirk, pers. comm., January 19, 2012).

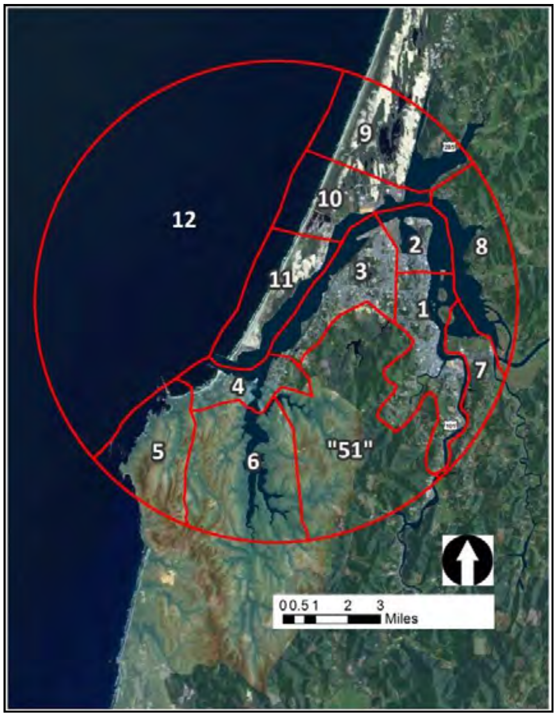



Figure 1. The local Christmas Bird Count is divided into 12 survey areas. Due to various limitations (e.g., incomplete access, time and effort constraints), comprehensive coverage of the survey area is not possible. Effort is focused on areas that are both accessible and suitable habitat for birds. 1= Downtown Coos Bay, 2= North Bend, 3= Empire, 4= Charleston and Bastendorff, 5= Cape Arago, 6= South Slough, 7= Millicoma Marsh, 8= East Bay, 9= Horsefall and Upper Bay, 10= North Spit, 11= North Jetty, 12= Pelagic habitat, "51" = Coos Bay Water Board Lands. Data: Cornu et al. 2012

**Terrestrial Birds**

This data summary focuses on birds that are primarily associated with terrestrial habitats, including raptors, owls, songbirds, fowl-like birds, doves and pigeons, hummingbirds, and woodpeckers. Many of these species also depend on aquatic resources.

Information about these species is presented at both a statewide and local level. Status and trends of terrestrial birds across Oregon came from the BBS (USGS 2014). Locally, data were provided by the Audubon's CBC (Audubon 2014). Additional information about the breadth of the BBS and CBC data is presented above in the Aquatic Birds section. The presentation of data detailing local bird status and trends was supplemented by personal communications with local bird experts (T. Rodenkirk, pers. comm., January 19, 2012; R. Namitz, pers. comm., January 19, 2012).

**Birds of Special Concern**

Western snowy plover (*Charadrius alexandrinus nivosus*; SNPL) data came primarily from the Oregon Biodiversity Information Center (ORBIC), which publishes the results of annual SNPL surveys in a series of reports (Lauten et al. 2012). These data were supplemented by additional SNPL surveys conducted by others with special interests (e.g., the Jordan Cove Energy Project) and state-sponsored research by the United States Army Corps of Engineers and USFWS (Hewitt et al. 2006; USACE 2007; USFWS 2013a).

Information about double-crested cormorant (*Phalacrocorax auritus*; DCCO) populations came primarily from the United States Fish and Wildlife Catalog of Oregon Seabird Colonies (USFWS 2014b; Naughton et al. 2007). These data are supported by a USGS assessment of cormorant population trends in western North America (Adkins and Roby 2010). In addition, an Oregon Department of Fish and Wildlife (ODFW) study examining the cormorant diet composition in Oregon's Tillamook estuary provided information about salmonid predation (Adrean 2013).

Marbeled murrelet (*Brachyramphus marmoratus*; MAMU) population trends in the Pacific Northwest are well documented by a series of state-sponsored technical reports from the following agencies: United States Forest Service (USFS), United States Department of Agriculture (USDA), USFWS, Pacific Northwest Research Station, and Washington State Department of Natural Resources (Hamer and Nelson 1995, Raphael et al. 2011, Strong 2010, Falxa et al. 2011). This information was supplemented by geographic information system (GIS) shapefiles from USFWS and Oregon Department of Forestry marbled murrelet habitat designation (USFWS 1997 and 2011, ODF 2014).

Spotted owl (*Strix occidentalis caurina*) population trends are also well documented by state agencies including USDA, USFS, and Pacific Northwest Research Station (Davis et al. 2011; Forsman et al. 2013). This documentation was supported by independent researchers (Forsman 1976,1977; Zabel et al. 1996; Courtney et al. 2004). Spatial information and critical habitat designations came from USFWS publications (USFWS 2012, 2013b).

**Data Gaps and Limitations**

The temporal and/or geographic scopes of the data are not comprehensive. As mentioned, CBC data gaps occur in years during which the CBC was not conducted (2010 and 2014). An additional data gap occurs in 1987-1989 when local CBC data were not reported to the Audubon database (T. Rodenkirk, pers. comm., 2015).

In addition, CBC data collection is focused on areas of suitable habitat that are easily accessible, and may be limited by other factors (e.g., volunteer time constraints, volunteer training).

The BBS is conducted along 144 bird observation routes across Oregon. David Ziolkowski (pers. comm., November 24, 2014) explains that these routes are randomly selected to create a sufficiently large sample in order to "represent habitats in proportion to their natural occurrence on the landscape." He adds that multiple studies have shown that this sample design effectively represents bird habitat, but, since "observational" routes occur along roads, open water habitats are slightly underrepresented while developed habitats are marginally overrepresented.

Data from bird surveys are inherently subject to several "co-varying factors" that may be correlated with survey results (e.g., stylistic and skill differences between observers, survey effort, and habitat change). For example, imagine a hypothetical survey for which participation has increased steadily over time, and the raw data show that sightings have also increased. In this case, assuming that the number of sightings may be correlated with effort, it is difficult to determine what portion of the observed trend is due to a true change in bird abundance because some of the observed difference may have resulted from increased effort.

To account for theses co-varying factors, the BBS processes its data using a Bayesian hierarchical model developed by the USGS

(2014). The model calculates a relative bird abundance metric. In some cases, the reliability of model calculations is limited by deficiencies in the data (e.g., small sample size, poor precision, etc.)(USGS n.d.).

No such model has been developed for the CBC. Consequently, only raw CBC data have been reported. The use of raw data presents a series of concerns and limitations. The raw CBC data have not been adjusted for:

- Misidentification- Although volunteers are generally very knowledgeable about local bird species, experts speculate that some data may contain bird species misidentifications (particularly in the 1980s). For example, citizen scientists that participated in the CBC prior to 1982 may have misidentified long-billed curlew, mistaking this species for the whimbrel (Rodenkirk 2012).
- The abilities of volunteers- For example, song identification is the primary means for detecting the swamp sparrow; this skill requires advanced birding knowledge (Rodenkirk 2012). Therefore, it's difficult to determine if an increase in swamp sparrow sightings corresponds to a true abundance trend.
- Survey effort- Changes in effort may correspond to changes in some abundance metrics (e.g., species diversity)(Figure 2).
- Habitat change- Habitat change within the survey area may result in a redistribution of bird species. For example, the natural succession of forest habitat in an undisturbed area may result in the redistribution of species that require open canopies to areas of less dense vegetation (e.g., clear cuts in the uplands), potentially resulting in a lower raw count even though total abundance may remain unchanged.
- Climate variables (e.g., El Niño events)- The arrival and departure of migratory birds to the lower Coos watershed is often a function of climate variables (e.g., year-to-year changes in temperature and precipitation). In years with climatic anomalies, the timing of the CBC may not correspond with the presence of every species that winters in the Coos estuary.


Figure 2. Christmas Bird Count data for both survey effort (red) and number of species recorded (yellow) is available from 1990-2013. These variables tend to "track" each other well, meaning that years with high effort tend to correspond to years with high avian diversity. Since the raw data have not been corrected for co-varying trends such as survey effort, it's difficult to determine how much of an observed abundance trend may be due to true underlying patterns. Data: Audubon 2014

In lieu of statistical modeling, local bird experts were consulted to help distinguish between true abundance trends and observed patterns likely caused by other factors (Rodenkirk 2012; T. Rodenkirk, pers. comm., January 19, 2012; R. Namitz, pers. comm., January 19, 2012).

Consultation with local experts also helps identify known inaccuracies in the Audubon (2014) data. For example, Rodenkirk (pers. comm., 2015) explains that CBC volunteers frequently confuse the short billed curlew with the long billed curlew. Although the short billed curlew is a very rare sighting in the lower Coos watershed, the raw Audubon (2014) data report a high number of sightings on a regular basis. These inaccuracies are not corrected by the Audubon Society prior to publication. To avoid including inaccurate data, the trends from Audubon (2014) have been carefully scrutinized and compared against reliable, unpublished data from local experts (T. Rodenkirk, pers. comm., 2015).

The data may also be subject to technological limitations. For example, counts of double-crested cormorant colonies are conducted by low-altitude aerial photo analyses. In some cases, these methods limit experts' ability to discern between cormorant species (J. Lawonn, pers. comm., 2014). This report only used data from aerial photos that were positively identified as double-crested cormorants.

Both the BBS and the Catalog of Oregon Seabird Colonies use breeding population counts as proxies for abundance. Experts suggest, however, that the use of breeding populations alone may underestimate bird use of estuarine habitats since breeding population data don't include non-breeding birds foraging in the estuary (Adrean 2013).

Both CBC raw data and BBS relative abundance data are meant to index overall inter-annual trends in bird abundance (i.e., changes in relative abundance from one year to the next). These data should not be interpreted as estimates of the total population size. Due to methodological differences between these surveys, extreme caution should be taken when making direct comparisons between data sources.

Finally, it should be noted that two sources were used in compiling marbled murrelet habitat data. Both data sources were combined to produce a general idea of marbled murrelet nesting habitat abundance in the project vicinity. Federal critical habitat designation is based on computer modeling of habitat suitability and state habitat designation is based on field observations of marbled murrelet nesting behavior (ODF 2014, USFWS 2011).

**References**

Adkins, J. Y. and D. D. Roby. 2010. The Status Assessment of the Double-Crested Cormorant (*Phalacrocorax auritus*) in Western North America: 1998-2009. [Final report prepared for the United States Army Corps of Engineers]. Accessed 2 February 2014. Available online http://farallones.noaa.gov/eco/seabird/pdf/articles/monitoringandstatus/adkinsroby2010.pdf

Adrean, L. 2013. Avian Predation Program 2012 Final Report. Oregon Department of Fish and Wildlife. Accessed 2 February 2014. Available online http://www.dfw.state.or.us/conservationstrategy/avian_predation_mgmt.asp

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. [Report prepared for the Partnership for Coastal Watersheds Steering Committee]. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Courtney, S. P., J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dumbacher, R. C. Fleischer, A. B. Franklin, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, and L. Sztukowski. 2004. Scientific Evaluation of the Status of the Northern Spotted Owl. Sustainable Ecosystems Institute. Portland, OR.

Davis, R. J., K. M. Dugger, S. Mohoric, L. Evers, and W. C. Aney. 2011. Status and Trends of Northern Spotted Owl Populations and Habitats. [Technical Report from the United States Department of Agriculture, United States Forest Service, and Pacific Northwest Research Station].

Falxa, G, J. Baldwin, M. Lance, S. L. Miller, S. F. Pearson, M. G. Raphael and C. S. Strong. 2011. Status of the Marbled Murrelet in the Northwest Forest Plan area: Ten years of population monitoring. Accessed 08 October 2014. Available online http://www.dnr.wa.gov/publications/lm_hcp_mamu_annl_mntrng_rprt0910.pdf

Forsman, E. D. 1976. A preliminary investigation of the Spotted Owl in Oregon. [M.S. thesis]. Oregon State University. Corvallis, OR.

Forsman, E. D. 1977. Spotted Owl abundance in young versus old-growth forests, Oregon. Wildlife Society Bulletin 5: 43-47.

Forsman, E. D., C. McCafferty, E. Divine, S. Kane, J. Mowdy, T. Plawman, A. Price, and M. Sullivan. 2013. Demographic Characteristics of Spotted Owls in the Oregon Coast Ranges, 1990-2012. [Wildlife Ecology Team: Wildlife Habitat Relationships in Washington and Oregon FY 2012].

Hamer, T. E. and S. Kim Nelson. 1995. Ecology and Conservation of the Marbled Murrelet. Chapter 6: Characteristics of Marbled Murrelet Nest Trees and Nesting Stands. [General Technical Report PSW-152]. Accessed 13 October 2014. Available online http://www-test.fs.fed.us/psw/publications/documents/gtr-152/

Hewitt, R., K. M. Burton, and S. J. Tucker. 2006. 2005-2006 Pre-Construction Wildlife Surveys for Proposed Jordan Cove Liquefied National Gas Plant, Coos Bay, Oregon. [Report prepared by LBJ Enterprises, Eureka, CA].

Lauten, D. J., K. A. Castelein, J. D. Farrar, A. A. Kotaich, and E. P. Gaines. 2012. The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast- 2012. [A report prepared by the Oregon Biodiversity Information Center]. Accessed 06 October 2012. Available online http://www.fws.gov/arcata/es/birds/wsp/documents/siteReports/Oregon/2012_Oregon_Snowy_Plover_Distribution_and_Reproductive_Success.pdf

National Audubon Society (Audubon). 2014. Audubon Christmas Bird Count: Historical Results by Count. [Coos Bay Sitkum Dock Count ORCB]. Accessed 04 November 2014. Available online http://netapp.audubon.org/CBCObservation/Historical/ResultsByCount.aspx

Naughton, M. B., D. S. Pitkin, R. W. Lowe, K. J. So, and C. S. Strong. 2007. Catalog of Oregon Seabird Colonies. [Area 270 North Coos Bay]. Accessed 07 October 2014. Available online http://www.fws.gov/oregoncoast/PDF/Catalog_of_Oregon_Seabird_Colonies/Catalog_of_Oregon_Seabird_Colonies_9-270N.pdf

Olson, S. M. (Compiler). 2014. Pacific Flyway Data Book. United States Fish and Wildlife Service. Vancouver, WA.

Oregon Department of Forestry (ODF). 2014. Marbled Murrelet Management Area shapefile.

Raphael, M. G., G. A. Falxa, K. M. Dugger, B. M. Galleher, D. Lynch, S. L. Miller, S. Kim Nelson, and R. D. Young. 2011. Status and Trend of Nesting Habitat for the Marbled Murrelet. [Technical Report from the United States Department of Agriculture, United States Forest Service, and Pacific Northwest Research Station].

Rodenkirk, T. J. 2012. Birds of Coos County, Oregon: Status and Distribution. [Unpublished Manuscript].

Strong, C. S. 2010. Population and Productivity Monitoring of Marbled Murrelets in Oregon During 2009. [Report prepared by Crescent Coastal Research for the United States Fish and Wildlife Service].

United States Army Corps of Engineers (USACE). 2007. Aquatic Nuisance Species Workshop. Appendix A: Coos Bay Western Snowy Plover Habitat Management, OR, Section 1135 (b). Accessed 06 October 2014. Available online http://el.erdc.usace.army.mil/workshops/07may-ans/Summary_Final.pdf

United States Fish and Wildlife Service (USFWS). 1997. Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, OR. 203 pp.

United States Fish and Wildlife Service (USFWS). 2011. Marbled Murrelet Critical Habitat Shapefile.

United States Fish and Wildlife Service (USFWS). 2012. Northern Spotted Owl Critical Habitat Shapefile. Avaible online http://www.fws.gov/oregonfwo/species/data/northernspottedowl/Maps.asp

United States Fish and Wildlife Service (USFWS). 2013a. Species Fact Sheet: Western Snowy Plover. Accessed 06 October 2014. Available online http://www.fws.gov/oregonfwo/species/data/westernsnowyplover/

United States Fish and Wildlife Service (USFWS). 2013b. Northern Spotted Owl Recovery Information Site: Critical Habitat. Accessed 13 October 2014. Available online http://www.fws.gov/oregonfwo/species/data/northernspottedowl/CriticalHabitat/default.asp

United States Fish and Wildlife Service (USFWS). 2014a. Mid-Winter Waterfowl Survey Query Form. [An online data query tool from the Division of Migratory Bird Management]. Accessed 04 November 2014. Available online https://migbirdapps.fws.gov/mbdc/databases/mwi/mwsoptions.asp

United States Fish and Wildlife Service (USFWS). 2014b. Catalog of Oregon Seabird Colonies. [Unpublished data].

United States Geological Survey Patuxent Wildlife Research Center (USGS). 2014. North American Breeding Bird Survey data set 1966-2013, version 2014.0. [Access to raw data via link to FTP site]. Available online https://www.pwrc.usgs.gov/bbs/RawData/Choose-Method.cfm

United States Geological Survey Patuxent Wildlife Research Center (USGS). n.d. Regional Credibility Measures. Accessed 18 December 2014. Available online http://www.mbr-pwrc.usgs.gov/bbs/credhm09.html

Zabel, C. J., S. E. Salmons, and M. Brown. 1996. Demography of Northern Spotted Owls in Southwestern Oregon. Studies in Avian Biology 14: 77-82.

# How the Local Effects of Climate Change Could Affect Birds of the Southern Oregon Coast

*Several climate-related changes have the potential to affect critical bird habitat as well as abundance and distribution of birds on the southern Oregon coast:*

- *Sea level rise could threaten the viability or existence of critical tidal wetland habitat.*
- *Changes in the timing of seasonal events such as migration and egg deposition could affect the reproductive success and survivorship of birds.*
- *Climate-related species range expansions/contractions could reorganize the structure of native bird communities.*

Top: Brant geese
Photo: Jeffery Coats
Bottom: Common yellowthroat
Photo: Greg Lasley

This summary highlights general avian responses to anticipated climate-related changes on the southern Oregon coast, citing specific examples where possible. Since virtually all birds are highly mobile and many are migratory, information about habitats and climate trends both inside and outside the project area are relevant.

Due to the vast diversity of bird species on the southern Oregon coast and the variation of their life histories, a complete review of the anticipated effects of climate change for each species is beyond the scope of this project. For species-specific inquiries not directly addressed by this climate change summary, please refer to species distribution models such as the Audubon Climate Report (Audubon 2014b).

**Addressing Uncertainty in Bird Response to Climate Change**

A substantial amount of uncertainty is involved in predicting the local affects of climate change on birds. This uncertainty is summarized by the following factors:

- Magnitude of local changes: The magnitude of climate-related change is likely to vary across the landscape. For example, the effects of sea level rise (SLR) depends on local tides, currents, storm patterns, rates of local tectonic uplift, and other elements that may dampen or amplify local SLR (Audubon 2014a).
- Migration: Since bird species are often migratory, they depend on a diverse chain of (sometimes distant) habitats for survival and reproduction (Audubon n.d.). Therefore, seemingly unrelated changes to climate in distant habitats may directly affect local bird populations.
- Adaptability: Audubon (2014a) explains that bird species' responses to climate change may depend on individual species' ability to colonize new areas/adapt to changing conditions. They add that the responses of the more highly mobile, adaptable species are particularly difficult to anticipate.
- Competition and Predation: The response of one bird species to changing climate conditions can affect other bird species' populations. Audubon (2014a) suggests that climate-related variables may result in a redistribution of predators or competitors (including the shifting or expansion of non-native bird species ranges) that may prevent birds from successfully colonizing areas even if they are "climatically stable" (i.e., maintaining appropriate habitat conditions).

To address these uncertainties researchers use various data analysis methods. For example, some perform "meta-analyses," a robust compilation and analysis of data from multiple studies (Parmesan and Yohe 2003, Root and Hughes 2005 cited from World Wildlife Fund [WWF] 2006). Others use models to generate a suite of different climate change and avian response scenarios (e.g., bioclimatic models)(Audubon 2014b).

Using these techniques, researchers have reached a general consensus that climate change is already affecting bird species behavior, distribution, and population dynamics across the globe (WWF 2006, Audubon 2014a, Parmesean and Yohe 2003). Changes in sea level, temperature, and precipitation have caused shifts in the timing of bird migrations and reproduction timing/success, as well as shifts in birds' geographic distribution.

**Sea Level Rise (SLR)**

A diverse collection of birds rely on the food and shelter provided year-round by estuarine and near-shore ocean habitats for survival (Page et al. 1992). Additionally, many migratory species require these habitats for seasonal foraging during migration. The persistence and/or quality of these habitats may be jeopardized by sea level rise (SLR). For example, intertidal mudflats and marshes, which are critical habitats for many bird species, will be affected by SLR. Scientists have not yet determined whether those habitats in the Coos estuary, whose elevations relative to tidal elevations are maintained by tidally-driven sediment inputs, will be able to keep pace with SLR. If not, those habitats may be significantly altered ("drowned") by the higher tide levels associated with SLR. However, sedimentation rates may increase with SLR, which would allow mudflat and marsh elevations to remain constant relative to tidal flooding levels and would maintain viable estuarine bird habitat.

Researchers suggest that SLR could change the character of intertidal bird habitats, because greater tidal ranges would cause increased salinity in brackish and freshwater habitats due to increased salt water inundation (Dalton et al. 2013; Glick et al. 2007). This transition may affect the distribution of birds who use these environments as foraging grounds, while forcing species who rely on less saline intertidal environments higher into the estuary (Dalton et al. 2013).

The issues associated with SLR are exacerbated by continued development of coastal shore lands. Research has demonstrated that habitat disturbances from human activities and domestic pets can degrade bird habitat by reducing their foraging efficiency, disrupting opportunities to rest, and compromising breeding habitat (Lafferty 2001; Brown et al. 2000; Powell and Collier 2000). Reproduction and survivorship may be reduced if continued

*Sea Level Rise*

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, the National Research Council (NRC), predicted SLR rates as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100 for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary).*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

SLR pushes birds towards habitats where they would be increasingly subjected to chronic disturbances. Similarly, bird habitats may be jeopardized in areas where marshes border developed land, because humans are unlikely to allow intertidal habitats to migrate inland in response to SLR due to the high value of real estate near the existing high tide zone (Glick et al. 2007; Yamanaka et al. 2013).

**Migration, Reproduction, and Climate**

Studies suggest that birds have modified their "phenology" (timing of important seasonal events such as migration and reproduction) in response to shifting climate variables (Rosenzweig et al. 2007, OCCRI 2010, Becker et al. 2007, Sydeman et al. 2009). For example, meta-analyses indicate that the timing of worldwide spring bird migrations occurred approximately 2-3 days earlier per decade (Parmesean and Yohe 2003, Root and Hughes 2005 cited from WWF 2006). However, phenology is changing much faster for certain species. For example, Root et al. (2003) concluded that common murres (*Uria aalge*) in North America are migrating up to 24 days earlier per decade as the climate continues to change. A similar relationship exists between climate and the timing of egg deposition, with bird species generally advancing the time of egg laying as the climate warms (Hussell 2003; Dunn 2004). Shifts in phenology could affect the survivorship and reproductive success of bird species if they are unable to coordinate the timing of seasonal events with other important ecosystem processes (e.g., matching nestlings' food demands with peak food supplies such as insects)(WWF 2006).

Climate change may further limit reproduction in birds by modifying species abundance and availability of high quality breeding habitat. Research shows that waterfowl abundance in the northern Great Plains' Prairie Pothole Region (PPR), which produces 50-80% of the continent's breeding migrating duck population (Wong et al. 2012; WWF 2006), is correlated with climatic variables (e.g., soil moisture, precipitation, and temperature)(Podruzny et al. 2002; Bethke and Nudds 1995; Forcey et al. 2011; Sorenson et al. 1998). Even in the absence of precipitation changes, experts forecast that a marginal increase (~2.5° C) in average temperature from 1998 levels may reduce waterfowl habitat in the PPR by as much as 66% (Sorenson et al. 1998).

The effects of climate on bird survival rates reaches beyond wetland breeding habitat for waterfowl. Bolger et al. (2005) found that drought in California corresponded to a 97% reduction in the reproductive success of four land bird species, including the wrentit (*Chamaea fasciata*), spotted towhee (*Pipilo maculatus*), California towhee (*Pipilo crissalis*), and rufous-crowned sparrow(*Aimophila ruficeps*), in semi-arid habitats. They anticipate these species are particularly vulnerable to climate change as precipitation is forecast to decrease and become more variable in California's semi-arid bird habitats.

**Shifting Geographic Distributions**

In addition to altering migration timing, birds appear to be expanding and contracting their ranges in response to climate change. For example, Parmesean and Yohe (2003) analyzed studies of over 1,700 birds species across the globe and discovered "significant range shifts averaging 6.1 km (3.8 miles) per decade towards the poles." The Oregon Climate Change Research Institute (OCCRI 2010) suggests the same trend is happening in the Pacific Northwest, with local birds tending to shift their distributions northward as climate continues to change.

Shifts in the geographic distribution of bird species are noteworthy because they essentially "reshuffle" natural communities, introducing birds to new prey species, predators, competitors, parasites, and diseases (Root and Hughes 2005 cited from WWF 2006, Rocke and Samuel 1999).

In the project area uplands, the connection between climate-related range expansion and competition for resources is exemplified by the northern barred owl (*Strix varia varia*). Over the past 50 years, researchers have noted that the barred owl has expanded its range into southwestern Canada, the northern Rockies, and the Pacific Northwest, where it's invaded the range of the northern spotted owl (*Strix occidentalis caurina*)(Courtney et al. 2004). The United States Fish and Wildlife Service (USFWS 2013) recognize resource competition from the barred owl as a potential threat to the spotted owl. Some surveys on the Oregon coast show that the spotted owl decline corresponds to concurrent increases in barred owl abundance, suggesting that this competitive threat may be substantial in the forests surrounding the project area (Forsman et al. 2013).

Bird species that do not have the flexibility to expand their range (e.g., island and mountain birds) are particularly vulnerable, because even moderate climate-related changes may exceed their ability to adapt by shifting migration or population distribution patterns (WWF 2006).

*Neotropical Migrants in the Project Area*

*Local bird experts have noted an increase in the overwintering populations of several "neotropical migrant" species (common yellowthroats, orange-crowned warblers, and yellow-breasted chats). Neotropical migrants are birds that spend the summer in the northern temperate and polar latitudes and migrate south to the tropics where climate and food availability are more agreeable during winter months. This trend could be indicative of a general warming pattern in the temperate latitudes, although more data are needed to determine the exact correlation between climate change and neotropical migrant abundance.*

*Sources: T. Rodenkirk, pers. comm., 2012; R. Namitz, pers. comm., 2012; Audubon 2014c; Cornu et al. 2012*

**References**

Becker, B. H., M. Z. Peery, and S. R. Beissinger. 2007. Ocean Climate and Prey Availability Affect the Trophic Level and Reproductive Success of the Marbled Murrelet, an Endangered Seabird. Marine Ecology Progress Series 329: 267-279.

Bethke, R. W. and T. D. Nudds. 1995. Effects of Climate Change and Land Use on Duck Abundance in Canadian Prairie-Parklands. Ecological Applications 5: 588–600.

Bolger D. T., M. A. Patten, and D. C. Bostock. 2005. Avian reproductive failure in response to an extreme climatic event. Oecologia 142: 398- 406.

Brown S., C. Hickey and B. Harrington (eds.). 2000. The U.S. Shorebird Conservation Plan. Manomet Center for Conservation Sciences. Manomet, MA. Accessed 14 January 2015. Available online http://www.shorebirdplan.org/wp-content/uploads/2013/01/USShorebirdPlan2Ed.pdf

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. [Report prepared for the Partnership for Coastal Watersheds Steering Committee]. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Courtney, S. P., J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dumbacher, R. C. Fleischer, A. B. Franklin, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, and L. Sztukowski. 2004. Scientific Evaluation of the Status of the Northern Spotted Owl. Sustainable Ecosystems Institute. Portland, OR.

Dalton, M. M., P. W. Mote, and A. K. Snover (eds.). 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press.

Dunn, P. 2004. Breeding dates and reproductive performance. Advances in Ecological Research 35: 69-87.

Forcey, G. M., W. E. Thogmartin, G. M. Linz, W. J. Bleier, and P. C. McKann. 2011. Land use and climate influences on waterbirds in the Prairie Potholes. Journal of Biogeography 38: 1694-1707.

Forsman, E. D., C. McCafferty, E. Divine, S. Kane, J. Mowdy, T. Plawman, A. Price, and M. Sullivan. 2013. Demographic Characteristics of Spotted Owls in the Oregon Coast Ranges, 1990-2012. [Wildlife Ecology Team: Wildlife Habitat Relationships in Washington and Oregon FY 2012].

Glick, P., J. Clough, and B. Nunley. 2007. Sea-level Rise and Coastal Habitat in the Pacific Northwest: An analysis for Pudget Sound, Southwestern Washington, and Northwestern Oregon. National Wildlife Federation. Accessed 15 January 2014. Available online http://www.nwf.org/pdf/Wildlife/PacificNW-SeaLevelRise.pdf

Hussell, D. J. T. 2003. Climate change, spring temperatures and timing of breeding of tree swallows (*Tachycineta bicolor*) in southern Ontario. Auk 120: 607-618.

Lafferty, K. D. 2001. Birds at a Southern California beach: seasonality, habitat use, and disturbance by human activity. Biodiversity and Conservation 10: 1949-1962.

National Audubon Society (Audubon). 2014a. Audubon's Birds and Climate Change Report: A Primer for Practitioners. National Audubon Society. New York. Contributors: Gary Langham, Justin Schuetz, Candan Soykan, Chad Wilsey, Tom Auer, Geoff LeBaron, Connie Sanchez, Trish Distler. Version 1.2.

National Audubon Society (Audubon). 2014b. Audubon Climate Report. [interactive online SDM]. Accessed 13 January 13, 2015. Available online http://climate.audubon.org/

National Audubon Society (Audubon). 2014c. Audubon Christmas Bird Count: Historical Results by Count. [Coos Bay Sitkum Dock Count ORCB]. Accessed 04 November 2014. Available online http://netapp.audubon.org/CBCObservation/Historical/ResultsByCount.aspx

National Audubon Society (Audubon). n.d. Audubon Strategic Plan 2012-2015: A Roadmap for Hemispheric Conservation. Accessed 13 January 2015. Available online http://www.audubon.org/sites/default/files/documents/audubon_strategic_plan_-_web_2012.pdf

National Oceanic and Atmospheric Administration (NOAA) Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Available online http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Washington, DC: The National Academies Press. 201 pp.

Oregon Climate Change Research Institute (OCCRI). 2010. Oregon Climate Assessment Report. K. D. Dello and P. W. Mote (eds). College of Oceanic and Atmospheric Sciences. Oregon State University. Corvallis, OR.

Page, G. W., D. Shuford, J. E. Kjelmyr, and L. E. Stenzel. 1992. Shorebird Numbers in Wetlands of the Pacific Flyway: A Summary of Counts from April 1988 to January 1992. Accessed 26 November 2014. Available online http://www.calwater.ca.gov/Admin_Record/C-056771.pdf

Parmesan, C. and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421(6918): 37-42.

Podruzny, K. M., J. H. Devries, L. M. Armstrong, and J. J. Rotella. 2002. Long-Term Response of Northern Pintails to Changes in Wetlands and Agriculture in the Canadian Prairie Pothole Region. Journal of Wildlife Management 66: 993–1010.

Powell, A. N. and C. L. Collier. 2000. Habitat use and reproductive success of western snowy plovers at new nesting areas created for California least terns. Journal of Wildlife Management, 64(1): 24-33. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.jstor.org/stable/3802971?seq=1#page_scan_tab_contents.

Rocke, T. E. and M. D. Samuel. 1999. Water and Sediment Characteristics Associated with Avian Botulism Outbreaks in Wetlands. The Journal of Wildlife Management 63: 1249-1260.

Root, T. L., J. T. Price, K. R. Hall, S. H. Schneider, C. Rosenzweig, and J. A. Pounds. 2003. Fingerprints of global warming on wild animals and plants. Nature 421(6918): 57-60.

Root T. L. and L. Hughes. 2005. Present and future phenological changes in wild plants and animals. In: Lovejoy T. E. and Hannah. L. (eds.). Climate Change and Biodiversity. New Haven and London: Yale University Press. 61 pp.

Rosenzweig, C., G. Casassa, D. J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T. L. Root, B. Seguin, and P. Tryjanowski. 2007. Assessment of observed changes and responses in natural and managed systems. In: M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson (eds.). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press: 79-131.

Sorenson, L. G., R. Goldberg, T. L. Root, and M. G. Anderson. 1998. Potential effects of global warming on waterfowl populations breeding in the northern Great Plains. Climatic Change 40(2): 343-369.

Sydeman, W. J., K. L. Mills, J. A. Santora, S. A. Thompson, D. F. Bertram, K. H. Morgan, B. K. Wells, J. M. Hipfner, and S. G. Wolf. 2009. Seabirds and Climate in the California Current: A Synthesis of Change. California Cooperative Oceanic Fisheries Investigations Reports 50: 82-104.

United States Fish and Wildlife Service (USFWS). 2013. Northern Spotted Owl Recovery Information Site: Critical Habitat. Accessed 13 October 2014. Available online http://www.fws.gov/oregonfwo/species/data/northernspottedowl/CriticalHabitat/default.asp

Wong, L., G. C. van Kooten, and J. A. Clarke. 2012. The Impact of Agriculture on Waterfowl Abundance: Evidence from Panel Data. Journal of Agricultural and Resource Economics 37(2): 231-334.

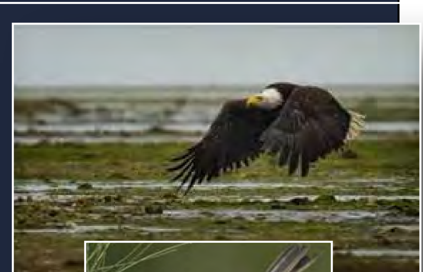
World Wildlife Fund (WWF). 2006. Bird Species and Climate Change. [A Publication for Nature Australia]. Accessed 14 January 2015. Available online http://d2ouvy59p0dg6k.cloudfront.net/downloads/wwfsummaryfinal.pdf

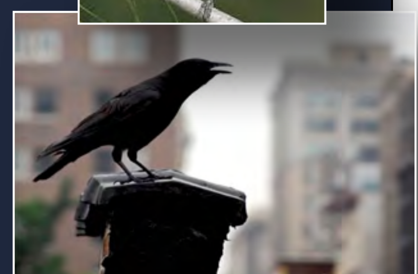
Yamanaka, T., D. Raffaelli, and P. White. 2013. Non-linear interactions determine the impact of sea-level rise on estuarine benthic biodiversity and ecosystem processes. PLoS ONE 8(7): 1-8.

# Terrestrial Birds in the Lower Coos Watershed


*Summary:*

- *Since 1980, some terrestrial bird species have become more abundant while others have declined. However, most birds show no clear trend, suggesting that local bird populations are generally stable.*
- *Neotropical migrants may be overwintering in the Coos system more frequently, a trend that could be correlated with changing climate.*
- *Conservation efforts appear to have enhanced local populations for some key bird species (e.g., ospreys and bald eagles).*
- *Some highly adaptable, "synathropic" species such as crows, ravens, pigeons, and doves may benefit from habitat created by human development*



**Evaluation**

Most terrestrial bird populations appear to be stable, displaying neither increasing nor decreasing trends.

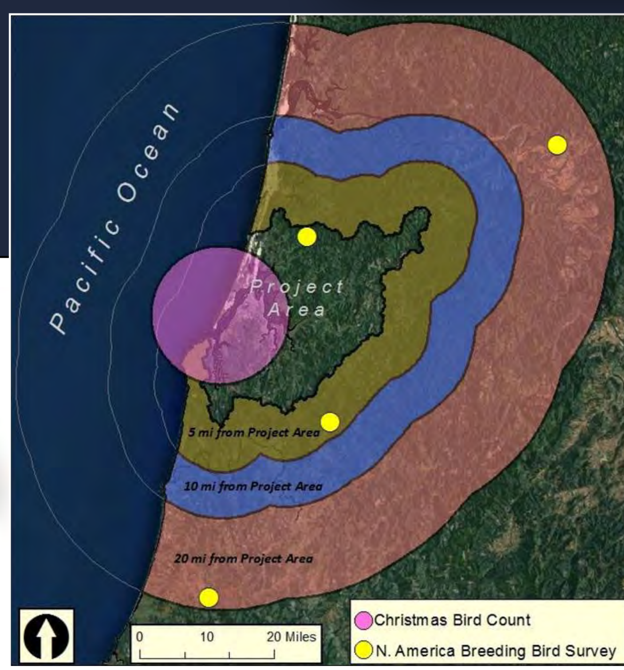



Figure 1. Terrestrial bird survey sites in and near the project area. Data: Rodenkirk n.d., USGS 2014

**What's happening?**

Raptors

This section summarizes the status and trends of raptor populations, including hawks, eagles, and other birds of prey. Regional data are presented at a statewide level using breeding population estimates as a proxy for abundance. A discussion of Coos estuary data, which use Audubon Christmas Bird Count (CBC) sightings to project trends in local raptor abundance, follows (Figure 1). The Local Raptor Trends section describes the status of raptor species that display the most apparent abundance trends since the 1980s.

*Statewide Raptor Trends*

The United States Geological Survey (USGS) Patuxent (MD) Wildlife Research Center (2014) conducts the North American Breeding Bird Survey (BBS), which includes 144 survey sites in Oregon. One of the Oregon sites is located within the project area and three sites are located near the project area (Figures 1 and 2). This survey is conducted annually along preselected observational "routes." The BBS data are used here as indices of relative bird species abundance and should not be interpreted as estimates of the total population size (D. Ziolkowski, pers. comm., November 24, 2014).

Figure 3 displays the BBS abundance data for six raptors species that have displayed clear trends (1966-2012) in Oregon. It should be noted that some of these trends are subject to data limitations (e.g., small sample size) that can reduce the reliability of the results. Please see the chapter summary for more information about these limitations.

*Local Raptor Trends*

Below we focus on raptor species in the Coos estuary that show strong evidence of changing populations:

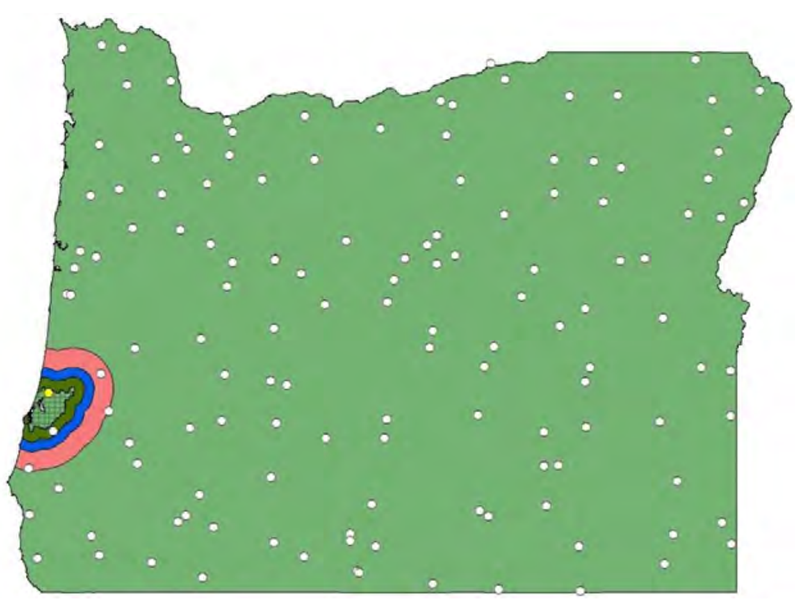


Figure 2. USGS Patuxent Wildlife Research Center conducts the North American Breeding Bird Survey (BBS) along observational routes at 144 sites in Oregon (white), including one site within the study area (yellow). The project area (cross hatch) has been highlighted for reference. Habitat within proximity to the project area (< 20 miles) is also highlighted (see Figure 1 for reference). Data: USGS 2014

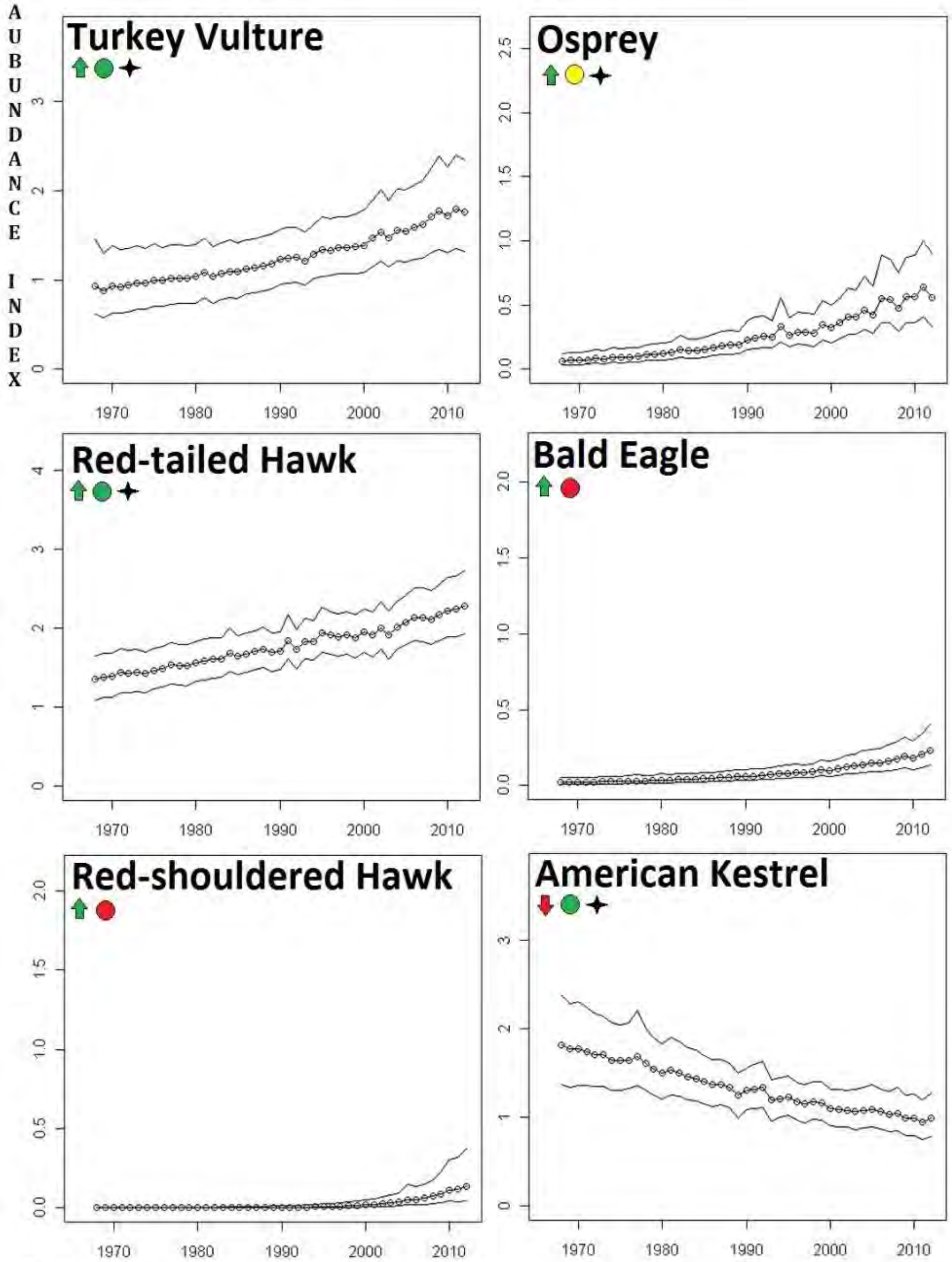




Figure 3. North American Breeding Bird Survey (BBS) data for state-wide abundance trends (1966-2012).The BBS data show six raptor species exhibiting clear trends over time. The American kestrel (*Falco sparverius*) has shown a statistically significant decline, while the Turkey Vulture (*Cathartes aura*) , osprey (*Pandion haliaetus*) , and Red-tailed Hawk (*Buteo jamaicensis*) have shown significant increases. Data: USGS 2014

*Osprey (Pandion haliaetus)*

From 1980-1997, there were no Osprey sightings in the Coos estuary during the CBC (Audubon 2014, Rodenkirk 2012b, Cornu et al. 2012). However, since 1997, Ospreys have been sighted consistently, with 1-3 birds wintering annually (Audubon 2014; Rodenkirk 2012; T. Rodenkirk, pers. comm., January 19, 2012; Cornu et al. 2012, )(Figure 4).

Figure 4. Osprey are commonly found in the Coos estuary during summertime, but CBC data indicate that the wintering population of osprey has increased over time. Photo Credit: B.N. Singh taken from Cornell 2014

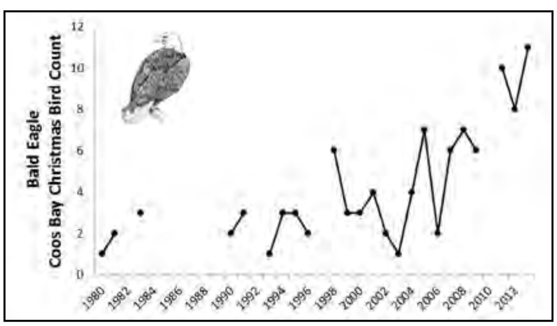



Figure5. Coos Bay CBC data indicate that local midwinter bald eagle abundance has generally increased since 1980. Some data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012

*Bald Eagle (Haliaeetus leucocephalus)*

Historically, bald eagle populations were in danger of extinction throughout their range, but they have since recovered (USFWS 2013). The CBC data, which show a generally increasing trend of midwinter eagle abundance in the Coos estuary, suggest that the overall recovery of this species may be mirrored by the recovery of local bald eagle populations (Figure 5).

*Red-shouldered Hawk (Buteo lineatus)*

Red-shouldered hawks were not sighted during the Coos Bay CBC until 1993. Sightings have generally increased since then, averaging nearly 12 sightings annually from 2006-2013 alone (Figure 6).

*Other Raptors*

Many raptors species are abundant in the Coos estuary, but most of these birds have displayed neither clearly increasing nor clearly decreasing population trends over time. Figure 7 summarizes CBC data for commonly sighted raptors in Coos Bay.

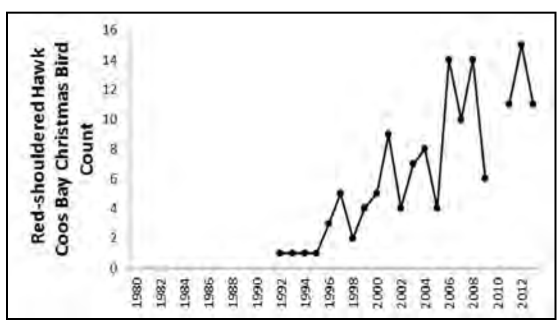



Figure 6. Coos Bay CBC data indicate that local midwinter red-shouldered hawk abundance has generally increased since 1980. Some data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012

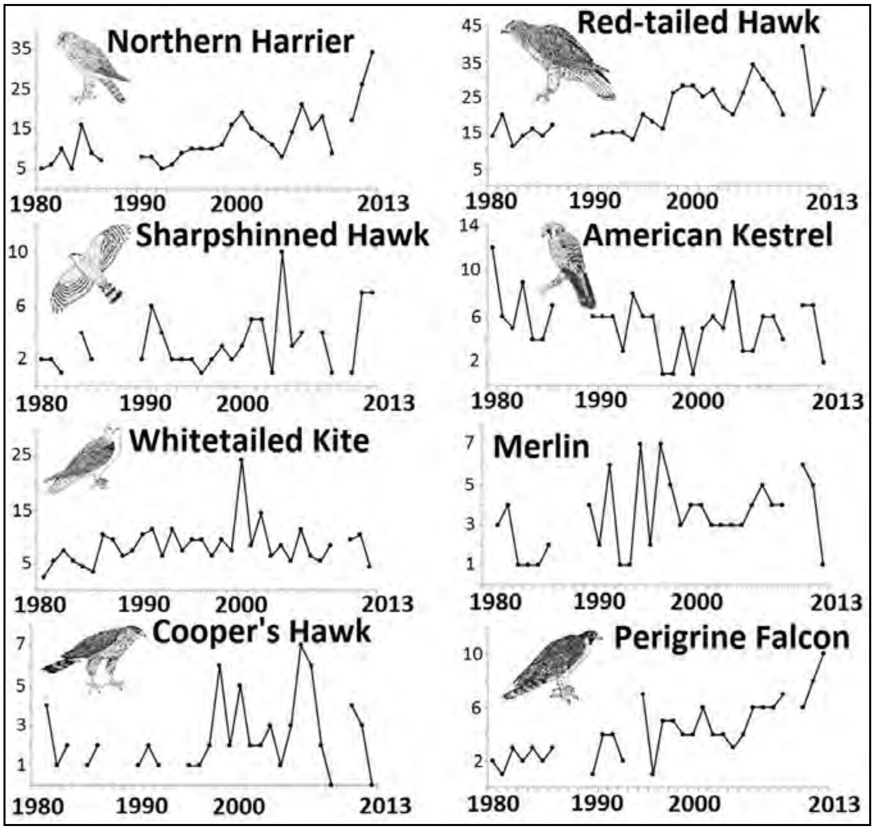



Figure 7. Common raptor species that display neither clearly increasing nor clearly decreasing population trends in the Coos estuary (1980-2013). Data: Audubon 2014, Rodenkirk 2012; Bird Sketches: Csuti et al. 1997

<u>Owls</u>

This section discusses trends in owl abundance at a statewide level as well as locally. Emphasis is given to species whose populations have displayed clear trends over time.

The northern spotted owl (*Strix occidentalis caurina*) and the northern barred owl (*Strix varia varia*) are mentioned here briefly. Trends for these species are discussed in further detail in the Birds of Special Concern data summary.

*Statewide Owl Trends*

The great horned owl (*Bubo virginianus*) is the only owl species surveyed by BBS to exhibit a clear trend (Figure 8). It appears great horned owl populations are decreasing, though the trend is not statistically significant.

Research suggests that the northern barred owl and northern spotted owl have exhibited clear trends at a regional level. Since the early 1990s, the barred owl has expanded its range into southwestern Canada, the northern Rockies, and Pacific Northwest, while the spotted owl has declined throughout its range (Courtney et al. 2004, Davis et al. 2011, Zabel et al. 1996, Forsman et al. 2013).

*Owls in the Lower Coos Watershed*

Few owl species appear to exhibit either clearly increasing or clearly decreasing population trends in the project area. The exceptions are the northern spotted and barred

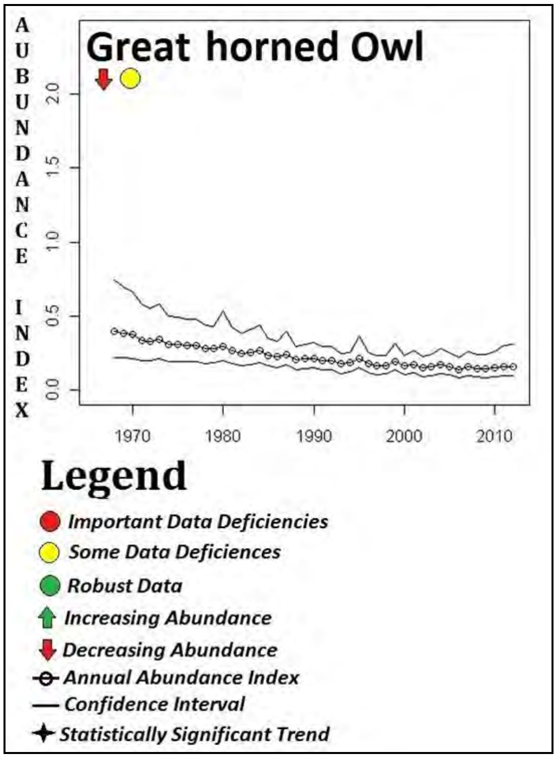



Figure8. Data from the BBS suggest that great horned owl populations statewide have declined over time, although this trend is not statistically significant. Data: USGS 2014

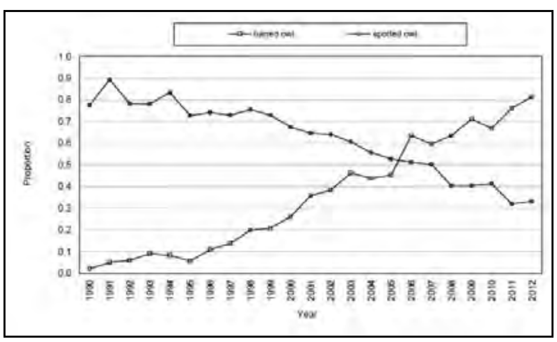



Figure 9. Proportion of spotted owl sites in which barred owls and spotted owls were detected on the Oregon Coast Ranges Study Area, 1990-2012 Caption and Figure: Forsman et al. 2013

owls. In upland habitats associated with the lower Coos watershed, spotted owl populations have declined while barred owl populations have grown (Figure 9).

| Common Name | Scientific Name | Abundance Index |
|---|---|---|
| Great Horned Owl | *Bubo virginianus* | 27 |
| Barn Owl | *Tyto alba* | 22 |
| Western Screech-Owl | Megascops kennicottii | 21 |
| Northern Saw-whet Owl | *Aegolius acadicus* | 16 |
| Northern Pygmy-Owl | *Glaucidium gnoma* | 14 |
| Barred Owl | *Strix varia* | 4 |
| Short-eared Owl | *Asio flammeus* | 4 |

Table 1. List of commonly observed owl species in the lower Coos watershed. Abundance index shows the number of years that the species was observed during the CBC (1980-2013). The CBC was not conducted from 1987-1989 and again in 2010. Therefore, if a species is present every year since 1980, the corresponding abundance index is 30. Data: Audubon 2014, Rodenkirk 2012

Table 1 summarizes local CBC count data for the most commonly observed owl species. In some cases, the CBC owl species data are relatively sparse, because not all owls are observed every year (e.g., northern saw-whet owl, northern pygmy owl). Available data indicate no clear abundance trend for commonly sighted owl species (Figure 10).

Songbirds

This section summarizes data for “passerines,” meaning bird species of the order Passeriformes, commonly referred to as “songbirds.” Songbirds comprise a diverse group of many recognizable bird species (e.g., chickadees, tits, warblers, finches, thrushes, sparrows, etc.). Statewide abundance trends are presented briefly followed by a discussion of local songbird population trends. Emphasis is given to species that have displayed clear trends over time.

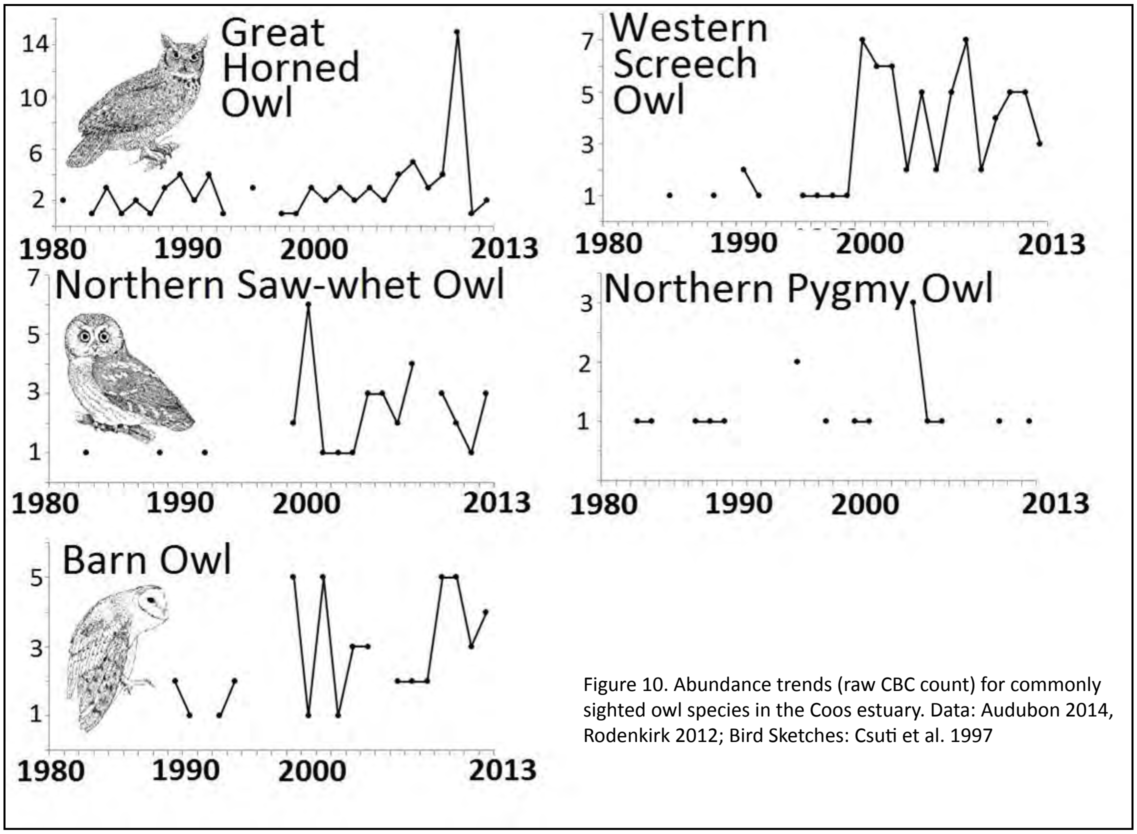



Figure 10. Abundance trends (raw CBC count) for commonly sighted owl species in the Coos estuary. Data: Audubon 2014, Rodenkirk 2012; Bird Sketches: Csuti et al. 1997

*Songbirds in Oregon*

The BBS indicates that 21 songbird species have shown statistically significant declines since 1966. Only 2 species have had statistically significant increase. Figure 11 summarizes the BBS data for 27 passerine species exhibiting clear population trends in Oregon since 1966.

*Songbirds in the Lower Coos Watershed*

Below we focus on passerine species in the lower Coos watershed that show strong evidence of changing populations:

*Black Pheobe (Sayornis nigricans)*

Black pheobes were not sighted during the local CBC from 1980-1995. However, starting in 1996, this species has been sighted every year and has become increasingly abundant (Figure 12).

*Common Yellowthroat (Geothlypis trichas)*

From 1980-2001, the Coos Bay CBC did not record any common yellowthroat sightings. Since 2002, the species has been sighted in the Coos estuary 5 times during the local CBC, and is now frequently found overwintering in several Coos County locations (Audubon 2014, Rodenkirk 2012)(Figure 13).

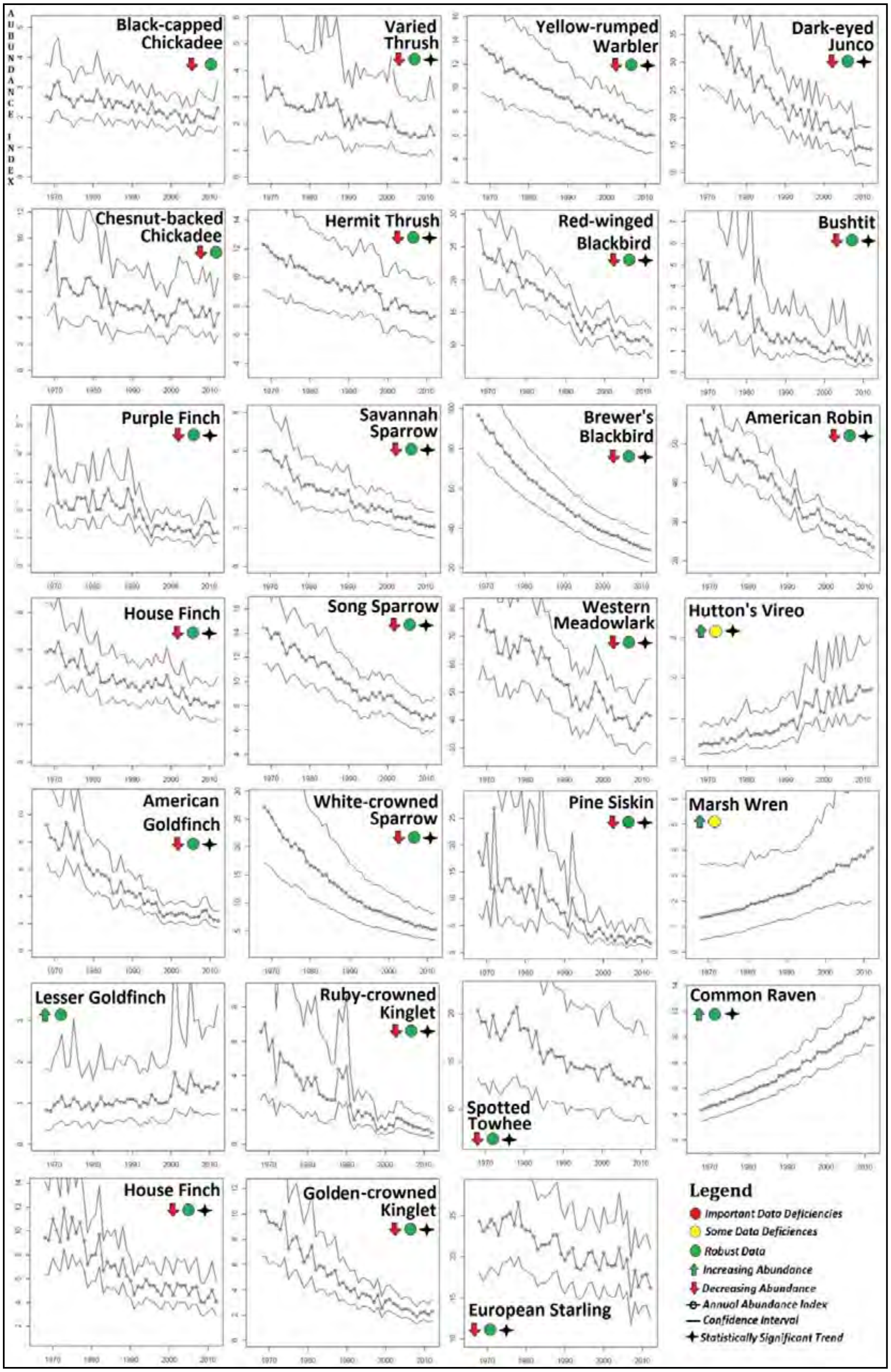



Figure 11. BBS abundance data for songbird populations in Oregon showing clear abundance trends (1966-2012). Data: USGS 2014

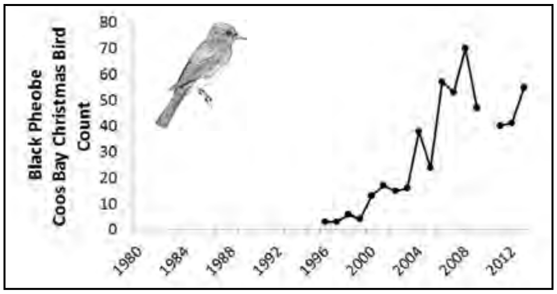



Figure 12. Coos Bay CBC data indicate that local midwinter black phoebe abundance has increased, with consistent sightings beginning in 1996 and increasing since then. Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Bird Sketch: Csuti et al. 1997

Figure 13. Historically, the common yellowthroat has not been observed overwintering in the Coos estuary. However, the Coos Bay CBC has recorded a single sighting of common yellowthroat in 2002, 2003, 2006, 2008, 2011, and 2012. Data: Audubon 2014, Rodenkirk 2012; Photo credit: Gerrit Vyn taken from Cornell 2014

*Yellow-breasted Chat (Icteria virens)*

In 2012, a yellow-breasted chat was sighted at a feeder in Coos Bay, representing the first winter record of this species in Oregon (Cornu et al. 2012). This bird is a neotropical migrant, which means that its midwinter presence may be indicative of a changing climate, although more data are needed to determine if a cause and effect relationship exists (see Why is it happening?)

*Cedar Waxwing (Bombycilla cedrorum)*

The CBC has sighted cedar waxwings periodically from 1980-2005. However, beginning in 2006, local midwinter sightings have become more consistent and often more frequent (Figure 14).

*Swamp Sparrow (Melospiza georgiana)*

The local CBC rarely sighted swamp sparrows prior to 1996, but volunteers have recored sightings every year since then (Figure 15).

*Red-winged Blackbird (Agelaius phoeniceus)*

Red-winged blackbirds are historically abundant in the Coos estuary. This species has been sighted every year during the local CBC since 1980, but the frequency of sightings has increased overtime (Figure 16).

*Sparrow species*

Many sparrow species have been historically abundant in the Coos estuary. Six sparrow species have been sighted with increasing frequency during the local CBC, including the golden-crowned sparrow (*Zonotrichia atricaplillia*), house sparrow (*Passer domesticus*), song sparrow (*Melospiza melodia*), white-crowned sparrow (*Zonotrichia leucophrys*), white-throated sparrow (*Zonotrichia albicollis*), and Lincoln's sparrow (*Mesospiza lincolnii*). Summary statistics describing trends in the raw CBC count for these six species are found in Table 2.

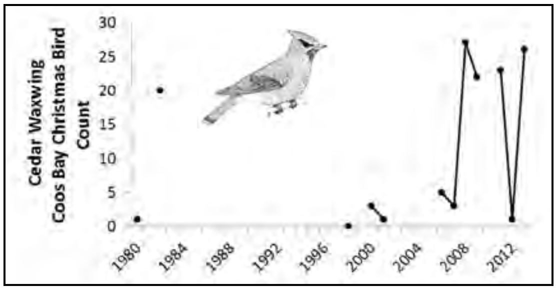



Figure 14. Cedar waxwings have been sighted in the Coos estuary during the CBC since 2006. Sightings have often occurred in greater numbers in recent years than they have in the past. Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Bird Sketch: Csuti et al. 1997

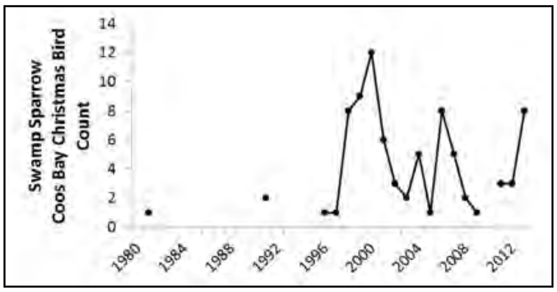



Figure 15. Coos Bay CBC swamp sparrow sightings have become more common since 1996. Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012

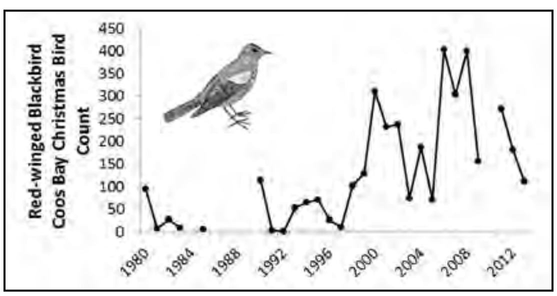



Figure 16. Red-winged blackbirds continue to be abundant in the Coos estuary. Midwinter sightings have become more common, suggesting that the species may be increasing abundant over time. Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Bird Sketch: Csuti et al. 1997

*American Crow (Corvus brachyrhynchos), Common Raven (Corvus corax), and Stellar's Jay (Cyanocitta Stelleri)*

These three species belong to the family Corvidae and have shown clear increasing trends since 1980. All three birds are historically abundant in the Coos estuary, with multiple sightings occurring every survey year since 1980. CBC sightings are becoming more frequent and may indicate increasing abundance in the project area (Figure 17).

*Other Common Songbirds*

In addition to the songbird species mentioned above, there are many other passerines commonly found locally. Most of these species do not exhibit a clear abundance trend over time. Table 3 summarizes raw CBC data (1980-2013) for 27 of the most commonly counted songbirds in the lower Coos watershed.

<u>Fowl-like Birds</u>

This section summarizes data for fowl-like birds of the order Galiformes that are closely associated with terrestrial habitats, including quail, pheasant, grouse, and turkey species. Statewide abundance trends are presented, followed by a discussion of songbird population patterns in the Coos estuary. Emphasis is given to species that have displayed clear trends over time.

*Fowl-like Birds in Oregon*

The BBS data indicate that two fowl-like bird species, including the wild turkey (*Melegris*

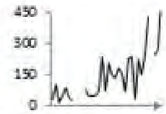
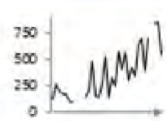
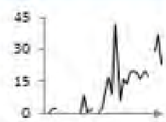
| | | | Abundance Index, Raw Christmas Bird Count (1980-2013) | | |
|---|---|---|---|---|---|
| Common Name | Scientific Name | Photo | Average Count (1980-1994) | Average Count (1995-2013) | Abundance Trend |
| Golden-crowned Sparrow | *Z. atricaplilla* |  Photo: Gerrit Vyn | 18 | 177 |  |
| House Sparrow | *P. domesticus* |  Photo: Raymond Belhumeur | 52 | 210 |  |
| Song Sparrow | *M. Melodia* |  Photo: Christine Haines | 167 | 447 |  |
| White-crowned Sparrow | *Z. leucophrys* |  Photo: Jim Ellis | 185 | 483 |  |
| White-throated Sparrow | *Z. albicollis* |  Photo: Kelly Colganazar | 3 | 13 |  |
| Lincoln's Sparrow | *M. lincolnii* |  Photo: Kelly Azar | 2 | 18 |  |

Table 2. Six species of commonly occurring sparrow species have been counted with increasing frequency during the Coos Bay CBC. This table summarizes that trend by comparing average raw CBC count for two time periods (1980-1994 and 1995-2013). Time series graphs (right) showing increasing trends (1980-2013) are also presented. Data: Audubon 2014, Rodenkirk 2012; Photos: Cornell 2014

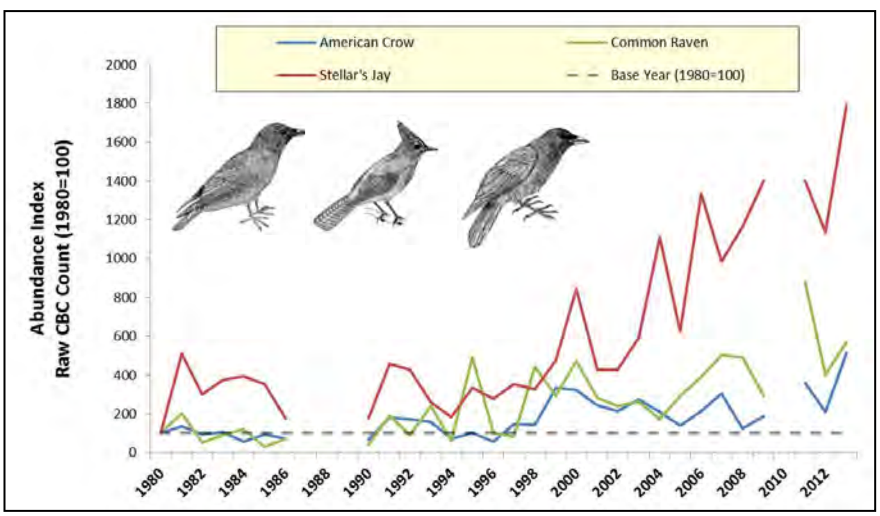



Figure 17. Coos Bay CBC data indicate that local midwinter abundance of three "corvids," including the American crow, common raven, and Stellar's jay, has shown a clearly increasing trend since 1980. Raw CBC count for these species is indexed relative to 1980-levels above (1980=100). Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Bird Sketches: Csuti et al. 1997

| Common Name | Scientific Name | Photo | Abundance Index, Raw Christmas Bird Count (1980-2013) Average Count | Maximum Count | Abundance Trend |
|---|---|---|---|---|---|
| American Robin | *T. migratorius* | Photo: Christopher L. Wood | 699 | 1,745 | |
| Black-capped Chickadee | *P. atricapillus* | Photo: Christopher L. Wood | 122 | 337 | |
| Brewer's Blackbird | *E. cyanocephalus* | Photo: Jamie Chavez | 83 | 314 | |
| Bushtit | *P. minimus* | Photo: Gerrit Vyn | 74 | 188 | |
| Chesnut-backed Chickadee | *P. rufescens* | Photo: cdbtx | 118 | 213 | |
| European Starling | *S. vulgaris* | Photo: Finiky | 1,354 | 3,279 | |
| Golden-crowned Kinglet | *R. satrapa* | Photo: Kelly Azar | 193 | 562 | |
| Hermit Thrush | *C. guttatus* | Photo: Ganesh Jayaraman | 47 | 260 | |
| House Finch | *C. mexicanus* | Photo: Maria Corcacas/PFW | 172 | 346 | |
| Marsh Wren | *C. palustris* | Photo: Andy Johnson | 32 | 148 | |
| Ruby-crowned Kinglet | *R. calendula* | Photo: Ken Schneider | 257 | 876 | |
| Townsend's Warbler | *D. townsendi* | Photo: Bob Gunderson | 33 | 95 | |
| Varied Thrush | *I. naevius* | Photo: Glenn Bartley | 174 | 818 | |
| Western Meadowlark | *S. neglecta* | Photo: Robinsegg | 62 | 136 | |
| Wrentit | *C. fasciata* | Photo: Bob Gunderson | 92 | 266 | |
| American Goldfinch | *S. tristis* | Photo: keefee | 41 | 219 | |
| Bewick's Wren | *T. bewickii* | Photo: Brian L. Sullivan | 12 | 40 | |
| Pine Siskin | *S. pinus* | Photo: Raymond Lee | 300 | 3,7067 | |
| Hutton's Vireo | *V. huttoni* | Photo: B.L. Sullivan | 5 | 14 | |
| Red-breasted Nuthatch | *S. canadensis* | Photo: aka heehaw | 20 | 184 | |
| Yellow-rumped Warbler | *D. coronata* | Photo: Kelly Colgan Azar | 388 | 1,140 | |
| Brown Creeper | *C. americana* | Photo: Kelly Colgan Azar | 3 | 10 | |
| Dark-eyed Junco | *J. hyemalis* | Photo: Christopher L. Wooc | 481 | 973 | |
| Purple Finch | *C. purpureus* | Photo: Scott A. Haber | 10 | 31 | |
| Fox Sparrow | *P. iliaca* | Photo: Gerrit Vyn | 264 | 938 | |
| Red Crossbill | *L. curvirostra* | Photo: Ganesh Jayaraman | 126 | 856 | |
| Spotted Towhee | *P. maculatus* | Photo: Steve Ting | 81 | 243 | |

Table 3. Many passerines do not exhibit any clear abundance trends in the lower Coos watershed. This table summarizes raw CBC data for some of the most commonly occurring songbirds in the Coos estuary. Time series graphs (right) showing increasing trends (1980-2013) are also presented. Data: Audubon 2014, Rodenkirk 2012; Photos: Cornell 2014

*gallopavo*) and ring-necked pheasant (*Phasianus colchicus*), show clear abundance trends (1966-2013)(Figure 18). In Oregon, turkeys are becoming more abundant, while pheasants are becoming less abundant.

*Fowl-like birds in the Lower Coos Watershed*

The California quail (*Callipepla californica*) is the only fowl-like bird that is sighted nearly every year during the local CBC. Raw CBC counts for this species indicate no clear abundance trend (Figure 19). In addition to the California quail, ring-necked pheasant and ruffed grouse (*Bonasa umbellus*) have been sighted on rare occasions (i.e., 1-3 sightings periodically from 1983-2003). Mountain quail (*Oreortyx pictus*) was counted in 2006-2008 ( < 10 sightings annually). Historically, wild

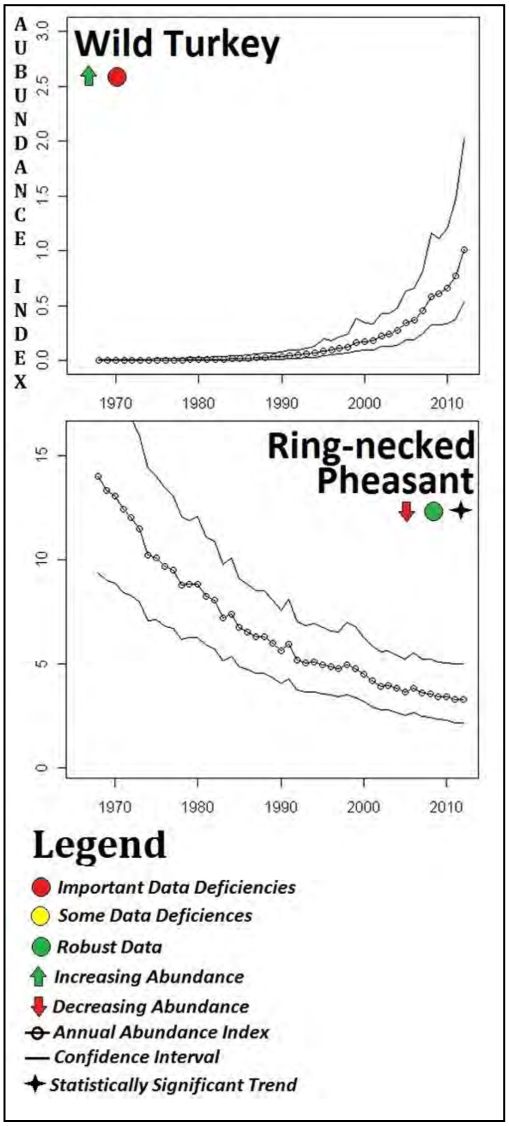



Figure 18. BBS abundance data for fowl populations in Oregon showing clear trends (1966-2012). Data: USGS 2014

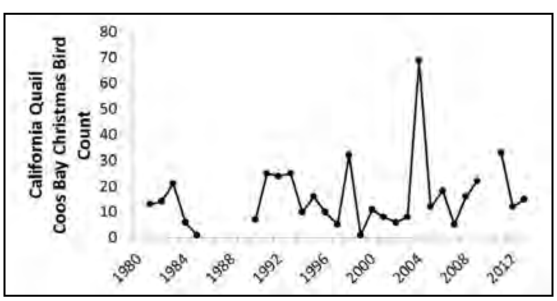



Figure 19. Raw CBC count for California quail in the lower Coos watershed. Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012

turkeys have not been counted during the local CBC. However, the CBC in 2011, 2012, and 2013 reported 28, 10, and 12 turkey sightings, respectively. More data are needed to determine if these sightings are indicative of a trend (e.g., increasing local abundance or range expansion). Figure 20 summarizes the raw CBC data for all fowl-like birds observed in the study area from 1980-2013.

Doves and Pigeons

This section summarizes data for birds of the order Columbiformes, which are commonly known as doves and pigeons. Regional data are presented at a statewide level using breeding population estimates as a proxy for abundance, followed by a discussion of Coos estuary data, which use CBC sightings to project trends in local abundance. The local data section highlights dove and pigeon species that display the most apparent trends since the 1980s.

*Doves and Pigeons in Oregon*

The BBS data indicate that only the mourning dove (*Zenaida macroura*) shows a clear abundance trend (decreasing abundance) at the regional level (1966-2013)(Figure 21).

*Doves and Pigeons in the Coos Estuary*

Below we focus on Dove and Pigeon species in the lower Coos watershed that show strong evidence of changing populations:

| Yr | Mountain Quail | California Quail | Ring-necked Pheasant | Ruffed Grouse | Wild Turkey |
|---|---|---|---|---|---|
| 1980 | | | 1 | | |
| 1981 | | 13 | | | |
| 1982 | | 14 | | | |
| 1983 | | 21 | | 2 | |
| 1984 | | 6 | | 1 | |
| 1985 | | 1 | | 1 | |
| 1986 | | | 3 | 1 | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | 7 | 2 | 1 | |
| 1991 | | 25 | 3 | | |
| 1992 | | 24 | 3 | | |
| 1993 | | 25 | 3 | | |
| 1994 | | 10 | 1 | CW | |
| 1995 | 1 | 16 | 1 | 1 | |
| 1996 | | 10 | CW | | |
| 1997 | | 5 | 1 | | |
| 1998 | | 32 | 1 | 2 | |
| 1999 | | 1 | 3 | | |
| 2000 | | 11 | | 1 | |
| 2001 | | 8 | 1 | | |
| 2002 | | 6 | | 2 | |
| 2003 | | 8 | | 1 | |
| 2004 | | 69 | CW | CW | 1 |
| 2005 | CW | 12 | 2 | | |
| 2006 | 4 | 18 | | 0 | |
| 2007 | 1 | 5 | CW | | |
| 2008 | 10 | 16 | | | |
| 2009 | CW | 22 | | | |
| 2010 | | | | | |
| 2011 | CW | 33 | | | 28 |
| 2012 | | 12 | | | 10 |
| 2013 | | 15 | | | 12 |

**Legend**

present; not observed — > 10 sightings — ≥ 10 sightings

not present; not observed

CBC not conducted; no data

Figure 20. Observations of fowl-like species during the CBC (1980-2013). More frequent observation corresponds to darker blue. Raw count data for each year are indicated (number). "CW" means the species was present during the CBC week, but it was not observed during the count. Data: Audubon 2014, Rodenkirk 2012

*Eurasian Collared Dove (Streptopelia decaocto)*

The Eurasian Collared Dove was first sighted during the CBC in 2007 (Audubon 2014, Rodenkirk 2012). Since then, they have become increasing abundant; CBC sightings have increased notably (Audubon 2014, Rodenkirk 2012)(Figure 22).

*Band-tailed Pigeon (Patagioenas fasciata)*

Band-tailed pigeons were sighted in three mid-1980s CBC's and again from 1998-2009 (Aubuon 2014). They have not been counted during the CBC since 2009; scientists indicate they're very rarely sighted in the winter (Audubon 2014, Rodenkirk 2012).

Hummingbirds

This section summarizes available data for hummingbird species of the order Apodiformes that have shown clear abundance trends either statewide or locally.

*Hummingbirds in Oregon*

The BBS data show a clear abundance trend over time for the rufous humingbird (*Selasphorus rufus*), which appears to be decreasing in abundance (Figure 23).

*Hummingbirds in the Coos Estuary*

Anna's hummingbird (*Calypte anna*) is the only hummingbird species regularly sighted during the Coos Bay CBC. The frequency of

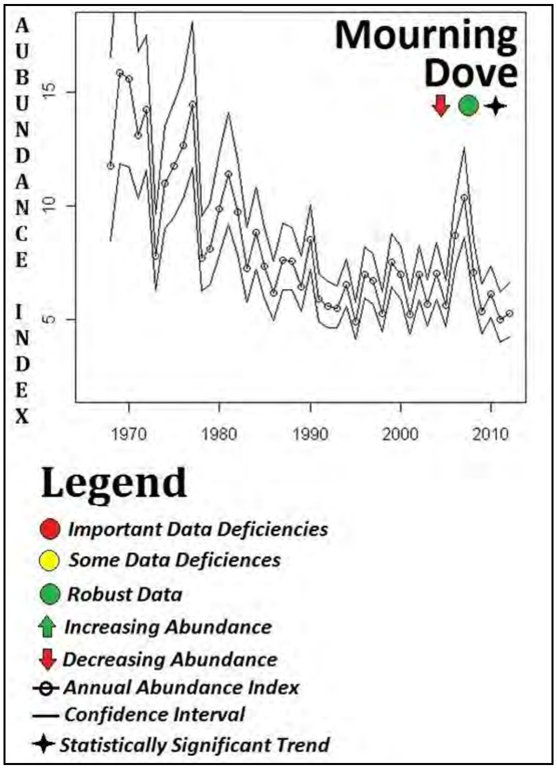



Figure 21. BBS abundance data for the mourning dove (*Zenaida macroura*) in Oregon. This species is the only dove species showing a clear abundance trend (1966-2012) in the BBS data. Data: USGS 2014

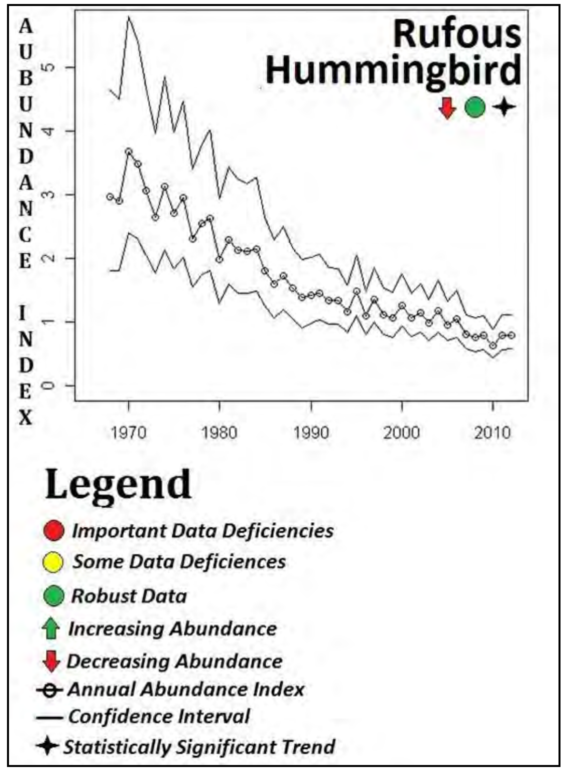



Figure 23. BBS abundance data for the rufous hummingbird, the only hummingbird species showing a clear abundance trend statewide (1966-2013). Data: USGS 2014

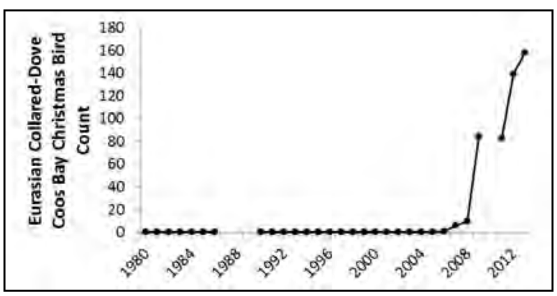



Figure 22. Raw CBC count for Eurasian collared-dove (1980-2013). Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012

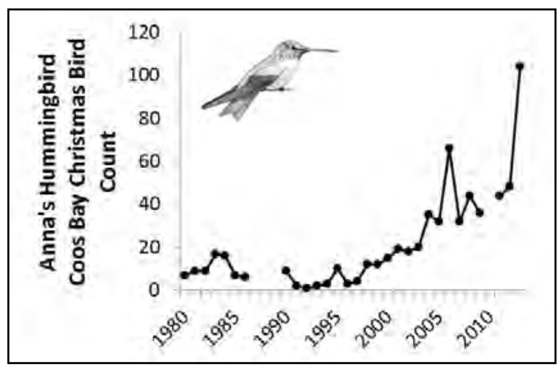



Figure 24. Raw CBC data (1980-2013) suggest that local populations of Anna's hummingbird may be increasingly abundant. Data gaps occur during years in which the CBC was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Bird Sketch: Csuti et al. 1997

Anna's hummingbird midwinter sightings has increased over time, suggesting the species is becoming more locally abundant (Figure 24).

<u>Woodpeckers</u>

This section summarizes available data for birds of the order Piciformes, which are commonly referred to as woodpeckers, sapsuckers, and flickers. The data summary focuses on birds that have shown clear abundance trends either statewide or locally.

*Woodpeckers in Oregon*

The BBS data indicate that five woodpecker species of have shown clear abundance trends statewide since 1966 (Figure 25). Pileated woodpeckers, yellow-bellied sapsuckers, and re-breasted sapsuckers appear to be increasing in abundance over time, while northern flickers, and red-naped sapsuckers appear to be decreasing in abundance in Oregon.

*Woodpeckers in Lower Coos Watershed*

Several woodpecker species are commonly sighted in the Coos estuary. However, it's difficult assess any abundance trends. CBC sightings of some species (e.g., northern flicker) are rare and do not show any apparent trend. Table 4 summarizes the raw CBC data for woodpecker species in the Coos estuary.

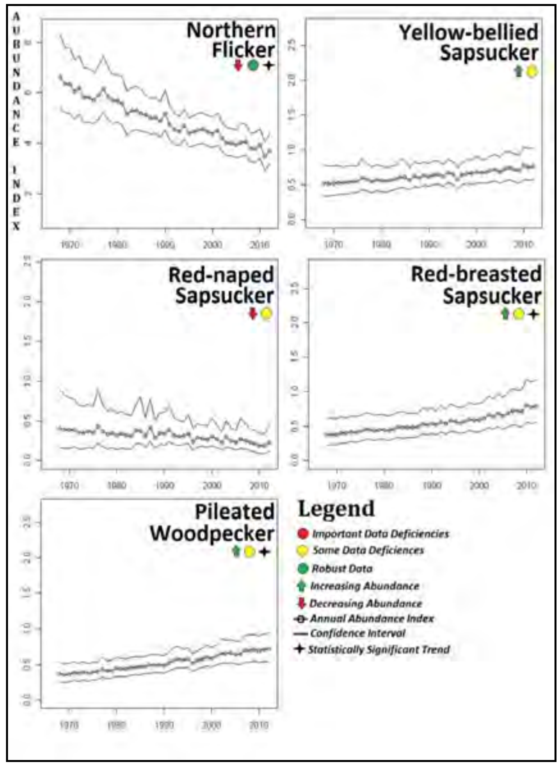



Figure 25. BBS abundance data for woodpecker species that have shown clear abundance trends statewide (1966-2013). Data: USGS 2014

**Why is it happening?**

Multiple factors can often work together to determine local bird abundance trends (e.g., land use changes occurring simultaneously with climate anomalies may work to the detriment of some species while favoring others). Similar to aquatic birds, some terrestrial bird species are highly migratory. Therefore, factors affecting distant habitats may affect bird species survival rates which will be reflected in local abundance data.

Birds expand their ranges when the resources they rely on for survival become available to them in different geographic areas (Cornu et al. 2012). Habitat alterations related to human activities and climate change are

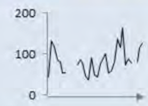
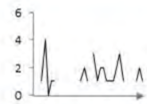
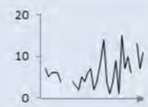
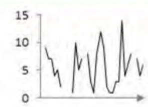
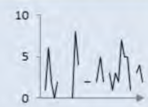
| | | | Abundance Index, Raw Christmas Bird Count (1980-2013) | | |
|---|---|---|---|---|---|
| Common Name | Scientific Name | Photo | Average Count | Maximum Count | Abundance Trend |
| Northern Flicker | *C. auratus* |  *Photo: Bill Bunn* | 83 | 163 |   |
| Red-breasted Sapsucker | *S. ruber* |  *Photo: Lois Manowitz* | 2 | 4 |   |
| Downy Woodpecker | *P. pubescens* |  *Photo: Ronaldok* | 6 | 15 |   |
| Hairy Woodpecker | *P. villosus* |  *Photo: Christopher L. Wood* | 6 | 14 |   |
| Pileated Woodpecker | *D. pileatus* |  *Photo: Gerrit Vyn* | 3 | 8 |   |

Table 4. This table summarizes raw CBC data for some of the most commonly occurring woodpeckers in the Coos estuary. Time series graphs (right) showing increasing trends (1980-2013) are presented. Data: Audubon 2014, Rodenkirk 2012; Photos: Cornell 2014

also leading factors in bird range expansions (Askins 2000). This might explain the range expansions of black pheobes and red-shouldered hawks, which have moved northward toward Tillamook County and east to the Williamete Valley over the past 30 years (T. Rodenkirk, pers. comm., January 19, 2012).

Human population growth and urban development may benefit birds in some cases (Cornu et al. 2012). Peery and Henry (2010) explain that "The expansion of human activities into rural areas and natural landscapes has resulted in widespread increases in the abundance of synanthropic species (birds that live near humans and benefit from an association with human habitat)." In fact, some birds that have the ability to adapt to a wide range of habitat conditions (e.g., crows, ravens) have been observed in higher density in urban settings (Kelly et al. 2002). Doves and pigeons are also famously synanthropic species. The Eurasian collared-dove, an introduced species, was first recorded in Oregon in 1999 (Cornu et al. 2012). By 2006, Eurasian collared-doves had established themselves in all 36 Oregon counties, including Coos (R. Namitz, pers. comm., January 19, 2012; T. Rodenkirk, pers. comm., January 19, 2012).

In some cases, active habitat management and restoration have resulted in species recoveries. Similar to the brown pelican (see Aquatic birds), the bald eagle and peregrine falcon have benefited from the efforts of volunteers and avian professionals alike (Cornu et al. 2012). In both cases, the effort has been substantial enough to remove the species from the federal Threatened and Endangered Species List (USFWS 2014).

Some evidence suggests that the overwintering population of neotropical migrants (e.g., common yellowthroats, orange-crowned warblers, and yellow-breasted chats) in Coos County may be increasing (R. Namitz, pers. comm., January 19, 2012; T. Rodenkirk, pers. comm., January 19, 2012; Rodenkirk 2012a; Audubon 2014). Neotropical migrants are birds that spend the summer in the northern temperate and polar latitudes and migrate south to the tropics where climate and food availability is more agreeable in the winter months (Cornu et al. 2012). This trend could be indicative of a general warming pattern in the temperate latitudes, although more data are needed to determine the exact correlation between climate change and neotropical migrant abundance.

Habitats availability also influences local abundance trends. The Coos estuary and associated uplands represent important breeding, foraging, and roosting habitats for many bird species. As habitats are lost or restored, bird distributions may shift to reflect changes in the availability of important resources (e.g., food/prey, cover, etc.) and changes in the presence/absence of predators.

**Background**

Oregon's total wildlife diversity accounts for more than 42% of all terrestrial vertebrates in the United States and Canada (Csuti et al. 1997). Birds species comprise much of that diversity; many remain in Oregon year-round and others visiting the state during migration.

Because birds use the lower Coos watershed and estuary for a variety of activities (breeding, nesting, roosting, foraging, etc.), trends in local bird abundance and migration timing can signal important changes to habitat availability or suitability; these habitat changes have the potential to affect both birds and other wildlife (Cornu et al. 2012). Birds can often be considered "indicator species," because changes in their status can provide an early warning about less detectable trends in local environmental conditions.

Changes in the abundance of one bird species can sometimes directly affect other species. For example, the range expansions of the northern barred owl are likely to negatively affect local populations of northern spotted owls (see Birds of Special Concern data summary in this chapter). However, this kind of direct cause/effect relationship doesn't always exist. In the case of the Eurasian collared-dove, some concern exists about competitive pressures on native mourning doves (*Zenaida macroura*). However, research suggests that although the two species have similar diets, the Eurasian collared-dove "does not appear more behaviorally aggressive or competitively successful than mourning doves" (Poling and Hayslette 2006).

**References**

Askins, R. A. 2000. Restoring America's Birds: Lessons from Landscape Ecology. New Haven and London: Yale University Press.

Cornell University (Cornell). 2014. All About Birds: Your Online Guide to Birds and Bird Watching. [An interactive tool from the Cornell Lab of Ornithology]. Accessed 25 November 2014. Available online www.allaboutbirds.org

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. [Report prepared for the Partnership for Coastal Watersheds Steering Committee]. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Courtney, S. P., J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dumbacher, R. C. Fleischer, A. B. Franklin, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, and L. Sztukowski. 2004. Scientific Evaluation of the Status of the Northern Spotted Owl. Sustainable Ecosystems Institute. Portland, OR.

Csuti, B. A., T. A. O'Neil, M. M. Shaughnessy, E. P. Gaines, J. C. Hak. 1997. Atlas of Oregon Wildlife, first edition. Corvallis: Oregon State University Press.

Davis, R. J., K. M. Dugger, S. Mohoric, L. Evers, and W. C. Aney. 2011. Status and Trends of Northern Spotted Owl Populations and Habitats. [Technical Report from the United States Department of Agriculture, United States Forest Service, and Pacific Northwest Research Station].

Forsman, E. D., C. McCafferty, E. Divine, S. Kane, J. Mowdy, T. Plawman, A. Price, and M. Sullivan. 2013. Demographic Characteristics of Spotted Owls in the Oregon Coast Ranges, 1990-2012. [Wildlife Ecology Team: Wildlife Habitat Relationships in Washington and Oregon FY 2012].

Kelly, J. P., K. L. Etienne, and J. E. Roth. 2002. Abundance and Distribution of the Common Raven and American in the San Francisco Bay Area, California. Western Birds 33(3): 202-217.

National Audubon Society (Audubon). 2014. Audubon Christmas Bird Count: Historical Results by Count. [Coos Bay Sitkum Dock Count ORCB]. Accessed 04 November 2014. Available online http://netapp.audubon.org/CBCObservation/Historical/ResultsByCount.aspx

Peery, M. Z. and R. W. Henry. 2010. Recovering Marbled Murrelets via Corvid Management: A Population Viability Analysis Approach. Biological Conservation 143: 2414-2424.

Poling, T. D. and S. E. Hayslette. 2006. Dietary Overlap and Foraging Competition between Mourning Doves and Euarasian Collared-Doves. The Journal of Wildlife Management 70(4): 998- 1004.

Rodenkirk, T. J. 2012. Birds of Coos County, Oregon: Status and Distribution. [Unpublished Manuscript].

Rodenkirk, T. J. n.d. Map of Christmas Bird Count Coverage Area. [Unpublished Data].

United States Fish and Wildlife Service (USFWS). 2013. Bald Eagle Fact Sheet: Natural Historical, Ecology, and History of Recovery. Accessed 08 December 2014. Available online http://www.fws.gov/Midwest/eagle/recovery/biologue.html

United States Fish and Wildlife Service (USFWS). 2014. Endagered Species. Accessed 06 October 2014. Available online http://www.fws.gov/endangered/

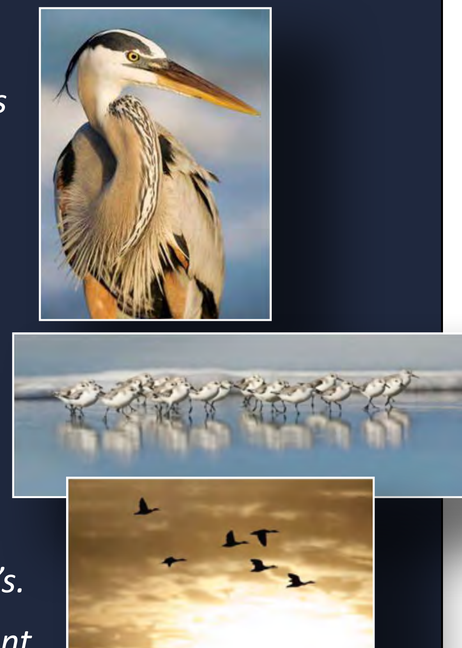
United States Geological Survey Patuxent Wildlife Research Center (USGS). 2014. North American Breeding Bird Survey data set 1966-2013, version 2014.0. [Access to raw data via link to FTP site]. Available online https://www.pwrc.usgs.gov/bbs/RawData/Choose-Method.cfm

Zabel, C. J., S. E. Salmons, and M. Brown. 1996. Demography of Northern Spotted Owls in Southwestern Oregon. Studies in Avian Biology 14: 77-82.

# Aquatic Birds in the Lower Coos Watershed

*Summary:*

- *Duck populations have recovered from late-1980's lows. Some species populations appear to be increasing while others are decreasing.*
- *Canada geese have become increasingly abundant in the Coos estuary since their reintroduction in the 1970s.*
- *There are few significant changes in wading bird populations statewide. Local populations appear to be relatively stable. The exception is cattle egret populations which have declined locally since the 1980's.*
- *Brown pelicans appear to be more abundant in Coos Bay in recent years. Few other seabirds and shorebirds show clear trends.*

**Evaluation**

Most aquatic bird populations appear to be stable, displaying neither increasing nor decreasing trends.

**Evaluation**

Waterfowl are abundant. Ducks have recovered from record low populations. Canada geese are increasingly common.

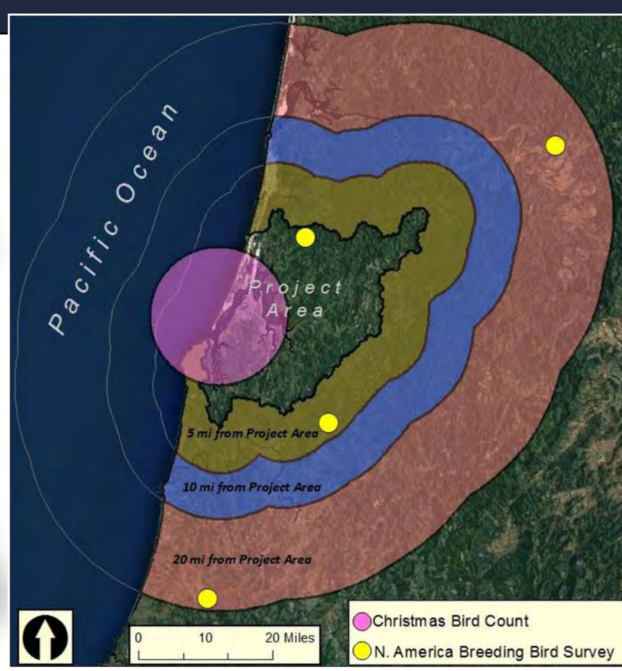



Figure 1. Aquatic bird survey sites in and near the project area. Data: Rodenkirk n.d., USGS 2014

## What's happening?

Waterfowl

This section summarizes the status and trends of geese and ducks. Regional data are presented at a statewide level using breeding population estimates as a proxy for abundance. Coos estuary bird information is also presented which uses Audubon's Christmas Bird Count (CBC) data from Coos Bay to characterize trends in local waterfowl abundance (Figure 1). Finally, a Local Waterfowl Trends section highlights waterfowl species that display the most apparent trends since the 1980s.

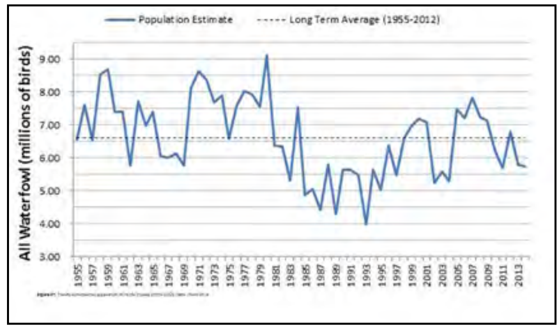



Figure 2. Trends in midwinter population of Pacific Flyway (1955-2012). Data: Olson 2014

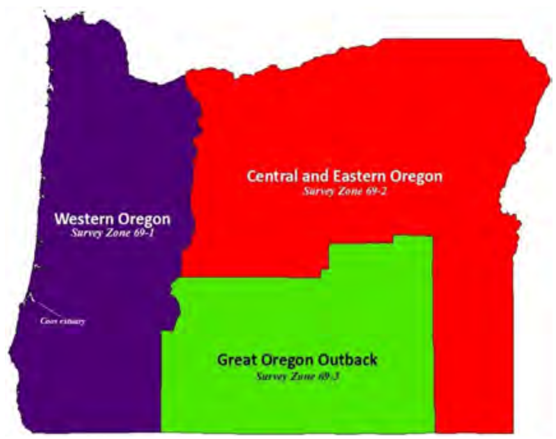



Figure 3. Spatial extent of Pacific Flyway midwinter population survey zones. Source: Modified from Olson 2014

*Pacific Flyway, Statewide, and Regional Waterfowl Trends*

Oregon is part of a North American migratory corridor known as the Pacific Flyway (see Background). During their annual midwinter survey, the United States Fish and Wildlife Service (USFWS) estimated approximately 5.76 million waterfowl in the Pacific Flyway,

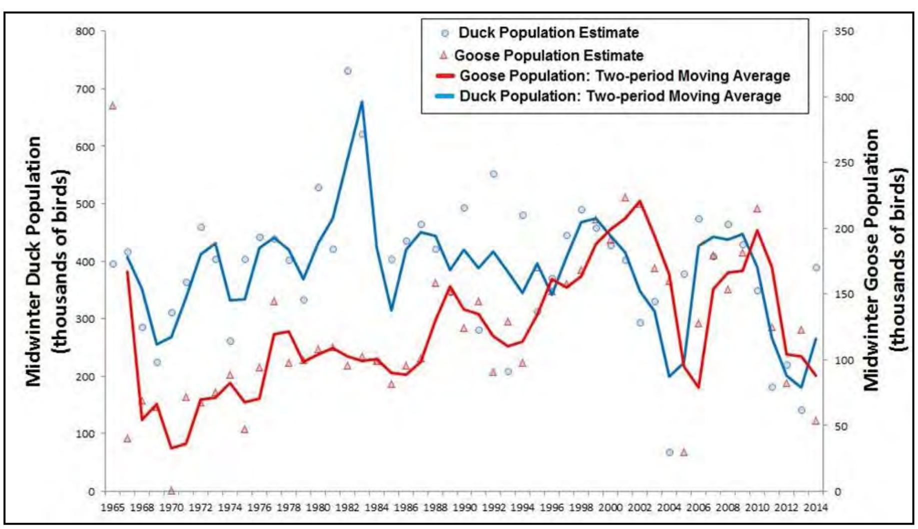



Figure 4. Trends in midwinter population of ducks (blue) and geese (red) in Oregon (1965-2014). Point estimates for midwinter population of ducks (dots) and geese (triangles) are connected by a two-period moving average, which helps to bring out underlying trends by imposing "smoothness" on the population data. Data: USFWS 2014b

including all species of ducks, geese, and swans (Olson 2014). The estimated midwinter Pacific Flyway population has increased since record lows in the late 1980s and early 1990s, but has not recovered to historic levels (Figure 2).

In Oregon, the midwinter Pacific Flyway survey is conducted in three survey zones (Figure 3). Figure 4 shows historic waterfowl abundance in Oregon (i.e., in all three of the Oregon midwinter Pacific Flyway survey zones); Figure 5 shows the abundance in western Oregon alone.

Since 1965, duck abundance statewide shows no clear trend. Goose abundance in Oregon generally increased from the early 1970s to

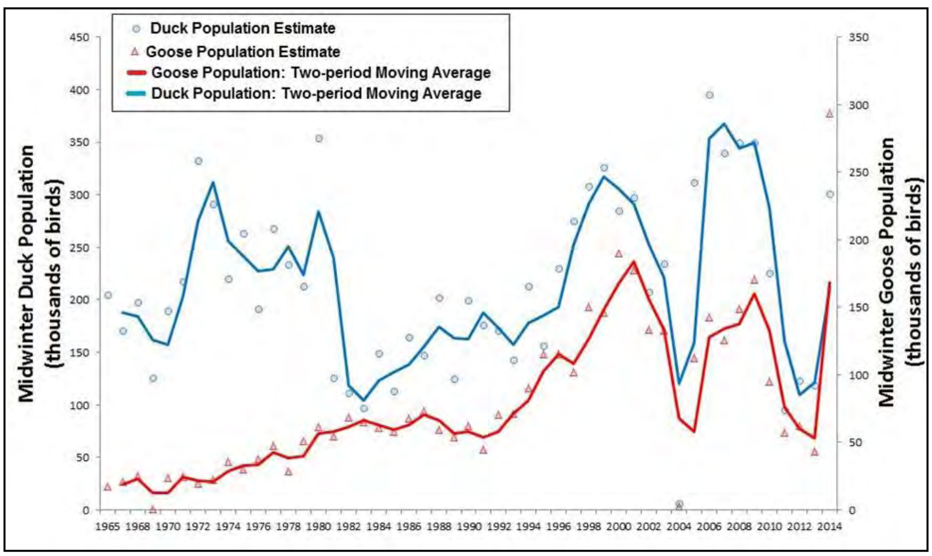



Figure 5. Trends in midwinter population of ducks (blue) and geese (red) in the Western Oregon Pacific Flyway survey zone (see Figure 3) (1965-2014). Point estimates for midwinter population of ducks (dots) and geese (triangles) are connected by a two-period moving average, which helps expose underlying trends by imposing “smoothness” on the population data. Data: USFWS 2014b

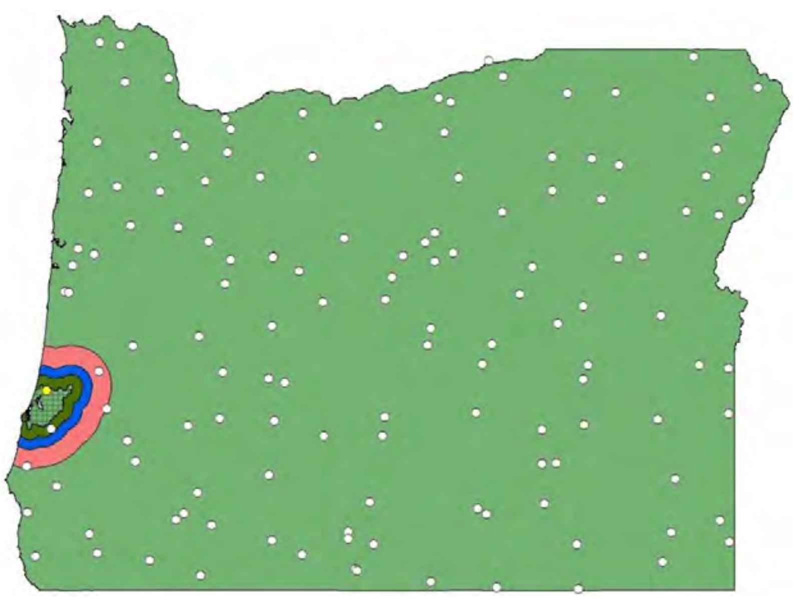


Figure 6. USGS Patuxent Wildlife Research Center conducts the North American Breeding Bird Survey (BBS) along observational routes at 144 sites in Oregon (white), including one site within the study area (yellow). The project area (cross hatch) has been highlighted for reference. Habitat within proximity to the project area (< 20 miles) is also highlighted (see Figure 1 for reference). Data: USGS 2014

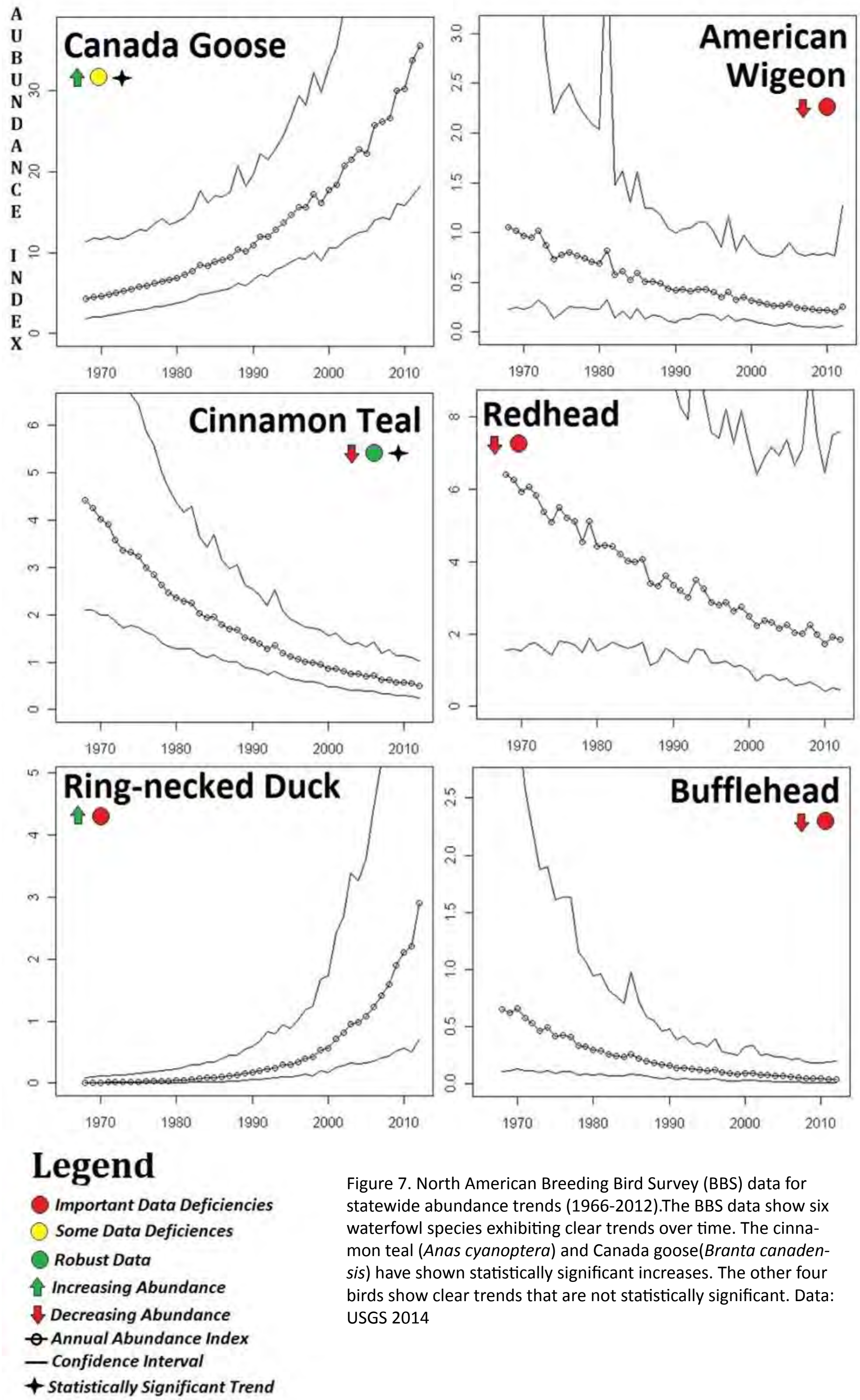



Figure 7. North American Breeding Bird Survey (BBS) data for statewide abundance trends (1966-2012).The BBS data show six waterfowl species exhibiting clear trends over time. The cinnamon teal (*Anas cyanoptera*) and Canada goose(*Branta canadensis*) have shown statistically significant increases. The other four birds show clear trends that are not statistically significant. Data: USGS 2014

the early 2000s. Oregon waterfowl populations (i.e., both geese and ducks) declined substantially in both the mid-2000s and in recent years. Annual variation in waterfowl abundance appears to be larger than average in the past 15 years than it has historically.

Similar to statewide trends, the western Oregon duck population is neither consistently increasing nor decreasing. Duck abundance in western Oregon has been variable from year to year, with the greatest changes occurring in the early 1980s, the mid-2000s, and during recent years. Western Oregon goose abundance increased significantly from 1965-2000. However, similar to ducks, the regional goose population also declined in the mid-2000s and in recent years. Regional waterfowl trends mirror the statewide patterns in that waterfowl abundance appears to vary more in the past 15 years than it has historically.

The United States Geological Survey (USGS) Patuxent (MD) Wildlife Research Center (2014) conducts the North American Breeding Bird Survey (BBS) which includes 144 survey sites in Oregon. One of the Oregon sites is located within the project area and three sites are located near the project area (Figures 1 and 6). This survey is conducted annually along preselected observational "routes." The BBS data are used here as indices of relative bird species abundance and should not be interpreted as estimates of the total population size (D. Ziolkowski, pers. comm., 2014).

Figure 7 displays the BBS abundance data for six waterfowl species in Oregon which have displayed clear trends in relative population change between 1966 and 2012. It should be noted that some of these trends are subject to data limitations (e.g., small sample size) that can reduce the reliability of the results. Please see the chapter summary for more information about these limitations.

*Local Waterfowl Trends*

Midwinter waterfowl sightings in the Coos estuary have increased over time for some species (e.g., Canada goose, mallards, and harlequin ducks) and decreased for others (e.g., brant, redheads, and canvasbacks). Some waterfowl species (e.g., buffleheads) are abundant in the study area but have displayed neither clearly increasing nor decreasing population trends over time.

Local waterfowl species which show strong evidence of changing populations:

*Canada Goose (Branta canadensis)*

Similar to regional trends, Canada goose sightings have steadily increased over the past few decades (Cornu et al. 2012)(Figure 8). Historically, the local CBC recorded as few as one sighting per hour in 1991, a number that increased to more than eight sightings per hour by 2010 (T. Rodenkirk, pers. comm., January 19, 2012).

*Brant Goose (Branta bernicla)*

Brant sightings have decreased since the mid-1980s. The CBC has not recorded any brant sightings since 2007 (Figure 9 black line). Brant have generally declined across western Oregon (Figure 9 dashed line).

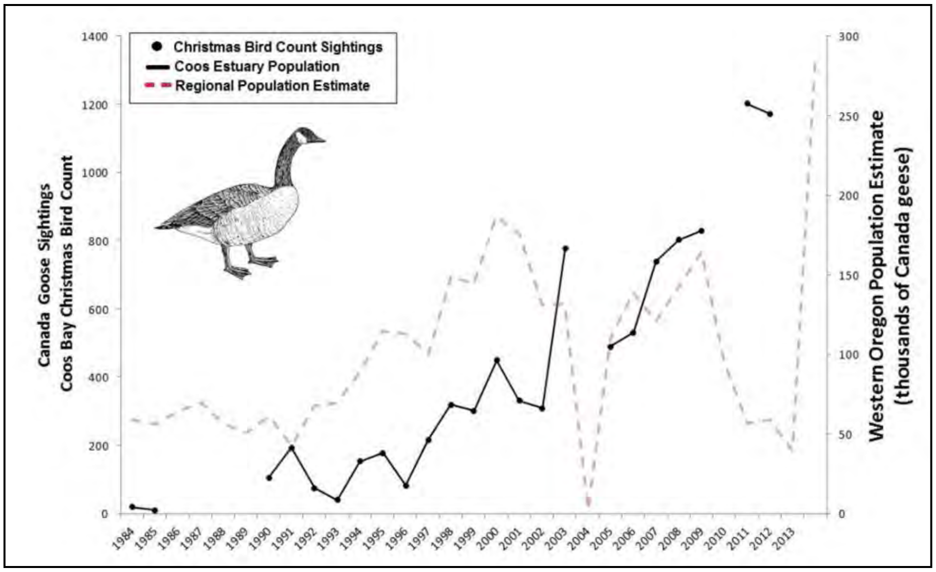



Figure 8. Indicators of Canada goose abundance in the Coos estuary (black) and across western Oregon (red)(1984-2012). Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012, USFWS 2014a; Sketch: Csuti et al. 1997

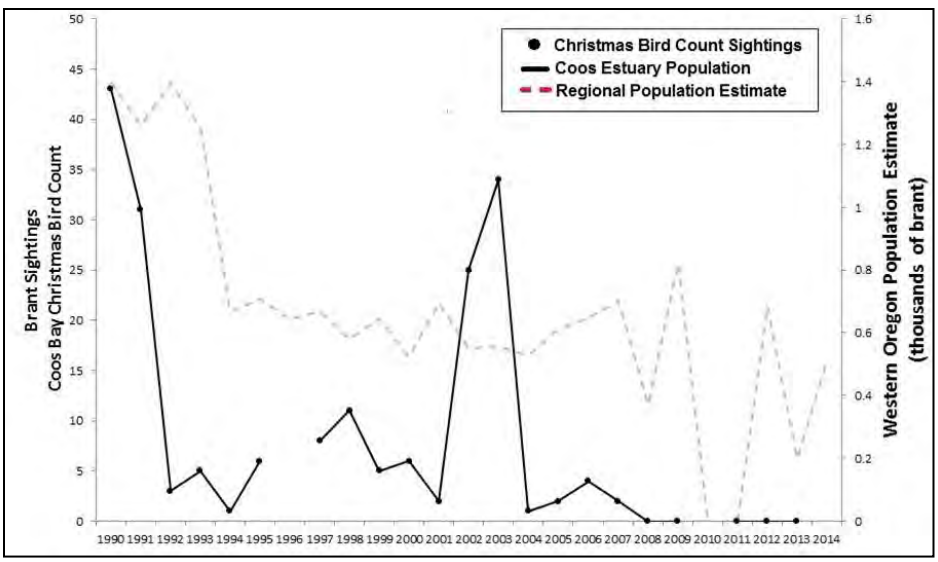



Figure 9. Indicators of brant abundance in the Coos estuary (black) and across western Oregon (red)(1984-2012). Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012, USFWS 2014a

*Greater White-fronted Goose (Anser albifrons)*

Historically, the greater white-fronted goose was not sighted in Coos Bay. However, sightings have increased dramatically since the late-2000s. Local greater white-fronted goose populations remain much higher relative to previous decades (Figure 10).

*Mallard (Anas platyrhynchos)*

Mallards have been sighted in the lower Coos watershed every year during the Christmas bird count, and the number of sightings has steadily increased over the past decades (Cornu et al. 2012)(Figure 11).

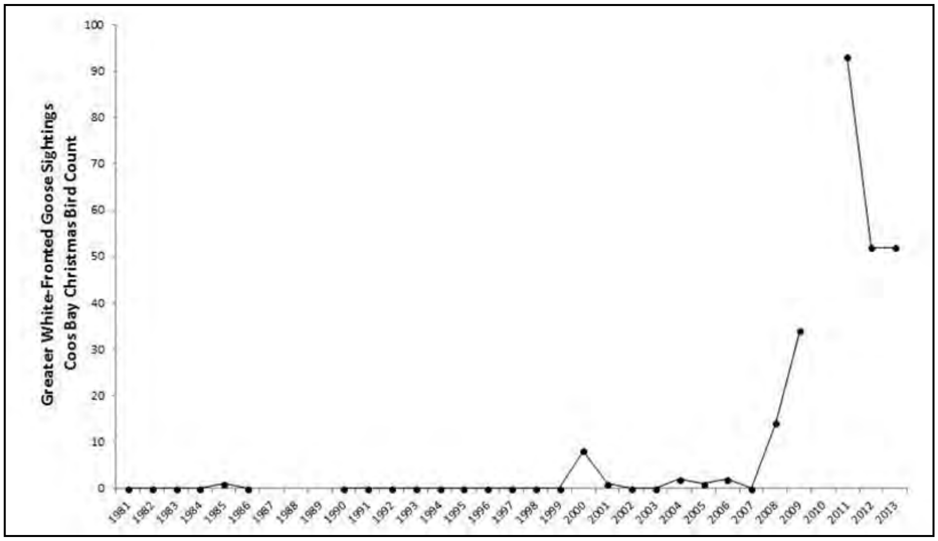



Figure 10. Greater white-fronted goose abundance in the Coos estuary. Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012

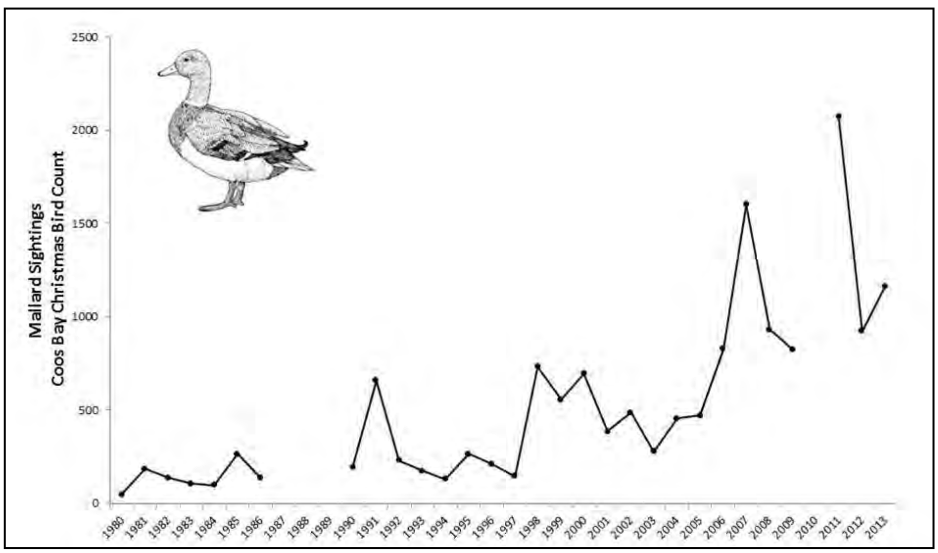



Figure 11. Mallard abundance in the Coos estuary. Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Sketch: Csuti et al. 1997

### *Redheads (Aythya americana)*

Redheads, once a relatively common CBC sighting in the Coos estuary, have not been recorded every year the CBC, especially since 1999. Redhead sightings appear to have fallen dramatically over the past few decades (Cornu et al. 2012)(Figure 12).

### *Canvasbacks (Aythya valisineria)*

Canvasbacks appear to be relatively abundant in the Coos estuary prior to the early 1990s. However, sightings have decreased dramatically over the past few decades (Figure 13). This trend, though more pronounced for the Coos estuary, generally matches the decline shown in the regional data.

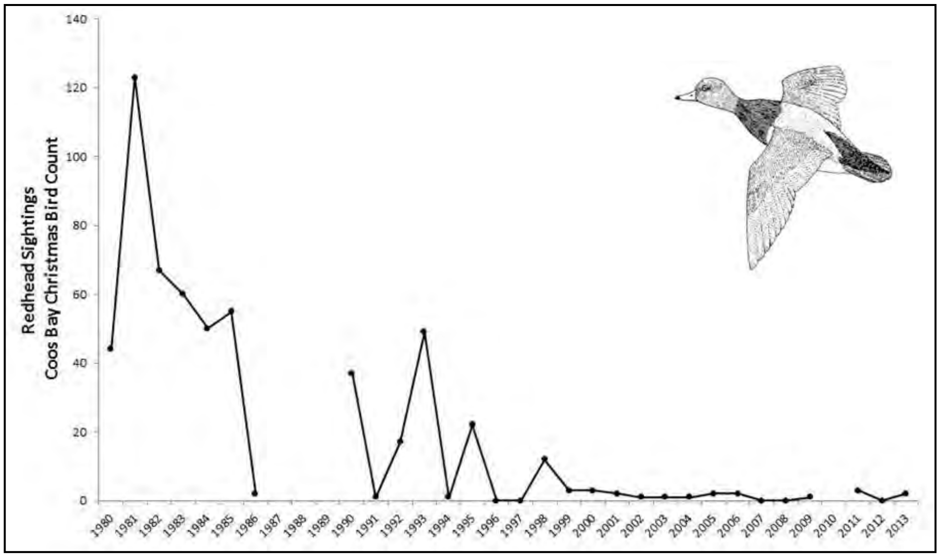



Figure 12. Redhead abundance in the Coos estuary. Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Sketch: Csuti et al. 1997

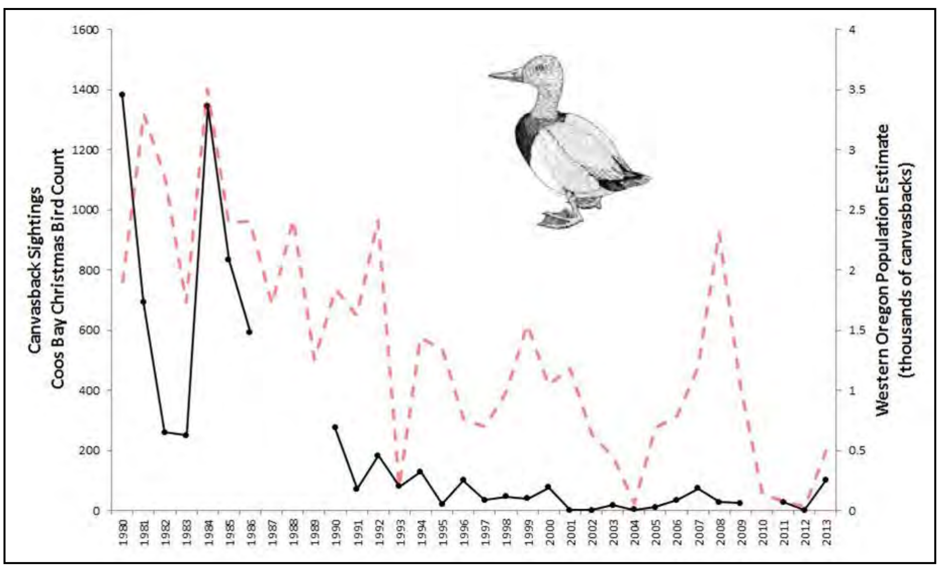



Figure 13. Indicators of canvasback abundance in the Coos estuary (black) and across western Oregon (red)(1984-2012). Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012, USFWS 2014a; Sketch: Csuti et al. 1997

### *Harlequin Ducks (Histrionicus histrionicus)*

Harlequin duck sightings have increased throughout the early 2000s, with peak-levels occurring in the most recent years (Cornu et al. 2012)(Figure 14).

### *Other Common Waterfowl*

In addition to the species mentioned above, several waterfowl species were observed during the local CBC every year since 1980 and are worth mentioning: northern pintail (*Anas acuta*), scaups (*Aythya spp.*), American wigeon (*Anas americana*), mergansers (*Mergus spp.*), northern shoveler (*Anas clypeata*),


Figure 14. Harlequin duck abundance in the Coos estuary. Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Sketch: Csuti et al. 1997

scoters (*Melanitta spp.*), gadwall (*Anas strepera*), and ruddy duck (*Oxyura jamaicensis*). Although these birds commonly occur within the study area, they have displayed neither clearly increasing, nor clearly decreasing population trends over the past two decades (Figure 15).

<u>Wading Birds</u>

This section summarizes the status and trends of herons and egrets. Statewide abundance trends are presented using the BBS data (see Pacific Flyway, Statewide, and Regional Waterfowl Trends). This presentation is followed by a discussion of local data generated by the Coos estuary CBC.

*Wading Bird Trends in Oregon*

The Oregon BBS data include eight wading bird species that show either clearly increasing or clearly decreasing trends in the past several decades (Figure 16). These data indicate that breeding herons (i.e., the great blue heron, *Ardea herodias*, and black-crowned night heron, *Nycticorax nycticorax*, collectively) may have decreased marginally from 1980-levels. This interpretation is supported by Liebezeit and Larson (2014), who report that the BBS data show a declining trend for heron populations in both the Pacific Northwest region as well as in Oregon. However, they add that the decline does not appear to be statistically significant. Contrary to the marginal decline in heron abundance, breeding egrets (i.e., the great egret, *Ardea alba*, and the snowy egret, *Egretta thula*, collectively) appear to be more abundant in recent years than in the past.

*Local Wading Bird Trends*

Historically, heron and egret species have been abundant locally. However, the most apparent population trend within the study area has been displayed by the cattle egret:

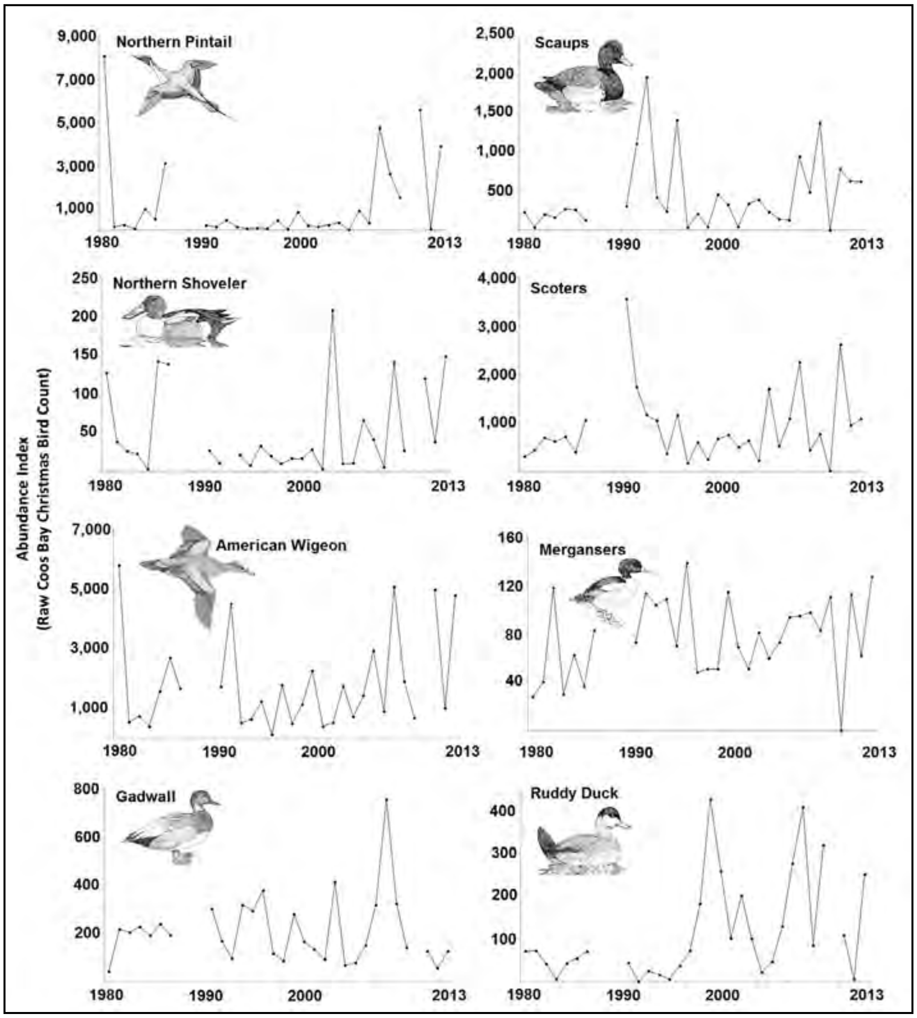



Figure 15. Common waterfowl species that display neither clearly increasing nor clearly decreasing population trends in the Coos estuary (1980-2013). "Scaups" include both the greater scaup (*Aythya marila*) and the lesser scaup (*Anthya affinis*); "Mergansers" include the hooded merganser (*Lophodytes cucullatus*), common merganser (*Mergus merganser)*, and the red-breasted merganser (*mergus serrator*); "Scoters" include the surf scoter (*melanitta perspicillata*), white-winged scoter (*melanitta fuscal*),and black scoter (*Melanitta americana*). Data: Audubon 2014, Rodenkirk 2012; Bird Sketches: Csuti et al. 1997

*Cattle Egret (Bubulcus ibis)*

This species rapidly expanded its range in the 1970s and 80s (Cornu et al. 2012). It was observed in the Coos estuary every year during the CBC until 1986 but has not been sighted since (Audubon 2014, Rodenkirk 2012)(Figure 17).

*Other Common Wading Birds*

Several common heron and egret species have been observed during the Coos estuary CBC every year since 1980 (Figure 18). The great blue heron and great egret are the most abundant wading birds in the Coos system, with numerous CBC sightings (approximately 50-100) occurring every year (Audubon 2014, Rodenkirk 2012). In addition, the snowy egret and the black-crowned night heron are also commonly sighted but appear to be less abundant- fewer than 10 sightings most years (Audubon 2014, Rodenkirk 2012). Although these species occur within the study area, they have displayed neither clearly increasing nor clearly decreasing trends over the past two decades.

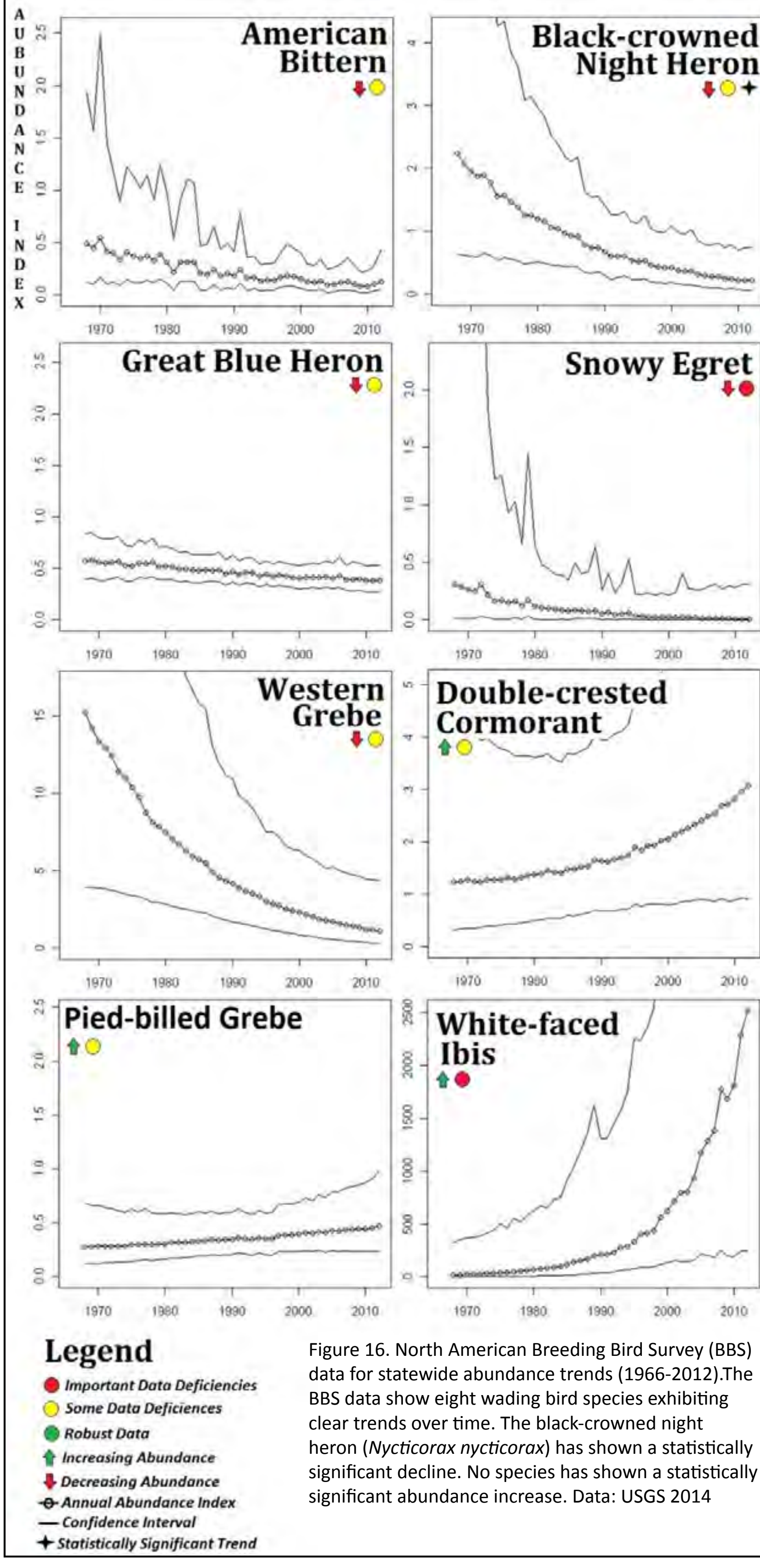



Figure 16. North American Breeding Bird Survey (BBS) data for statewide abundance trends (1966-2012).The BBS data show eight wading bird species exhibiting clear trends over time. The black-crowned night heron (*Nycticorax nycticorax*) has shown a statistically significant decline. No species has shown a statistically significant abundance increase. Data: USGS 2014

## Seabirds and Shorebirds

BBS data include eight seabird and shorebird species that exhibit clear trends in the number of sightings since 1966 (Figure 19).

*Local Seabird and Shorebird Trends*

Historically, seabird and shorebird species have been abundant in the Coos estuary.

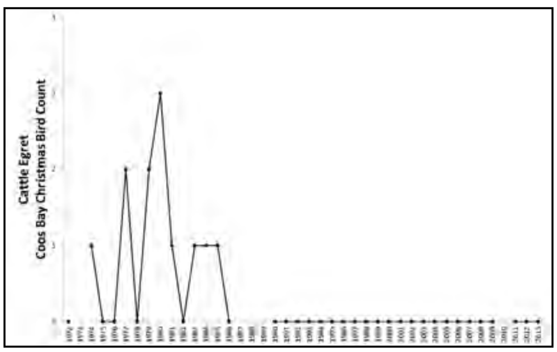



Figure 17. Cattle egrete abundance in the Coos estuary. Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012

While some species' local presence exhibits increasing or decreasing trends, most have displayed neither clearly increasing nor clearly decreasing trends. Their historical abundance is characterized by substantial "inter-annual variability" (i.e., substantial changes from year-to-year) and statistical "noise" (i.e., unexplained variation or randomness that deviates from long-term trends).

Below we focus on two seabird and shorebird species that have exhibited clear trends over time. Because of their special status, we focus on two additional seabird and shorebird species, double-crested cormorant (*Phalacrocorax auritus*) and snowy plover (*Charadrius alexandrinus*), in greater detail in the Birds of Special Concern data summary.

*Brown Pelican (Pelecanus occidentalis)*

Brown pelicans averaged about seven Coos

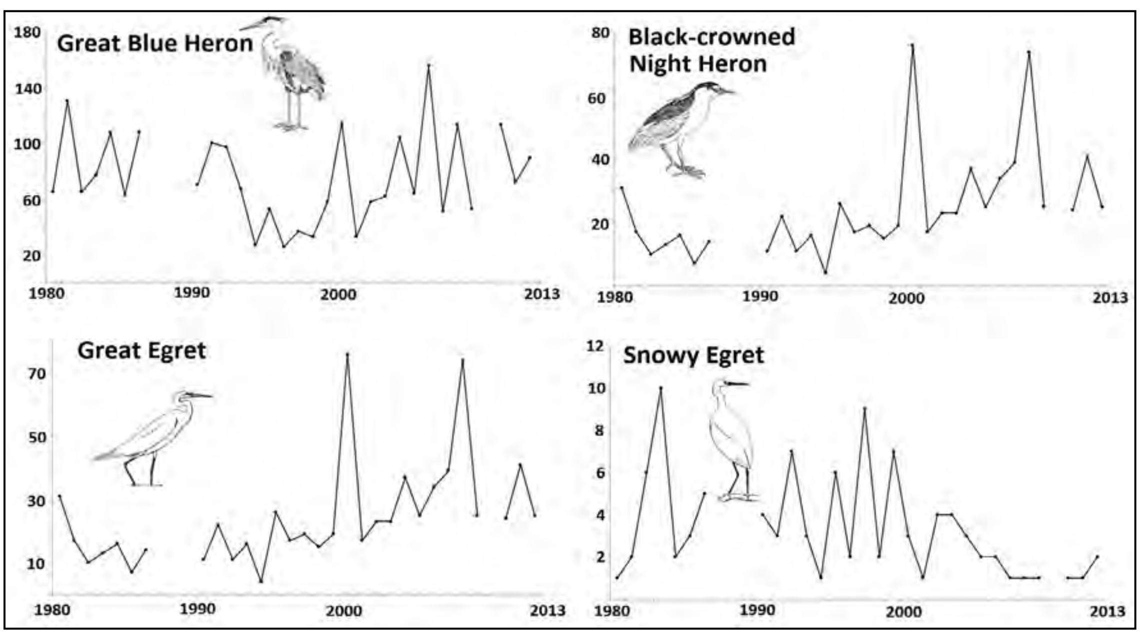



Figure 18. Common wading bird species that display neither clearly increasing nor clearly decreasing population trends in the Coos estuary (1980-2013). Data gaps in CBC data exist for years during which the Count was not conducted (2010) or not reported (1987-89).Data: Audubon 2014, Rodenkirk 2012; Bird Sketches: Csuti et al. 1997

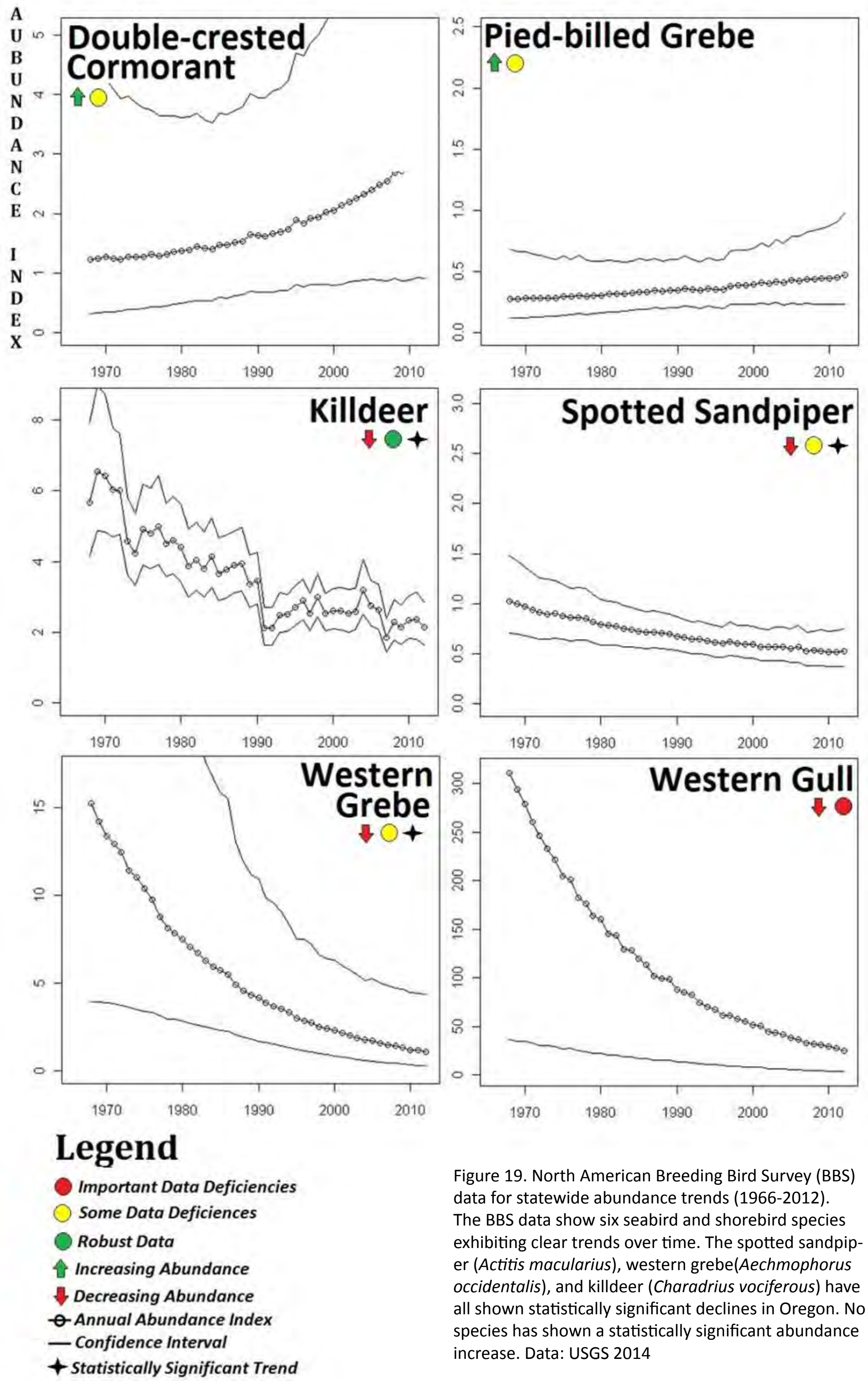



Figure 19. North American Breeding Bird Survey (BBS) data for statewide abundance trends (1966-2012). The BBS data show six seabird and shorebird species exhibiting clear trends over time. The spotted sandpiper (*Actitis macularius*), western grebe(*Aechmophorus occidentalis*), and killdeer (*Charadrius vociferous*) have all shown statistically significant declines in Oregon. No species has shown a statistically significant abundance increase. Data: USGS 2014

estuary CBC sightings annually from 1980-2000 (Audubon 2014, Rodenkirk 2012). However, anomalously high brown pelican counts occurred from 2002- 2009 (813 annual sightings on average) with the largest anomaly (2,717 sightings) occurring in 2008 (Cornu et al. 2012; Audubon 2014, Rodenkirk 2012). Brown pelican sightings have since returned to pre-2002 levels. Local CBC efforts reported 20 sightings in 2011, 8 sightings in 2012, and no sightings in 2013 (Audubon 2014, Rodenkirk 2012).

In 1973, USFWS listed the brown pelican as a federally endangered species (USFWS 2009). It was removed from the endangered species list in 2009 due to recovery (see Why is it happening?)(USFWS 2009, 2014a). However, it remains listed by the Oregon Department of Fish and Wildlife as an endangered species in Oregon (ODFW 2014).

*Whimbrel (Numenius phaeopus)*

The CBC has not sighted Whimbrel in the Coos estuary since 1982 (Cornu et al. 2012, Audobon 2014). Local bird experts speculate that citizen scientists may have confused this species with the long-billed curlew (Numenius americanus) in previous counts (T. Rodenkirk, pers. comm., January 19, 2012). The long-billed curlew is seen more regularly, although in small numbers (Cornu et al. 2012, Audubon 2014, Rodenkirk 2012).

*Northern Fulmar (Fulmarus glacialis)*

Historically, northern fulmars are rarely sighted during the local CBC, with only two sightings prior to 1980 (Cornu et al. 2012, Audubon 2014, Rodenkirk 2012). However, sightings have since increased, occurring on seven separate occasions between 1980-1997 (Audubon 2014, Rodenkirk 2012).

*Other Common Seabirds and Shorebirds*

There have been 28 seabird and shorebird species counted every year since 1980 during the Coos CBC. The majority of these species do not exhibit any clear abundance trend. However, data for a few species may suggest weak trends (e.g., red-necked grebe, western sandpiper, etc.). Table 1 presents data describing the relative abundance of the 28 most common seabird and shorebird species in the Coos estuary.

**Why is it happening?**

Resident and migrating waterfowl, wading birds, seabirds, and shorebirds are inextricably linked to wetland habitats, which they use for food, shelter, nesting, and roosting (ODFW n.d., NRCS 2005). As with other animals, the abundance of local bird populations is determined by a complex set of biophysical relationships. Local bird population shifts often result from a combination of several factors, including human activities, climatic variables, and biological interactions. These factors can work together to change the suitability of wetland habitat, affecting local bird species abundance.

Some aquatic birds are highly migratory and depend on many other (sometimes distant) terrestrial systems (e.g., grasslands, forests, tundra, rocky offshore islets, etc.)(NAWMP 2012). For this reason, it can be difficult to

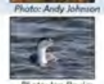
| Common Name | Scientific Name | Photo | Abundance Index, Raw Christmas Bird Count (1980-2013): Average Count | Maximum Count | Abundance Trend |
|---|---|---|---|---|---|
| Dunlin | *C. alpina* |  Photo: Graham Montgomery | 2,023 | 6,599 | |
| Western Gull | *L. occidentalis* |  Photo: Gerrit Vyn | 1,350 | 2,782 | |
| Sanderling | *C. alba* |  Photo: Gerrit Vyn | 725 | 5,238 | |
| Mew Gull | *L. canus* |  Photo: Andy Johnson | 614 | 6,228 | |
| Western Sandpiper | *C. mauri* |  Photo: Gerrit Vyn | 538 | 2,437 | |
| Least Sandpiper | *C. minutilla* |  Photo: Andy Johnson | 431 | 1,257 | |
| Glaucous-winged Gull | *L. glaucesens* |  Photo: Dennis Chesebo | 330 | 971 | |
| Western Grebe | *A. occidentalis* |  Photo: Gerrit Vyn | 291 | 722 | |
| California Gull | *L. californicus* |  Photo: Gerrit Vyn | 250 | 2,432 | |
| Black-bellied Plover | *P. squatarola* |  Photo: Gerrit Vyn | 244 | 607 | |
| Killdeer | *C. vociferus* |  Photo: Kevin Bolton | 178 | 1,629 | |
| Black Turnstone | *A. melanocephala* |  Photo: Gerrit Vyn | 146 | 278 | |
| Double-crested Cormorant | *P. auritus* |  Photo: David Stephens | 144 | 309 | |
| Pacific Loon | *G. pacifica* |  Photo: Glenn Bartley | 140 | 2,199 | |
| Ring-billed Gull | *L. delawarensis* |  Photo: Raymond Lee | 115 | | |
| Pelagic Cormorant | *P. pelagicus* |  Photo: Brian L. Sullivan | 112 | 415 | |
| Horned Grebe | *P. auritus* |  Photo: Glenn Bartley | 105 | 325 | |
| Common Loon | *G. immer* |  Photo: Joe Urban | 90 | 187 | |
| Greater Yellowlegs | *T. melanoleuca* |  Photo: Raymond Lee | 56 | 140 | |
| Semipalmated Plover | *C. semipalmatus* |  Photo: Gerrit Vyn | 55 | 224 | |
| Herring Gull | *L. argentatus* |  Photo: Andy Johnson | 53 | 215 | |
| Red-throated Loon | *G. stellata* |  Photo: Ian Davies | 48 | 175 | |
| Brandt's Cormorant | *P. penicillatus* |  Photo: Brian J. Smith | 45 | 238 | |
| Red-necked Grebe | *P. grisegena* |  Photo: Raymond Lee | 35 | 131 | |
| Belted Kingfisher | *C. alcyon* |  Photo: Nick Chill | 33 | 59 | |
| Black Oystercatcher | *H. bachmani* |  Photo: Mike Baird | 24 | 43 | |
| Pied-billed Grebe | *P. podiceps* |  Photo: Gerrit Vyn | 15 | 52 | |
| Spotted Sandpiper | *A. macularia* |  Photo: Bob Gunderson | 5 | 20 | |

Table 1. Abundance of common seabirds and shorebirds in the Coos Watershed (1980-2013) from local CBC data (raw count). The data should be interpreted as an index of relative abundance rather than an estimate of the total population size. Species are arranged by their 30-year average count (1980-2013) in order of highest average abundance to lowest average abundance. Abundance trends (right) are graphed by plotting annual raw count against year. Gaps in the data occur during years for which no local CBC data were collected (2010) or not reported (1987-89). Data: Audubon 2014, Rodenkirk 2012; Photos: Cornell 2011


Figure 20. Waterfowl "flyways" of North America showing major migratory corridors of ducks, geese, and swans. Prarie Potholes Region (cross hatch) is superimposed over the Pacific (greend), Central (red), Mississippi (Blue), and Atlantic (teal) Flyways Data: Ducks Unlimited 2008a, 2008b

understand the exact reasons behind local trends, because seemingly unrelated factors affecting far away habitats may have a direct impact on survival rates and, therefore, local abundance.

These difficulties notwithstanding, scientists offer the following explanations for changes in resident and migrating waterfowl, wading birds, seabirds, and shorebird abundance in the study area:

*Waterfowl*

A substantial amount of research examining the factors that influence waterfowl abundance has been focused on an area called the "Prairie Pothole Region" (PPR)(Figure 20). Although the PPR represents only 10% of North America's waterfowl breeding habitat it accounts for over 50% of the continent's duck population (Wong et al. 2012). The PPR research has shown that waterfowl abundance is correlated with several variables, including both climatic (i.e., precipitation, soil moisture,

*<u>North American Waterfowl Mgmt. Plan</u>*

*In 1986, the United States and Canadian governments outlined strategies for the conservation, protection, and enhancement of waterfowl habitat in the North American Waterfowl Management Plan (NAWMP; the Plan). Mexico became a Plan signatory in 1994.*

*The Plan, last updated in 2012, identifies three waterfowl conservation goals:*

1. *Abundant and resilient waterfowl populations to support hunting and other uses without imperiling habitat.*

2. *Wetland and related habitat sufficient to sustain waterfowl populations at desired levels, while providing recreational areas and ecological services that benefit society.*

3. *Growing numbers of waterfowl hunters, other conservationists, and citizens who enjoy and actively support waterfowl and wetlands habitat.*

*Sources: USFWS 2014c, NAWMP 2012*

and pond density) and land-use attributes (i.e., agricultural activities)(Podruzny et al. 2002, Baldassarre et al. 1994, Bethke and Nudds 1995, Miller 2000).

In the Pacific Flyway (Figure 2), waterfowl abundance declined to historic lows in the late-1980s and early-1990s (Page et al. 1992, NAWMP 2012, Olson 2014, USFWS 2014c). Following the decline, waterfowl populations recovered throughout the 90s. However, they declined again in both the mid-2000s and recent years (USFWS 2014b).

The decline of waterfowl in the late 1980s and early 1990s was due, in part, to habitat loss. Approximately 53% of all original wetland habitat in the contiguous United States had been converted to human land uses by 1985, including wetlands in the PPR and along the Pacific Flyway that were diked/drained or filled for agricultural, industrial, and residential development (USFWS 2014c, Page et al. 1992). The loss of wetland habitat likely contributed to sharp decline of many wetland-dependent species during these years (Page et al. 1992).

The recovery of waterfowl populations in the 1990s was largely due to increased habitat restoration efforts. The North American Waterfowl Management Plan (NAWMP, the Plan; see sidebar), an international agreement designed to restore waterfowl populations by protecting, enhancing, and restoring habitat, was signed in 1986 (USFWS 2014c). Since the implementation of the Plan, "joint ventures" (i.e., partnerships between stakeholders, including but not limited to federal, state, provincial, tribal, and local governments) have made strategic investments totaling $7.5 billion to protect, conserve, and restore 22 million acres of key waterfowl habitat across North America, resulting in substantially larger populations in many cases (USFWS 2014c, NAWMP 2012).

Declines in waterfowl abundance since 2000 may be related to climatic trends. In their Waterfowl Population Status Report, USFWS (2014d) notes that, "In the Pacific Flyway, below-normal winter precipitation and snowpack [in 2013] led to continued poor habitat conditions in many areas." They go on to cite below-normal winter precipitation as a cause

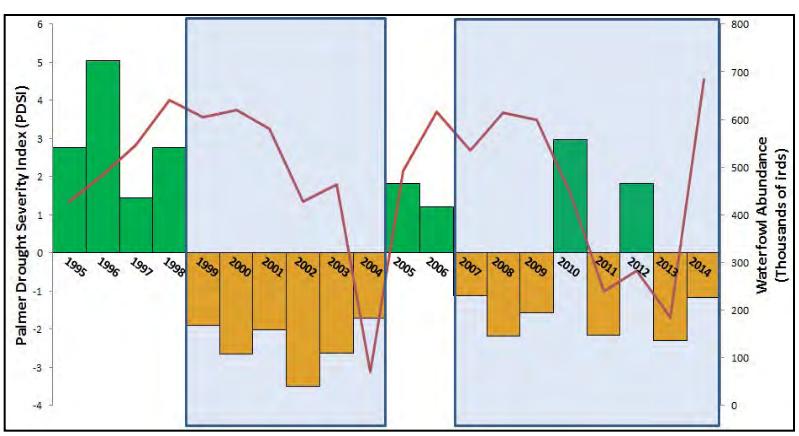



Figure 21. Midwinter abundance of both geese and ducks in the Pacific Flyway (red) plotted against December "dryness" (i.e., a measure of both precipitation and temperature) in Oregon (1995-2014). Dryness is indexed using the Palmer Drought Severity Index (PDSI), which uses both precipitation and temperature to measure dryness; positive values correspond to wet years and negative values represent dry years. Generalized periods of drought (2000-2005 and 2008-2014) are highlighted by blue boxes. Data: USFWS 2014a, NOAA 2014.

of deteriorated habitat conditions in western Oregon. Climate data in Oregon appear to align with waterfowl abundance (Figure 21). Periods of drought are followed by periods of reduced waterfowl abundance. While climatic variables likely contributed to the waterfowl abundance trends, some unexplained variation remains.

Goose populations in Oregon have consistently increased since the 1970s (USFWS 2014b). The Subcommittee on Pacific Population of Western Canada Geese (2000) explains that a series of Canada Goose transplanting programs and natural population growth has resulted in the expansion of this species' historic distribution. They add that the goose's range expansion has been supported by numerous management programs (e.g., provision of nesting structures) designed to increase the production of Canada geese in the western United States. Local bird experts note that introduced populations of Canada Geese have been present in Coos County since at least 1976. The CBC recorded double-digit Canada goose sightings in 1984, and their findings have been increasing ever since (T. Rodenkirk, pers. comm., January 19, 2012, 2012b).

*Wading Birds*

Local wading bird populations have displayed few clear trends in the past decades. CBC data in the Coos system suggest that cattle egret populations may be less abundant in the Coos estuary now than they were prior to the mid-80s (Audubon 2014, T. Rodenkirk, pers. comm., January 19, 2012). Similarly, the BBS suggests that several species of wading birds may be in decline in Oregon, but these trends are generally not statistically significant (See Figure 16)(USGS 2014).

Similar to other aquatic birds, the conversion of wetland habitat for agricultural, residential, commercial, and other land uses may threaten their well-being or directly affect wading bird abundance (NRCS 2005). It's important to recognize that habitat limiting factors (e.g., wetland conversions to human uses, poorly implemented compensatory wetland mitigation projects, declines in water quality, etc.) could lead to declines even in wading bird populations that currently appear to be relatively stable (Liebezeit and Larson 2014).

*Seabirds and Shorebirds*

Most seabird and shorebird populations in the study area have shown neither a clearly increasing nor a clearly decreasing population trend over the past few decades (Table 1). There are two notable exceptions: the local brown pelican populations appear to have recovered since the 1980s, while whimbrel populations have declined (Audubon 2014, T. Rodenkirk, pers. comm., January 19, 2012).

The USFWS (2009) explains that brown pelican populations declined in the early 1970s primarily due to exposure to DDT and other contaminants, which affected pelicans' ability to produce hard egg shells. Decreased food availability and human disturbance of nesting colonies during that time also affected brown pelican populations. USFWS suggests that regulations and restrictions controlling the use of DDT and other contaminants as well as the establishment of nesting reserves have led to a successful recovery.

The local trend of declining whimbrel populations may reflect data quality assurance and control concerns. CBC data are the best available tool for tracking the status and trends of local bird populations. These data are generally reliable, because bird sightings are most often recorded by, or in the presence of, observers with ample birding knowledge. However, not all sightings take place in the presence of experienced birders so there's always the possibility for error. Tim Rodenkirk (pers. comm., January 19, 2012), a local bird expert and long-time coordinator of the Coos Bay CBC, speculates that early Coos Bay CBC volunteers may have confused the whimbrel with the long-billed curlew. The long-billed curlew is seen in the Coos estuary more regularly, although in small numbers (Cornu et al. 2012, Audubon 2014, Rodenkirk 2012). For more information about data concerns, see the Chapter Summary.

Shorebirds use the Coos estuary in winter and during migration for many purposes (e.g., roosting and foraging). Foraging flocks tend to occupy the habitat around the estuary (Rodenkirk 2012). The abundance of flocks in proximity to the estuary is influenced largely by food availability, access to exposed mudflats, presence and exposure to predators, and human disturbance (Cornu et al. 2012).

During high tide, human disturbance affects the distribution of roosting shorebirds (Peters and Otis 2007). The Coos estuary is used extensively for recreational fishing, crabbing, and shellfish harvesting, and its shores used for ATV riding, camping, hiking, horseback riding, and other activities.

In some cases, human disturbance can create roosting habitat. For example, one of the best high tide roosts for shorebirds in the project area is located on the North Spit in the Lower Bay Subsystem. Historically, birds roosted here in the deflation plain at the site of an effluent holding pond for a Weyerhaeuser pulp mill. However, after the closure of the mill, natural succession has reclaimed the site, limiting the suitability of this habitat for shorebird roosting. The Cape Arago Audubon Society is working with the Oregon International Port of Coos Bay to develop a habitat management plan that would support features necessary for high-tide roosting in this area.

## References

Baldassarre, G. A., E. G. Bolen, and D. A. Saunders. 1994. Waterfowl Ecology and Management. New York City, NY: John Wiley & Sons, Inc.

Bethke, R. W. and T. D. Nudds. 1995. Effects of Climate Change and Land Use on Duck Abundance in Canadian Prairie-Parklands. Ecological Applications 5: 588–600.

Cornell University (Cornell). 2011. All About Birds: Your Online Guide to Birds and Bird Watching. [an interactive tool from the Cornell Lab of Ornithology]. Acessed 25 November 2014. Available online www.allaboutbirds.org

Cornu, C. E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. [Report prepared for the Partnership for Coastal Watersheds Steering Committee]. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Csuti, B. A., T. A. O'Neil, M. M. Shaughnessy, E. P. Gaines, and J. C. Hak. 1997. Atlas of Oregon Wildlife, first edition. Corvallis: Oregon State University Press.

Ducks Unlimited. 2008a. GIS Spatial Data Download. [DU International Conservation Planning Regions Shapefile]. Accessed 26 November 2014. Available online http://www.ducks.org/conservation/gis/gis-spatial-data-download

Ducks Unlimited. 2008b. GIS Spatial Data Download. [DU Flyways Shapefile]. Accessed 26 November 2014. Available online http://www.ducks.org/conservation/gis/gis-spatial-data-download

Liebezeit, J. and C. Larson. 2014. Great Blue Heron Rookery Status in the Portland Metro Region: 2009-2014. [Audubon Society of Portland]. Accessed 18 November 2014. Available online http://audubonportland.org/files/research/heron-monitoring-2014

Miller, M. W. 2000. Modeling Annual Mallard Production in the Prairie-Parkland Region. Journal of Wildlife Management 64: 561–575.

National Audubon Society (Audubon). 2014. Audubon Christmas Bird Count: Historical Results by Count. [Coos Bay Sitkum Dock Count ORCB]. Accessed 04 November 2014. Available online http://netapp.audubon.org/CBCObservation/Historical/ResultsByCount.aspx

National Oceanic and Atmospheric Administration (NOAA). 2014. Climate at a Glance. [Online interactive data tool from the National Climatic Data Center]. Accessed 26 November 2014. Available online http://www.ncdc.noaa.gov/cag/

Natural Resources Conservation Service (NRCS). 2005. Wading Birds: Fish and Wildlife Management Leaflet. [A publication of the Wildlife Habitat Management Institute]. Accessed 01 December 2014. Available online http://www.wildlifehc.org/new/wp-content/uploads/2010/10/Wading-Birds.pdf

North American Waterfowl Management Plan (NAWMP). 2012. North American Waterfowl Management Plan 2012: People Conserving Waterfowl and Wetland. Accessed 26 November 2014. Available online http://www.nawmprevision.org/sites/default/files/NAWMP-Plan-EN-may23.pdf

Olson, S. M. (compiler). 2014. Pacific Flyway Data Book. United States Fish and Wildlife Service. Vancouver, WA.

Oregon Department of Fish and Wildlife (ODFW). 2014. Threatened, Endangered, and Candidate Fish and Wildlife Species. Accessed 06 October 2014. Available online http://www.dfw.state.or.us/wildlife/diversity/species/docs/Threatened_and_Endangered_Species.pdf

Oregon Department of Fish and Wildlife (ODFW). n.d. Oregon's Wading Birds. Accessed 01 December 2014. Available online http://www.dfw.state.or.us/species/docs/wading.pdf

Page, G. W., D. Shuford, J. E. Kjelmyr, and L. E. Stenzel. 1992. Shorebird Numbers in Wetlands of the Pacific Flyway: A Summary of Counts from April 1988 to January 1992. Accesed 26 November 2014. Available online http://www.calwater.ca.gov/Admin_Record/C-056771.pdf

Peters, K. A. and D. L. Otis. 2007. Shorebird Roost-site Selection at Two Temporal Scales: is Human Disturbance a Factor? Journal of Applied Ecology 44: 196-209.

Podruzny, K. M., J. H. Devries, L. M. Armstrong, and J. J. Rotella. 2002. Long-Term Response of Northern Pintails to Changes in Wetlands and Agriculture in the Canadian Prairie Pothole Region. Journal of Wildlife Management 66: 993–1010.

Rodenkirk, T. J. 2012. Birds of Coos County, Oregon: Status and Distribution. [Unpublished Manuscript].

Rodenkirk, T. J. n.d. Map of Christmas Bird Count Coverage Area. [Unpublished Data].

Subcommittee on Pacific Population of Western Canada Geese. 2000. Pacific Flyway Management Plan for the Pacific Population of Western Canada Geese. [Unpublished report]. Pacific Flyway Study Committee (c/o USFWS, MBMO). Portland, OR.

United States Fish and Wildlife Service (USFWS). 2009. Species Fact Sheet: Brown Pelican. Accessed 25 November 2014. Available online http://www.fws.gov/oregonfwo/Species/Data/BrownPelican/

United States Fish and Wildlife Service (USFWS). 2014a. Endagered Species. Accessed 06 October 2014. Available online http://www.fws.gov/endangered/

United States Fish and Wildlife Service (USFWS). 2014b. Mid-Winter Waterfowl Survey Query Form [an online data query tool from the Division of Migratory Bird Management]. Accessed 04 November 2014. Available online https://migbirdapps.fws.gov/mbdc/databases/mwi/mwsoptions.asp

United States Fish and Wildlife Service (USFWS). 2014c. North American Waterfowl Management Plan: History. Accessed 01 December 2014. Available online http://www.fws.gov/birdhabitat/NAWMP/index.shtm

United States Fish and Wildlife Service (USFWS). 2014d. Waterfowl Population Status, 2014. Accessed 01 December 2014. Available online http://www.fws.gov/migratorybirds/NewReportsPublications/PopulationStatus/Waterfowl/StatusReport2014.pdf

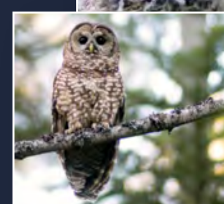
United States Geological Survey Patuxent Wildlife Research Center (USGS). 2014. North American Breeding Bird Survey data set 1966-2013, version 2014.0. [Access to raw data via link to FTP site]. Available online https://www.pwrc.usgs.gov/bbs/RawData/Choose-Method.cfm

Wong, L., C. van Kooten, and J. A. Clarke. 2012. The Impact of Agriculture on Waterfowl Abundance: Evidence from Panel Data. Journal of Agricultural and Resource Economics 37(2): 231-334.

# Birds of Special Concern in the Lower Coos Watershed


*Summary:*

- *Oregon coast western snowy plover populations have increased since the early 1990s. Our Lower Bay subsystem is one of the most productive breeding habitats statewide.*
- *Marbled murrelet populations are declining across their range. The forests of Coastal Oregon may include some of the murrelets' most critical refuges if current trends continue.*
- *Regional northern spotted owl populations have declined since the early 1990s. Locally, the rate of decline is a matter of debate and may even be negligible.*
- *Local double-crested cormorant populations have nearly recovered after declines in recent years. More information is needed to fully understand the impacts of cormorant predation on juvenile salmon populations.*

**Evaluation**

Western Snowy plovers have had increasing reproductive success on the North Spit since the 1990s.

**Evaluation**

Spotted owl populations may be declining at a very modest pace. The size of local populations may be stabilizing.

**Evaluation**

Marbled murrelet populations continue to decline throughout their range. Local populations may be declining moderately.

**Evaluation**

More information is needed to evaluate double-crested cormorants' predation on salmon.

DATA GAP

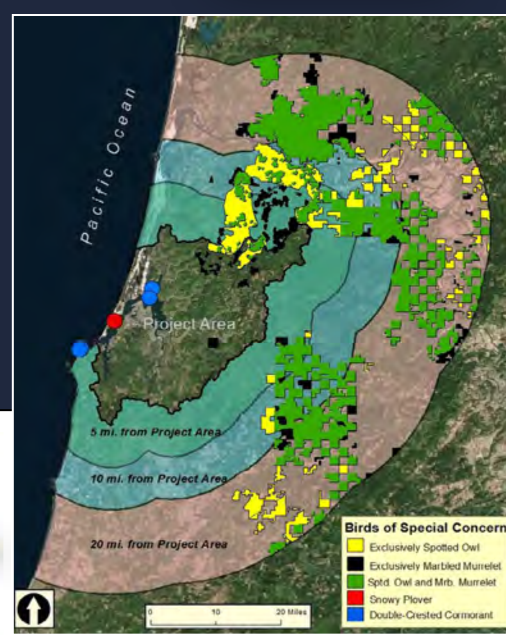



Figure 1. Bird habitat of special concern within the lower Coos watershed (Project Area), including critical habitat designation for the marbled murrelet (black), the northern spotted owl (yellow) as well as the location of double-crested cormorant colonies (blue) and snowy plover habitats (red). Plover habitats and cormorant colonies not to scale. Data: USFWS 2011, 2012, 2014c, 2014a; Naughton et al. 2007

**What's happening?**

Because of their close ties to important economic and cultural resources in the study area (e.g., timber, salmon, dune recreation), the following birds of special concern were selected for this data summary: western snowy plover (*Charadrius niosus*), double-crested cormorant (*Phalacrocorax auritus*), marbled murrelet (*Brachyramphus marmoratus*), northern spotted owl (*Strix occidentallis*), and California condor (*Gymnogyps californianus*). Several of these species are rare, endangered, or threated and have been the focus of substantial public concern (see Background)(Figure 1).


Figure 2. The location of nine snowy plover monitoring sites on the southern Oregon coast, including one site in the Lower Bay Subsystem (bold). The study area is highlighted above (green). Source: Lauten et al. 2012

<u>Western Snowy Plover (*Charadrius alexandrinus nivosus*)</u>

In 2012, Lauten et al. compiled data from nine snowy plover (SNPL) monitoring sites on the southern Oregon coast (Figure 2). Their data indicate that, since 1990, the reproductive success of the snowy plover on the southern Oregon coast has been variable year-to-year but increasing overall (Figure 3). In addition, overwintering snowy plover survival rates on the southern Oregon coast were higher than average in 2012 (73% survival; 64% 1994-2011 mean survival)(Lauten et al. 2012).

Within the study area, the Lower Bay Subsystem- the North Spit in particular- is important breeding habitat for the local snowy plover population (Lauten et al. 2012; USACE 2007; Hewitt et al. 2006). The United States Fish and Wildlife Service (USFWS 2005) designated a large part of North Spit as critical snowy plover habitat (Figure 4). Nesting occurs primarily on the southern end of this habitat designation (Hewitt et al. 2006).

Like the regional data, the reproductive success of snowy plovers on the North Spit is characterized as "very high" for both nest success and in-migration of reproductive adults (Lauten et al. 2012; Hewitt et al. 2006). Since 1992, the reproductive effort of the North Spit adult population has been increasingly successful with 50 local snowy plover fledglings observed 2012 (an 82% increase from 1992 levels)(Lauten et al. 2012). The North

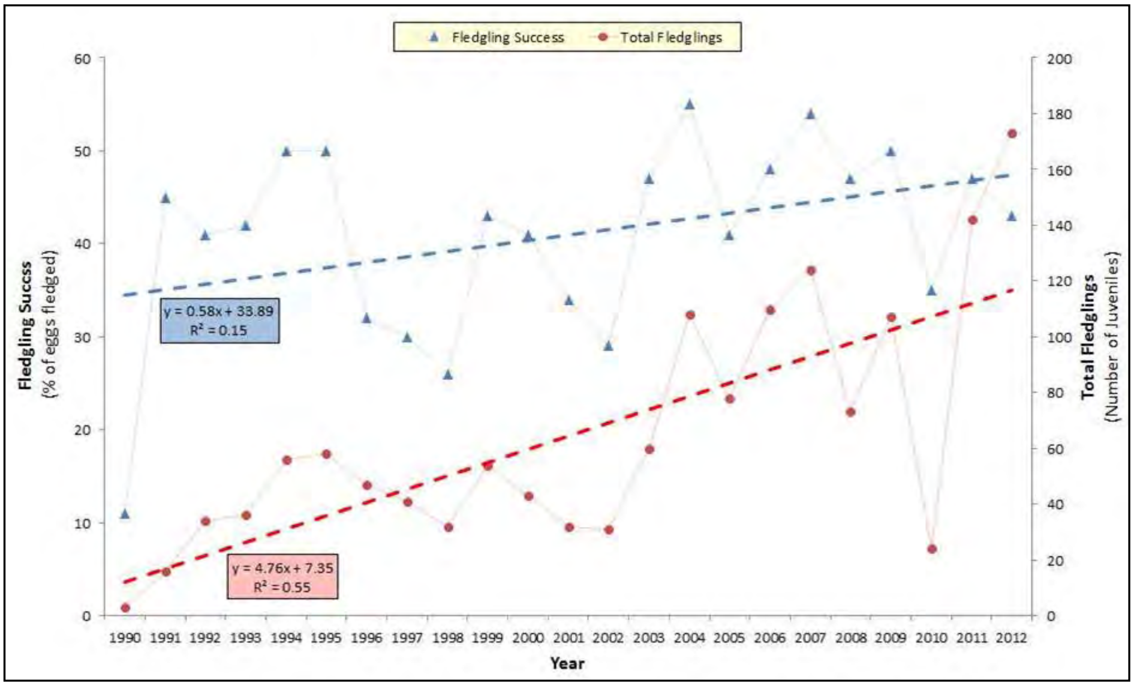



Figure 3. The regional reproductive success of snowy plovers summed across nine southern Oregon coast monitoring sites (see Figure 2). Fledgling success (blue) is defined as the ratio of number of fledglings: number of eggs. In 2012, fledgling success was 43%, a 32% increase from 1990-levels. Fledgling success appears to follow a weak linear relationship, with only 15% of variation in fledgling success ($R^2$=0.15) being described by a constant increase of 0.58% annually. In 2012, total fledglings (red) increased to 173 juveniles, a 57% increase from 1990-levels. The increase fledgling population follows a moderately strong linear increase, with 55% of variation in total fledglings being described by a constant increase of 4.76 juveniles annually. Data: Lauten et al. 2012


Figure 4. The location of critical snowy plover habitat within the study area. Source: USFWS 2014c

Spit fledgling success rate has been highly variable from year to year, and annual rates of linear change since 1992 are not statistically different from zero (p=0.94). However, researchers note that nest success on the North Spit in 2012 was "well above average" and that the hatch rate was "the highest on the coast" (Lauten et al. 2012). North Spit SNPL population trends are shown in Figure 5.

Snowy plover populations have been federally listed as threatened since 1993 (USFWS 2014b), and listed as threatened, imperiled, or locally endangered on other registries, including the Oregon Department of Fish and Wildlife (ODFW) and global and state Natural Heritage Programs (ODFW 2012; ORBIC 2013).

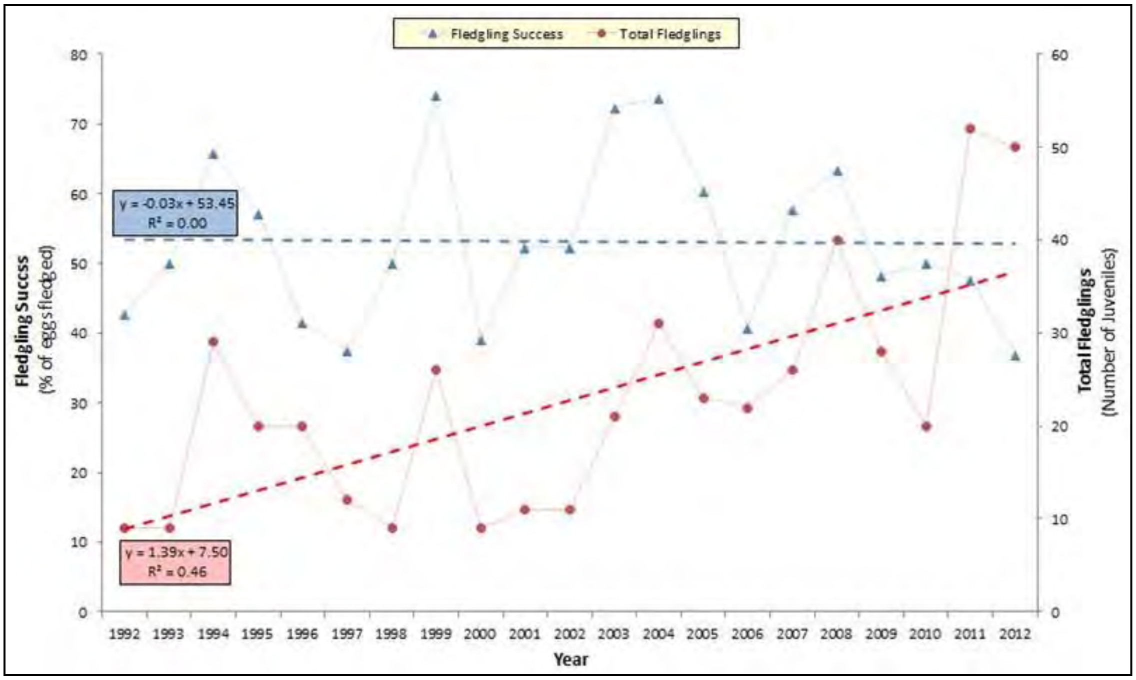



Figure 5. The local reproductive success of snowy plovers on the North Spit (Lower Bay Subsystem). Fledgling success (blue) is defined as the ratio of number of fledglings: number of eggs. Local fledgling success rates is described by neither a linear increase nor a linear descrease since 1992 ($R^2$=0). However, the increase the North Spit fledgling population (red) follows a moderately strong linear increase, with 46% of variation in total fledglings being described by a constant increase of 1.39 juveniles annually. Data: Lauten et al. 2012

Double-Crested Cormorant (*Phalacrocorax auritus*)

According to the USFWS (2014a), there were approximately 16,850 breeding double-crested cormorant (DCCO) pairs in Oregon in 2013. Most of these birds (14,900 breeding pairs) are located in the Columbia River Estuary, which supports the largest DCCO colony in western North America (USFWS 2014a; Lyons et al. 2014; Adkins and Roby 2010). Excluding Columbia River, there were 1,937 breeding DCCO pairs in coastal Oregon in 2013, a 54% increase from 2012 (1,260 breeding pairs) (USFWS 2014a; Adrean 2013). Despite recent increases, DCCO populations have decreased statewide from 2009 peak levels (2,384 breeding pairs)(Adkins and Roby 2010).

There are two DCCO colonies within the study area near the McCullough Bridge. An additional three colonies are in close proximity to the study area near Gregory Point (Figure 6).

Historically, the study area DCCO colonies have been larger than the Gregory Point colonies (Table 1). The data suggest that local DCCO breeding populations may have decreased throughout the mid-2000s, but have since recovered (USFWS 2014a)(Figure 7). USFWS (2014a) estimates that there were 326 DCCO breeding pairs in the Coos Bay area in 2013 (down 15% from 2003)(Table 1).

Public concern is often voiced about the consumption of juvenile salmonids by DCCOs, which are known to prey on more than 250

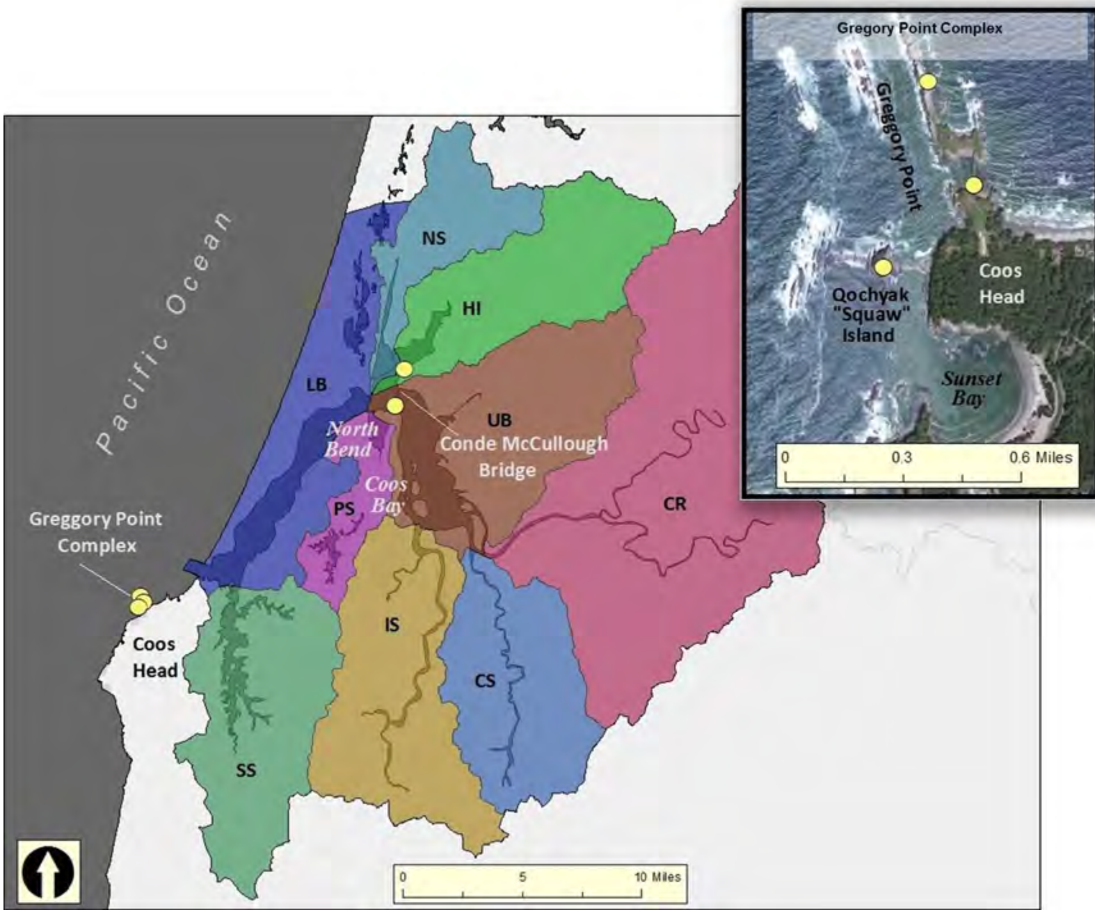



Figure 6. Location of double-crested cormorant colonies (yellow dots) within the study area and adjacent nearshore habitat. The location of colonies near Gregory point is provided in the insert. SS= South Slough, IS= Isthmus Slough, CS= Catching Slough, CR= Coos River, UB= Upper Bay, PS= Pony Slough, HI= Haynes Inlet, NS= North Slough, LB= Lower Bay Data: Naughton et al. 2007; USFWS 2014a

| Colony | Subsystem | Breeding Pairs |
|---|---|---|
| 2003 | | |
| Haynes Colony | Haynes Inlet | 145 |
| Conde McCullough Bridge Pilings | Upper Bay | 114 |
| **Breeding Pairs Within Study Area** | | **259** |
| Chief's Island | Outside of Study Area | 0 |
| Gregory Point | Outside of Study Area | 16 |
| Qochyak (Squaw) Island | Outside of Study Area | 107 |
| **Breeding Pairs within Gregory Point Complex** | | **123** |
| 2013 | | |
| Conde McCullough Bridge Pilings | Upper Bay | 207 |
| **Breeding Pairs Within Study Area** | | **207** |
| Chief's Island | Outside of Study Area | 11 |
| Gregory Point | Outside of Study Area | 6 |
| Qochyak (Squaw) Island | Outside of Study Area | 102 |
| **Breeding Pairs within Gregory Point Complex** | | **119** |

Table 1. Population trends in double-crested cormorant breeding colonies indicate a substantial reduction in numbers relative to 2003 levels and a shifting of the breeding population favoring the Greggory Point Complex over colonies within the study area. Data: Naughton et al. 2007; USFWS 2014a

species of freshwater and marine fishes (Adkins and Roby 2010). To address this concern, ODFW conducted a DCCO diet study in Tillamook Bay (Adrean 2013). They estimated that DCCOs consumed approximately 8,000 juvenile Coho (about 4% of all outmigrating Coho smolts) over two months (Adrean 2013).Their data indicate that the salmonid component of the DCCO diet was significantly higher in April than in May (Figure 8). Steelhead (47%) and Coho (21%) comprised the largest proportion of salmonids consumed (Table 2).

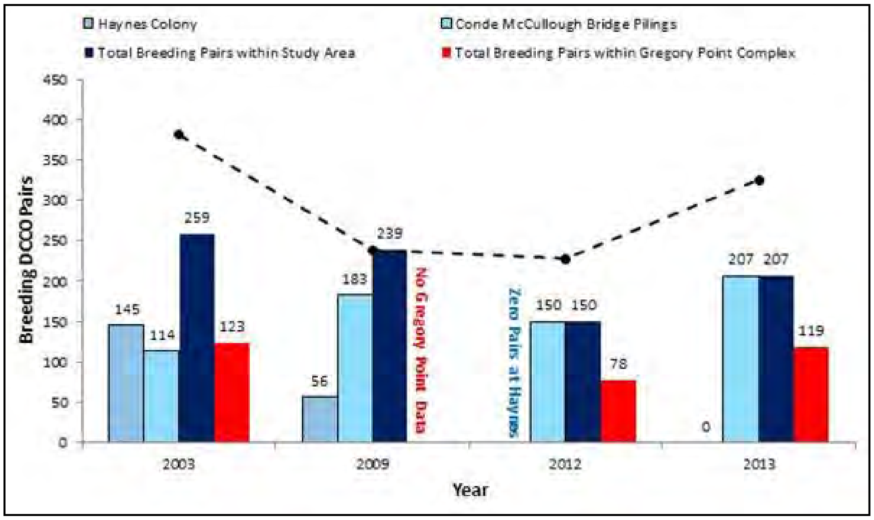



Figure 7. Population trends in double-crested cormorant breeding colonies within the study area (blue) and at the Gregory Point Complex (red). Total population numbers (breeding pairs) are shown above their respective bars. The total local breeding population (dashed line) is the vertical sum of colonies within the study area and Gregory Point colonies. Data Naughton et al. 2007; USFWS 2014a

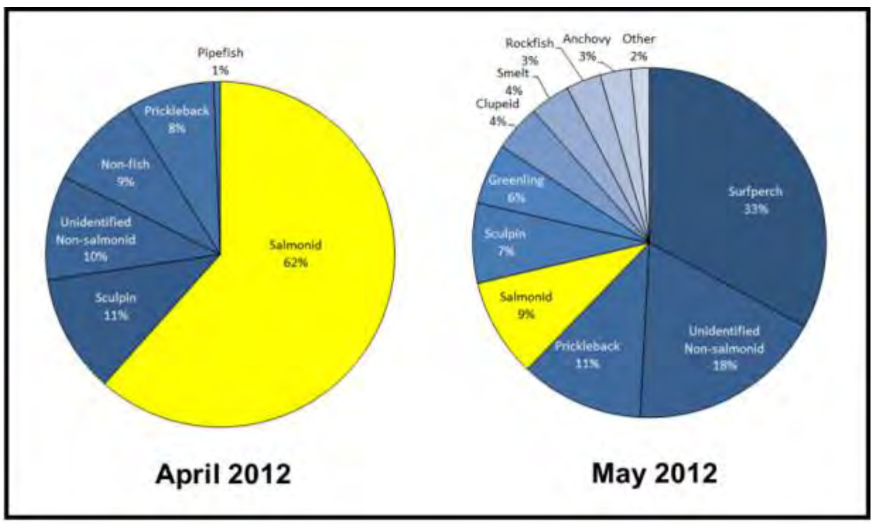



Figure 8. The composition of the double-crested cormorant diet during a two-month study period at Tillamook Bay in spring 2012. Data: Adrean 2013

In 2013, ODFW expanded the DCCO predation study to include two additional estuaries. Their preliminary results indicate that salmonids comprise about 6, 11, and 7% of the DCCO diet in the Tillamook, Umpqua, and Rogue systems, respectively. Almost all salmonids detected in the 2013 DCCO predation study were juvenile Coho salmon (J. Lawonn, pers. comm., April 21, 2014).

This analysis corroborates research conducted by Oregon State University (OSU) and the United States Geological Survey (USGS) on the Columbia River (BRNW 2009) which suggests that juvenile salmonids comprise approximately 10% of the DCCO diet on average (range = 2-25%). It's also consistent with previous studies indicating that sand lance (*Ammodytes hexapterus*), clupeids (herrings and sardines), cottids (sculpins), embiotocids (surf perches), engraulids (anchovies), pholids (gunnels), and stichaeids (pricklebacks) are important prey for DCCO populations in western North America (Adkins and Roby 2010).

| Salmonid Species | Proportion of All Salmonids Consumed |
|---|---|
| Steelhead | 47% |
| Coho | 21% |
| Cutthroat | 16% |
| Chum | 11% |
| Unidentified | 5% |

Table 2. Salmonid component of the double-crested cormorant diet in Tillamook Data: Adrean 2013ww

The DCCO is not listed as a threatened or endangered species (ODFW 2012; ORBIC 2013; USFWS 2014b).

<u>Marbled Murrelet (*Brachyramphus marmoratus*)</u>

Marbled murrelet (MAMU) monitoring in federal forests is conducted within “conservations zones” (USFWS 1997)(see Pacific Northwest Forest Plan sidebar). The Coos estuary is near the boundaries of conservation zones 3 and 4 (Figure 9).

Researchers report a decline in MAMU populations over the past decade throughout the Pacific Northwest (Raphael et al. 2011; Strong 2010; Falxa et al. 2011). The decline is thought to be substantial. Populations in Oregon, Washington, and California have decreased about 3.7% annually (a 30% reduction in total population between 2001-2009 alone)(Raphael et al. 2011; Falxa et al. 2011).

The fastest rate of MAMU population decline is occurring in northwest Washington. More modest population declines are occurring at the southern end of the murrelet’s range (Table 3).


Figure 9. The five marine marbled murrelet conservation zones adjacent to the Northwest Forest Plan (NWFP) area. The inland breeding distribution within the NWFP area is shaded, and the Plan boundary is outlined. Data and caption: Raphael et al. 2011

Survey data indicate the MAMU populations of coastal Oregon are some of the largest on the west coast. Falxa et al. (2011) estimate that the population of conservation zone 3 (Columbia River to Coos Bay) is approximately 7,200. They add that this zone alone accounts for about 43% of the entire population of Oregon, Washington, and California. They also found that the highest at-sea density on the west coast occurred in zone 3 (4.53 birds/$km^2$). Some suggest that the forests associated with zone 3 may play an increasingly important role if current MAMU population trends continue.

| Zone | Annual change (%) Estimate | SE | 95% Confidence limits Lower | Upper | Adjusted $R^2$ | $P$ |
|---|---|---|---|---|---|---|
| All zones | −3.7 | 0.4 | −4.8 | −2.7 | 0.89 | <0.001 |
| 1 | −7.4 | 1.6 | −11.2 | −3.5 | 0.67 | 0.002 |
| 2 | −6.5 | 2.9 | −13.1 | 0.06 | 0.29 | 0.06 |
| 3 | −1.5 | 1.7 | −5.4 | 2.6 | 0.00 | 0.41 |
| 4 | −0.9 | 1.2 | −3.9 | 2.0 | 0.00 | 0.47 |
| 5 | −0.5 | 9.3 | −21.7 | 26.3 | 0.00 | 0.97 |

Table 3. Estimated annual rates of decline of marbled murrelet populations (2000-2010) in conservation zones along the west coast (see Figure 8). The Coos estuary is at the boundary of zones 3 and 4 (yellow). Data: Raphael et al. 2011

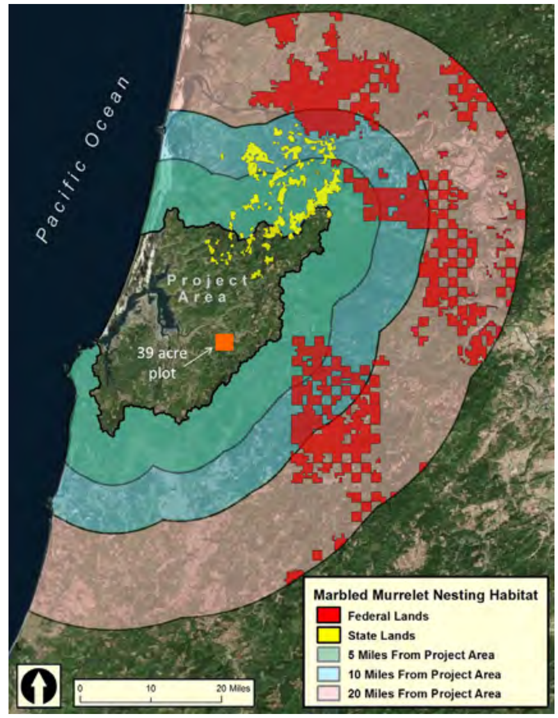



Figure 10. Critical nesting habitat on state and federal lands within the nesting range of marbled murrelets associated with the lower Coos watershed (Project Area). The nesting range is defined as approximately 20 miles or less from the project area boundary. The approximate location of the 39-acre plot of nesting habitat within project area is also mapped above. The size of this parcel has been enlarged to facilitate easy viewing. Data: USFWS 2011

In 1996, USFWS designated critical habitat for the MAMU (USFWS 1997). USFWS reserves the critical habitat designation for old-growth forests that either contain potential nesting trees or are located within 0.8 kilometers (0.5 miles) of potential nesting trees. They define potential nesting trees as "…large trees, generally more than 81 centimeters (32 inches) in diameter at breast height with the presence of potential platforms or deformities such as large or forked limbs, broken tops, dwarf mistletoe infections, witches' brooms, or other formations providing platforms of sufficient size to support adult marbled murrelets" (USFWS 1997).

Due to the characteristics of local forests, critical MAMU habitat is relatively scarce in the study area; only one 39-acre parcel of critical murrelet habitat (in the Coos River Subsystem) is located inside the project boundary (USFWS 2011)(Figure 10). Murrelets are more likely to nest in the uplands immediately outside the project area where more mature forest stands can still be found. Hamer and Nelson (1995) estimate that Pacific Northwest MAMUs nest an average distance of 17 km (11 miles) from the coast. They report that Oregon murrelets will nest as far as 40 km (25 miles) inland.

Marbled murrelets are likely to use habitat within the project area for activities other than nesting (e.g., foraging in coastal waters) (Raphael et al. 2011). The Audubon Christmas Bird Count (CBC) frequently records 1-4 MAMUs annually, with the most recent sighting (2 individuals) occurring 2013 (Figure 11).

The marbled murrelet is listed as a threatened species at both a state and federal level (USFWS 2014b; ODFW 2012; ORBIC 2013).

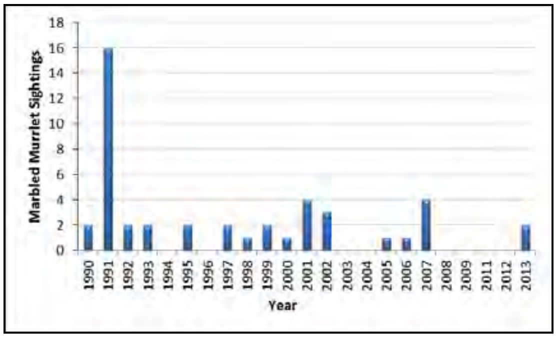



Figure 11. Marbled murrelet sightings in Coos Bay from the Audubon Christmas Bird Count (1990-2013). Data: Audubon 2014, Rodenkirk 2012.

Northern Spotted Owl (*Strix occidentalis caurina*)

Davis et al. (2011) compiled northern spotted owl demographic data from 9 study areas within 12 Pacific Northwest "physiographic provinces," which collectively represent the extent of the northern spotted owl range (Figure 12). Their data indicate a decline in northern spotted owl populations throughout its range since the early 1990s (Figure 13). The average rate of decline was estimated at about 2.8% annually, with the greatest total loses (40-60% reduction in the adult population since 1994) occurring in Washington and northern Oregon.

Spotted owl populations on the southern Oregon coast mirror regional population declines, although some debate exists. Zabel et al. (1996) estimated spotted owl population declines in the forest immediately outside the study area at a rate of 7% annually from 1990-1993. Similarly, Forsman et al. (2013) noted a steady decline in spotted owl survey detection rates on the Oregon coast from 1990-2011. Some research suggests that the local spotted owl decline has been "moderate" (Courtney et al. 2004). High variability in the spotted owl population data (as evidenced by sizable confidence intervals) also leaves open the possibility that local spotted owl populations may declining very slowly, if at all (Davis et al. 2011; Courtney et al. 2004).

The USFWS (2013b) defines critical spotted owl habitat as "…forest types of sufficient area, quality, and configuration to support the needs of territorial owl pairs throughout the year… including habitat for nesting, roosting, foraging, and dispersal." Forest habitat matching this description is found almost entirely outside of the project area boundary,

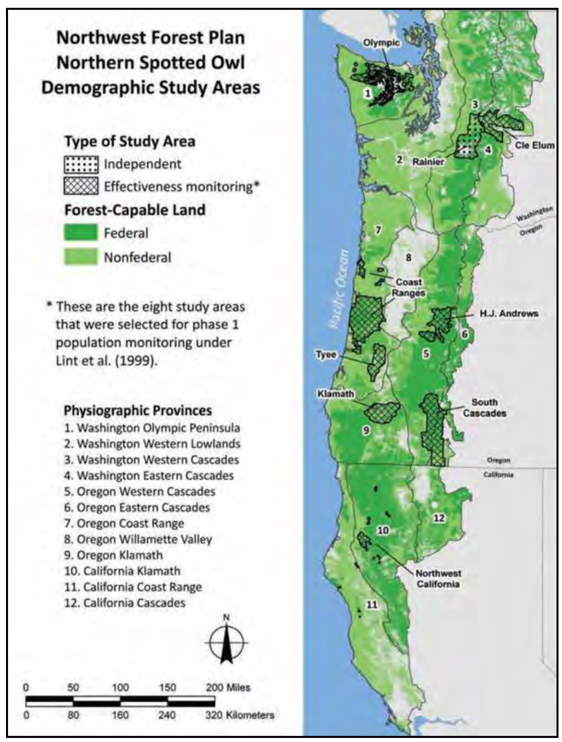



Figure 12. Demographic study areas (shaded) and physiographic Provinces (numbered) for northern spotted owl status and trends study. Study areas are comprised primarily of federal lands administered under the Northwest Forest Plan. Figure: Davis et al. 2011

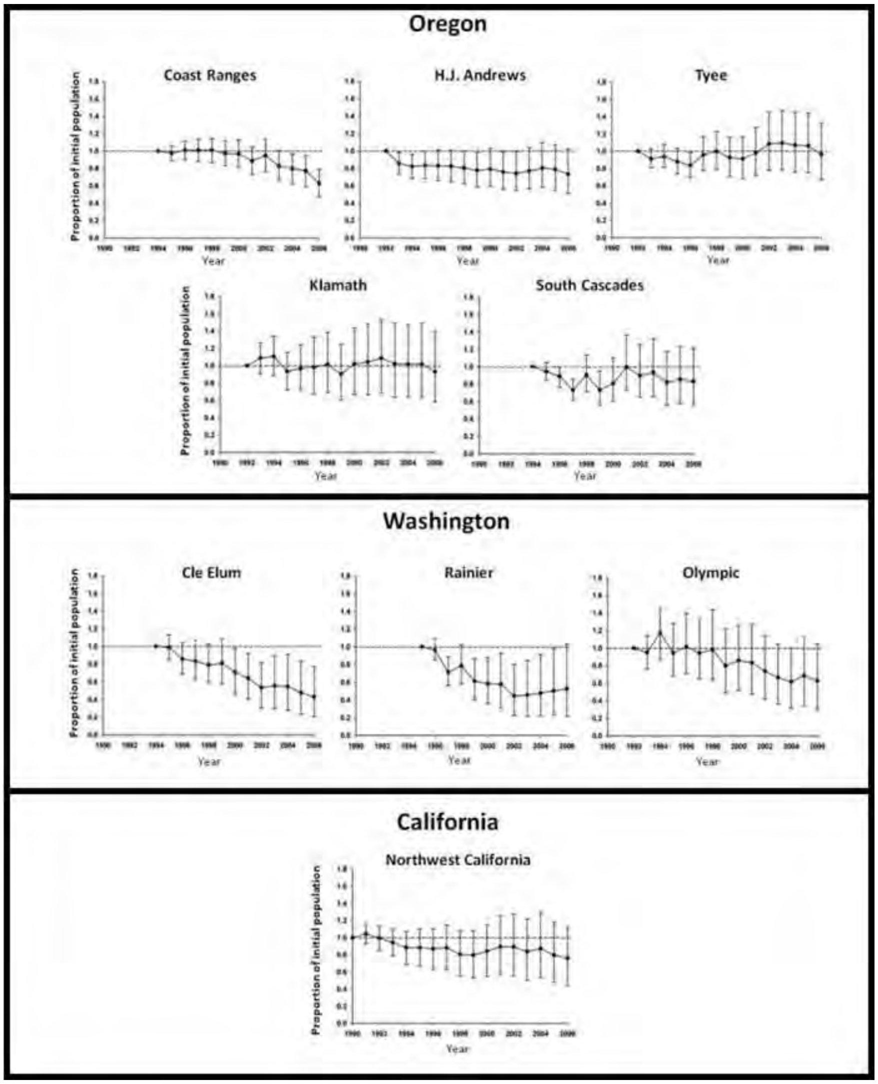



Figure 13. Northern spotted owl population trends (1990-2008) in Oregon, Washington, and California study sites with 95% confidence intervals. Data are expressed in terms of percent change since the early 1990s. Population trends falling below the dashed line indicate declining numbers. Data: Davis et al. 2011

although some critical spotted owl habitat exists in the northern part of the Coos River Subsystem (Figure 14).

The spotted owl is listed as a threatened species at both a state and federal level (USFWS 20104b; ODFW 2012; ORBIC 2013).

<u>California Condor (*Gymnogyps californianus*)</u>

California condor bones found in the archaeoligical record and historic observations suggest that condors were once a permanent resident of southwest Oregon (Miller 1942, Wilber 1973, Finley 1908, USFWS 2013c, USFWS 1996). Range contraction in the 19th century and population declines in the 20th century diminished local condor populations

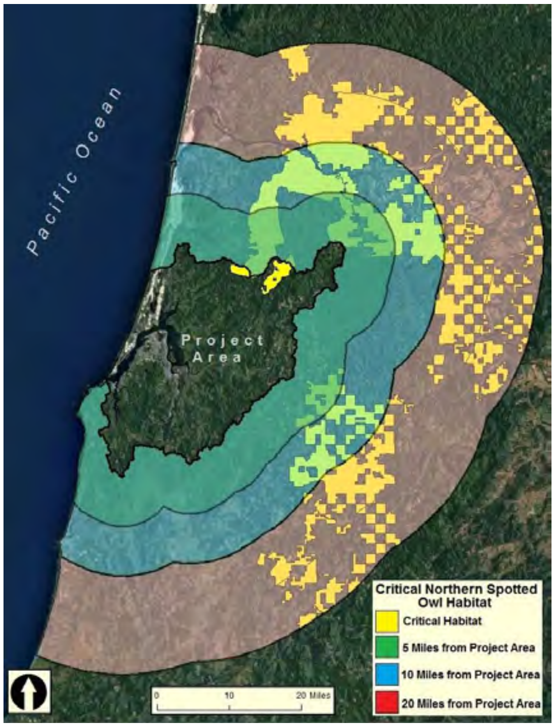



Figure 14. Critical northern spotted owl habitat (yellow) within the lower Coos watershed (Project Area) and immediately associated uplands ( > 20 miles from project area boundary. Data: USFWS 2012

and distribution (Miller 1942, USFWS 1996, USFWS 2013c)(see Why is it happening?). Currently, wild populations of California condors (*Gymnogyps californianus*) exist only in central and southern California, northern Arizona, southern Utah, and northern Baja California (Figure 15).

Although the current range of the California condor does not include Oregon, many scientists and conservationists have expressed interest in restoring this extremely rare bird to its historic range in the Pacific Northwest. Currently, the Oregon Zoo (n.d.) aids USFWS condor restoration efforts by breeding condor pairs in captivity for release in California and Arizona. While restoration in other states continues, California condor re-introduction to the Pacific Northwest remains under on-going discussions.

From 2012-2014, Varland et al. (2012) collected contaminates (i.e. lead, organochlorines) from carrion at several locations in coastal Oregon and Washington, including specimens from the Lower Bay subsystem. Their research used other avian scavengers, such as eagles, vultures, and ravens, as surrogate species for the California condor; by determining the level of contamination in both marine mammal carcasses and in the birds that scavenge them, they could predict potential risks to re-introduced California condors. Varland et al. conclude that estimating the potential risks posed by contaminants to re-introduced condors is not yet possible because their small sample sizes limit their ability to effectively analyze the data.

California condors remain federally listed as an endangered species (USFWS 2014b).

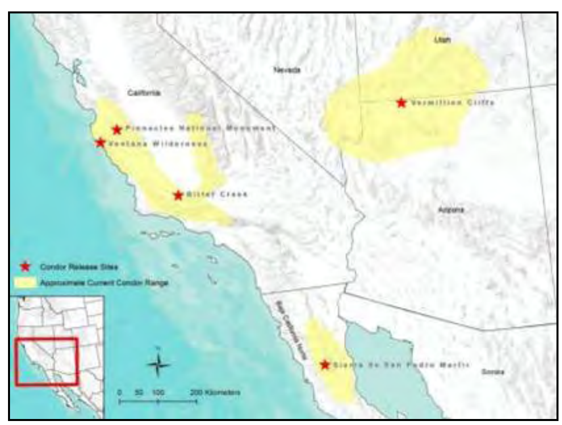


Figure 15. California condor range (yellow) and active release sites (red stars) Figure and Caption: USFWS 2013c

**Why is it happening?**

Western Snowy Plover (*Charadrius alexandrinus nivosus*)

Historically, snowy plovers nested in at least 29 known locations on the Oregon coast (USFWS 2013a). However, European beach grass (*Ammophila arenaria*), a fast-spreading, persistent invasive species, has colonized formerly open sandy dune habitats and changed dune formations (USFWS 2013a; Wiedemann 1984). Beach grass-related habitat changes are compounded by both development in beach habitats and the heavy recreational use of coastal dunes (Powell and Collier 2000). As a result, there was a substantial loss of plover breeding habitat (approximately 72% of historic habitat lost on the Oregon coast) and a subsequent decline of reproductive snowy plover adults in the early 1990s (USFWS 2013a; USACE 2007). Of the remnant SNPL breeding habitats in Oregon, the Coos Bay's North Spit remains one of the most important and productive in the state (Lauten et al. 2012; USACE 2007; Hewitt et al. 2006).

Recent improvements in the reproductive success of local snowy plover populations are likely the result of a combination of the almost heroic efforts by scientists and land managers to: 1) restore plover breeding habitat; 2) reduce SNPL predator populations; and 3) monitor breeding populations (Burrell 2012 cited from Lauten et al. 2012; Lauten et al. 2012; USACE 2007).

Double-Crested Cormorant (*Phalacrocorax auritus*)

Adkins and Roby (2010) explain that double-crested cormorant populations have expanded dramatically over the past 50 years throughout western North America, with the largest increases occurring in the Columbia River Estuary. They suggest this trend is the result of various statutory and ecological factors, including the inclusion of double-crested cormorants in the Migratory Bird Treaty, the prohibition of DDT, and cormorants' increased use of artificial breeding habitats. They also note that west coast cormorant populations are kept in check by growing bald eagle (*Haliateeus leucocephalus*) populations, episodic human disturbance, and the long-term effects of pollutants. As a consequence, double-crested cormorant populations remain an order of magnitude less than their counterparts in central and eastern North America.

Understanding the effects of cormorant predation on local juvenile salmonids is difficult. Counts of breeding populations alone underestimate estuary use, because they do not include the (potentially substantial) population of non-breeding birds that use the estuary as a foraging ground (Adrean 2013).

In addition, double-crested cormorant stomach content data vary substantially from month-to-month. One interpretation of the data is that these birds tend to be opportunistic feeders (Sullivan et al. 2006) which means that juvenile salmonids may represent a relatively large share of the local double-crested cormorant diet during smolt outmigration (i.e., when this prey species is most readily available). It's worth noting, however, that the conclusions drawn from cormorant stomach content studies may be site-specific, because different fisheries operate under unique physical, biological, and cultural conditions (Sullivan et al. 2006). More information is needed about the dietary preferences of local cormorant populations to fully understand the effects of predation on salmonids in the Coos system.

Juvenile salmonids in the Coos system are also subject to predation by other species, including seals and sea lions. For more information about salmon in the Coos estuary, see Chapter 13: Fish in the Lower Coos Watershed.

<u>Marbled Murrelet (*Brachyramphus marmoratus*)</u>

Although MAMUs use the lower watershed during many life stages, they are most closely associated with their use of late-successional and old-growth coastal forests for nesting (Raphael et al. 2011). In the MAMU species recovery plan, the USFWS (1997) notes that preserving MAMU nesting habitat is critically important to the recovery of the species, because murrelet population size is "strongly and positively correlated" with habitat availability (Raphael et al. 2011; USFWS 1997).

Raphael et al. (2011) estimate that over 490,000 acres of suitable murrelet nesting habitat (about 13% of the suitable habitat throughout its range) were lost between 1994 and 2007 (Table 4). They recognize fire as a major cause of habitat loss on federal land and timber harvest as the primary cause on non-federal land.

These same researchers also suggest that a large majority of Oregon's prime murrelet nesting habitat is located within the Coast Range. In 2007, there were approximately 936,000 acres of suitable nesting habitat in Oregon's Coast Range alone (71% of all suitable nesting habitat statewide). The availability of this type of nesting habitat in Oregon's Coast Range has decreased by about 32% from 1994 levels, the year in which the Northwest Forest Plan (NWFP) was first enacted. The greatest losses during this time period were on non federal lands within the Coast Range, which lost approximately 43,000 acres of prime nesting habitat primarily due to timber harvests.

<u>Northern Spotted Owl (*Strix occidentalis caurina*)</u>

Research in nearby Elliot State Forest shows that local spotted owls are highly dependent on large tracts of old-growth forest, requiring an average "home range" (i.e., the area used to obtain cover, food, mates, and care for young) of about 842- 1,108 hectares (2,000-2,700 acres)(Glenn et al. 2004). Meiman et al. (2003) explains that home ranges are especially important to non-migratory species like the northern spotted owl, which depends on the resources within the home range for year-round survival. Even when other closed-canopy forests are available, spotted owls are known to travel large distances to establish a home range in the old-growth forest habitats

| Land Class | High Suitability Nesting Habitat | Losses Fire | Harvest | Other | Total | % |
|---|---|---|---|---|---|---|
| **Federal Reserved:** | | | | | | |
| Oregon | 745.2 | 51.2 | 4.3 | 0.6 | 56.1 | 7.5 |
| Washington | 1,387.7 | 0.3 | 4.4 | 3.0 | 7.8 | 0.6 |
| California | 30.2 | 0.1 | 0.1 | 0.1 | 0.3 | 1.0 |
| **Total** | **2,163.1** | **0.4** | **4.5** | **3.1** | **8.1** | **0.4** |
| **Federal Nonreserved:** | | | | | | |
| Oregon | 144.0 | 5.3 | 5.4 | 0.4 | 11.1 | 7.7 |
| Washington | 113.8 | 0.0 | 1.0 | 0.3 | 1.3 | 1.2 |
| California | 4.8 | 0.0 | 0.0 | 0.1 | 0.1 | 2.0 |
| **Total** | **118.6** | **5.3** | **6.5** | **0.4** | **1.4** | **1.2** |
| **Nonfederal:** | | | | | | |
| Oregon | 486.2 | 0.4 | 157.6 | 4.4 | 162.5 | 33.4 |
| Washington | 802.8 | 0.3 | 229.4 | 13.8 | 243.5 | 30.3 |
| California | 97.6 | 0.1 | 7.3 | 0.5 | 7.9 | 8.1 |
| **Total** | **1386.6** | **0.9** | **394.3** | **18.7** | **413.9** | **29.8** |
| **All Forests:** | | | | | | |
| Oregon | 1,375.4 | 56.9 | 167.4 | 5.4 | 229.7 | 16.7 |
| Washington | 2,304.3 | 0.6 | 234.9 | 17.1 | 252.6 | 11.0 |
| California | 132.6 | 0.1 | 7.4 | 0.7 | 8.3 | 6.3 |
| **Total** | **3,812.3** | **57.8** | **409.7** | **23.2** | **490.7** | **12.9** |

Table 4. Baseline estimates for high suitability marbled murrelet nesting habitat (thousands of acres in 1994) in Oregon, Washington, and California compared to habitat loss (thousands of acres 1994-2007) from fire, timber harvest, and other causes (e.g., insects, disease, and other long term disturbances). Forests are classified by ownership (federal and nonfederal) and "land use allocation" status (reserved and nonreserved). The commercial harvest of timber on federally owned reserved forest land is generally not permitted under the Northwest Forest Plan. Timber harvest on nonreserved land is allowed. Data: Raphael et al. 2011

that meet their biological requirements (Carey et al. 1990).

The suitability of spotted owl habitats has been compromised because old-growth forest habitats in the Pacific Northwest have decreased dramatically from historic levels. It's estimated that only a small percentage (5-20%) of original old growth forest in Oregon, Washington, and California remain (Raphael et al. 2011). Loses from timber harvest, disease and insects, wildfire, and other forest threats have continued across the entire northern spotted owl range in recent decades. Moeur et al. (2011) estimate that all NWFP lands (both federal and non-federal) experienced a net loss of over half a million acres from 1994-2007, with forests in Oregon's Coastal Range alone losing approximately 141,000 acres (11% reduction) over this same time period.

Alterations to spotted owl habitats (e.g., commercial thinning) are likely to result in significant habitat-use responses (Meiman et al. 2003). For example, research shows that spotted owls in Oregon's Coast Range will traverse areas up to 85% larger to establish a home range in fragmented forests than they would in late-successional forests (Carey et al.

1992). These types of behavioral responses may affect local owl populations, because any reduction in the owls' home range habitat quality will require them to travel further to meet food requirements possibly decreasing their survival rates or reproductive fitness (Meiman et al. 2003).

Population responses to habitat loss and fragmentation are likely to be compounded by other factors, such as competition for resources by the barred owl and disease.

Over the past 50 years, researchers have noted that the northern barred owl (*Strix varia varia*) has expanded its range into southwestern Canada, the northern Rockies, and the Pacific states, where it has invaded the range of the northern spotted owl (Courtney et al. 2004). USFWS (2013b) recognizes resource competition from the barred owl as a potential threat to the spotted owl. Some surveys on the Oregon coast show that the spotted owl population decline corresponds to a concurrent increases in barred owl abundance, suggesting that this competitive threat may be substantial in the forests surrounding the study area (Figure 16).

Finally, the West Nile Virus is now considered to be an emergent threat to the spotted owl (Courtney et al. 2004). Although little is known about the exact impact of this disease on owl populations, early research indicates that there is considerable concern that spotted owls may be susceptible to the disease (Rappole et al. 2000, Komar et al. 2003, Male 2003).

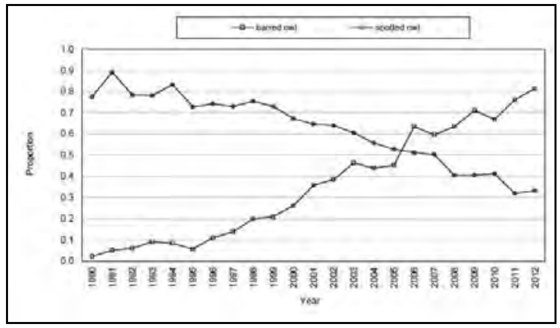


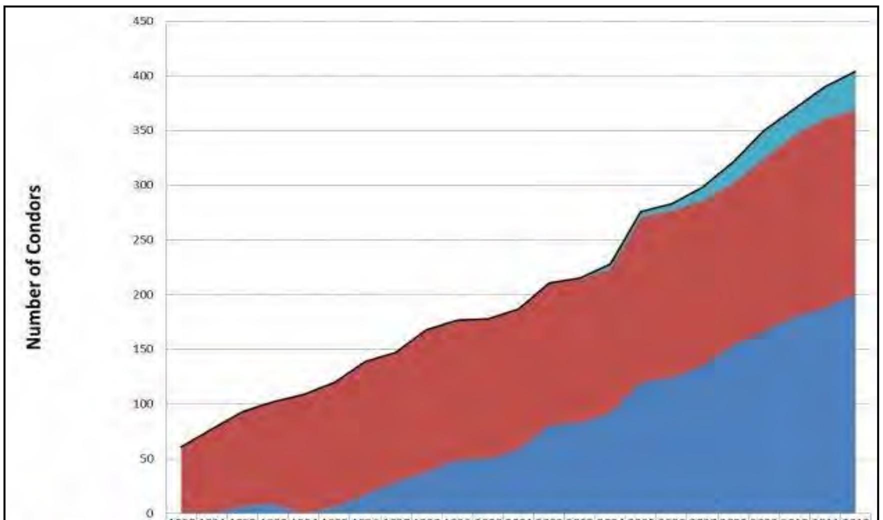

Figure 16. Proportion of spotted owl sites in which barred owls and spotted owls were detected on the Oregon Coast Ranges Study Area, 1990-2012 Caption and Figure: Forsman et al. 2013

<u>California Condor (*Gymnogyps californianus*)</u>

Fossil records and historic observations indicate that the California condor was a permanent resident of Oregon prior to the turn of the 19th century (Miller 1942, Wilber 1973, USFWS 1996, USFWS 2013c, D'Elia and Haig 2013)(Figure 17). Range contraction and severe population decline have effectively removed this species from the Pacific Northwest (Miller 1942, USFWS 1996, USFWS 2013c). Researchers have suggested that secondary poisoning from consumption of carrion, shootings, exposure to DDT and other pesticides, reproductive problems, and collisions with man-made objects (including power lines) as reasons for condor population declines (USFWS 1996). Complex life history and low fecundity likely intensified these factors (Wilber 1973, USFWS 1996).

California condor conservation efforts begin as early as 1930 focused initially on habitat preservation (USFWS 2013c). Beginning in the mid-1970s, USFWS launched intensive efforts to preserve the California condor gene pool by encouraging captive breeding programs, and reintroducing condors to the wild while

Figure 17. Irene Finley taunts a young condor known as "General" by playing a game of keep-away at her home along the banks of the Willamette River near Portland, Oregon circa 1906. Figure and Caption: D'Elia and Haig 2013




| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wild Fledged | | | | | | | | | | | | | | 1 | 4 | 5 | 6 | 12 | 19 | 26 | 24 | 29 | 35 |
| Captive Population | 61 | 77 | 86 | 93 | 109 | 114 | 122 | 118 | 130 | 128 | 128 | 129 | 130 | 131 | 132 | 151 | 153 | 151 | 148 | 158 | 166 | 173 | 169 |
| Captive Released | 0 | 0 | 7 | 9 | 0 | 6 | 17 | 29 | 38 | 49 | 50 | 58 | 81 | 83 | 92 | 120 | 124 | 135 | 154 | 166 | 180 | 188 | 200 |
| Total Population | 61 | 77 | 93 | 102 | 109 | 120 | 139 | 147 | 168 | 177 | 178 | 187 | 211 | 215 | 228 | 276 | 283 | 298 | 321 | 350 | 370 | 390 | 404 |

Figure 18. Conservation, reintroduction, and captive breeding efforts have worked together to re-establish a small wild-fledged California condor population (green) in recent years Figure: USFWS 2013c

continuing to protect condor habitat (USFWS 1996, USFWS 2013c). Condor numbers reached a historic low in 1986, when only 9 individuals remained in the wild (USFWS 2013c). Conservation efforts have since lead to a subsequent recovery of the species (Figure 18). The California condor has not yet been re-introduced to the full extent of its historic range but populations exist in California, Utah, and Arizona (Figure 15)(USFWS

2013c). It remains listed as on the federal registry of endangered species (USFWS 2014b).

**Background**

Habitat requirements associated with the birds described in this data summary sometimes overlap with the development and natural resource uses that have fueled Pacific Northwest coastal economies for decades. These often conflicting overlaps have generated a substantial amount of public concern, followed by detailed scientific, political and economic considerations of the trade-offs associated with various human land use strategies. The continued effort to balance habitat conservation with economic progress and recreational access is a matter of on-going debate.

<u>Western Snowy Plover</u>

The western snowy plover is a small shorebird weighing approximately 34-58 g (1-2 oz) and reaching only 15-17 cm (6-7 in.) in length by adulthood (USFWS n.d.). The Pacific coast population, which is listed as a threatened species at both the federal and state level, nests near tidal waters on the shore of the mainland coast, peninsulas, offshore islands, bays, and estuaries from southern Washington to Baja California, Mexico (USFWS n.d., 2014b; ODFW 2012; ORBIC 2013).

In their Species Fact Sheet series, USFWS (n.d.) describes the life history of the snowy plover as follows:

- Nesting occurs on flat, open areas with sandy or saline substrate, with the clutch size commonly between 1-3 eggs.
- Plover chicks leave the nest within hours of hatching but are unable to fly for about a month, leaving them vulnerable to predation in the early stages of their lives.
- Some "resident" snowy plovers remain in their breeding grounds year-round, while others migrate in the winter.
- Snowy plovers have "high site fidelity," meaning they often return to the same spot year-after-year to nest.

Over the past few decades, the availability of snowy plover habitat on the Pacific coast of North America has been limited by several factors, including the spread of invasive beach grass, urbanization, and heavy recreational use of coastal dunes (see Why is it happening?)(USFWS 2013a; Wiedemann 1984; Powell and Collier 2000). The subsequent plover population decline across the Pacific Northwest has sparked an on-going debate regarding the need to protect critical habitats while continuing to realize the economic benefits associated with coastal development and recreation.

<u>Double-Crested Cormorant</u>

The double-crested cormorant nests along coasts and in inlets throughout the Pacific coast of western North America (USFWS 2006). This species feeds almost exclusively on fish (Sullivan et al. 2006; USFWS 2006). Due to their dietary preferences, dramatic increases in cormorant populations in recent decades have been perceived by commercial and sport fisherman (and others) as a significant cause for concern (Adkins and Roby 2010; Sullivan et al. 2006; USFWS 2006). On the southern Oregon coast, this is particularly true in regard to the predation of salmon species, a highly valued cultural and economic resource.

Sullivan et al. (2006) explain that studies designed to assess the impact of cormorant predation on fisheries are often inconclusive, because obtaining the necessary information can be complicated and expensive (particularly in large, open systems). They add that conclusions may be site-specific, because different fisheries operate under unique physical, biological, and cultural conditions. The exact impact of double-crested cormorant predation on the Coos salmon fishery is unknown and a source of continued controversy.

Marbled Murrelet

The MAMU is a small seabird that forages in coastal waters from central California to southwest Alaska (Raphael et al. 2011). Although MAMUs spend the majority in their life in coastal waters, they nest in the uplands and sometimes travel long distances to nest in coastal forests (Hamer and Nelson 1995). MAMUs show a clear preference for nesting platforms with features characteristic of late-successional (old-growth) forests (USFWS 1997, Raphael et al. 2011). In the late-1980s and early-1990s, controversy surrounding the management of old-growth forests in the Pacific Northwest resulted in legislation that changed the way these forests are managed (see Northwest Forest Plan sidebar).

Northern Spotted Owl

The northern spotted owl's range extends from southwestern British Columbia to central Mexico (Gutiérrez et al. 1995 cited from Courtney et al. 2004). Similar to the marbled murrelet, the northern spotted owl is closely associated with commercially valuable old-growth, coniferous forests, which it uses for foraging, nesting, and roosting (Carey 1985; Courtney et al. 2004; Meiman et al. 2003; Zabel et al. 1996).

Historically, the northern spotted owl was considered a rare resident of Pacific Northwest forests (Bent 1938 cited from Courtney et al. 2004). However, research in the 1970s revealed that spotted owls in the Pacific Northwest are more abundant in old-growth forests than initially thought (Forsman 1976, 1977; Gould 1977). Courtney et al. (2004) explain that this discovery, coupled with increased logging activity after World War II, created concern for the conservation status of this species. Conservation efforts became controversial when continued research concluded that spotted owls' habitat requirements include large plots of late-successional forest with high commercial value (see Northwest Forest Plan sidebar). The debate continues today.

*Northwest Forest Plan*

*In the late 1980s and early 1990s, a series of lawsuits effectively halted timber harvest in the Pacific Northwest. In response to this environmental crisis, President Clinton enacted the Forest Plan for a Sustainable Economy and Sustainable Environment, which mandated that federal land managers and regulatory agencies work together to develop a plan to resolve this conflict. This legislation brought sweeping changes to the management of forest in Oregon, Washington, and California and has since become known as the "Northwest Forest Plan" (NWFP).*

*The NWFP provides critical habitat protection for the northern spotted owl and the marbled murrelet, and now requires regional interagency monitoring of these and additional resources .*

*The federal assessment of Pacific Northwest marbled murrelet populations is conducted within a series of "conservation zones," developed as part of USFWS's Recovery Plan for the marbled murrelet. Most highly suitable marbled murrelet habitat (about 89%) now occurs on federally administered land.*

*Sources: USFWS 1997, Charnley et al. 2008, REO n.d., Raphael et al. 2011*

California Condor

The California condor is a scavenger that feeds primarily on large mammalian caracasses (e.g., deer, elk, livestock, etc)(USFWS 2013c). Historic records indicate that condors north of California had become rare by the mid-19th century (Wilber 1973, USFWS 2013c). USFWS (2013c) describes the California condor as "the only remaining member of its genus in the family Cathartidae," calling it "one of the rarest bird species in the world."

**References**

Adkins, J. Y. and D. D. Roby. 2010. The Status Assessment of the Double-Crested Cormorant (*Phalacrocorax auritus*) in Western North America: 1998-2009. [Final report prepared for the United States Army Corps of Engineers]. Accessed 2 February 2014. Available online http://farallones.noaa.gov/eco/seabird/pdf/articles/monitoringandstatus/adkinsroby2010.pdf

Adrean, L. 2013. Avian Predation Program 2012 Final Report. Oregon Department of Fish and Wildlife. Accessed 2 February 2014. Available online http://www.dfw.state.or.us/conservationstrategy/avian_predation_mgmt.asp

Bent, A. C. 1938. Life Histories of North American Birds of Prey, Part 2. United States National Museum Bulletin 170: 202-213.

Bird Research Northwest (BRNW). 2009. Caspian Tern Research on the Lower Columbia River: 2008 Final Season Summary. [Real Time Research, Bend OR]. Oregon State University. Corvallis, OR. Accessed 7 May 2014. http://www.birdresearchnw.org/08%20Final%20Season%20Summary.pdf

Burrell, M. 2012. Integrated Predator Damage Management Report for the Western Snowy Plover (*Charadrius alexandrinus nivosus*) 2011 Breeding Season. [Unpublished report for the Oregon Department of Fish and Wildlife-Nongame Program, Portland, and the Coos Bay District Bureau of Land Management, Coos Bay, and the Dunes National Recreational Area, Reedsport].

Carey, A. B. 1985. A summary of the scientific basis for spotted owl management. In: R. J. Gutierrez and A. B. Carey (eds.). Ecology and management of the spotted owl in the Pacific Northwest. United States Forest Service General Technical Report PNW-185.: 100-114.

Carey, A. B., J. A. Reid, and S. P. Horton. 1990. Spotted Owl Home Range and Habitat use in Southern Oregon Coast Ranges. The Journal of Wildlife Management 54(1): 11-17.

Carey, A. B., S.P. Horton, and B.L. Biswell. 1992. Northern spotted owls: influence of prey base and landscape character. Ecological Monographs 62(2): 223-250.

Charnley, S., C. Dillingham, C. Stuart, C. Moseley, and E. Donoghue. 2008. Northwest Forest Plan-The First 10 Years (1994-2003): Socioeconomic Monitoring of the Klamath National Forest and Three Local Communities. Accessed 08 October 2014. Available online http://www.fs.fed.us/pnw/pubs/pnw_gtr764.pdf

Courtney, S. P., J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dumbacher, R. C. Fleischer, A. B. Franklin, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, and L. Sztukowski. 2004. Scientific Evaluation of the Status of the Northern Spotted Owl. Sustainable Ecosystems Institute. Portland, OR.

Davis, R. J., K. M. Dugger, S. Mohoric, L. Evers, and W. C. Aney. 2011. Status and Trends of Northern Spotted Owl Populations and Habitats. [Technical Report from the United States Department of Agriculture, United States Forest Service, and Pacific Northwest Research Station].

D'Elia, J. and S. Haig. 2013. California Condors in the Pacific Northwest. University of Oregon Press.

Falxa, G, J. Baldwin, M. Lance, S. L. Miller, S. F. Pearson, M. G. Raphael and C. S. Strong. 2011. Status of the Marbled Murrelet in the Northwest Forest Plan area: Ten years of population monitoring. Accessed 08 October 2014. Available online http://www.dnr.wa.gov/publications/lm_hcp_mamu_annl_mntrng_rprt0910.pdf

Finley, W. L. 1908. Life History of the California Condor Part II: Historical Data and Range of the Condor. The Condor 10 (1): 3-10.

Forsman, E. D. 1976. A preliminary investigation of the Spotted Owl in Oregon. [M.S. thesis]. Oregon State University. Corvallis, OR.

Forsman, E. D. 1977. Spotted Owl abundance in young versus old-growth forests, Oregon. Wildlife Society Bulletin 5:43-47.

Forsman, E. D., C. McCafferty, E. Divine, S. Kane, J. Mowdy, T. Plawman, A. Price, and M. Sullivan. 2013. Demographic Characteristics of Spotted Owls in the Oregon Coast Ranges, 1990-2012. [Wildlife Ecology Team: Wildlife Habitat Relationships in Washington and Oregon FY 2012].

Glenn, E. M., M. C. Hansen, and R. G. Anthony. 2004. Spotted Owl Home-Range and Habitat Use in the Young Forests of Western Oregon. The Journal of Wildlife Management 68(1): 33-50.

Gould, G. I. Jr. 1977. Distribution of the Spotted Owl in California. Western Birds 8: 131-146.

Gutiérrez, R. J., A. B. Franklin, and W. S. LaHaye. 1995. Spotted owl (*Strix occidentalis*).In: A. Poole and F. Gill (eds.). The birds of North America, No. 179. The Academy of Natural Sciences and The American Ornithologists' Union. Washington, DC.

Hamer, T. E. and S. Kim Nelson. 1995. Ecology and Conservation of the Marbled Murrelet. Chapter 6: Characteristics of Marbled Murrelet Nest Trees and Nesting Stands. [General Technical Report PSW-152]. Accessed 13 October 2014. Available online http://www-test.fs.fed.us/psw/publications/documents/gtr-152/

Hewitt, R., K. M. Burton, and S. J. Tucker. 2006. 2005-2006 Pre-Construction Wildlife Surveys for Proposed Jordan Cove Liquefied National Gas Plant, Coos Bay, Oregon. [Report prepared by LBJ Enterprises, Eureka, CA].

Koford, C. B. 1953. The California Condor. National Audubon Society Research Report No. 4.

Komar, N., S. Langevin, S. Hinten, N. Nemeth, E. Edwards, D. Hettler, B. Davis, R. Bowen, and M. Bunning. 2003. Experimental infection of North American birds with New York 1999 strain of West Nile virus. Emerging Infections Diseases 9(3): 311-322.

Lauten, D. J., K. A. Castelein, J. D. Farrar, A. A. Kotaich, and E. P. Gaines. 2012. The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast- 2012. [A report prepared by the Oregon Biodiversity Information Center]. Accessed 06 October 2012. Available online http://www.fws.gov/arcata/es/birds/wsp/documents/siteReports/Oregon/2012_Oregon_Snowy_Plover_Distribution_and_Reproductive_Success.pdf

Lyons, D. E., D. D. Roby, A. F. Evans, N. J. Hostetter, and K. Collis. 2014. Benefits to Columbia River Anadromous Salmonids from Potential Reductions in Predation by Double-Crested Cormorants Nesting at the East Sand Island Colony in the Columbia River Estuary. [A report prepared for USACE by USFWS, USGS, and Real Time Research Inc.] Accessed 7 October 2014. Available online http://www.birdresearchnw.org/final%20esi%20dcco%20benefits%20analysis.pdf

Male, T. 2003. Potential Impacts of West Nile Virus on American Avifaunas. Conservation Biology 17(3): 928-930.

Meiman, S., R. Anthony, E. Glenn, T. Bayless, A. Ellingson, M. C. Hansen, and C. Smith. 2003. Effects of Commercial Thinning on Home-Range and Habitat Use Patters of a Male Northern Spotted Owl: A Case Study. Wildlife Society Bulletin 31(4): 1254-1262.

Miller, A. H. 1942. A California Condor bone from the coast of southern Oregon. Murrelet 23: 77.

Moeur, M., J. L. Ohmann, R. E. Kennedy, W. B. Cohen, M. J. Gregory, Z. Yang, H. M. Roberts, T. A. Spies, and M. Fiorella. 2011. Status and Trends of Late-Successional and Old-Growth Forests. [Technical Report from the United States Department of Agriculture, United States Forest Service, and Pacific Northwest Research Station].

National Audubon Society (Audubon). 2014. Christmas Bird Count: Current and Historic Data. Raw data accessed 13 October 2014. Available online http://netapp.audubon.org/cbcobservation/

Naughton, M. B., D. S. Pitkin, R. W. Lowe, K. J. So, and C. S. Strong. 2007. Catalog of Oregon Seabird Colonies. [Area 270 North Coos Bay]. Accessed 07 October 2014. Available online http://www.fws.gov/oregoncoast/PDF/Catalog_of_Oregon_Seabird_Colonies/Catalog_of_Oregon_Seabird_Colonies_9-270N.pdf

Oregon Biodiversity Information Center (ORBIC). 2013. Rare, Threatened and Endangered Species of Oregon. Institute for Natural Resources, Portland State University. Portland, Oregon. 111 pp.

Oregon Department of Fish and Wildlife (ODFW). 2012. Threatened, Endangered, and Candidate Fish and Wildlife Species. Accessed 06 October 2014. Available online http://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidate_list.asp

Oregon Zoo. n.d. California Condor. Accessed 15 January 2015. Available online http://www.oregonzoo.org/discover/animals/california-condor

Powell, A. N. and C. L. Collier. 2000. Habitat use and reproductive success of western snowy plovers at new nesting areas created for California least terns. Journal of Wildlife Management 64(1): 24-33. Jamestown, ND: Northern Prairie Wildlife Research Center Online. http://www.jstor.org/stable/3802971?seq=1#page_scan_tab_contents

Raphael, M. G., G. A. Falxa, K. M. Dugger, B. M. Galleher, D. Lynch, S. L. Miller, S. Kim Nelson, and R. D. Young. 2011. Status and Trend of Nesting Habitat for the Marbled Murrelet. [Technical Report from the United States Department of Agriculture, United States Forest Service, and Pacific Northwest Research Station].

Rappole, J. H., S. R. Derrickson, and Z. Hubálek. 2000. Migratory birds and spread of West Nile virus in the western hemisphere. Emerging Infectious Diseases 6(4): 319-328.

Regional Ecosystem Office (REO). n.d. 15 Year Report for the Northwest Forest Plan. Accessed 08 October 2014. Available online http://www.reo.gov/monitoring/reports/15yr-report/

Rodenkirk, T. J. 2012. Birds of Coos County, Oregon: Status and Distribution. [Unpublished Manuscript].

Strong, C. S. 2010. Population and Productivity Monitoring of Marbled Murrelets in Oregon During 2009. [Report prepared by Crescent Coastal Research for the United States Fish and Wildlife Service].

Sullivan, K. L., P. D. Curtis, R. B. Chipman, and R. D. McCullough. 2006. The Double-Crested Comorant: Issues and Management. Accessed 14 October 2014. Available online http://wildlifecontrol.info/pubs/Documents/Cormorant/Cormorant.pdf

United States Army Corps of Engineers (USACE). 2007. Aquatic Nuisance Species Workshop. [Appendix A: Coos Bay Western Snowy Plover Habitat Management, OR, Section 1135 (b)]. Accessed 06 October 2014. Available online http://el.erdc.usace.army.mil/workshops/07may-ans/Summary_Final.pdf

United States Fish and Wildlife Service (USFWS). 1996. California Condor Recovery Plan, Third Revision. Portland, OR. 62 pp.

United States Fish and Wildlife Service (USFWS). 1997. Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, Oregon. 203 pp.

United States Fish and Wildlife Service (USFWS). 2006. Alaska Seabird Information Series: Double-Crested Cormorant . Accessed 14 October 2014. Available online http://www.fws.gov/alaska/mbsp/mbm/seabirds/pdf/dcco.pdf

United States Fish and Wildlife Service (USFWS). 2011. Marbled Murrelet Critical Habitat Shapefile.

United States Fish and Wildlife Service (USFWS). 2012. Northern Spotted Owl Critical Habitat Shapefile. Available online http://www.fws.gov/oregonfwo/species/data/northernspottedowl/Maps.asp

United States Fish and Wildlife Service (USFWS). 2013a. Species Fact Sheet: Western Snowy Plover. Accessed 06 October 2014. Available online http://www.fws.gov/oregonfwo/species/data/westernsnowyplover/

United States Fish and Wildlife Service (USFWS). 2013b. Northern Spotted Owl Recovery Information Site: Critical Habitat. Accessed 13 October 2014. Available online http://www.fws.gov/oregonfwo/species/data/northernspottedowl/CriticalHabitat/default.asp

United States Fish and Wildlife Service (USFWS). 2013c. California Condor (*Gymnogyps californianus*) 5-Year Review and Evaluation. Accessed 15 January 2015. Available online http://ecos.fws.gov/docs/five_year_review/doc4163.pdf

United States Fish and Wildlife Service (USFWS). 2014a. Catalog of Oregon Seabird Colonies. [Unpublished data].

United States Fish and Wildlife Service (USFWS). 2014b. Endagered Species. Accessed 06 October 2014. Available online http://www.fws.gov/endangered/

United States Fish and Wildlife Service (USFWS). 2014c. Critical Habitat, Western Snowy Plover Shapefile. Estuarine and Coastal Sciences Laboratory of the South Slough National Estuarine Research Reserve. Accessed 06 October 2014.

United States Fish and Wildlife Service (USFWS). n.d. Species Fact Sheet: Western Snowy Plover (*Characdrius alexandrinus nivosus*). Accessed 14 October 2014. Available online http://www.fws.gov/wafwo/species/Fact%20 sheets/WSPSpeciesProfileFinal.pdf

Varland, D. E., S. Ford, G. Johnson, and T. Hamer. 2012. Monitoring the Health of Avian Scavengers on the Pacific Coast. [Report from the Avian Health and Disease Program of the United States Fish and Wildlife Service].

Wiedemann, A. M. 1984. The ecology of Pacific Northwest Coastal Sand Dunes: A community profile. [U.S. Fish and Wildlife Service FWS/OBS-84-04]. 130 pp.

Wilbur, S. R. 1973. The California Condor in the Pacific northwest. The Auk: 196-198.

Zabel, C. J., S. E. Salmons, and M. Brown. 1996. Demography of Northern Spotted Owls in Southwestern Oregon. Studies in Avian Biology 14: 77-82.

# **Chapter 17:** Mammals in the Lower Coos Watershed

*Erik Larsen, Rose Rimler, Jenni Schmitt, Colleen Burch Johnson - South Slough NERR*

***Small Mammals:*** *Little is known about the status small mammals in the project area.*

***Large Mammals****: Although exact estimates of large mammals in the project area are not available, population trends at a statewide level may offer some clues. Roosevelt elk, black bear, and cougar populations are likely stable and even increasing in the project area. There is reason to believe that black-tailed deer may be declining due to the loss of habitat and disease.*

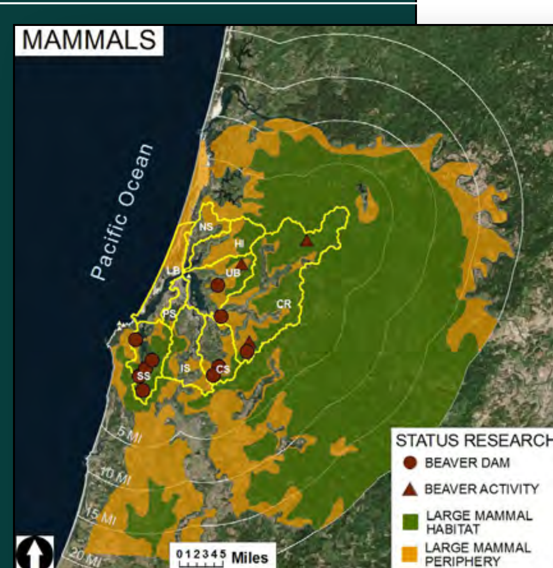
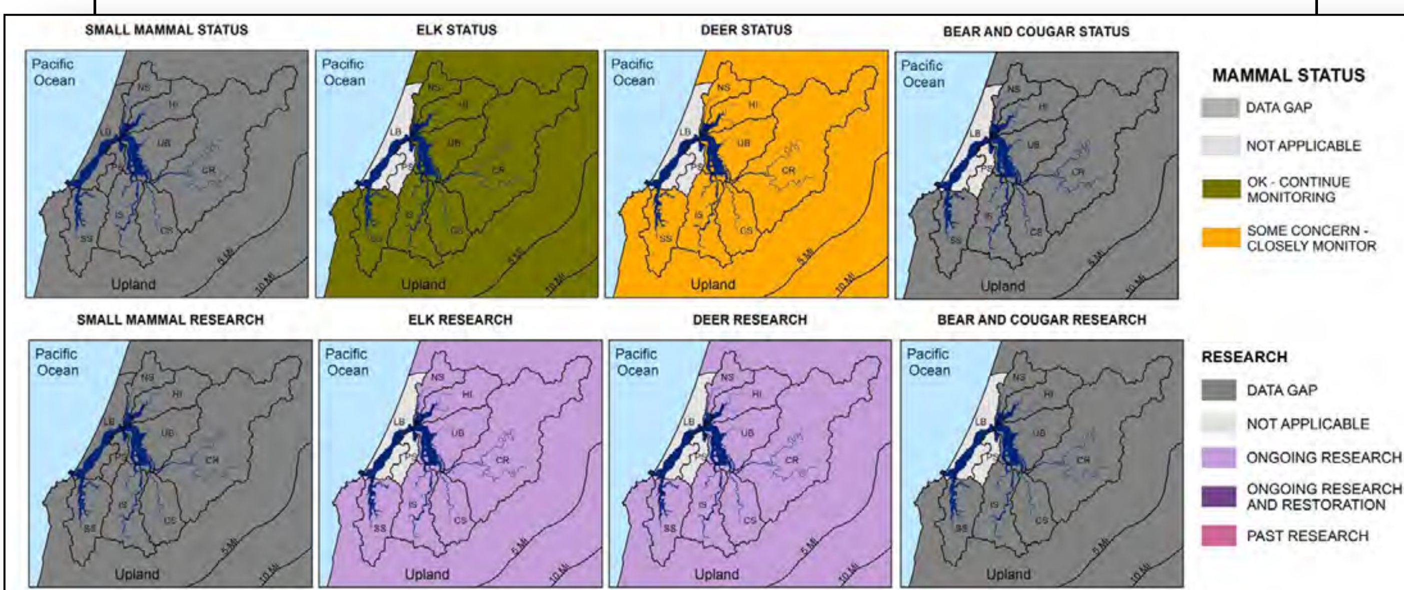



**Figure 1. Distribution of mammal activity/habitat within the project area.** Subsystems: CR- Coos River, CS- Catching Slough, HI- Haynes Inlet, IS- Isthmus Slough, LB- Lower Bay, NS- North Slough, PS- Pony Slough, SS- South Slough, UB- Upper Bay



## Chapter 17: Mammals in the Lower Coos Watershed

*This section includes two data summaries: **Small Mammals**, and **Large Mammals**— which describe the status and trends of important mammalian species the lower Coos watershed.*

This chapter focuses on population trends for key mammals within the project area and mammal habitat less than 20 miles outside the project area boundary (see Figure 1). The key mammals discussed include the North American beaver (*Castor canadensis*) and raccoon (*Procyon lotor*) in the Small Mammals data summary, and Roosevelt elk (*Cervus canadensis roosevelti*), black-tailed deer (*Odocoileus hemionus columbianus*), black bear (*Ursus americanus*), and cougar (*Puma concolor*) in the Large Mammals data summary. Although other deer and elk species such as the Rocky Mountain Elk (*Cervus canadensis nelsoni*) and mule deer (*Odocoileus hemionus*) occur elsewhere in Oregon (e.g., central and eastern Oregon), they are not discussed extensively in the large Mammals data summary.

This chapter is not intended to be a review of hunting regulations. To ensure compliance with Oregon state laws, hunters are encouraged to contact the Oregon Department of Fish and Wildlife (ODFW).

<u>Small Mammals:</u> Information about the abundance and distribution of beavers at a statewide level was provided by ODFW (2004, 2006a). Additional information was provided in peer-reviewed studies by Hiller (2011), ODFW (2013), and Nordholm and Miller (2008). Data detailing the presence of beavers in streams within the project area were provided by ODFW-sponsored research (Nordholm and Miller 2008), which was supplemented by work from the University of Oregon (Cramer 2010).

Very little is known about the abundance and distribution of raccoons within the project area and state-wide. However, some information about the behavior of raccoons as intertidal predators is available from Davidson (1990).

Basic ecological information about small mammals (including beaver-salmonid interactions) and assessments of public opinion are available through ODFW (n.d.a), Oregon State University (Csuti et al. 1997), the Audubon Society (n.d.), and other researchers (Cramer 2010, Collen and Gibson 2001, Davidson 1990, Duke 1982, Fouty 2003, Jones et al. 1996, Kemp et al. 2012, Lawton and Jones 1995, Leidhold-Bruner et al. 1992, Needham and Morzillo 2011, Petro et al. 2015, Rodgers et al. 1987, Snodgrass and Meffe 1998, Wright et al. 2002).

Large Mammals: The most recent data for deer and elk herd composition, elk population trends, and Deer Hair Loss Syndrome prevalence within ODFW's Tioga and Sixes Game Management Units (GMUs or Units) were provided by ODFW's Charleston Field Office (ODFW 2015). Data describing recent trends in cougar populations were provided by the same source but are only available at a statewide level.

Interpretation of recent deer and elk population trends within ODFW's Tioga and Sixes GMUs was facilitated by personal communication with a local expert (S. Love, pers. comm., April 29, 2015). A series of ODFW management plans and hunting forecasts (ODFW 2003, 2006b, 2008, 2012, 2014) provided information regarding many of the topics discussed in the large mammals data summary, including population estimates at a statewide level, historical context for interpreting long-term trends, and a description of the contributing factors explaining historic trends.

In many cases, interpretations of historic large mammal population status and trends offered by ODFW (2003, 2006b, 2008, 2012, 2014) are supported by information from peer-reviewed journal articles, books, technical reports, and other resources as follows: Deer and elk- Ackerman et al. 1984, Anderson 1983, Beier and Barrett 1993, Cashman et al. 1992, Logan et al. 1996, Neal et al. 1987, Oregon Forest Resources Institute 2013, Pamplin 2003, Robinette et al. 1959, USDA n.d., White et al. 2010, Yarkovich et al. 2011; Bears- Bailey 1936, Foreyt 2001, Herrero et al. 2011, Pamplin 2003, Pelton 2000, Rogers and Rogers 1976, Samuel et al. 2001, White et al. 2010, Yarkovich et al. 2011; Cougars: Ackerman et al. 1984, Anderson 1983, Anderson and Lindzey 2005, Beier and Barrett 1993, Cashman et al. 1992, Chinitz 2002, Cougar Management Guidelines Working Group 2005, Iriarte et al. 1990, Keister and Van Dyke 2002, Logan et al. 1996, Neal et al. 1987, Nowak 1999, Robinette et al. 1959, White et al. 2010, Yarkovich et al. 2011.

Information about basic large mammal ecology and range maps are provided by both ODFW (2006b, 2008, 2012, n.d.b) and peer-reviewed sources (Graber 1990, Hellgren et al. 1997, Hellgren and Vaughan 1989, Link 2004, Vander Heyden and Meslow 1999).

**Data Gaps and Limitations**

Small Mammals: Information about historic and current beaver abundance is available at a statewide level, but this information likely underestimates true beaver abundance because data collection is often restricted to salmon-bearing streams.

Beaver data from the project area are limited, and focus entirely on the South Slough Subsystem. It should be noted that the reliability of beaver abundance data is limited by methodological shortcomings. For example, in surveying beaver populations, the presence of beaver activity (e.g., ponds, dams, trails, chews, etc.) is commonly used as a proxy for beaver abundance. However, research shows that these indicators may be poor substitutes for population information because the number of beavers present may not be correlated with the number of lodges, bank dens, or beaver dams in any one area (Swafford et al. 2003). Camera trapping as a beaver surveying method may hold promise, but for Cramer (2010) the camera's motion sensor was triggered by wind-blown vegetation and not by the presence of beavers.

Large Mammals: Estimating the population of deer, elk, bears, and cougars is difficult due to these animals' secretive life histories and their densely vegetated habitats (ODFW 2006b, 2008). Love (pers. comm., April 29, 2015) explains that aerial survey methods rely on the visual detection of animals to produce an estimate of herd composition, a method with limitations (e.g., weather and dense cover) that can reduce the effectiveness of the survey effort. He adds that alternative survey methods (e.g., true population counts using ground survey techniques) generally produce less reliable results because the presence of surveyors in the field can influence the behavior of the animals being surveyed.

Bear survey methods involve deploying bacon baits containing a tetracycline biomarker used to generate mark-recapture data (see Background section in the Large Mammals data summary). Since this survey takes place during spring when bears are very active, the baits must be placed at least 5 linear miles apart to ensure that a single bear does not consume multiple baits in any one year.

As a result, the geographic extent of a bear survey area must be expansive to ensure enough bears are marked to produce reliable population estimates with sufficiently small confidence intervals (S. Love, pers. comm., April 29, 2015). For this reason, bear population data are not available for relatively small areas (e.g., the lower Coos watershed).

In addition to spatial limitations, it should be noted that bear survey data rely on the successful harvest of a bear and the removal and processing of one of its pre-molar teeth in a laboratory. Since these processes can take a considerable amount of time, bear population estimates are considered to be a "lagging indicator," meaning that the current population estimate is designed to indicate trends occurring two years prior (S. Love, pers. comm., April 29, 2015).

Bear surveys also rely on the telltale marks which bears leave on trees to verify that a bear (rather than some other animal) has consumed the tetracycline bait. Although this method is fairly accurate, it's not 100% reliable since gray foxes (*Urocyon cinereoargenteus*), which leave similar scratch marks on trees, have been documented eating tetracycline baits intended for bears.

According to ODFW (2006b), generating an estimate of cougar abundance is "not an exact science." These estimates often rely on computer-generated models whose accuracy relies on reviews of existing literature. Model-generated estimates are typically presented as ranges between two numbers determined by the data's confidence intervals.

For more information about the confidence intervals of statewide cougar estimates, see the Oregon Cougar Management Plan (ODFW 2006b).

Finally, it should be noted that use of alternative metrics (e.g., annual patterns in harvest data, damage reports, etc.) as a proxy for total large mammal populations is subject to a variety of limitations, due to several extraneous variables. For example, variation in harvest rates may be related to food availability rather than true abundance trends (Fieberg et al. 2010, Howe et al. 2010). Similarly, data related to non-hunting conflicts may reflect changes in landscape characteristics, land use, or regulations rather than actual population trends (Merkle et al. 2011, Howe et al. 2010). Harvest data alone are subject to substantial variation related to hunter effort and hunter success, two variables that are at least partially independent of game abundance (e.g., precipitous reductions in the success rate of Oregon bear and cougar hunters in 1994 following the prohibition of dogs and bait as hunting aids).

**References**

Ackerman, B. B., F. G. Lindzey, and T. P. Hemker. 1984. Cougar food habits in southern Utah. Journal of Wildlife Management. 48:147-155.

Anderson. A. E. 1983. A critical review of literature on puma (*Felis concolor*). Colorado Div. Wildl. Spec. Rep. No. 54. Ft. Collins, Colorado, USA. 91 pp

Anderson, C.R., and F.G. Lindzey. 2005. Experimental evaluation of population trend and harvest composition in a Wyoming cougar population. Wildlife Society Bulletin 33(1):179- 188.

Audubon Society of Portland. n.d. Living with Urban Wildlife: Raccoons. Accessed 24 April 2015 from http://audubonportland.org/files/brochures/living-with-raccoons.pdf/at_download/file

Bailey, V. 1936. The mammals and life zones of Oregon. North American Fauna No. 5. U.S. Government Printing Office, Washington, D.C

Beier, P. and R. Barrett. 1993. The cougar in the Santa Ana Mountain Range, California. Final report to California Department of Fish and Game, University of California, Berkeley, California, USA. 105 pp.

Cashman, J. L., M. Pierce, and P. R. Krausman. 1992. Diets of mountain lions in southwestern Arizona. Southwest Naturalist. 37: 324-326

Chinitz, A.E. 2002. Laying the groundwork for public participation in cougar management: a case study of southwestern Oregon (Puma concolor). M.S. Thesis, Univ. Oregon, Eugene, Oregon, USA. 158 pp.

Collen, P., and R. J. Gibson. 2001. The general ecology of beavers (*Castor spp.*), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish: a review. Reviews in Fish Biology and Fisheries. 10: 439–461.

Cougar Management Guidelines Working Group. 2005. Cougar Management Guidelines. WildFutures, Bainbridge Island, Washington, USA. 77 pp.

Cramer, Alison. 2010. The Role of beavers in Salmon Management: A Literature Review and Test of Method. [Undergraduate Honors Thesis, Department of Biology, University of Oregon].

Csuti, B., T. A. O'Neil, M. M. Shaughnessy, E. P. Gaines, J. C. Hak. 1997. Atlas of Oregon Wildlife, first edition. Oregon State University Press. Corvallis.

Davidson, Seana K. 1990. Raccoon Foraging in the Tidal Flats of the Coos Estuary. [Undergraduate Thesis, Department of Biology, University of Oregon].

Duke, Stephen D'wayne. 1982. Distribution of Fishes and Their Relationships to Environments in Selected Coastal Streams, Douglas and Coos Counties, Oregon. Masters Thesis. Department of Fisheries, University of Oregon.

Fieberg, J. R., K. W. Shertzer, P. B. Conn, K. V. Noyce, and D. L. Garshelis. 2010. Integrated population modeling of black bears in Minnesota: implications for monitoring and management. PLoS ONE 5(8): e12114. doi:10.1371/journal.pone.0012114

Foreyt, W. J. 2001. Salmon poisoning disease. Pages 480–486 in Samuel, W. M., M. J. Pybus, and A. A. Kocan, editors. Parasitic diseases of wild mammals, second edition. Iowa State Press, Ames, IA.

Fouty, Suzanne C. 2003. Current and Historic Stream Channel Response to Changes in Cattle and Elk Grazing Pressure and Beaver Activity. Doctoral Thesis. Deptarment of Geography, University of Oregon.

Graber, D. M. 1990. Winter behavior of black bears in the Sierra Nevada, California. International Conference on Bear Research and Management 8:269–272

Hellgren, E. C., and M. R. Vaughan. 1989. Denning ecology of black bears in a southeastern wetland. Journal of Wildlife Management 53:347–353.

Hellgren, E. C., D. S. Maehr, and D. L. Doan-Crider. 1997. Serum chemistry of southern populations of black bears (*Ursus americanus*). American Midland Naturalist 137:95–105

Herrero, S., A. Higgins, J. E. Cardoza, L. I. Hajduk, and T. S. Smith. 2011. Fatal attacks by American black bear on people: 1900–2009. Journal of Wildlife Management 75:596– 603.

Hiller, T. L. 2011. Oregon furbearer program report, 2010-2011. Oregon Department of Fish and Wildlife, Salem, Oregon, USA.

Howe, E. J., M. E. Obbard, R. Black, and L. L. Wall. 2010. Do public complaints reflect trends in human-bear conflict? Ursus 21:131–142.

Iriarte, J.A., W. L. Franklin, W. E. Johnson and K. H Redford. 1990. Biogeographic variation of food habits and body size of the America puma. Oecologia 85: 185–190.

Jones, C. G., J. H. Lawton, and M. Shachak. 1996. Organisms as ecosystem engineers. In Ecosystem Management (pp. 130-147). Springer New York.

Keister, G. P. Jr. and W. A. Van Dyke. 2002. A predictive population model for cougars in Oregon. Northwest Science. 76(1):15-25.

Kemp, P. S., T. A. Worthington, T. E. Langford, A. R. Tree, and M. J. Gaywood. 2012. Qualitative and quantitative effects of reintroduced beavers on stream fish. Fish and Fisheries. 13(2): 158-181.

Lawton, J. H. and C. G. Jones. 1995. Linking species and ecosystems: organisms as ecosystem engineers. In Linking species & ecosystems (pp. 141-150). Springer US.

Leidholt-Bruner, K., D. E. Hibbs, and W. C. McComb. 1992. Beaver dam locations and their effects on distribution and abundance of coho fry in two coastal Oregon streams. Northwest Science. 66: 218–223.

Link, Russell. 2004. Living with Wildlife in the Pacific Northwest. University of Washington Press. 350 pp.

Logan, K. A., L. L. Sweanor, T. K. Ruth, and M. G. Hornocker. 1996. Cougars of the San Andres Mountains, New Mexico. Final Report, Federal Aid in Wildlife Restoration, W– 128–R. New Mexico Department of Game and Fish, Santa Fe, New Mexico, USA. 280 pp.

Merkle, J. A., P. R. Krausman, N. J. Decesare, and J. J. Jonkel. 2011. Predicting spatial distribution of human-black bear interactions in urban areas. Journal of Wildlife Management 75:1121–1127

Neal, D. L., G. N. Steger, and R. C. Bertram. 1987. Mountain lions: preliminary finds on homerange use and density in the central Sierra Nevada. U.S. Department of Agriculture, PSW Forest and Range Experiment Station. Research Note PSW-392. 6 pp.

Needham, M. D. and A. T. Morzillo. 2011. Landowner incentives and tolerances for managing beaver impacts in Oregon. Final project report for Oregon Department of Fish and Wildlife (ODFW) and Oregon Watershed Enhancement Board (OWEB). Corvallis, OR: Oregon State University, Department of Forest Ecosystems and Society.

Nordholm, Katherine E. and Bruce A. Miller. 2008. Beaver Activity in Winchester Creek, Coos River: an Inventory of Dams, Pools, and Potential Barriers to Fish Passage. [a report for the Salmonid Life-Cycle Monitoring Project of Oregon Department of Fish and Wildlife].

Nowak, R. M. 1999. Walker's mammals of the world. Sixth Edition, Volume I., John Hopkins Univ. Press. Baltimore, Maryland, USA. 836pp.

Oregon Department of Fish and Wildlife (ODFW). 2003. Oregon's Elk Management Plan. Accessed 29 April 2015 from http://www.dfw.state.or.us/wildlife/management_plans/docs/ElkPlanfinal.pdf

Oregon Department of Fish and Wildlife (ODFW). 2004. Beaver Pool Presence in Habitat Surveys. Data accessed 22 April 2015 from ODFW Data Clearinghouse https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=1

Oregon Department of Fish and Wildlife (ODFW). 2006a. Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife (ODFW). 2006b. Oregon Cougar Management Plan. Accessed 29 April 2015 from http://www.dfw.state.or.us/wildlife/cougar/docs/cougarPLAN-Final.pdf

Oregon Department of Fish and Wildlife (ODFW). 2008. Oregon Black-Tailed Deer Management Plan. Accessed 29 April 2015 from http://www.dfw.state.or.us/wildlife/docs/oregon_black-tailed_deer_management_plan.pdf

Oregon Department of Fish and Wildlife (ODFW). 2012. Oregon Black Bear Management Plan. Accessed 30 April 2015 from http://www.dfw.state.or.us/wildlife/management_plans/docs/Black_Bear_Management_Plan_2012.pdf

Oregon Department of Fish and Wildlife (ODFW). 2013. Oregon Department of Fish and Wildlife Fact Sheet: Oregon's State Mammal. Oregon Conservation Strategy program. Accessed 21 April 2015 from http://www.dfw.state.or.us/conservationstrategy/docs/Beaver_factsheet.pdf

Oregon Department of Fish and Wildlife (ODFW). 2014. Oregon Big Game Hunting Forecast. Accessed 29 April 2015 from http://www.dfw.state.or.us/rr/hunting_forecast/docs/2014_hunting_forcast.pdf

Oregon Department of Fish and Wildlife (ODFW). 2015. Herd Composition, Trend Estimates, and Dear Hair Loss Syndrome. [Unpublished data from the ODFW Charleston Field Office].

Oregon Department of Fish and Wildlife (ODFW). n.d.a. Living with Wildlife: American Beaver. [Living with Wildlife Fact Sheet Series]. Accessed 24 April 2015 from http://www.dfw.state.or.us/wildlife/living_with/

Oregon Department of Fish and Wildlife (ODFW). n.d.b. Oregon Wildlife Species: Mammals. Accessed 02 May 2, 2015 from http://www.dfw.state.or.us/species/#Mammals

Oregon Forest Resources Institute. 2013. Wildlife in Managed Forests: Deer and Elk. [Technical report prepated by Cafferata Consulting and the Oregon Forest Research Institute for the USDA Forest Service]. Accessed April 29, 2015 from http://oregonforests.org/sites/default/files/publications/pdf/OFRI%20managed%20forests%20elk%20deer_for_web.pdf

Pamplin, N.P. 2003. Ecology of Columbian black-tailed deer fawns in western Oregon. M.S. Thesis, Oregon State University, Corvallis, OR. 75 pp.

Pelton, M. R. 2000. Black bear. Pages 389–408 in S. Demarais and P. R. Krausman, editors. Ecology and management of large mammals in North America. Prentice Hall, Upper Saddle River, New Jersey, USA.

Petro, V.M., J.D. Taylor, and D.M Sanchez. 2015. Evaluating landowner-based beaver relocation as a tool to restore salmon habitat. Global Ecology and Conservation. 3: 447-486.

Robinette, W. L., J. S. Gashwiler, and O. W. Morris. 1959. Food habits of the cougar in Utah and Nevada. Journal of Wildlife Management 23:261–273.

Rodgers, J. D., R. D. Ewing, and J. D. Hall. 1987. Physiological changes during seaward migration of wild juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences.44:452–457.

Rogers, L. L., and S. M. Rogers. 1976. Parasites of bears: a review. International Conference on Bear Research and Management 3:411–429.

Samuel, W. M., M. J. Pybus, and A. A. Kocan, editors. 2001. Parasitic diseases of wild mammals, second edition. Iowa State Press, Ames, Iowa, USA

Snodgrass, J. W. and G. K. Meffe. 1998. Influence of beavers on stream fish assemblages: effects of pond age and watershed position. Ecology. 79: 928–942.

Swafford, Seth R., Dale L. Nolte, Kris Godwin, Charles A. Sloan, and Jeanne Jones. 2003. Beaver Population Size Estimation in Mississippi. USDA National Wildlife Research Center - Staff Publications. Paper 277.

United States Department of Agriculture (USDA). n.d. Habitat Management for Black-tailed Deer in the State of Oregon. [Report from the Natural Resources Converation Service]. Accessed May 1, 2015 from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_042116.pdf

Vander Heyden, M., and E. C. Meslow. 1999. Habitat selection by female black bears in the Central Cascades of Oregon. Northwest Science 73:283–294

White, C. G., P. Zagar, and M. W. Gratson. 2010. Influence of predator harvest, biological factors, and landscape on elk calf survival in Idaho. Journal of Wildlife Management 74:355–369.

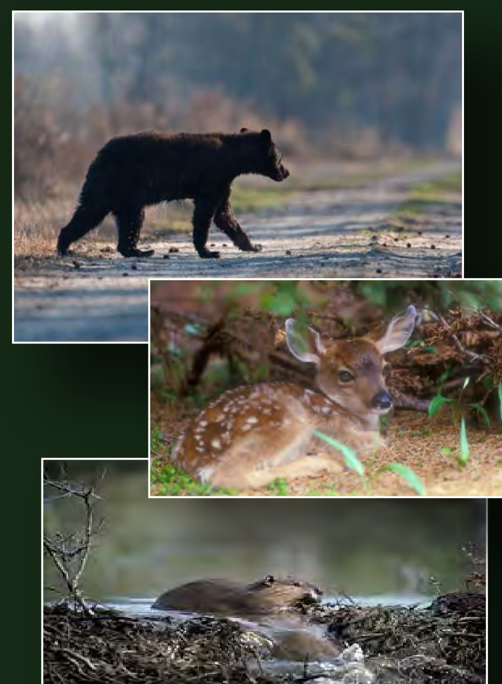
Wright, J. P., C. G. Jones, and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia,132(1), 96-101.

Yarkovich, J., J. D. Clark, and J. L. Murrow. 2011. Effects of black bear relocation on elk calf recruitment at Great Smoky Mountains National Park. Journal of Wildlife Management 75:1145–1154

# How the Local Effects of Climate Change Could Affect Mammals in the Lower Coos Watershed

*Several climate-related changes have the potential to affect the abundance and distribution of mammals on the Oregon coast:*

- *Changes to the composition and distribution of forest vegetation may affect predation rates, food availability, and fawn mortality in deer and elk.*
- *Mammals may modify their geographic distributions in response to climatic variation, a trend which could limit the overall fitness of some animals.*
- *The range expansion of diseases and parasites could increase the frequency of some pathogens in mammals.*



Photos: Black Bear: Mike Dunn; Black-tailed deer fawn: Bob Schillereff; Beaver: Steve Blizard

This data summary highlights general mammal responses to anticipated climate-related changes on the southern Oregon coast, citing specific examples where possible. Unfortunately, relatively little is known about the potential response of mammals to climate change. Most of the available research focuses on wild "ungulates" (i.e., hoofed mammals) in habitats in northern latitudes (e.g., Scandivinia and the Canadian arctic) and in the Mountain West region (i.e., Colorado, Wyoming, and Montana). Although the exact response of ungulates to climate change in Pacific Northwest is uncertain (ODFW 2008), the responses by deer and elk are expected to be similar (see the Shifting Geographic Distributions section below).

Climate change's overall effects on mammals in the Pacific Northwest will be influenced by a complex web of ecological responses to change at various scales (ODFW 2008). Some ecological responses will affect mammals' overall fitness and ability to survive by modifying the availability of food and cover, changing predator-prey relationships, and changing the likelihood of parasitic infection or disease. Mammal survival will depend on the ability of species to adapt to changing conditions in existing habitats or migrate into new, more hospitable areas.

**Changing Habitat Conditions**

Climate change may alter the characteristics of important habitat features. Mysterud and Ostbye (1999) explain that vegetation density affects many important aspects of ungulate behavior, including grouping tendencies (Hirth 1977, Lagory 1986), vigilance (Goldsmith 1990), alarm and flight responses (Lagory 1987), and circadian rhythms (Andersen 1989). Deer also rely on actively growing plants as a source of forage (ODFW 2008). Since climate change is expected to directly affect the abundance, distribution, and density of local vegetation, large mammals will need to adapt to changing habitat conditions (Chmura et al. 2011, Dalton et al. 2013). In addition, decreases in vegetation density appears, not surprisingly, to be correlated to increased predation rates for both juvenile (Linnell et al. 1995, Aanes and Andersen 1996, Canon and Bryant 1997) and adult (Jedrzejewska et al. 1994) ungulate species. Similarly, alterations to plant phenology (e.g., reproductive timing) and the availability of forage may result in the redistribution of ungulate species with potential reproductive consequences (see Shifting Geographic Distributions section below). Deer and elk populations may also be affected if climate-related changes to habitat structure (e.g., increasingly open forest canopy) result in increased wintertime and springtime exposure to precipitation (see sidebar), because wet conditions may be associated with increased fawn mortality (Putman et al. 1996).

Mammals may also be affected by human-induced changes. For example, the introduction of new roads may limit the ability of large mammals (e.g., bears) to adapt to climate-related changes by impeding their movements (Brody and Pelton 1989, Noss 2001). Similarly, high density roads in the winter range of deer and elk may reduce food availability for large predatory mammals (e.g., cougars) while simultaneously increasing the potential for mortality of all large mammals as a result of non-hunting conflicts with humans (ODFW 2006).

*Changes in Precipitation Timing, Frequency and Intensity*

*In the future, precipitation in coastal Oregon is expected to remain a predominately wintertime phenomenon (i.e., most precipitation will continue to occur in the winter). However, the extent to which precipitation timing, frequency and intensity on the Oregon coast may change remains uncertain. There is evidence that high-intensity storms are becoming more frequent, and that the frequency of weak to moderate-strength storms is declining.*

*Sources: Sharp 2012, OCCRI 2010, OSU 2005*

*Uncertainty in Predicting Local Effects of Climate Change*

*There is inherent uncertainty in predicting what the local effects of climate change are likely to be. The uncertainties generally fall into three categories: 1) Natural variability of the earth's climate; 2) Climate sensitivity (how the earth's climate system responds to increases in future greenhouse gas levels); and 3) Future greenhouse gas emissions.*

*To manage for these uncertainties, climate scientists use multiple models ("multi-model ensembles") that incorporate the estimated range of possible natural variability, climate sensitivity, and future greenhouse gas emission values when investigating climate-related change. The models typically generate a range of values for potential future air temperatures, ocean surface temperatures, sea level rise, etc., which naturally become increasingly variable the longer into the future the model is asked to predict. This approach gives communities a range of projections to consider when developing climate change vulnerability assessments and adaptation plans.*

*Sources: Sharp 2012, Hawkins and Sutton 2009*

**Shifting Geographic Distributions**

In Scandinavia, northern Canada, Colorado, Wyoming, and Montana, changes in wild ungulates' distribution in response to climatic variability are well-documented (Post and Stenseth 1999, Post et al. 1997, Inouye et al. 2000, Romme and Turner 1991, Wang et al. 2002). As mentioned above, changes in ungulate behavior may reflect climate-related changes in the growth patterns and reproductive timing of key forage plant species (Post and Stenseth 1999, Romme and Turner 1991). For example, changes in ungulate forage may affect the herd density and overall fitness of elk populations in Oregon (ODFW 2008), which in turn affect elk herd fecundity (reproductive success) since elk herd fecundity has been shown to be influenced by herd density (Stuart et al. 2005).

Similar to ungulates, there is some evidence to suggest that the North American beaver populations (*Castor canadensis*) are also likely to shift their ranges in response to climate-related changes. Research from Canada shows that beaver density is highly variable in response to increasing temperatures in southern Québec (Jarema et al. 2009).

Climate change may produce other important habitat modifications that could influence beaver population ranges in the Pacific Northwest. For example, some of the region's coastal freshwater marshes and swamps are expected to become more saline due to the intrusion of seawater as sea level rise continues (Glick et al. 2007, Scavia et al. 2002). Although there is currently no research about the potential effects of sea level rise on beaver populations (and specifically populations in the Coos estuary), it's possible that the slow conversion of freshwater to brackish habitats could result in the redistribution of beaver populations as key habitat features change (e.g., availability of food and materials for building structures). It should be noted that beavers currently inhabit brackish marshes in South Slough and the Coos estuary, so the extent to which salt water intrusion will affect beaver distributions will need to be monitored.

**Diseases and Parasites**

In recent years, diseases and parasites (especially Deer Hair Loss Syndrome and Adenovirus Hemorrhagic Disease) have resulted in the decline of deer populations in western Oregon (ODFW 2008; S. Love pers. comm., April 29, 2015). Hoberg et al. (2008) explains that temperature increases associated with climate change have "a substantial influence on the spatial and temporal distribution of pathogens and the emergence of disease [in wild ungulates]." In Oregon, the range of diseases and parasites, including the lice which contribute to Deer Hair Loss Syndrome, is likely to expand as climate change continues (ODFW 2008). However, the exact response of pathogens to climate change is likely to vary (Hoberg et al. 2008).

**Role of Beaver Structures in Climate Change**

A team of researchers in Colorado has recently discovered the importance of active beaver colonies in carbon sequestration (see sidebar). Wohl et al. (2012) estimate that although environments closely associated with beaver activity (i.e., low-gradient, broad valley bottoms with floodplains dominated by sediment and coarse wood) represent only 25% of mountain headwater habitats in Rocky Mountain National Park, they store about 75% of the system's total carbon. Since habitat "manufactured" by beavers appears to be an important carbon sink, it's possible that beaver activity may help to mitigate the effects of climate change by preventing greenhouse gases from entering the atmosphere and accelerating warming trends. However, beaver ponds are also sources of greenhouse gas emissions (carbon dioxide, methane and nitrous oxide gases)(Hauser 1999, Welsh 2013). More research is needed to determine the extent to which beaver ponds are net sinks or sources of carbon.

In-stream beaver structures trap and accumulate sediment, reduce stream velocities, and change the hydrologic characteristics of the surrounding environment (Butler and Malanson 2005). In some cases, beaver activity in the Coos estuary is known to promote the recruitment of a few non-native (and potentially invasive) plant species, including velvet grass (*Holcus lanatus*), trefoil (*Lotus corniculatus*), and reed canary grass (*Phalaris arundinacea*) (Cornu 2005). The failure of beaver dams and subsequent drainage of beaver ponds create unvegetated bare patches in marshes which invasive plants can colonize and ultimately dominate. If climate change results in conditions that cause increased numbers of abandoned beaver dams, it's possible the distribution of invasive vegetation will increase in project area freshwater marshes.

*Carbon Sequestration in Coastal Estuaries*

*Vegetated tidal wetlands, including emergent marshes, forested and scrub-shrub swamps, and seagrass beds, play an important role in the global carbon cycle by sequestering carbon dioxide from the atmosphere continuously over many growing seasons, building stores of carbon in wetland soils high in organic content. Thus, wetlands that store carbon mitigate carbon dioxide emissions into the atmosphere and moderate climate change.*

*Source: Crooks et al. 2014*

**References**


Aanes, R., and R. Andersen. 1996.The effects of sex, time of birth, and habitat on the vulnerability of roe deer fawns to red fox predation. Canadian Journal of Zoology 74:1857-1865.

Andersen, R. 1989. Interactions between a generalist herbivore, the moose *Alces alces*, and its winter food resources: a study of behavioural variation. Dissertation, University of Trondheim, Trondheim, Norway.

Brody, A. J., and M. P. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. Wildlife Society Bulletin 17:5-10.

Butler, D. R., and G.P. Malanson. 2005. The geomorphic influences of beaver dams and failures of beaver dams. Geomorphology, 71(1), 48-60.

Canon, S.K., and E.C. Bryant. 1997. Bed-site characteristics of pronghorn fawns. Journal of Wildlife Management 61:1134-1141.

Chmura, D. J., P. D. Anderson, G. T. Howe, C. A. Harrington, J. E. Halofsky, D. L. Peterson, D. C. Shaw, and B. J. St. Clair. 2011. "Forest Responses to Climate Change in the Northwestern United States: Ecophysiological Foundations for Adaptive Management." Forest Ecology and Management 261 (7): 1121-1142.

Cornu, C.E. 2005. Restoring Cox, Dalton, and Fredrickson Creek Marshes. South Slough NERR Coastal Resource Management Series. CRMS-2005-2. Coos Bay, Oregon.

Crooks, S., J. Rybczyk, K. O'Connell, D. L. Devier, K. Poppe, and S. Emmett-Mattox. 2014. Coastal Blue Carbon Opportunity Assessment for the Snohomish Estuary: The Climate Benefits of Estuary Restoration. Report by Environmental Science Associates, Western Washington University, EarthCorps, and Restore America's Estuaries. February 2014.

Dalton, M. M., P. W. Mote, and A. K. Snover [Eds.]. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Washington, DC: Island Press.

Glick, P., J. Clough, and B. Nunley. 2007. "Sea-Level Rise and Coastal Habitats in the Pacific Northwest." National Wildlife Federation, Seattle, WA.

Goldsmith, A.E. 1990. Vigilance behavior of pronghorns in different habitats. Journal of Mammalogy 71:460-462

Hauser, R. 1999. Boreal Ecosystems Atmosphere Study. Online article accessed May 2015 at http://earthobservatory.nasa.gov/Features/SilvusBorealis/

Hawkins, E. and R. Sutton. 2009. The potential to narrow uncertainty in regional climate predictions, Bulletin of the American Meteorological Society (BAMS) 90, 1095-1107, doi:10.1175/2009BAMS2607.1

Hirth, D.H. 1977. Social behavior of white-tailed deer in relation to habitat. Wildlife Monographs 52:1-55.

Hoberg, E. P., L. Polley, E.J. Jenkins and S. J. Kutz. 2008. Pathogens of domestic and free-ranging ungulates: global climate change in temperate to boreal latitudes across North America. Rev Sci Tech OIE, 27, 511-528.

Inouye, D. W., B. Barr, K. B. Armitage, and B. D. Inouye. 2000. Climate change is affecting altitudinal migrants and hibernating species. Proceedings of the National Academy of Sciences, 97(4), 1630-1633.

Jarema, S. I., J. Samson, B. J. McGill, and M. M. Humphries. 2009. Variation in abundance across a species' range predicts climate change responses in the range interior will exceed those at the edge: a case study with North American beaver. Global Change Biology, 15(2), 508-522.

Jedrzejewska, B. H. Okarma, W. Jedrzejewki, and L. Milkowski. 1994. Effects of exploitation and protection on forest structure, ungulate density and wolf predation in Bialowieza Primeval Forest, Poland. Journal of Applied Ecology 31:664-676.

Lagory, K.E. 1986. Habitat, group size, and the behaviour of white-tailed deer. Behaviour 98:168-179.

Lagory, K.E. 1987. The influence of habitat and group characteristics on the alarm and flight response of white-tailed deer. Animal Behaviour 35:20-25.

Linnell, J.D., R. Aanes, and R. Andersen. 1995. Who killed Bambi? The role of predation in neonatal mortality of temperate ungulates. Wildlife Biology 1:209-223.

Mysterud, Atle, and Eivind Ostbye. 1999. Cover as Habitat Element for Temperate Ungulates: Effects on Habitat Selection and Demography. Wildlife Society Bulletin. 27(2): 385-394.

Noss, Reed F. 2001. Beyond Kyoto: Forest Management in a Time of Rapid Climate Change. Conservation Biology. 15(3): 578-590.

Oregon Climate Change Research Institute (OCCRI). 2010. “Chapter 6. Impacts of Climate Change on Oregon’s Coasts and Estuaries”, in Oregon Climate Assessment Report. K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR.

Oregon Department of Fish and Wildlife (ODFW). 2006. Oregon Cougar Management Plan. Accessed 29 April 2015 from http://www.dfw.state.or.us/wildlife/docs/oregon_black-tailed_deer_management_plan.pdf

Oregon Department of Fish and Wildlife (ODFW). 2008. Oregon Black-Tailed Deer Management Plan. Accessed 29 April 2015 from http://www.dfw.state.or.us/wildlife/docs/oregon_black-tailed_deer_management_plan.pdf

Oregon State University (OSU). 2005. Scientific Consensus Statement on the Likely Impacts of Climate Change on the Pacific Northwest. Unpublished report no. 2004-3. Corvallis OR. Retrieved from: http://ir.library.oregonstate.edu/jspui/handle/1957/113

Post, E., N.C. Stenseth, R. Langvatn, J.M. and Fromentin. 1997. Global climate change and phenotypic variation among red deer cohorts. Proceedings of the Royal Society of London. Series B: Biological Sciences, 264(1386), 1317-1324.

Post, E., and N.C. Stenseth. 1999. Climatic variability, plant phenology, and northern ungulates. Ecology, 80(4), 1322-1339.

Putman, R.J., J. Langbein, and A.J. M. Hewison, and S.K. Sharma. 1996. Relative roles of density-dependent and density-independent factors in population dynamics of British deer. Mammal Review 26:81-101.

Romme, William H. and Monica G. Turner. 1991. Implications of Global Climate Change for Biogeographic Patterns in the Greater Yellowstone Ecosystem. Conservation Biology. 5(3): 373-386.

Scavia, D., J. C. Field, D. F. Boesch, R. W. Buddemeier, V. Burkett, D. R. Cayan, and J. G. Titus. 2002. Climate change impacts on US coastal and marine ecosystems. Estuaries, 25(2), 149-164.

Sharp, D. 2012. Climate Change and the Lower Coquille Watershed. Unpublished report. Oregon Climate Change Research Institute/EcoAdapt. Retrieved from: http://ecoadapt.org/programs/awareness-to-action/Lower-Coquille-Vulnerability-Project

Stewart, K. M., R.T. Bowyer, B.L. Dick, B.K. Johnson, and J.G. Kie. 2005. Density-dependent effects on physical condition and reproduction in North American elk: an experimental test. Oecologia, 143(1), 85-93.

Wang, G., N. T. Hobbs, F. J. Singer, D. S. Ojima, and B. C. Lubow. (2002). Impacts of climate changes on elk population dynamics in Rocky Mountain National Park, Colorado, USA. Climatic Change, 54(1-2), 205-223.

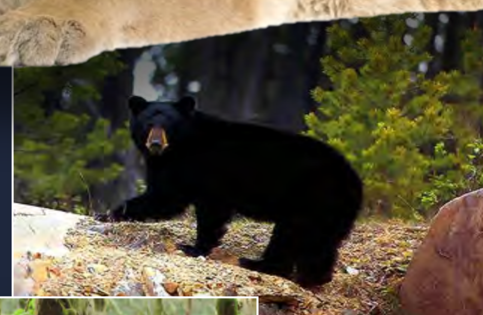
Welsh, M. 2013. Exploring greenhouse gas emissions from beaver ponds in southern Rhode Island. Sr. Honors project. University of Rhode Island. http://digitalcommons.uri.edu/srhonorsprog/328/

Wohl, E., K. Dwire, N. Sutfin, L. Polvi, and R. Bazan. 2012. Mechanisms of carbon storage in mountainous headwater rivers, Nature Communications, 3, 1263, doi:10.1038/ncomms2274.

# Large Mammals in the Lower Coos Watershed


*Summary:*

- *The exact number of large mammals in the project area is unknown, but statewide abundance trends are apparent.*
- *Local elk populations are likely stable and may even be increasing. They exceed management objectives that are designed to protect elk while providing quality hunting opportunities.*
- *Disease and habitat loss are likely the drivers of declining deer populations across the state.*
- *Oregon's cougar population has recovered from near extinction in the 1960s.*

Photos:
Cougar: **ODFW**
Bear: **Brian Wolitski**
Elk: **Vickie Lewis**

**Evaluation**

Available data suggest that Roosevelt elk populations are generally increasing within the project area.

**Evaluation**

Available data suggest black tailed deer populations may be declining at the state level due to habitat loss and disease.

**Evaluation**

More information is needed to evaluate the status of bear populations in the project area.

**DATA GAP**

**Evaluation**

More information is needed to evaluate the status of cougar populations in the project area.

**DATA GAP**

**What's happening?**

This data summary focuses on population trends of large mammals within the project area, habitat immediately adjacent to the project area boundary (i.e., < 20 miles), and statewide. These species include Roosevelt elk (*Cervus canadensis roosevelti*), black-tailed deer (*Odocoileus hemionus columbianus*), black bear (*Ursus americanus*), and cougar (*Puma concolor*). Although other deer and elk species such as the Rocky Mountain Elk (*Cervus canadensis nelsoni*) and mule deer (*Odocoileus hemionus*) occur elsewhere in Oregon (e.g., central and eastern Oregon), they are not discussed extensively in this data summary. Where possible, data are presented for each Game Management Unit (Figure 2). However, due to the limitations of survey methods, data are often available only on a statewide scale (see Chapter Summary for data limitations).

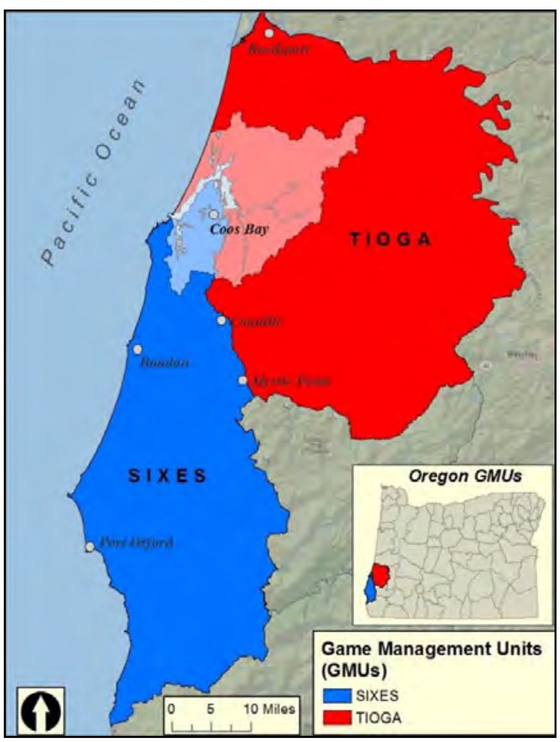



Figure 2. Game Management Units in proximity to the project area (white). The project area contains part of both the Sixes (blue) and the Tioga (red) GMU. Data: ODFW 2010.

<u>Elk and Deer</u>

The Oregon Department of Fish and Wildlife (ODFW) conducts annual surveys of both elk and deer in the Game Management Units (GMUs or Units) across the state (Figure 2). The purpose of these surveys is to generate both herd composition and population trend data (see sidebar).

Elk population estimates suggest that herds statewide appear to be stable and even increasing from the 1970s to 2001 (Figure 3) (ODFW 2003a). More recent data indicate that this trend has continued since 1991 (Figure 4)(Oregon Forest Resources Institute 2013). Elk population trend data suggest that herds in proximity to the project area exceed (Sixes) or nearly meet (Tioga) their total pop-

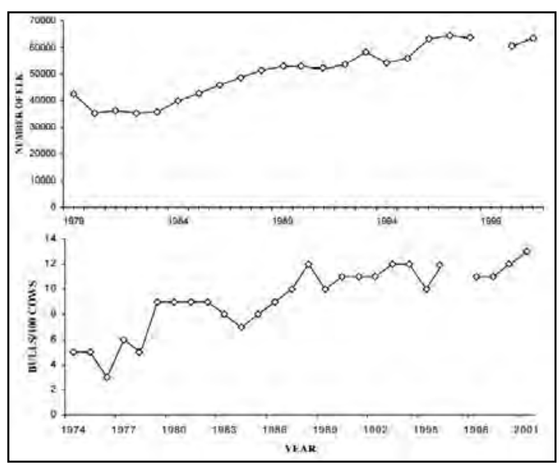



Figure 3. Statewide elk population trend (top) and post-hunting season bull elk ratio (bottom) from the mid-to-late 1970s to 2001 show a general trend of increasing abundance. Figure modified from: ODFW 2003a.

*Monitoring and Managing Deer and Elk Populations*

*As a supplement to total population estimates, wildlife managers collect herd composition data, which are used to assess the status and demographic trends in deer and elk populations. For example, demographic data are commonly used to calculate the "buck ratio" or "bull ratio" (i.e., ratio of males per 100 females) as well as the ratio of juveniles to females. These indicators are particularly useful to wildlife managers, because they can be used to estimate determinants of herd size, including the overwinter survival of juveniles and adult "escapement" (i.e., number of deer and elk surviving hunting season). A well-informed understanding of herd demographics helps wildlife managers maintain the proper mix of males to females, which allows for quality recreational opportunities while insuring that deer and elk populations reach their full reproductive potential.*

*Sources: S. Love, pers. comm., April 29, 2015; Bender 2006; ODFW 2008*

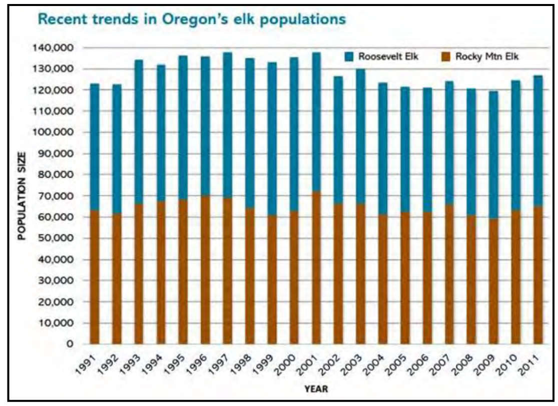



Figure 4. The historic (1970-2000) trend of stable or generally increasing elk populations statewide has continued in the most recent decade. Rocky Mountain elk (*Cervus Canadensis nelsoni*) is a distinct subspecies of elk that does not occur in the project area. Figure: Oregon Forest Resources Institute 2013.

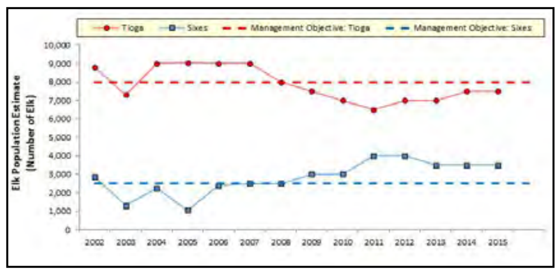



Figure 5. Populations trend data (2002-2015) in the Tioga (red) and Sixes (blue) Units shown relative to the management objectives (dashed) for each GMU. Management Objectives vary by GMU, because hunting regulations are different in the Tioga Unit than they are in the Sixes Unit. Data: ODFW 2015b.

ulation management objectives (Figure 5). Herd composition data for both the Tioga and Sixes unit show that bull ratios have met their management objectives for over 20 years and suggest that local populations are likely increasing (Figure 6)(ODFW 2015b). It's important to note the bull ratio data (Figure 6) are a much more reliable indicator of overall population trends than the data presented in Figure 5 (See Chapter Summary for data limitations)(S. Love, pers. comm., April 29, 2015).

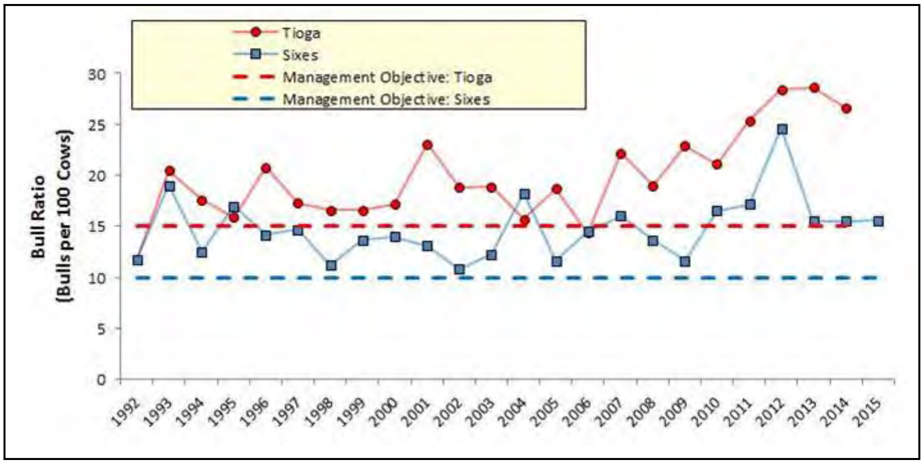



Figure 6. Bull ratio of elk populations (2004-2015) in the Tioga (red) and Sixes (blue) Units shown relative to the management objectives (dashed) for each GMU. Management Objectives vary by GMU, because hunting regulations differ between the two Units. Data: ODFW 2015b

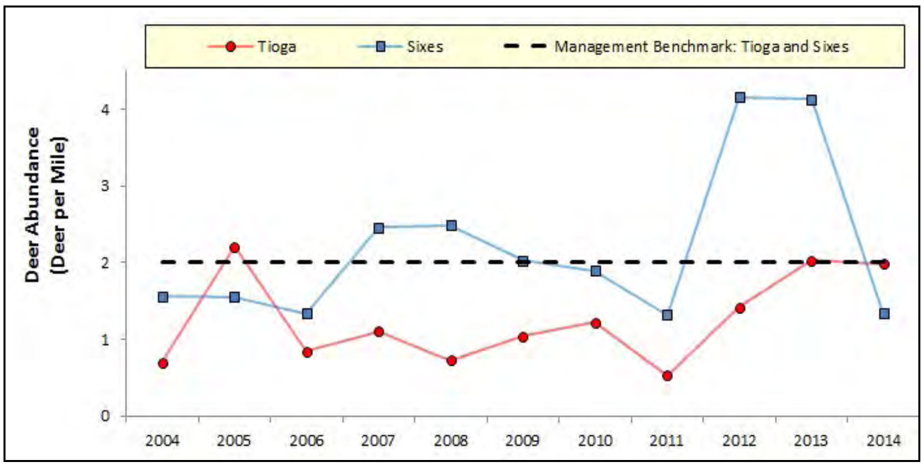



Figure 7. Deer densities (2004-2104) in the Tioga (red) and Sixes (blue) Units shown relative to the general management benchmark (dashed). Data are deer per linear mile. Data: ODFW 2015b.

Black-tailed deer populations have declined across the state in recent decades. ODFW (2008) estimates that Oregon supported a population of approximately 452,000 black-tailed deer statewide in 1979. Although Oregon's black-tailed deer population varied between 4-500,000 deer from 1979-1989, researchers have documented a clearly declining trend across Oregon throughout the 1990s, resulting in statewide population estimates as low as 320,000 deer in 2004 (ODFW 2008). Despite a trend of general decline, it appears that some herds may be increasing in areas with adequate resource availability, and although the western Oregon deer population is still low, buck ratios met their 2013 benchmarks in most GMUs (Oregon Forest Resources Institute 2013, ODFW 2014). ODFW (2014) reports that deer populations in Coos County "appear to be stable" with some indication that deer are becoming more abundant in parts of the Sixes and Tioga Units. Unlike elk (for which specific management objectives have been set), deer management is guided by more general "benchmarks" (S. Love, pers. comm., April 29, 2015). In both the Tioga and Sixes Unit, wildlife managers attempt to maintain an average density of approximately 2 deer per linear mile in both the Tioga and Sixes Unit (Figure 7).

Bears

Bear populations appear to be stable and even increasing throughout their range (ODFW 2012). Estimates indicate that the North American population of bears has increased substantially over the last decade and is currently between 750,000-918,000 bears (Pelton 2000, Herrero et al. 2011, ODFW 2012). Bears have also become increasingly abundant in Oregon. Historic estimates suggest that Oregon supported approximately 9,000 bears in the 1930s (Bailey 1936). By the 1980s, the estimated size of the Oregon bear population had approximately doubled to reach 18,000 bears (ODFW 1987). This trend has continued in recent decades with the bear population reaching 25,000 in the 1990s and remaining between 25-35,000 statewide in the 2000s. (ODFW 1993, ODFW n.d.a.). Due to the limitations of survey methods, bear population estimates are not available for individual GMUs (see Chapter Summary for data limitations).

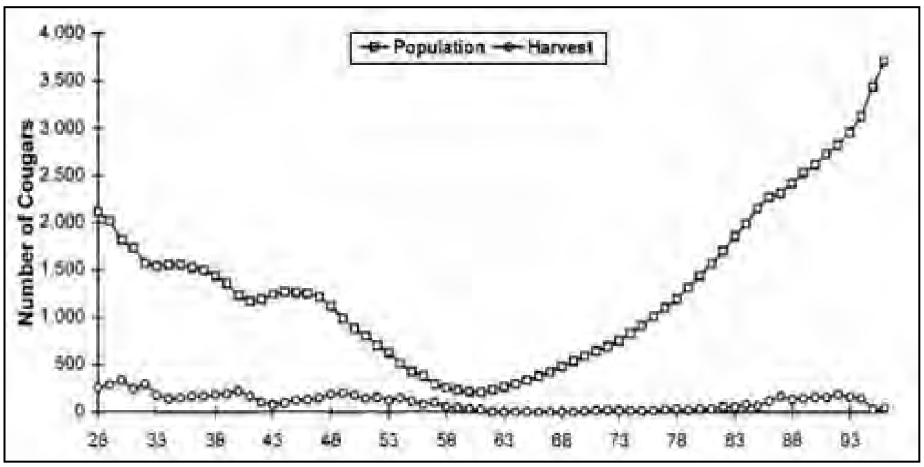



Figure 8. Oregon cougar population, as determined from simulation modeling and harvest, 1929-1992. Cougars were bountied until 1961. The season was closed until 1970 when limited hunting began. Caption and Figure: Keister and Van Dyke 2002

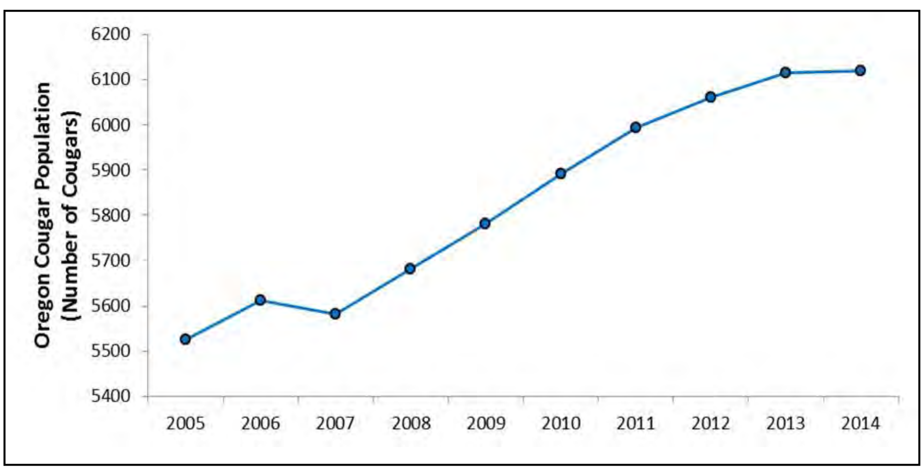



Figure 9. Population modeling suggests that cougars are becoming more abundant in recent years (2005-2014). Currently, Oregon supports over 6,000 cougars. Data: ODFW 2015b

Cougars

The historic range of cougars is one of the most extensive of any North American wildlife species (Nowak 1999). Despite their historic abundance, Oregon's cougar population declined dramatically through the first half of the 20th century largely as a result of bounty hunting programs (see Why is it happening?). By 1960, an estimated population of only 200 cougars remained statewide (ODFW 2006).

Since the 1960s, cougar populations have recovered, expanding their range and becoming more abundant in Oregon (Keister and Van Dyke 2002, ODFW 2006)(Figure 8), a trend which has continued in recent years. Researchers estimate that Oregon currently hosts a cougar population of over 6,000 animals statewide (Figure 9)(ODFW 2015b, n.d.b.). Due to the limitations of survey methods, cougar population estimates are not available for individual GMUs (see Chapter Summary for data limitations).

**Why is it happening?**

The abundance and distribution of large mammals is determined by the complex interaction of a number of factors, including predator-prey relationships, disease and parasites, human dimensions (i.e., both hunting and non-hunting factors such as livestock damage, human/pet safety, and vehicle collisions), and habitat availability.

Predation

The population distribution and abundance of cougars, bears, deer, and elk are all directly related (Cougar Management Guidelines Working Group 2005, Neal et al. 1987, White et al. 2010, Yarkovich et al. 2011). Deer and elk populations are affected by predation from both cougars (Neal et al. 1987) and bears (White et al. 2010, Yarkovich et al. 2011). Although cougars prey on a variety of species, it's universally accepted that deer are their primary food staple even when other prey species (e.g., elk, pronghorn, and big horn sheep) are available (Ackerman et al. 1984, Anderson 1983, Robinette et al. 1959, Cashman et al. 1992, Beier and Barrett 1993, Logan et al. 1996, ODFW 2006). The amount of prey consumed by a cougar depends on the characteristics of each animal, including the cougar's sex, age, size, and reproductive status, as well as weather conditions and competition/scavenging by other species (e.g., bears, birds, and coyotes)(Iriarte et al. 1990, ODFW 2006).

High cougar predation rates reduce the size of deer and elk populations. Sustained predation of small deer populations may jeopardize their ability to persist, particularly when high predation rates overlap with other stressors (e.g., harsh winter conditions or habitat loss) (Neal et al. 1987). In addition to cougar predation, deer fawns are consumed by coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and bear (Pamplin 2003). In rare cases, deer have also been killed by domestic dogs (ODFW 2008).

Diseases and Parasites

Oregon deer and elk populations are vulnerable to a number of diseases and parasites, including Deer Hair Loss Syndrome (DHLS), Adenovirus Hemorrhagic Disease (AHD), and Chronic Wasting Disease (CWD)(see sidebar). DHLS appears to occur in deer throughout western Oregon and the prevalence of DHLS varies widely (from 2-46% of deer sampled) by GMU (ODFW 2006). Recent data show that DHLS is currently affecting deer in both the Tioga Unit (27% of deer sampled) and Sixes Unit (12% of deer sampled)(ODFW 2015b). From 2003-2005 alone, ODFW (2006) documented 153 AHD-positive deer and 2 AHD-positive elk occurring in 21 GMUs across the state, including the Tioga Unit (Figure 10). CWD has been prevalent in Colorado and Wyoming since the 1990s, but it has not been documented in Oregon; wildlife managers continue monitoring deer and elk populations across the state for the presence of CWD (ODFW 2008; S. Love, pers. comm., April 29, 2015).

Bears are exposed to a number of pathogens, including bacterial (brucellosis, plague, Salmon Poisoning Disease), viral (infectious canine hepatitis, parvovirus), fungal, and parasitic diseases (Trichinella, Giardia, tapeworms, and ectoparasites such as ticks and fleas)(Samuel et al. 2001, ODFW 2012). ODFW (2012) reports that parasites are the most commonly observed pathogens in Oregon bears. They add that, "while there is no evidence to suggest that parasites are a significant cause of mortality in bears… [some parasites found in bears] may present a public health risk for

*Diseases in Black-tailed Deer*

*Deer Hair Loss Syndrome (DHLS) results from an abnormally heavy infestation of parasitic lice. First documented in Washington in 1996, the disease has since moved south, affecting deer populations in western Oregon and northern California. DHLS produces hair discoloration, hair loss, weight loss, diarrhea, and lethargy; it can result in death, primarily from exposure. Although the louse has been detected on elk in southwestern Oregon, DHLS has not affected them.*

*Adenovirus Hemorrhagic Disease (AHD) is a viral infection causing rapid breathing, foaming at the mouth, diarrhea, weakness, ulcers, and ultimately death. First identified in California in 1994, the disease was first documented in SW Oregon in 2001.*

*Chronic Wasting Disease (CWD), present in Colorado and Wyoming for over 20 years, is a neurological disease that produces brain lesions in both deer and elk. Although no cases of CWD have been documented in Oregon, ODFW has been testing for the disease since 1996.*

*Sources: ODFW 2003b, 2008; S. Love, pers. comm., April 29, 2015*

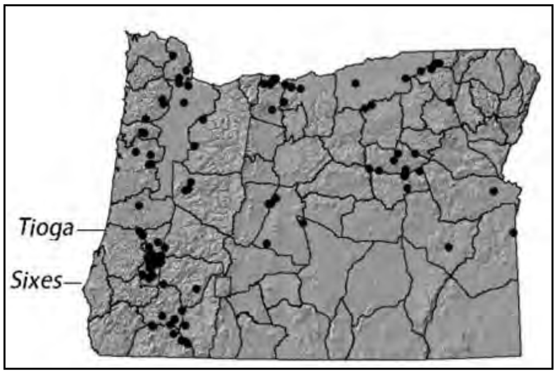



Figure 10. Location of serologically positive AHD samples collected from deer, elk, and captive reindeer in Oregon (2003-2005. Caption and Figure: ODFW 2006

humans." Salmon Poisoning Disease (SPD) is **specific to bears** in the Pacific Northwest. SPD is caused by a bacterium (*Nanophyetus salmincola*), which is carried by salmonids and can be transferred to bears upon consumption of an infected fish (ODFW 2012). Symptoms of SPD in bears includes lethargy, diarrhea, and anorexia (Rogers and Rogers 1976, Foreyt 2001). SPD may be fatal to bears, but there is no evidence to suggest that it poses a risk to humans (ODFW 2012).

Relatively little is known about diseases, parasites, and other pathogens in wild cougars. Many pathogens that are found in domestic cats may also be found in cougars, and there are rare, isolated instances of diseases appearing in Oregon cougars (ODFW 2006). Although several parasites have been documented in cougars throughout the northwest, ultimately very little is known about the effect of parasites in Oregon cougars (ODFW 2006).

Human Dimensions: Hunting

From 2003-2011, the deer hunting effort in the Tioga Unit has been sustained at high levels while deer harvest has decreased. During the same time period, hunting effort and harvest in the Sixes Unit has been consistent but at levels below those reported in the Tioga Unit. Figure 11 summarizes deer harvest and hunting effort for the two GMUs in the project area. Although local deer populations are affected by hunting, ODFW (2008) does not believe that deer harvest is a significant contributing factor to the decline of deer in Oregon. Rather, they attribute this decline primarily to habitat and disease issues, which are discussed in detail elsewhere in this data

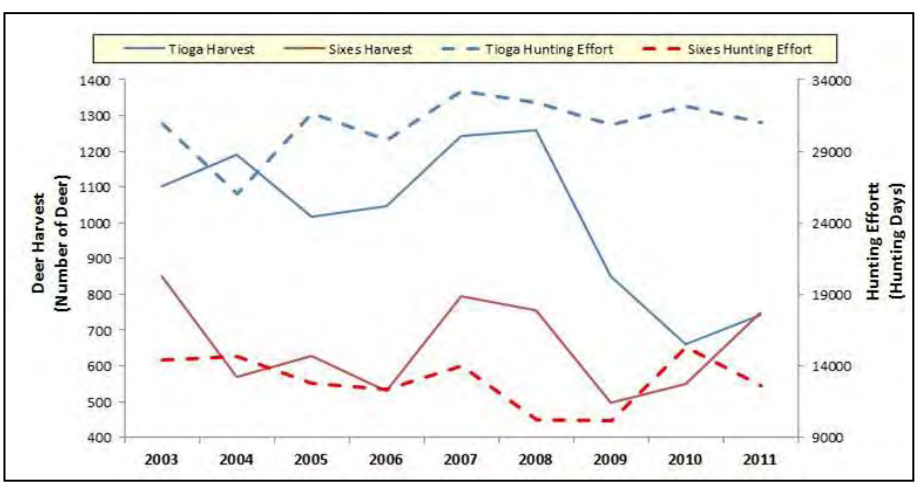



Figure 11. Deer harvest (solid) and hunting effort (dashed) in both the Tioga (blue) and Sixes (red) GMUs. Data: ODFW 2011.

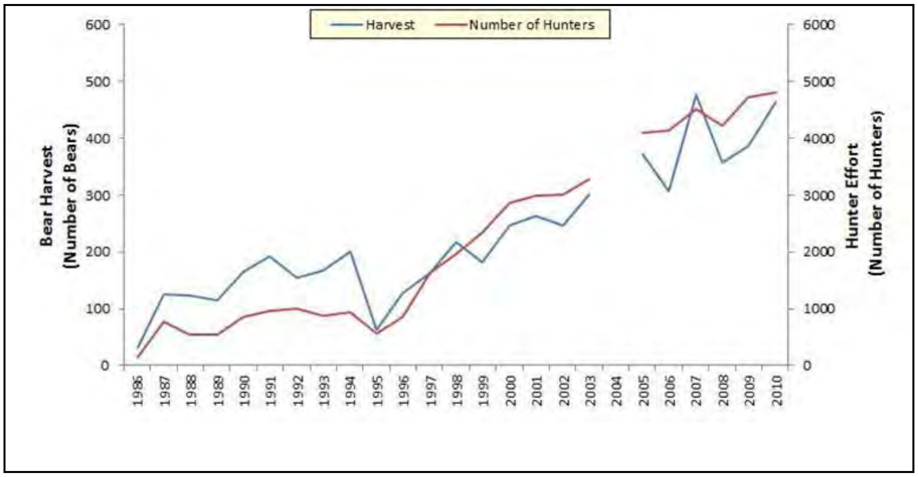



Figure 12. Bear harvest (blue) and hunting effort (red) in Oregon (1986-2010). Data: ODFW 2012

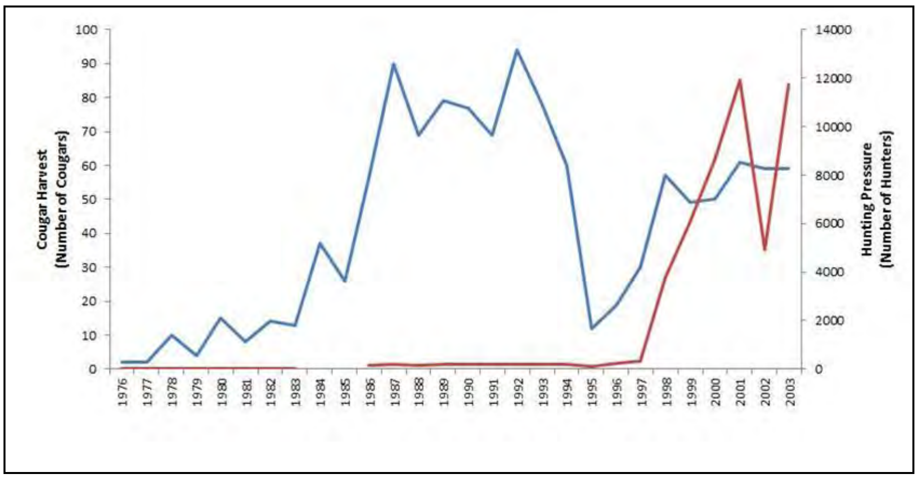



Figure 13. Cougar harvest (blue) and hunting effort (red) in Oregon (1976-2003). Generally, harvest has increased steadily since 1976 with the exception of a precipitous decline in 1994 following the prohibition of the use of dogs as cougar hunting aids in Oregon. Hunting participation ranged between approximately 20-30 hunters in the late-70s and early-80s. From 1986-1997, participation increased to approximately 150-200 hunters annually. The sharp increase in hunter participation beginning in the late 1990s likely reflects the availability of cougar tags, which increased dramatically during this same time. Data: ODFW 2006

summary (See Why is it happening?: Diseases and Parasites as well as Why is it happening?: Habitat).

Bear harvest in Oregon has increased steadily since the mid-1980s, with the exception of a sharp decline in 1994 when the use of dogs or bait for bear hunting was prohibited by law (Figure 12)(ODFW 2012). Hunting pressure on bears has also increased steadily over the past decades, with the total number of hunters increasing substantially while average effort per hunter (approximately 5-6 hunting days) has remained relatively unchanged from 1995 levels (ODFW 2012).

Cougar harvest for sport has been permitted under carefully regulated conditions since 1970 (Keister and Van Dyke 2002). Although some hunters specifically target cougars, most cougars are harvested by hunters (holding cougar tags) who encounter cougars by chance while hunting for other species (ODFW 2006). In western Oregon, cougar harvest has increased steadily over the past few decades coupled with substantial increases in hunting pressure beginning in the late 1990s (Figure 13). Due to their high reproductive potential and rapid growth, cougars are resilient to hunting pressure, especially if the harvest of adult females is carefully regulated (Anderson and Lindzey 2005, ODFW 2006).

The illegal harvest of large mammals is an on-going management concern in the state of Oregon. Unfortunately, the effects of poaching on deer, elk, bear, and cougar populations is difficult to determine, because the exact size of the illegal harvest is unknown.

<u>Human Dimensions: Non-hunting</u>

Although the exact amount of deer mortality from vehicle collisions in Oregon is unknown, it appears to be substantial in areas of western Oregon (Figure 14). For example, ODFW (2006) explains that 1,036 deer were removed from state highways and country roads in Jackson and Josephine Counties in 2005 alone. By comparison, they report that approximately 3,400 deer were harvested by hunters in these counties in the same year.

Most non-hunting conflicts between humans and bears in Oregon occur in rural and urban residential areas as well as recreational areas such as campgrounds. These encounters commonly occur in western Oregon and frequently involve food (ODFW 2012). To avoid these conflicts, Oregon law (ORS 469.731)


Figure 14. Heat map of Oregon Department of Transportation reported deer death (2007-2013) showing deer collision "hot spots" in Oregon. The size of the red dot indicates the number of reported deer fatalities, with large dots corresponding to more deer deaths. The most reported collisions in proximity to the project area during these years have occurred on highway OR-42. These data include only Oregon state highways and U.S. interstates. They are likely to underestimate the total number of deer mortalities from collisions, because many collisions with deer go unreported. Similarly, deer may not die immediately after collision in many cases. Data: ODOT 2014

prohibits knowingly placing food, garbage, or other attractants for bears. Human safety conflicts with bears are rare, and are typically related to bears that have been conditioned to human presence or human food sources (Herrero and Fleck 1990). ODFW (2012) began recording human safety conflicts involving bears in the 1980s. Since that time, they have recorded only 4 such conflicts statewide (none of which have resulted in human fatalities). However, the most recent of these conflicts occurred near Coos Bay in 2009, when a hunter approached a bear that was believed to be dead. The hunter survived with only a bite on the leg (ODFW 2012). Most conflicts are resolved by wildlife managers without the use of lethal force. Nevertheless, in rare circumstances, ODFW will euthanize bears that are in poor physical condition, have been


Figure 15. Number of cougars bountied annually in Oregon (1928-1961) Data and Caption: ODFW 2006

Figure 16. Cougar bounty hunters in British Columbia in the early 20th century. Cecil Smith (left) enjoyed some notoriety for his effectiveness as a cougar bounty hunter. Figure: KnowBC n.d.

habituated to human food, or cannot be captured safely (ODFW 2012). Increases in the frequency of bear conflicts may be related to management decisions (e.g., the prohibition of dogs as a bear hunting aid) or other factors (e.g., unseasonably cool and wet weather that can limit food availability)(ODFW 2012).

Historically, cougars were viewed as a direct predatory threat to the livestock industry and were harvested through bounty programs without regulation until the 1960s (Figures 15 and 16)(ODFW 2006). This practice resulted in dangerously low cougar numbers, which warranted legal protection by 1967 Oregon Legislature (Keister and Van Dyke 2002).

A 2002 public opinion poll of Oregonians in six southwest counties, including Coos County, shows that the traditional perception of cougars as a prominent predatory threat in Oregon has not changed. Although 64% of respondents agreed that “occasional contact with cougars should be accepted as part of living in the Pacific Northwest,” most Oregonians (75%) feel that they should have the right to kill a cougar they perceive as a threat “no matter what the government says” (Chinitz 2002). In recent years, non-hunting cougar mortalities have shown an increasing trend in Oregon (Figure 17). ODFW (2006) estimates that from 1987-1994 there were 186 cougar mortalities (23 mortalities/year) from livestock damage and human/pet safety alone. From 1995-2003, this number increased to 1,046 cougar mortalities (116 mortalities/year). In 2003, non-hunting mortality represented a substantial share (approximately 30-65%) of total annual cougar mortality statewide.

<u>Habitat</u>

Deer and elk rely on young forest habitats and commercial tree plantations as an important foraging resource (Figure 18)(Oregon Forest Resources Institute 2013, USDA n.d., ODFW 2006). The Oregon Forest Resources Institute (2013) explains that the passage of the Northwest Forest Plan (see sidebar) resulted in social, political, and legal mandates that limited harvest of late successional forests, but have also resulted in less early successional habitat on public lands. To reduce competition between conifer seedlings and other plants (e.g., grasses, forbs, and shrubs), managers

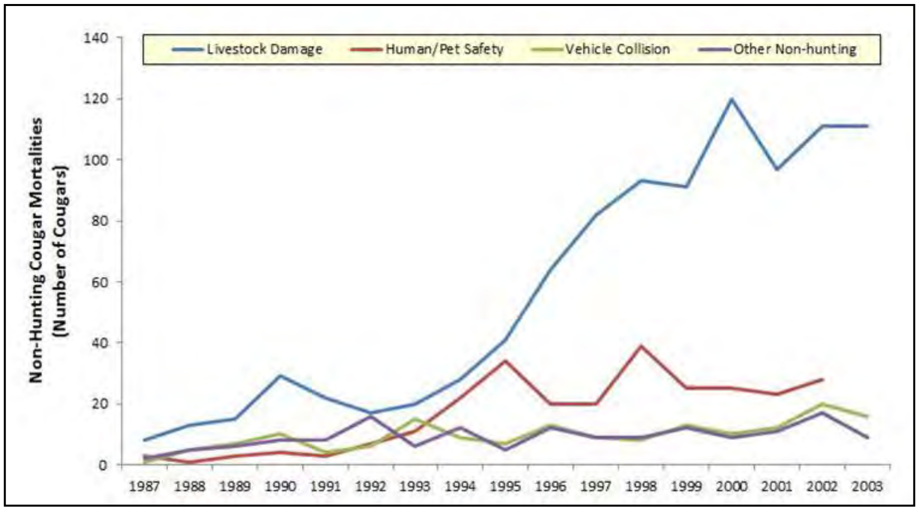



Figure 17. Non-hunting cougar mortality has been increasing statewide since the late 1980s, with the large majority of non-hunting mortality resulting from livestock damage. Data: ODFW 2006.

Figure 18. Deer and elk commonly browse planted seedlings in recently-reforested commercial tree plantations. Photo: Oregon Forest Research Institute 2013.

commonly apply herbicides to reforested areas for the first two years after timber harvest (Oregon Forest Resources Institute 2013). These practices may limit the suitability of deer, elk and bear foraging habitat in SW Oregon (S. Love, pers. comm., April 29, 2015; M. Vander Heyden, pers. comm., June 1, 2015), but the exact effects of these policies is under debate (OFRI 2013).

Forest management activities that adversely affect deer and elk may also affect cougar populations. Management practices that increase forage for prey species will also likely benefit cougars (ODFW 2006). Human development can affect cougars by increasing the potential for non-hunting conflicts and introducing high density roads in the winter range of deer and elk that may reduce prey availability (ODFW 2006). However, cougars are highly resilient to human disturbance (Anderson and Lindzey 2005, ODFW 2006).

**Background**

Only the Columbian black-tailed deer and Roosevelt elk occur within the project area (Figure 19). Oregon supports two additional deer species and one additional elk species. These are the mule deer (*Odocoileus hemionus*), white-tailed deer(*Odocoileus virginianus*), and Rocky Mountain elk (*Cervus canadensis nelsoni*). In addition, two subspecies of mule deer also occur in Oregon, including the Rocky Mountain mule deer (*Odocoileus hemionus hemious*) and the Columbian black-tailed deer (*Odocileus hemionus columbianus*).

*Northwest Forest Plan*

*In the late 1980s and early 1990s, a series of lawsuits effectively halted timber harvest in the Pacific Northwest. In response to this environmental crisis, President Clinton enacted the Forest Plan for a Sustainable Economy and Sustainable Environment, which mandated federal land managers and regulatory agencies to work together in developing a plan to resolve this conflict. This legislation brought sweeping changes to the management of forest in Oregon, Washington, and California and has since become known as the "Northwest Forest Plan" (NWFP).*

*Initially, the NWFP was intended to protect critical habitat within the range of the northern spotted owl (Strix occidentalis caurina). However, since its passage, the framework has been adapted to accommodate regional interagency monitoring of several additional resources, including federal-tribal relationships and the status and trends of watershed conditions, old-growth forests, socioeconomic conditions, and population and habitat for marbled murrelet.*

*Sources: USFWS 1997, Charnley et al. 2008, REO n.d., Raphael et al. 2011*

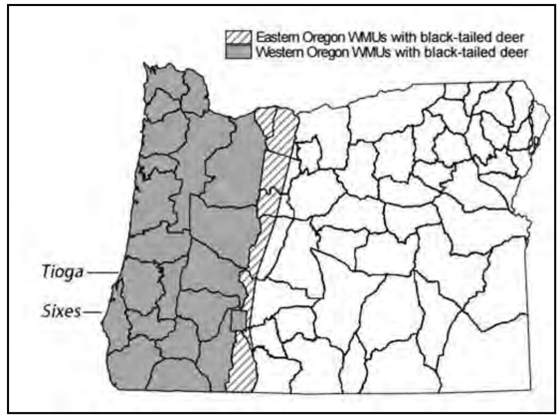



Figure 19. Range map showing the extent of black-tailed deer in Oregon. Although the range of Roosevelt elk in Oregon is not mapped, it corresponds to roughly the same area. Figure: ODFW 2008.

Deer and elk are herbivores, and rely on young forests for foraging habitat (Oregon Forest Resources Institute 2013, USDA n.d., ODFW 2006). However, unlike elk, which are able to process large volumes of poor quality forage, deer require high quality forage provided by plants that are actively growing (ODFW 2008). Although adult female and juvenile elk form herds, males (or "bulls") tend of be solitary most of the year (ODFW n.d.b.). Adult male deer (or "bucks") are also solitary, but, unlike elk, deer bucks do not herd groups of females during breeding (Link 2004).

The black bear is the only bear species in Oregon. Black bears occur in a wide range of habitats throughout Oregon, and are abundant in western Oregon, particularly in forests that combine understory vegetation food resources with concealment and escape cover (Figure 20)(Vander Heyden and Meslow 1999, ODFW 2012). Bears are omnivores that eat a variety of plants and animals, including berries, acorns, skunk cabbage, and other herbaceous plants as well as deer fawns, elk


Figure 20. Bear Distribution in Oregon Figure: ODFW 2012.

calves, carrion and insects (ODFW 2012; M. Vander Heyden, pers. comm., June 1, 2015). Although black bears hibernate from late fall to early spring, hibernation may not occur in the southern portion of their range, especially in coastal areas that have mild winter conditions (Hellgren and Vaughan 1989, Graber 1990, Hellgren et al. 1997).

Cougars occur throughout western Oregon and into parts of eastern Oregon, where their range is largely limited to the Ochoco, Blue, and Wallowa mountains (ODFW n.d.b.). The greatest cougar densities appear to be in the southwest and northeast portions of the state where deer and elk are also abundant (Figure 21)(ODFW 2006). Cougars are obligate carnivores that eat a variety of prey species but show clear preference for deer and elk (ODFW 2006). They are generally solitary animals active at all times of day and night and use caves as retreats (ODFW n.d.b.).

<u>Surveying Large Mammals</u>

Estimating the population of deer, elk, bears, and cougars is difficult due to the secretive life histories of these animals and the dense cover they inhabit (ODFW 2006, 2008). Consequently, wildlife managers commonly rely on alternatives to actual population counts (e.g., buck or bull ratios, damage reports, mark-recapture, etc.) to assess large mammal populations (ODFW 2008). These alternative metrics are used to inform management decisions, because, in many cases, they are more reliable than total population counts (S. Love, pers. comm., April 29, 2015).

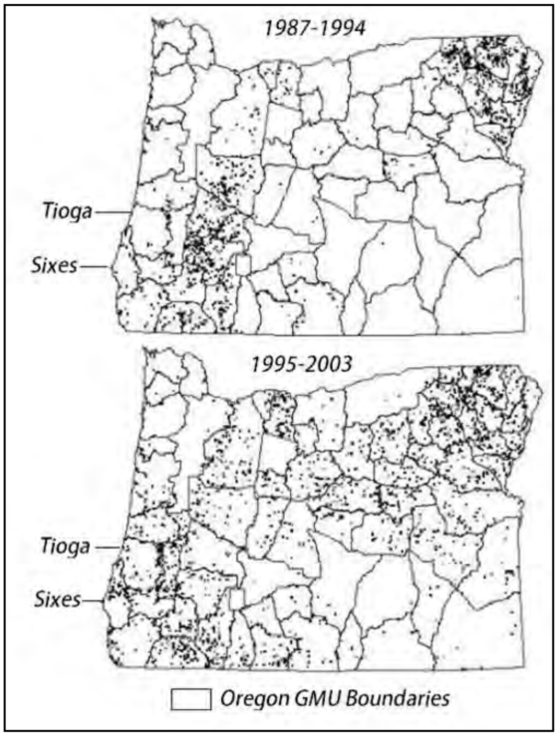



Figure 21. Approximate density of cougar populations in Oregon as shown by cougar mortalities (hunting and non-hunting) between 1987-1994 (top) and 1995-2003 (bottom). Figure: ODFW 2006

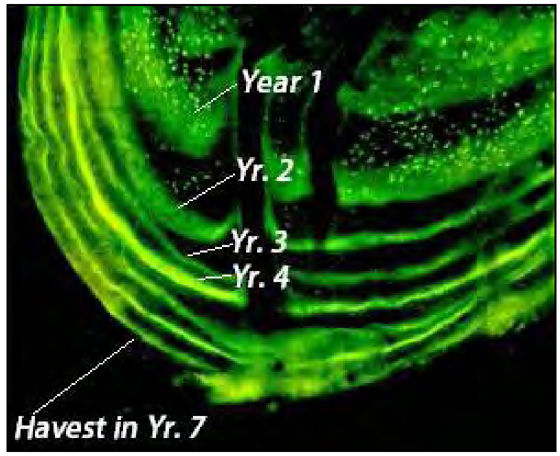



Figure 22. Biomarkers leave a stain on bears' tooth, which fluoresces under a special light. Using a microscope, biologists are able to determine the age of a bear at the time it consumes the biomarker and calculate the year the bait was ingested. The bright florescent annular ring in the example above indicates that a biomarker was consumed 3 years prior to harvest. A second florescent ring (unmarked in yr. 6) shows the consumption of an additional marker the year before harvest. Although bears may consume multiple biomarkers throughout their lifetime, it is unlikely that they will consume more than one annually due to the large distance between baits.

For deer and elk, population data are gathered using a variety of methods, including spotlighting or ground surveying, pellet group survey (i.e., collection of droppings along a transect), or aerial surveys (Bender n.d.). ODFW surveys for bears using a mark-recapture method in which bears ingest bacon baits that contain a benign "biomarker" that stains bear teeth. Since bear teeth grow continuously, putting on a new annular ring each year much like a tree does, biologists are able to "back-calculate" the date of biomarker consumption from teeth collected from harvested bears (Figure 22)(S. Love, pers. comm., April 29, 2015). However, due to the time it takes to harvest bears and process these data, bear population estimates lag by 2 years (S. Love, pers. comm., April 29, 2015). Similar to deer and elk, cougars surveys make use of scat collection data (ODFW 2015a)

**References**

Ackerman, B. B., F. G. Lindzey, and T. P. Hemker. 1984. Cougar food habits in southern Utah. Journal of Wildlife Management. 48:147-155.

Anderson. A. E. 1983. A critical review of literature on puma (*Felis concolor*). Colorado Div. Wildl. Spec. Rep. No. 54. Ft. Collins, Colorado, USA. 91 pp

Anderson, C.R., and F.G. Lindzey. 2005. Experimental evaluation of population trend and harvest composition in a Wyoming cougar population. Wildlife Society Bulletin 33(1):179- 188.

Bailey, V. 1936. The mammals and life zones of Oregon. North American Fauna No. 5. U.S. Government Printing Office, Washington, D.C

Beier, P. and R. Barrett. 1993. The cougar in the Santa Ana Mountain Range, California. Final report to California Department of Fish and Game, University of California, Berkeley, California, USA. 105 pp.

Bender, Louis C. 2006. Uses of Herd Composition and Age Ratios in Ungulate Management. Wildlife Society Bulletin. 34(4): 125-1230.

Bender, Louis C. n.d. Guidelines for Monitoring Elk and Mule Deer Numbers in New Mexico. [Publication from the College of Agricultural, Consumer, and Environmental Sciences of New Mexico Univ.]. Accessed 02 May 2015 from http://aces.nmsu.edu/pubs/_circulars/CR664.pdf

Cashman, J. L., M. Pierce, and P. R. Krausman. 1992. Diets of mountain lions in southwestern Arizona. Southwest Naturalist. 37: 324-326

Charnley, Susan, Candace Dillingham, Claudia Stuart, Cassandra Moseley, and Ellen Donoghue. 2008. Northwest Forest Plan-The First 10 Years (1994-2003): Socioeconomic Monitoring of the Klamath National Forest and Three Local Communities. Accessed 08 October 2014 from http://www.fs.fed.us/pnw/pubs/pnw_gtr764.pdf

Chinitz, A.E. 2002. Laying the groundwork for public participation in cougar management: a case study of southwestern Oregon (*Puma concolor*). M.S. Thesis, Univ. Oregon, Eugene, Oregon, USA. 158 pp.

Cougar Management Guidelines Working Group. 2005. Cougar Management Guidelines. WildFutures, Bainbridge Island, Washington, USA. 77 pp.

Foreyt, W. J. 2001. Salmon poisoning disease. Pages 480–486 in Samuel, W. M., M. J. Pybus, and A. A. Kocan, editors. Parasitic diseases of wild mammals, second edition. Iowa State Press, Ames, IA.

Graber, D. M. 1990. Winter behavior of black bears in the Sierra Nevada, California. International Conference on Bear Research and Management 8:269–272

Hellgren, E. C., and M. R. Vaughan. 1989. Denning ecology of black bears in a southeastern wetland. Journal of Wildlife Management 53:347–353.

Hellgren, E. C., D. S. Maehr, and D. L. Doan-Crider. 1997. Serum chemistry of southern populations of black bears (*Ursus americanus*). American Midland Naturalist 137:95–105

Herrero, S., and S. Fleck. 1990. Injury to people inflicted by black, grizzly or polar bears: recent trends and new insights. International Conference on Bear Research and Management 8:25–32.

Herrero, S., A. Higgins, J. E. Cardoza, L. I. Hajduk, and T. S. Smith. 2011. Fatal attacks by American black bear on people: 1900–2009. Journal of Wildlife Management 75:596– 603.

Iriarte, J.A., W. L. Franklin, W. E. Johnson and K. H Redford. 1990. Biogeographic variation of food habits and body size of the America puma. Oecologia 85: 185–190.

Keister, G. P. Jr. and W. A. Van Dyke. 2002. A predictive population model for cougars in Oregon. Northwest Science. 76(1):15-25.

KnowBC.com. n.d. Cecil Smith, Famed Vancouver Island Cougar Hunter. [Historic photo from KnowBC, an online encyclopedia published by Harbour Publishing]. Accessed 30 April 2015 from http://knowbc.com/limited/Books/Encyclopedia-of-BC/S/Smith-Cecil-Cougar

Link, Russell. 2004. Living with Wildlife in the Pacific Northwest. University of Washington Press. 350 pp.

Logan, K. A., L. L. Sweanor, T. K. Ruth, and M. G. Hornocker. 1996. Cougars of the San Andres Mountains, New Mexico. Final Report, Federal Aid in Wildlife Restoration, W– 128–R. New Mexico Department of Game and Fish, Santa Fe, New Mexico, USA. 280 pp.

Neal, D. L., G. N. Steger, and R. C. Bertram. 1987. Mountain lions: preliminary finds on homerange use and density in the central Sierra Nevada. U.S. Department of Agriculture, PSW Forest and Range Experiment Station. Research Note PSW-392. 6 pp.

Nowak, R. M. 1999. Walker's mammals of the world. Sixth Edition, Volume I., John Hopkins Univ. Press. Baltimore, Maryland, USA. 836pp.

Oregon Department of Fish and Wildlife (ODFW). 1987. Oregon black bear management plan, 1987. Oregon Department of Fish and Wildlife, Portland, Oregon, USA.

Oregon Department of Fish and Wildlife (ODFW). 1993. Oregon's black bear management plan, 1993– 1998. Oregon Department of Fish and Wildlife, Portland, Oregon, USA.

Oregon Department of Fish and Wildlife (ODFW). 2003a. Oregon's Elk Management Plan. Accessed 29 April 2015 from http://www.dfw.state.or.us/wildlife/management_plans/docs/ElkPlanfinal.pdf

Oregon Department of Fish and Wildlife (ODFW). 2003b. Fast Facts About Adenovirus Hemorrhagic Disease. Accessed 1 May 2015 from http://www.dfw.state.or.us/wildlife/health_program/andevirus/adenovirus.pdf

Oregon Department of Fish and Wildlife (ODFW). 2006. Oregon Cougar Management Plan. Accessed 29 April 2015 from http://http://www.dfw.state.or.us/wildlife/cougar/docs/cougarPLAN-Final.pdf

Oregon Department of Fish and Wildlife (ODFW). 2008. Oregon Black-Tailed Deer Management Plan. Accessed 29 April 2015 from http://www.dfw.state.or.us/wildlife/docs/oregon_black-tailed_deer_management_plan.pdf

Oregon Department of Fish and Wildlife (ODFW). 2010. ODFW Wildlife Management Units Shapefiles. [Spatial data hosted on ODFW Data Clearinghouse]. Accessed 27 April 2015 from https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=202&XMLname=805.xml

Oregon Department of Fish and Wildlife (ODFW). 2011. Big Game Hunting Statistics Archives. [Deer Hunding Trends 1952-2011]. Accessed 28 April 28, 2015 from http://www.dfw.state.or.us/resources/hunting/big_game/controlled_hunts/reports/big_game_statistics_archive.asp

Oregon Department of Fish and Wildlife (ODFW). 2012. Oregon Black Bear Management Plan. Accessed 30 April 2015 from http://www.dfw.state.or.us/wildlife/management_plans/docs/Black_Bear_Management_Plan_2012.pdf

Oregon Department of Fish and Wildlife (ODFW). 2014. Oregon Big Game Hunting Forecast. Accessed 29 April 2015 from http://www.dfw.state.or.us/rr/hunting_forecast/docs/2014_hunting_forcast.pdf

Oregon Department of Fish and Wildlife (ODFW). 2015a. Conceptural Framework to Estimate Statewide Cougar Densities. Accessed 02 May 2015 from http://www.dfw.state.or.us/wildlife/cougar/docs/Conceptual_Framework_to_Estimate_Cougar_Densities_March2015.pdf

Oregon Department of Fish and Wildlife (ODFW). 2015b. Herd Composition, Trend Estimates, and Dear Hair Loss Syndrome. [Unpublished data from the ODFW Charleston Field Office].

Oregon Department of Fish and Wildlife (ODFW). n.d.a. Living with Wildlife: Black Bears Accessed 30 April 2015 from http://www.dfw.state.or.us/wildlife/living_with/black_bears.asp

Oregon Department of Fish and Wildlife (ODFW). n.d.b. Oregon Wildlife Species: Mammals. Accessed 02 May 2, 2015 from http://www.dfw.state.or.us/species/#Mammals

Oregon Department of Transportation (ODOT). 2014. Interactive Roadkill Mapping Tool. [Online interactive graphic hosted by The Oregonian]. Accessed 1 May 2015 from http://www.oregonlive.com/commuting/index.ssf/2014/11/oregon_roadkill_mapping_over_4.html

Oregon Forest Resources Institute (OFRI). 2013. Wildlife in Managed Forests: Deer and Elk. [Technical report prepared by Cafferata Consulting and the Oregon Forest Research Institute for the USDA Forest Service]. Accessed April 29, 2015 from http://oregonforests.org/sites/default/files/publications/pdf/OFRI%20managed%20forests%20elk%20deer_for_web.pdf

Pamplin, N.P. 2003. Ecology of Columbian black-tailed deer fawns in western Oregon. M.S. Thesis, Oregon State University, Corvallis, OR. 75 pp.

Pelton, M. R. 2000. Black bear. Pages 389–408 in S. Demarais and P. R. Krausman, editors. Ecology and management of large mammals in North America. Prentice Hall, Upper Saddle River, New Jersey, USA.

Raphael, Martin G., Gary A. Falxa, Katie M. Dugger, Beth M. Galleher, Deanna Lynch, Sherri L. Miller, S. Kim Nelson, and Richard D. Young. 2011. Status and Trend of Nesting Habitat for the Marbled Murrelet. [Technical Report from the United States Department of Agriculture, United States Forest Service, and Pacific Northwest Research Station].

Regional Ecosystem Office (REO). n.d. 15 Year Report for the Northwest Forest Plan. Accessed 08 October 2014 from http://www.reo.gov/monitoring/reports/15yr-report/

Robinette, W. L., J. S. Gashwiler, and O. W. Morris. 1959. Food habits of the cougar in Utah and Nevada. Journal of Wildlife Management 23:261–273.

Rogers, L. L., and S. M. Rogers. 1976. Parasites of bears: a review. International Conference on Bear Research and Management 3:411–429.

Samuel, W. M., M. J. Pybus, and A. A. Kocan, editors. 2001. Parasitic diseases of wild mammals, second edition. Iowa State Press, Ames, Iowa, USA

United States Department of Agriculture (USDA). n.d. Habitat Management for Black-tailed Deer in the State of Oregon. [Report from the Natural Resources Converation Service]. Accessed May 1, 2015 from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_042116.pdf

United States Fish and Wildlife Service (USFWS). 1997. Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, Oregon. 203 pp.

Vander Heyden, M., and E. C. Meslow. 1999. Habitat selection by female black bears in the Central Cascades of Oregon. Northwest Science 73:283–294

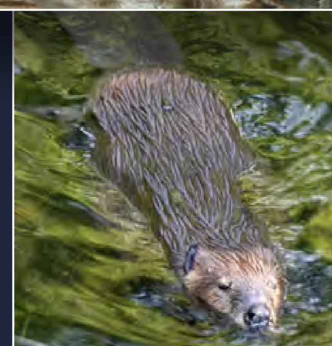
White, C. G., P. Zagar, and M. W. Gratson. 2010. Influence of predator harvest, biological factors, and landscape on elk calf survival in Idaho. Journal of Wildlife Management 74:355–369.

Yarkovich, J., J. D. Clark, and J. L. Murrow. 2011. Effects of black bear relocation on elk calf recruitment at Great Smoky Mountains National Park. Journal of Wildlife Management 75:1145–1154

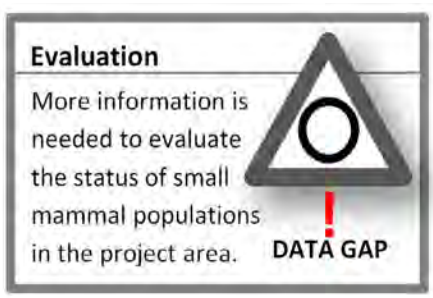
# Small Mammals in the Lower Coos Watershed

*Summary:*

- *No reliable estimate of beaver populations within the lower Coos watershed exists.*
- *Some researchers indicate beaver populations statewide are healthy, while others suggest beavers are declining in parts of Oregon.*
- *Raccoons are abundant and important terrestrial predators in intertidal habitats. However, little is known about the status and trends of raccoon populations in the lower Coos watershed.*



**Photos:**
**Raccoon:** Jim Cruce
**Beaver:** Gigner Holser




**What's happening?**

This data summary describes the status and trends of small mammals found in the lower Coos watershed (project area) for which data are available. Unfortunately, this short list includes only American beavers (*Castor canadensis*) and raccoons (*Procyon lotor*), and the available information is not specific to the project area. (For a discussion of other mammals found in the project area, see the Large Mammals data summary in this chapter.)

<u>American Beaver (*Castor canadensis*)</u>

Because information about the ecology, movements, and dispersal of the American beaver is lacking, it's not surprising that the overall status of beavers is relatively unconfirmed (Hiller 2011). Some researchers indicate that beavers are generally "doing well" in Oregon (Hiller 2011, Oregon Conservation Strategy 2011). Others estimate that beavers have declined in parts of the state (especially in southeastern Oregon)(ODFW 2006, Nordholm and Miller 2008).

From 1998-2003, the Oregon Department of Fish and Wildlife recorded beaver pool presence in salmon bearing streams of coastal Oregon (ODFW 2004)(Figure 1). Their data averaged over five years indicate that beavers inhabited approximately 17% of all salmon bearing streams in the Oregon Coast Coho Evolutionarily Significant Unit (ESU), with more beaver pools occurring in streams on the north coast (22%) and mid-coast (20%) than in either the Umpqua (4%) or mid-south coast (15%) Gene Conservation Groups (CGCs)(Figure 1). No abundance trend over time is immediately apparent from these data (Figure 2). It should be noted that these data clearly understate beaver presence in the lower watershed, because only pools occurring in salmon bearing streams were counted as part of the ODFW survey effort. In addition, comparisons between watersheds may be misleading due to differences in habitat/topography that influence beaver population numbers, distribution, and behavior.

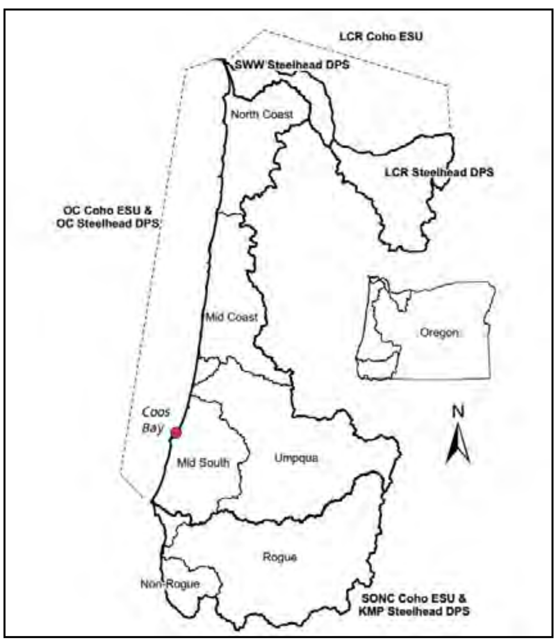



Figure 1. ODFW (2004) beaver pool data come from Coho salmon stream surveys, which occur along the coast within a series of "Gene Conservation Groups" (GCG). The Coos watershed is within in the Mid-South GCG. Collectively, the Mid-South, Umpqua, Mid-Coast, and North-Coast GCGs make up the Oregon Coast Coho "Evolutionarily Significant Unit" (ESU). Graphic: Constable and Suring 2013

What little information we have about beavers in the lower Coos watershed comes from the South Slough Subsystem. Nordholm and Miller (2008) conducted a survey to "document the distribution of beaver activity and quantify beaver pool habitat" in South Slough's Winchester Creek drainage. Their data reveal that numerous beaver dams occur in clusters in all tributaries of Winchester Creek (Figure 3 and Table 1). They add that "the presence of beaver-dammed pool habitat… provides a significant portion of total fish habitat in some reaches [of Winchester Creek]" (see Background)(Nordholm and Miller 2008).

In addition to mapping beaver dam locations and measuring the extent of beaver-dammed pool habitat, Nordholm and Miller were also able to compare their data with information from previously conducted surveys to estimate how the distribution of beaver dams on Winchester Creek has changed from 1999-2008. They concluded that the number of large perennial dams in the upper headwaters of the Middle fork has increased, while composition of dams on the West Fork has shifted

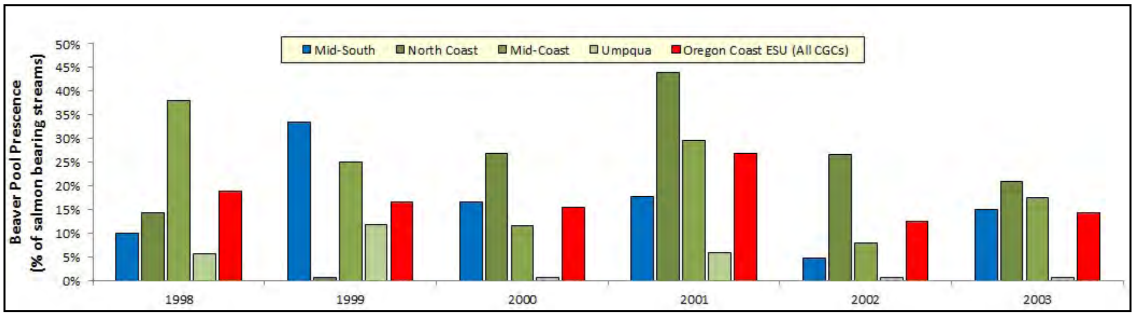



Figure 2. Beaver presence in salmon bearing streams on coastal Oregon as indicated by percent of salmon bearing streams containing beaver pools. The Coos estuary is located in the Mid-South CGC (blue). Data from this region are compared with three other coastal Oregon CGCs (green) as well as the Oregon Coast ESU (red). The Oregon Coast ESU is comprised of all four coastal CGCs, including the Mid-South CGC. Data: ODFW 2004

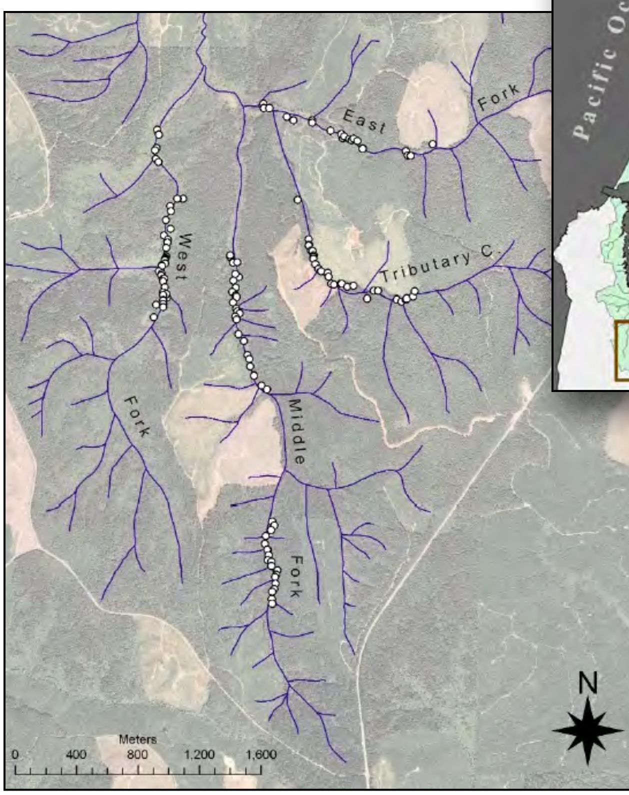




Figure 3. Location of beaver dams (pale yellow) on Winchester Creek in the South Slough Subsystem. The survey revealed 140 dams distributed in clusters and occurring in each tributary of the creek. Data and Figure: Nordholm and Miller 2008

| Segment | Total Dams | Total Survey Length (m) | Total Pool Length (m) | Percent Pool | Mean Pool Length (m) (± 95%CI) |
|---|---|---|---|---|---|
| Middle Fork | 45 | 5450 | 1156 | 21.2 | 28.2 (± 5.3) |
| West Fork | 42 | 3500 | 632 | 18.1 | 19.2 (± 6.6) |
| East Fork | 23 | 1850 | 488 | 26.4 | 23.2 (± 8.1) |
| Trib C | 30 | 2250 | 698 | 31.0 | 33.2 (± 28.3) |
| Total | | 13050 | 2974 | 22.8 | 25.6 |

Table 1. Summary statistics describing beaver presence in South Slough's Winchester Creek Data and Figure: Nordholm and Miller 2008

to include fewer perennial dams and a greater number of smaller, ephemeral dams. In fall 2004, several large west fork Winchester Creek beaver dams were breached by ODFW during an extended period of low flows to accommodate returning Coho salmon adults; with such low stream levels, the dams created uncrossable barriers, and the salmon only have one reach in the Winchester Creek system within which to spawn.

In 2010, Cramer attempted to estimate the population of beavers in the Anderson Creek drainage of the South Slough Subsystem using the "Rowcliffe Method" of bait and camera traps (Cramer 2010, Rowcliffe et al. 2008). Although these methods have been used successfully to assess wildlife populations in the past (Henchel and Ray 2003, Karanath and Nichols 1998), they did not generate enough data to estimate beaver populations in Anderson Creek. Cramer concludes that without "extreme modification" the Rowcliffe Method is "not a valid technique for estimating a beaver population."

Fisheries biologists and land managers have great interest in beaver ponds and pools and their associated influences on the surrounding habitat. These beaver-mediated habitats are discussed in the Background section of this data summary and in Chapter 11: Stream Habitat, Chapter 12: Vegetation, and Chapter 13: Fish.

<u>Raccoon (*Procyon lotor*)</u>

There are no data currently available that characterize raccoon populations in the project area. Through anecdotal observations, wildlife managers know that raccoons are locally abundant and that they are likely important predators in intertidal habitats within the lower Coos estuary. Research shows that raccoons forage in tidal wetlands (mudflats, marshes) for a variety of prey species, including crabs, oysters, clams, and segmented worms (Tyson 1950, Ivey 1948, Warrick and Wilcox 1981, Arbuckle 1982)(Figure 4). By studying intertidal animal communities, researchers have shown how predators influence the distribution and density of prey species, as well as the competitive interactions among intertidal organisms (Paine 1966, 1969; Peterson 1982; Summerson and Peterson 1984). Raccoons, as intertidal predators, likely influence the intertidal animal communities with which they interact, and yet raccoon populations are still not well studied.

Figure 4. A juvenile raccoon foraging in an intertidal environment in British Columbia. Photo: CBParker, avatarlogs.com

The information we do have about raccoons on Coos estuary tidal flats is based on an observational behavior study of raccoons in coastal habitats. Not surprisingly, Davidson (1990) concluded that local raccoons forage on a variety of intertidal organisms, including crabs, sea urchins, bivalves (i.e., clams, oysters, and mussels), as well as fruits, insects, and small fish. She adds that, although raccoons appear to be accustomed to human disturbance (e.g., spotlighting), their behavior is a function of their environment. Most notably, raccoons on tide flats near human development (e.g., Glasgow) tend to be nocturnal foragers, while raccoons in low-development areas (e.g., South Slough Subsystem) extend their foraging period into the daylight hours.

**Why is it happening?**

The effectiveness of beaver survey methods limits our ability to generate a reliable population estimate for the project area. Although traditional methods (i.e., live trapping) are somewhat reliable, they are costly and labor intensive (Swafford et al. 2003, Cramer 2010). The efficacy of other monitoring methods (e.g., camera trapping and visual inspection of food caches, scent mounds, or cuttings) is questionable at best (Swafford et al. 2003, Baker and Cade 1995, Cramer 2010).

The use of computer modeling to predict the distribution of European beavers (*Castor fiber*) has been somewhat successful in Austria (Maringer and Slotta-Bachmayr 2006). However, a number of factors (e.g., habitat abundance and behavioral diversity) may limit the ability to apply these models to American beaver populations in Pacific Northwest estuaries (Cramer 2010).

A more complete understanding of the behavior of beavers in the Pacific Northwest in also lacking. Cramer (2010) explains that most beaver research focuses on northern latitudes (e.g., northern Canada), where climate-dependent behaviors such as lodge building are common. She adds that, although beaver behavior on the Pacific Northwest coast is distinct from individuals in northern Canada, relatively little research has been completed on beavers in these habitats.

Raccoons are "opportunistic feeders," meaning their diets are highly variable with preference given to food sources that are most easily accessible (Kaufmann 1982). Davidson (1990) has documented this behavior in the Coos estuary by demonstrating a statistically significant ($P < 0.01$) preference for large (> 30mm) soft-shelled clams (*Mya arenaria*) taken from the highest zone of the intertidal flats. She hypothesizes that these clams are most readily available, because the higher elevation mudflats are devoid of seagrasses, which act as an impediment to raccoon foraging.

Figure 5. Range map showing the extent of North American beaver habitat (purple) in Oregon. Figure: Csuti et al. 1997

**Background**

The American beaver is the largest rodent in North America, and although beavers are most closely associated with mountain and coastal forest habitat, they occur extensively throughout Oregon anywhere were there is permanent water (Figure 5)(Csuti et al. 1997, ODFW n.d.). Beavers are often associated with their characteristic incisor teeth, which grow continuously and must be maintained by tree cutting and feeding on the outer bark of trees as well as grasses, forbs, and aquatic vegetation (ODFW n.d., Cramer 2010). Due to the high value and cultural significance of their pelts in the Pacific Northwest, beaver harvesting was historically common (see sidebar).

Beavers are considered "ecosystem engineers," because they effectively "manufacture" habitat by impounding (damming) water using immediately available materials, including wood, stones, mud, and plant parts (Jones et al. 1996, Wright et al. 2002, Lawton

Figure 6. A beaver dam on Cox Creek in the South Slough Subsystem illustrates the beaver's ability to use a variety of materials to impound water.

*__Beaver Harvest in the Pacific Northwest__*

*The unregulated trapping of beavers in the Pacific Northwest began in response to European market demands as early as the 16th century. With the exception of settlement on the east coast of North America, these trapping efforts predate all other Euro-American activities. The heavy beaver harvest led to a substantial reduction in beaver numbers over time. Researchers estimate the population of American beavers dropped from 60-400 million in the early 1600's to only 6-12 million by 1980.*

*Beaver trapping in Oregon was regulated as early as 1893, when trapping beavers was prohibited in eastern Oregon's Baker and Malheur Counties. Since then, beaver harvest regulations have changed intermittently, with periods of both stringent and liberal regulation throughout the 20th century. Beaver harvest is currently permitted in Coos County, but is subject to a number of regulations, which are outlined by Oregon Department of Fish and Widlife's Furbearer Trapping and Hunting Regulations.*

*Source: Phillips 1961; Cronon 1983; Warren 1927; Naiman et al. 1986, 1988; Hiller 2011.*

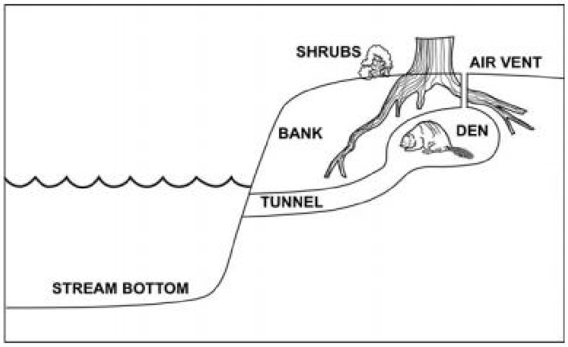



Figure 7. Beavers often construct occupy dens, which are often dug into the side of a stream bank and provide access to habitat via an underwater opening. Dens provide shelter and serve as a nursery for their young. Figure: ODFW n.d.

and Jones 1995, Cramer 2010, ODFW n.d.) (Figure 6). Beaver dams change the hydrology of the streams in which they live, often creating deep pools that provide protection from predators as well as easy access to both food resources and entrances to their dens (Cramer 2010, ODFW n.d.)(Figure 7).

Due to their tendency to modify the hydrology of the landscape around them (Fouty 2003), beavers have been the source of some controversy. The construction of beavers dams in sensitive areas (e.g., agricultural land, urban development, and near important infrastructure) can compromise the integrity of culverts, roads, septic systems, and other infrastructure, as well as impede the productive use of land (Cramer 2010, ODFW n.d.). But landowners may also benefit from beaver activity, which can reduce channel scouring and bank erosion, promote vegetation that helps bank stabilization, improve water quality by trapping silt and removing toxic chemicals, and create a number of recreational and aesthetic values associated with wetland areas (ODFW n.d., Needham and Morzillo 2011).

In 2011, ODFW conducted a survey to assess public opinion about beaver activity on private land across the state (Needham and Morzillo 2011). Of the 411 respondents in coastal Oregon, about one third (30%) of landowners indicated that they have experienced impacts (i.e., damage to their property or neighboring properties) from beaver activity on their land. Despite these damages, very few landowners (20% in coastal Oregon) felt that beavers are a nuisance, most (62%) agreed that "beaver populations should be left alone," and a strong majority (85%) believed that "beavers are a sign of a healthy environment" (Table 2).

The practice of relocating beavers from sensitive areas to more suitable habitat was publicly adopted in Oregon as early as 1932 (Hiller 2011). More recently, management agencies have begun purposefully relocating beavers to improve habitat quality for the federally listed coastal Coho salmon (*Orcorhynchus kisutch*). Research has documented juvenile Coho using beaver ponds in the South Slough Subsystem as overwintering habitat (Miller and Sadro 2003), and many believe that beaver activity may improve fish production while promoting overall habitat complexity (Leidhold-Bruner et al. 1992, Snodgrass and Meffe 1998, Collen and Gibson 2001, Kemp et al. 2012, Hiller 2011, Cramer 2010, Duke 1982).

Despite encouraging prospects, there is some evidence to suggest that the relocation of beavers for salmon habitat enhancement may not be an effective strategy, because it may result in low beaver survival and limited sal-

| | East | Coast | Portland | Southwest | Total |
|---|---|---|---|---|---|
| Beavers create wetlands that benefit other living things | 84 | 90 | 89 | 86 | 87 |
| I may never see a beaver, but it is important to me that they exist | 78 | 89 | 93 | 87 | 86 |
| I would get enjoyment from seeing beavers | 78 | 82 | 87 | 85 | 83 |
| Beavers are a sign of a healthy environment | 75 | 85 | 86 | 82 | 82 |
| People should be willing to tolerate some conflicts with beavers | 66 | 78 | 85 | 75 | 75 |
| Beavers have a right to exist regardless of any damage they cause | 46 | 69 | 70 | 64 | 61 |
| Beaver populations should be left alone | 46 | 62 | 66 | 59 | 58 |
| Beaver populations should be controlled | 61 | 45 | 33 | 43 | 47 |
| No beaver should be destroyed | 30 | 50 | 58 | 49 | 46 |
| Beaver damage to roads or other property is a major problem | 34 | 26 | 11 | 21 | 24 |
| Beavers are a nuisance animal | 30 | 20 | 9 | 22 | 21 |
| I am afraid of beavers | 2 | 3 | 7 | 5 | 4 |

Table 2. Oregon landowners' opinions about American beavers. Columns indicate percentage of respondents that agreed or strongly agreed with the corresponding statements. Sample size is 1,512 respondents statewide with responses categorized by region: East (432 responses), Coast (411), Portland (302), Southwest (367). Figure: Needham and Morzillo 2011

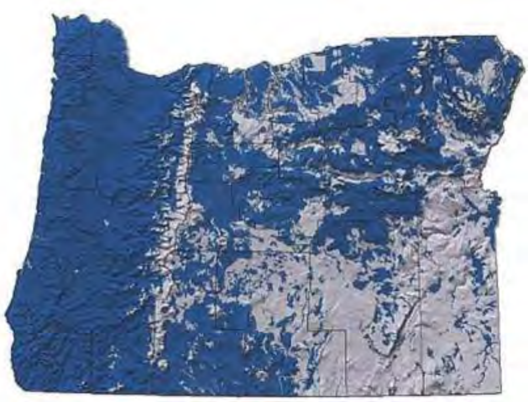


Figure 8. Range map showing the extent of raccoon habitat (purple) in Oregon. Figure: Csuti et al. 1997.

monid habitat development (dam production tended to be limited and ephemeral)(Petro et al. 2015, Rodgers et al. 1987).

Raccoons are versatile omnivores, meaning that they live in a broad range of habitats and have diverse diet preferences including both plants and animals (Csuti et al. 1997, Audubon n.d.). Raccoons occur almost ubiquitously throughout western Oregon and into the eastern half of the state as well, where they are restricted to canyons and river basins that hold permanent water (Figure 8)(Csuti et al. 1997). Raccoons are well adapted to live in urban and suburban habitats, where a lack of predators and access to reliable food sources (e.g., trash cans, compost bins, pet food bowls) allow raccoons to proliferate (Audubon n.d.).

**References**


Arbuckle, Jane. 1982. The Soft-Shelled Clame and its Environment: a Study in Jonesboro, Maine. [Technical report by the Maine Sea Grant Marine Advisory Program] Orono, Maine. University of Maine.

Audubon Society of Portland. n.d. Living with Urban Wildlife: Raccoons. Accessed 24 April 2015 from http://audubonportland.org/files/brochures/living-with-raccoons.pdf/at_download/file

Baker, B.W. and B.S. Cade. 1995. Predicting Biomass of Beaver Food from Willow Stem Diameters. Journal of Range Management. 48: 322-326.

Collen, P. and R. J. Gibson. 2001. The general ecology of beavers (*Castor spp.*), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish: a review. Reviews in Fish Biology and Fisheries. 10: 439–461.

Constable, R. J. Jr. and E. Suring. 2013. Abundance Monitoring of Juvenile Salmonids in Coastal Oregon and Lower Columbia Streams, 2012. Monitoring Program Report Number OPSW-ODFW-2011-1, Oregon Department of Fish and Wildlife, Salem.

Cramer, Alison. 2010. The Role of beavers in Salmon Management: A Literature Review and Test of Method. [Undergraduate Honors Thesis, Department of Biology, University of Oregon].

Cronon, W. 1983. Changes in the Land—Indians, Colonists, and the Ecology of New England. New Yroke, Hill and Wang.

Csuti, B., T. A. O'Neil, M. M. Shaughnessy, E. P. Gaines, J. C. Hak. 1997. Atlas of Oregon Wildlife, first edition. Oregon State University Press. Corvallis.

Davidson, Seana K. 1990. Raccoon Foraging in the Tidal Flats of the Coos Estuary. [Undergraduate Thesis, Department of Biology, University of Oregon].

Duke, Stephen D'wayne. 1982. Distribution of Fishes and Their Relationships to Environments in Selected Coastal Streams, Douglas and Coos Counties, Oregon. Masters Thesis. Department of Fisheries, University of Oregon.

Fouty, Suzanne C. 2003. Current and Historic Stream Channel Response to Changes in Cattle and Elk Grazing Pressure and Beaver Activity. Doctoral Thesis. Deptarment of Geography, University of Oregon.

Henschel, P. and J. Ray. 2003. Leopards in African Rainforests: Survey and Monitoring Techniques. Wildlife Conservation Society, New York, NY.

Hiller, T. L. 2011. Oregon furbearer program report, 2010-2011. Oregon Department of Fish and Wildlife, Salem, Oregon, USA.

Ivey, R. DeWitt. 1948. The Raccoon in the Salt Marshes of Northeastern Florida. Journal of Mammalogy. 29(3): 290-291.

Jones, C. G., J. H. Lawton, and M. Shachak. 1996. Organisms as ecosystem engineers. In Ecosystem Management (pp. 130-147). Springer New York.

Karanth, K.U., and J.D. Nichols. 1998. Estimation of tiger densities in India using photographic capture and recaptures. Ecology. 79: 2852-2862.

Kaufmann, J. H. 1982. Raccoon and allies. In: Chapman JA, Feldhamer GA (eds) Wild mammals of North America: biology, management and economics. Johns Hopkins University Press, Baltimore, MD, pp 567–585

Kemp, P. S., T. A. Worthington, T. E. Langford, A. R. Tree, and M. J. Gaywood. 2012. Qualitative and quantitative effects of reintroduced beavers on stream fish. Fish and Fisheries. 13(2): 158-181.

Lawton, J. H. and C. G. Jones. 1995. Linking species and ecosystems: organisms as ecosystem engineers. In Linking species & ecosystems (pp. 141-150). Springer US.

Leidholt-Bruner, K., D. E. Hibbs, and W. C. McComb. 1992. Beaver dam locations and their effects on distribution and abundance of coho fry in two coastal Oregon streams. Northwest Science. 66: 218–223.

Maringer, A. and L. Slotta-Bachmayr. 2006. A GIS-based Habitat-suitability Model as a Tool for the Management of Beavers *Castor fiber*. Acta Theriologica. 51: 373-382.

Miller, Bruce A. and Steve Sadro. 2003. Residence Time and Seasonal Movements of Juvenile Coho Salmon in the Ecotone and Lower Estuary of Winchester Creek, South Slough, Oregon. Transactions of the American Fisheries Society. 132: 3, 546-559.

Naiman, R.J., J.M. Melillo, and J.E. Hobie. 1986. Ecosystem Alteration of Boreal Forest Streams by Beaver (*Castor canadensis*). Ecology. 67: 1254-1269.

Naiman, R. J., C. A. Johnston, and J. C. Kelley. 1988. Alteration of North American streams by beaver. BioScience, 753-762.

Needham, M. D. and A. T. Morzillo. 2011. Landowner incentives and tolerances for managing beaver impacts in Oregon. Final project report for Oregon Department of Fish and Wildlife (ODFW) and Oregon Watershed Enhancement Board (OWEB). Corvallis, OR: Oregon State University, Department of Forest Ecosystems and Society.

Nordholm, Katherine E. and Bruce A. Miller. 2008. Beaver Activity in Winchester Creek, Coos River: an Inventory of Dams, Pools, and Potential Barriers to Fish Passage. [a report for the Salmonid Life-Cycle Monitoring Project of Oregon Department of Fish and Wildlife].

Oregon Conservation Strategy. 2011. Oregon Department of Fish and Wildlife Fact Sheet, Oregon's State Mammal. Accessed 21 April 2015 from http://www.dfw.state.or.us/conservationstrategy/docs/Beaver_factsheet.pdf

Oregon Department of Fish and Wildlife (ODFW). 2004. Beaver Pool Presence in Habitat Surveys. Data accessed 22 April 2015 from ODFW Data Clearinghouse https://nrimp.dfw.state.or.us/DataClearinghouse/default.aspx?p=1

Oregon Department of Fish and Wildlife (ODFW). 2006. Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Fish and Wildlife (ODFW). n.d. Living with Wildlife: American Beaver. [Living with Wildlife Fact Sheet Series]. Accessed 24 April 2015 from http://www.dfw.state.or.us/wildlife/living_with/

Paine, Robert. 1966. Food Web Complexity and Species Diversity. American Naturalist. 100: 65-75.

Paine, Robert. 1969. The *Pisaster-Tegula* Interactions: Prey Patches. Ecology. 50(6): 950-961.

Peterson, C. H. 1982. Clam Predation by Whelks (*Busycon spp*.): Experimental Tests of the Importance of Prey Size, Prey Density, and Seagrass Cover. Marine Biology 66:159-170.

Petro, V. M., J. D. Taylor, and D. M. Sanchez. 2015. Evaluating landowner-based beaver relocation as a tool to restore salmon habitat. Global Ecology and Conservation. 3: 447-486.

Phillips, P.C. 1961. The Fur Trade. Norman. University of Oklahoma.

Rodgers, J. D., R. D. Ewing, and J. D. Hall. 1987. Physiological changes during seaward migration of wild juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences. 44:452–457.

Rowcliffe, J. M., J. Field, S. T. Turvey, and C. Carbone. 2008. Estimating animal density using camera traps without the need for individual recognition. Journal of Applied Ecology. 45: 1228-1236.

Snodgrass, J. W. and G. K. Meffe. 1998. Influence of beavers on stream fish assemblages: effects of pond age and watershed position. Ecology. 79: 928–942.

Summerson, H. C. and C. H. Peterson. 1984. Role of Predation Organizing Benthic Communities of a Temperate-zone Seagrass Bed. Marine Ecology Program Series. 15: 63-77.

Swafford, S.R., D.L. Nolte, K. Godwin, C.A. Sloan, and J. Jones. 2003. Beaver Population Size Estimation in Mississippi. Wildlife Damage management, Internet Center for USDA National Wildlife Research Center-Staff Publications. University of Nebraska, Lincoln.

Tyson, Edwin L. 1950. Summer Food Habits of the Raccoon in Southwest Washington. Journal of Mammalogy. 31(4): 448-449.

Warren, E.R. 1927. The Beaver. The Williams and Wilkins Company.

Warrick, Sheridan F. and Elizabeth D. Wilcox. 1981. Big River: The Natural History of an Endangered Northern California Estuary. Santa Cruz: Environmental Field Program, University of California.

Wright, J. P., C. G. Jones, and A. S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia,132(1), 96-101.

# Chapter 18: Invasive and Non-native Species in the Lower Coos Watershed

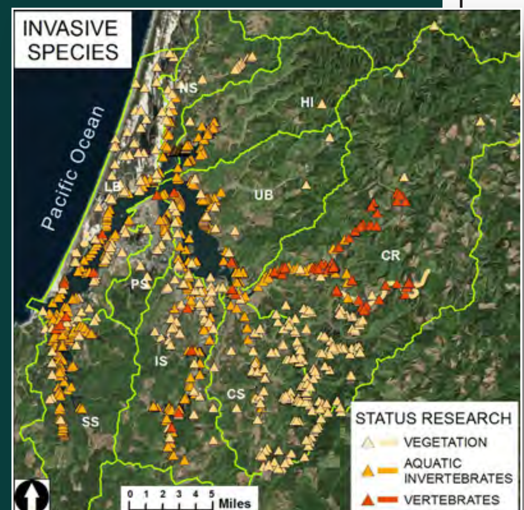
*Jenni Schmitt, Bree Yednock, Erik Larsen, Craig Cornu, Colleen Burch Johnson*
*-South Slough NERR*

***Vegetation:*** *The lower Coos watershed supports many invasive plants such as European beachgrass which has significantly altered the Lower Bay subsystem.*

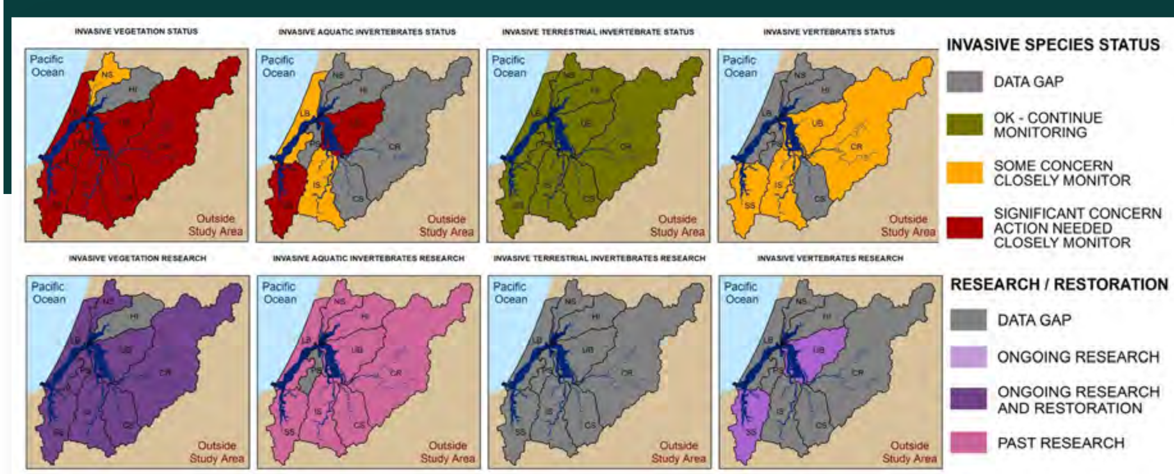
***Vertebrates:*** *Evidence indicates the local presence of large populations of invasive nutria, and small declining populations of non-native American shad and striped bass.*

***Terrestrial Invertebrates:*** *No invasive terrestrial invertebrate populations are currently established in the project area, though local forests are at risk of invasion.*

***Aquatic Invertebrates:*** *Over 60 non-native aquatic invertebrates species occur in the Coos estuary; additional invasions are likely. Despite the potential for significant ecological and economic effects, little is known about the status of most of these species.*




Subsystems: CR- Coos River CS- Catching Slough
HI- Haynes Inlet IS- Isthmus Slough LB- Lower Bay
NS- North Slough PS- Pony Slough SS- South Slough
UB- Upper Bay



## Chapter 17: Invasive and Non-native species in the Coos estuary and the Lower Coos Watershed

*This section includes the following data summaries: **Vegetation, Aquatic Invertebrates, Terrestrial Invertebrates, and Vertebrates**—which describe invasive and other non-native species in the Coos estuary and lower Coos watershed.*

Non-Native and Invasive Vegetation: This data summary provides profiles of 58 invasive or non-native plant species that are either already established in, or are imminent threats to the project area. The narrative is separated into three sections – invasive or non-native plants that are: 1) Predicted threats – invasive vegetation not yet found in the project area but will be in the future; 2) Partially contained threats – invasive vegetation currently found only in isolated populations within the project area; and 3) Established threats – invasive vegetation found across much or all of the project area.

Local distribution of each species is discussed where information is available. Sources include invasive species response plans, which often include targeted monitoring efforts (e.g., Howard et al. 2007; ODF 2014a and 2014b) and statewide species profiling efforts (ODA 2014). Information from scientific publications (e.g., Posey 1988 and Hacker et al. 2012) and Online spatial databases (e.g., USDA 2015a) were also referenced. The vast majority of early non-native vegetation species detections have come from local biologists noticing unusual plants (e.g. information personally communicated by A. Brickner 2015).

A Background section summarizes the information available describing the local or regional environmental and economic effects of each non-native or invasive vegetation species.

Non-Native and Invasive Aquatic Invertebrates: This data summary includes information for 62 species of non-native aquatic invertebrates and algae that have become established in the lower Coos watershed (project area), as well as 12 high risk aquatic non-native species not currently locally established but considered imminent threats. Information sources are mainly comprehensive invasion histories compiled for several US West Coast locations, including Coos Bay (Carlton 1979, Cohen and Carlton 1995, Wonham and Carlton 2005). Species distribution information within the Coos estuary comes from fouling community surveys (Hewitt 1993, de Rivera et al. 2005) and species-specific studies (e.g. Berman and Carlton 1991, Jordan 1989).

A Background section summarizes what little information is available describing the local or regional environmental, economic and public health effects associated with non-native or invasive aquatic invertebrates.

Non-Native and Invasive Terrestrial Invertebrates: Information about invasive terrestrial vertebrates comes primarily from Online publications by the United States Department of Agriculture (2003a, 2003b, 2006, 2008, n.d.a, n.d.b), Oregon State University (2011), Purdue University (Sadof 2009), and United States Forest Service (n.d.). Estimates of the extent of damage caused by invasive insects come from peer-reviewed scientific literature (Kovacs et al. 2010; Nowak et al. 2001). These sources are supplemented by personal communication with invasive species specialists working in Oregon (e.g., Williams pers. comm. 2015).

Non-Native and Invasive Vertebrates: This data summary summarizes available information for American shad, striped bass and nutria – three ecologically or economically significant species. For each species, we describe what's known about their current status and distribution, any available population trends, and information on their effects on native species. Other issues associated with each species is also discussed (e.g., bacterial infections of American shad, unprecedented levels of hermaphroditism in striped bass) .

Pathogens: While numerous invasive pathogens (e.g., fungi or viruses) exist, they were not covered in this chapter due to time constraints. Several serious plant pathogens of concern to the project area have been covered in the "Terrestrial Vegetation in the Lower Coos Watershed" within the Vegetation Chapter. These include the Port Orford cedar root rot pathogen (*Phytophthora lateralis*), and the fungus that causes Swiss needle cast disease (*Phaeocryptopus gaeumannii*).

**Data Gaps and Limitations**

Non-Native and Invasive Vegetation: A general lack of comprehensive spatial information on non-native and invasive vegetation species impose limitations on our data summary. There are two main reasons for the limitations: 1) Few comprehensive surveys or monitoring programs exist that identify locations of non-native and invasive plants in the project area; and 2) Many spatial data that do exist come from anecdotal, often chance observations, which can introduce skewed impressions of species distributions.

Even though other spatial data exist, to simplify this data summary only maps with the most comprehensive monitoring information (e.g. gorse and purple loosestrife) or those with location information of early invaders (e.g., Spanish heath and old man's beard) were included.

Non-Native and Invasive Aquatic Invertebrates: Only a few systematic surveys of invasive aquatic invertebrate species have been undertaken in the project area (e.g. Laferriere et al. 2010, Davidson 2006 and 2008), therefore there are large data gaps in our understanding of their distribution in the Coos estuary. Likewise, knowledge of environmental and economic effects of many aquatic species is lacking.

Non-Native and Invasive Terrestrial Invertebrates: The available information about the threat of non-native and invasive insect introductions to the project area is based on projections from academic and government agency scientists, and local experts. However, since recent technological advances have resulted in the accelerated movement of goods and people across the globe, the spread of invasive insects has become increasingly difficult to monitor and predict (Hulme 2009). While these expert opinions represent the best available information, it's possible that unforeseen events (e.g., previously unaccounted for vectors of transport) could lead to the introduction of non-native and invasive species not currently anticipated by the experts. In some cases, species that pose the highest risks have appeared intermittently in Oregon (e.g., gypsy moths). Early detection rapid response programs have eliminated these threats before they have become established locally. However, if isolated populations have gone undetected, it's possible that additional, yet to be discovered threats may currently exist within or in proximity to the project area.

Non-Native and Invasive Vertebrates: Striped bass and American shad data come from long-term Oregon Department of Fish and Wildlife (ODFW) monitoring efforts whose priorities shifted over time (ODFW 2009 and 2013). ODFW initially sampled (starting in 1965) all fishes in the Coos system, but shifted its focus to American shad and striped bass beginning in the late 1970's. As American shad and striped bass populations declined, ODFW's long-term monitoring focus shifted in 2006 to Chinook salmon. American shad and striped bass (along with other fishes) are still identified and counted during Chinook sampling. But American shad and striped bass population and distribution data should only be considered comprehensive between the late 1970's and 2006.

There are additional limitations to the American shad and striped bass data in the sampling methods used. Seining methods have remained standard over the years, but fish identification varies by staff abilities. In addition, the seining effort was not identical in all years (some sites were missed— especially after the sampling focus shifted to Chinook) and during some years sampling was skipped altogether. Finally, seining methods may have inadvertently introduced bias into the sampling since seining is not effective at capturing all fish (e.g., larger more mobile fish species).

Finally, descriptions of the health of American shad and striped bass rely on older information from the primary literature (e.g., Carlton 1989), and some theses (e.g., Anderson 1985).

Nutria data are limited as no standard protocols have been adopted to assess nutria distribution or abundance in Oregon. Sheffers and Sytsma (2007) used district ODFW wildlife biologists' best estimates to create a relative nutria density distribution map for Oregon (Figure 2 in the data summary). Although these scientists have an intimate knowledge of the watersheds in which they work, they were not always able to estimate relative nutria densities, leaving a large number of sub-watersheds unrepresented. Since these were judgment calls based on best professional knowledge, conclusions based on this map should be used with caution.

Comprehensive nutria density and distribution data are lacking for the project area and for Oregon in general, despite anecdotal evidence suggesting the local presence of relatively large sustaining populations and structural damage to local marsh habitats and human infrastructure.

**References**


Anderson, D. A. 1985. A Study of the Early Life History of the Striped Bass, *Morone saxatilis,* in Coos River Estuary, Oregon. M.S. Thesis. University of Oregon, Eugene.

Berman, J., and J. T. Carlton. 1991. Marine Invasion Processes: Interactions Between Native and Introduced Marsh Snails. Journal of Experimental Marine Biology and Ecology 150:267-281.

Carlton, J. T. 1979. Introduced invertebrates of San Francisco Bay. Pp. 427-444 in: San Francisco Bay: The Urbanized Estuary.

Carlton, J. T. 1989. Man's Role in Changing the Face of the Ocean: Biological Invasions and Implications for Conservation of Near-Shore Environments. Conservation Biology. 3(3): 265-273.

Cohen, A., and J. Carlton. 1995. Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasion of the San Francisco Bay and Delta. Report prepared for the US Fish and Wildlife Service and the National Sea Grant College Program, Connecticut Sea Grant.

Davidson, T. M. 2006. The Invasion of the Australasian Burrowing Isopod (*Sphaeroma quoianum*) in Coos Bay, Oregon. M.S. Thesis. University of Oregon, Eugene.

Davidson, T. M. 2008. Prevalence and Distribution of the Introduced Burrowing Isopod, *Sphaeroma quoianum*, in the Intertidal Zone of a Temperate Northeast Pacific Estuary (Isopoda, Flabellifera). Crustaceana 81:155-167.

de Rivera, C. E., G. Ruiz, J. Crooks, K. Wasson, S. Lonhart, P. Fofonoff, B. Steves, S. Rumrill, M. S. Brancato, and S. Pegau. 2005. Broad-scale Non-Indigenous Species Monitoring Along the West Coast in National Marine Sanctuaries and National Estuarine Research Reserves. Report prepared for the National Fish and Wildlife Foundation.

Hacker, S. D., P. Zarnetske, E. Seabloom, P. Ruggiero, J. Mull, S. Gerrity, and C. Jones. 2012. Subtle Differences in Two Non-Native Congeneric Beach Grasses Significantly Affect their Colonization, Spread, and Impact. Oikos. 121(1): 138-148.

Hewitt, C. L. 1993. Marine Biological Invasions: The Distributional Ecology and Interactions Between Native and Introduced Encrusting Organisms. Ph. D. Thesis. University of Oregon, Eugene.

Howard, V., M. Pfauth, M. Sytsma, and D. Isaacson. 2007. Oregon *Spartina* Response Plan. Portland State University, Portland, OR. 80 pp.

Hulme, P. E. 2009. Trade, Transport and Trouble: Managing Invasive Species Pathways in an Era of Globalization. Journal of Applied Ecology. 46(1): 10-18.

Jordan, J. R. 1989. Interspecific Interactions Between the Introduced Atlantic Crab *Rhithropanopeus harrisii* and the Native Estuarine Crab *Hemigrapsus oregonensis* in Coos Bay, Oregon. M.S. Thesis. University of Oregon, Eugene.

Kovacs, Kent F., Robert G. Haight, Deborah G. McCullough, Roridgo J. Mercader, Nathan W. Siegert, and Andrew M. Liebhold. 2010. Cost of Potential Emerald Ash Borer Damage in U.S. Communities, 2009-2019. Ecological Economics. 69: 569-578.

Laferriere, A. M., H. Harris, and J. Schaefer. 2010. Early Detection of a New Invasive Mesogastropod, *Assiminea parasitologica*, in Pacific Northwest Estuaries. South Slough National Estuarine Research Reserve with the Confederated Tribes of the Coos, Lower Umqua and Siuslaw Indians.

Nowak, D. J., Pasek, J. E., Sequeira, R. A., Crane, D. E., & Mastro, V. C. 2001. Potential Effect of *Anoplophora glabripennis* (Coleoptera: Cerambycidae) on Urban Trees in the United States. Journal of Economic Entomology. 94(1): 116-122.

Oregon Department of Agriculture (ODA). 2014. Oregon Noxious Weed Profiles. Accessed 13 March 2015: http://www.oregon.gov/oda/programs/weeds/oregonnoxiousweeds/pages/aboutoregonweeds.aspx

Oregon Department of Fish and Wildlife (ODFW). 2009. [Coos Bay spring gillnetting]. Unpublished raw data.

Oregon Department of Fish and Wildlife (ODFW). 2013. [Coos fish monitoring seine program]. Unpublished raw data.

Oregon Department of Forestry (ODF). 2014a. Gorse Aerial Survey GIS Data [GIS data files]. Accessed 10 March 2015: http://www.oregon.gov/odf/privateforests/pages/fhinvasives.aspx

Oregon Department of Forestry (ODF). 2014b. Mapping the Invasive Plant Gorse: An aerial Survey Special Project. Oregon Department of Forestry, Salem, OR. 2 pp.

Oregon State University (OSU). 2011. Oregon Forest Pest Detectors. [Online informational modules from the Department of Forestry at Oregon State University]. Accessed 2 July 2015: http://pestdetector.forestry.oregonstate.edu/programs/take-course

Posey, M. H. 1988. Community Changes Associated with the Spread of an Introduced Seagrass, *Zostera japonica.* Ecology. 69 (4): 974-983.

Sadof, Cliff. 2009. History of Gypsy Moth in North America. [Online Publication of the Extension Entomology Department at Purdue University]. Accessed 7 July 2015: http://extension.entm.purdue.edu/GM/index.php?page=history

Sheffels, T. and M. Sytsma. 2007. Report on Nutria Management and Research in the Pacific Northwest. Center for Lakes and Reservoirs, Portland State University. 57pp.

United States Department of Agriculture (USDA). 2003a. Gypsy Moth in North America. Accessed 7 July 2015: http://www.fs.fed.us/ne/morgantown/4557/gmoth/.

United States Department of Agriculture (USDA). 2003b. Gypsy Moth in North America: E. Leopold Trouvelot, Perpetrator of our Problem. Accessed 7 July 2015: http://www.fs.fed.us/ne/morgantown/4557/gmoth/trouvelot/.

United States Department of Agriculture (USDA). 2006. Balsam Woolly Adelgid. Forest, Insect, and Disease Leaflet 118. Accessed 2 July 2015: http://www.na.fs.fed.us/pubs/fidls/bwa.pdf

United States Department of Agriculture (USDA). 2008. Gypsy Moth: A Major Pest of Trees. Accessed 7 July 2015: http://www.oregon.gov/ODA/shared/Documents/Publications/IPPM/GypsyMothFactSheet.pdf.

United States Department of Agriculture (USDA). 2015a. Plants Database. US Department of Agriculture Natural Resources Conservation Service. Accessed 26 March 2015: http://plants.usda.gov/java/

United States Department of Agriculture (USDA). 2015b. Asian Gypsy Moth. [Publication of the Animal and Plant Health Inspection Service]. Accessed 7 July 2015: http://www.aphis.usda.gov/publications/plant_health/content/printable_version/fs_phasiangm.pdf

United States Department of Agriculture (USDA). n.d.a Invasive Pest Risk Maps: European Gypsy Moth – *Lymantria dispar dispar.* Accessed 6 July 2015: http://www.fs.fed.us/foresthealth/technology/invasives_lymantria_dispar_riskmaps.shtml

United States Department of Agriculture (USDA). n.d.b. Success Story- Gypsy Moth. Accessed 6 July 2015: http://www.fs.usda.gov/detail/r6/forest-grasslandhealth/invasivespecies/?cid=fsbdev2_027210

United States Forest Service. n.d. Balsam Woolly Adelgid. Accessed 2 July 2015: http://www.fs.fed.us/r6/nr/wildlife/decaid/IandDSpecies/Balsam%20woolly%20adelgid.html

Williams, Wyatt. 2015. Personal Communication July 2, 2015.

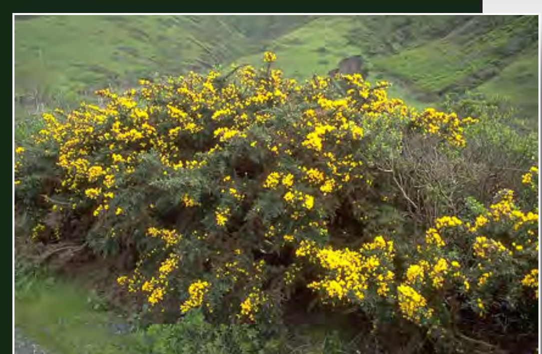
Wonham, M. J., and J. T. Carlton. 2005. Trends in Marine Biological Invasions at Local and Regional Scales: The Northeast Pacific Ocean as a Model System. Biological Invasions. 7:369-392.

# How Local Effects of Climate Change Could Affect Invasive Species in the Lower Coos Watershed

*Several climate change-related changes are expected on the Oregon coast that will potentially affect invasive species:*

- *Climate-related changes will likely facilitate invasive species invasions to alter the ecological communities in the Coos estuary*
- *Climate change is expected to increase the severity of extreme weather events, water temperature, hypoxia, sea level rise and alter oceanographic conditions each of which may promote invasive species invasions by creating conditions hospitable to non-native species*
- *Climate change could allow non-native species to more readily out-compete native species altering the population dynamics of biological communities in the lower the Coos watershed.*

Invasive tunicate (Didemnum vexillum) infestation.



Gorse. Photo: David Dalton, Reed College.

Climate change and invasive species are two topics at the forefront of the global environmental change crisis. Scientists have only recently begun to investigate the complex interactions between these two drivers of environmental change (Rahel and Olden 2008). Each poses a great threat to both ecological and human communities especially since the local and regional effects of climate change are expected to facilitate the spread of invasive plant and animal species. Changing climate may promote species invasions by creating environments that favor the survival of non-native over native species (Stachowicz et al. 2002).

Coastal regions are responding differently to climate change, so predicting the climate-related changes the project area will experience in the future is difficult (Scavia et al. 2002; USGS n.d.). We can predict that many aspects of climate change, including changing weather patterns, increasing ocean temperatures, increasing hypoxia events, sea level rise, and change in oceanographic conditions, will more than likely facilitate local non-native species invasions and range expansions.

In addition, the incidence of human-induced species introductions will likely change. Humans both knowingly and unknowingly transport plants, animals, fungi, and molds, (including vectors for pathogens), throughout the world. But successful introduction of these organisms to new habitats and hosts is often prevented due to the inhospitable conditions they encounter.  Increasing ocean and air temperatures, and changing storm patterns and hydrologic conditions may create more hospitable conditions for new invaders making successful formerly unsuccessful invasions (Stachowicz et al. 2002).  It should be noted that climate-related changes will also make inhospitable some formerly hospitable habitats and hosts. So in some areas climate change will also likely result in invasive species relief.

<u>Changing Weather Patterns</u>

Increased frequency and intensity of winter storms may change the current distribution of some invasive species in intertidal and subtidal estuarine habitats. For example, Bando (2006) showed that disturbance events "substantially enhanced *Zostera japonica* (a non-native eelgrass) productivity and fitness," suggesting that this invasive species' success is the result of both competitive interactions with native eelgrass and its positive response to disturbance events.

Although shifting weather patterns are likely to result in distributional changes to eelgrass species, this trend may not necessary result in a net loss of native species. Researchers in Willapa Bay, Washington, for example, have noted that the establishment of *Z. japonica* in intertidal habitats has resulted in changes to sedimentation that have facilitated the spread of native eelgrass into areas that would have otherwise been unsuitable (Fisher et al. 2011).

<u>Increasing Ocean Temperatures</u>

According to the Oregon Climate Change Research Institute (OCCRI)(2010), ocean surface waters are expected to increase 2-4°C (4-7°F) in Oregon within the next 100 years. Increased ocean temperatures will lead to range shifts requiring native marine organisms to shift northward or deeper in the ocean in pursuit of the cooler waters they require (OCCRI 2010).  Higher ocean temperatures could exceed the physiological tolerances of many native species, allowing non-native species to out-compete them

*Increasing Ocean Temperatures*

*Worldwide, ocean temperatures rose at an average rate of 0.13°F per decade between 1901 to 2012. Since 1880, when reliable ocean temperature observations first began, there have been no periods with higher ocean temperatures than those during the period from 1982 – 2012. The periods between 1910 and 1940 (after a cooling period between 1880 and 1910), and 1970 and the present are the periods during which ocean temperatures have mainly increased.*

*Translating worldwide ocean temperature trends to trends off the Oregon coast is complicated because of the high variability of sea surface temperatures affected by seasonal upwelling/downwelling and various climatic events that occur in irregular cycles (e.g., El Nino). Nearly 30 years (1967-1994) of water temperature data collected near the mouth of the Coos estuary suggest a very weak trend towards warming water temperatures. Fifteen years (1995-2010) of data from multiple stations in the Coos estuary's South Slough inlet show very little water temperature change.*

*Sources: EPA 2013; Shore Stations Program 1997; Cornu et al. 2012*

and fill their ecological niches (OCCRI 2010). Increased ocean temperatures can also affect water quality, cause shifts in food web dynamics, and alter the length or timing of reproductive and growing seasons each of which could aid the spread of non-native species (Carlton 2000).

For example, the invasive clubbed tunicate (*Styela clava*), present in the Coos estuary, is capable of withstanding temperature and salinity fluctuations beyond the range of many local native invertebrate species (Global Invasive Species Database n.d.). Clubbed tunicates have been collected on the Oregon Coast in water temperatures ranging from 11-27°C (52-81°F)(OSU 2013) but they're unable to reproduce at temperatures less than 15°C (59°F)(Eno et al. 1997). The clubbed tunicate may exhibit more reproductive success in higher ocean temperatures, allowing it to out-compete native species.

The Humboldt squid (*Dosidicus gigas*), a voracious predator that feeds on invertebrates (e.g., crustaceans) and small fish, and which normally ranges in warm waters from Chile to California, is an example of how increasing ocean temperatures can influence natural ranges. This species has already been sighted as far north as Puget Sound, WA, a northward range expansion expected to increase as oceans continue to warm (OCCRI 2010). Although this species has not been introduced from overseas, its arrival has the potential to significantly affect the structure of existing marine communities, because altering fundamental interactions within an ecosystem (e.g., predator-prey relationships) can change the way that plants and animals distribute themselves in their environment (Yamada 1977; Carlton 2000). Along with ecological concerns, there are economic implications to disrupting food webs that support commercially important fish in the northern Pacific ocean.

Anthropogenic dispersal of non-native species will be affected by warming ocean waters. Aquaculture is a major source of inadvertent non-native species releases into local environments. Increased ocean temperatures will force these facilities to move northward into colder waters (Rahel and Olden 2008), further increasing the non-native species pool available to invade new waters. This will be a concern for the Coos estuary should new aquaculture operations become established here.

*Sea Level Rise*

*Our local NOAA tide station in Charleston has documented an average rate of sea level rise (SLR) of 0.84 mm (0.03 inches) per year averaged over the past 30 years (0.27 feet in 100 years). The rate of SLR is expected to accelerate over time. For example, according to the National Research Council (NRC), predicted SLR rates for the area to the north of California's Cape Mendocino (the study's closest site to the Coos estuary), are reported as high as +23 cm (9 inches) by 2030; +48 cm (19 inches) by 2050; and +143 cm (56 inches) by 2100 .*

*Sources: NOAA Tides and Currents 2013, NRC 2012*

Increasing Frequency of Hypoxia Events

Dissolved oxygen concentrations in estuaries could be influenced by many factors associated with climate change including temperature, river flow, and ocean conditions. Dissolved oxygen concentration along the coastal Oregon ocean floor have been close to or fully depleted during recent summers (called hypoxic or dead zones), and have occurred more frequently along the Oregon coast in recent decades (OCCRI 2010, Grantham et al. 2004). Jewett and colleagues (2005) found that invasive invertebrate species cover was greatest on experimental settlement plates exposed to low dissolved oxygen waters and concluded that low dissolved oxygen events may enhance the success of invasive species.

Although scientists predict that global climate change will facilitate invasive species introductions that will likely alter community structure in estuaries (Stachowicz et al. 2002), all hope may not be lost. Norkko and colleagues (2011) showed that an invasive polychaete (*Marenzelleria spp*.) aided in the mitigation of hypoxia in the Baltic Sea through "bioirrigation" behavior (i.e., flushing their burrows with overlying water), which in turn decreased sediment-induced eutrophication. The Baltic Sea is far from the Coos estuary but this case study demonstrates possible local responses to climate change and its effects on invasive species.

*El Niño Southern Oscillation (ENSO)*

*ENSO, characterized by an abnormal warming of tropical Pacific waters, is a cyclical climate pattern that occurs every two to seven years. It affects weather and ocean currents in and around the Pacific ocean. Locally, ENSO is associated with drier conditions, warmer temperatures, and lower precipitation levels, although it can also result in greater winter storminess and flooding.*

*Source: Mysak 1986*

Sea Level Rise

Sea level rise is another climate-related change that has the potential to facilitate the spread of existing and newly arriving invasive species in our area. For example, Chinook salmon (*Oncorchynchus tshawytsacha*) compete for food and space with the non-native American shad (*Alosa sapidissima*), a competition that has caused migratory delays for Chinook in the Columbia River (Hesselman 2012). Since changes in sea level have been linked negatively to Chinook salmon growth, maturation and return rates (Wells et al. 2007), these fish could be placed at a competitive disadvantage with respect to American shad as sea levels continue to rise- potentially leading to an increase in shad populations.

As sea level rises, Oregon's estuaries will become more inundated with marine water. Organisms associated with tidal wetlands further up the estuary will need to adjust to both longer tidal inundation periods and higher salinity levels. As changes in species distributions occur through the slow-moving disturbances caused by sea level rise, estuarine habitats may become more susceptible to invasive species.

On the other hand, sea level rise may aid in the management of invasive species already established in Oregon's estuaries. For example, purple loosestrife (*Lythrum salicaria*), an invasive freshwater marsh plant present in the lower Coos watershed (ODA 2014), does not tolerate saline conditions (Konisky and Bordick 2004). Sea level rise has the potential to relieve the Coos estuary of some of its purple loosestrife stands and other non-salt tolerant species (e.g., reed canary grass) in freshwater wetlands located in tidal systems.

Change in Oceanographic Conditions

Climate-related changes in oceanographic conditions including ocean acidification, local wind patterns, ocean currents, timing and intensity of coastal upwelling, and El Nino Southern Oscillation (ENSO) events (see sidebars) will have myriad effects on non-native species in Oregon's coastal watersheds by changing the productivity and water quality (including pH) in estuarine environments- the same conditions which are likely to facilitate the spread of invasive species (OCCRI 2010).

Change related to ocean conditions is expected to affect both terrestrial and aquatic organisms' dispersal patterns, a primary driver shaping ecological communities (Davis et al. 1998). Carlton (2000) explains that non-native marine organisms, especially those whose dispersal patterns are strongly affected by ENSO patterns, are generally expected to gradually shift northward with rising ocean and air temperatures, establishing themselves in newly hospitable environments in northward regions. He cites several examples of this phenomenon, including northward migrations of the following non-native marine species that originated in the western Pacific ocean and were first found in northern and central California then transported by ocean currents to the southern Oregon coast: *Blackfordia virginica* (hydroid), *Sphaeroma quoyanum* and *Iais californica* (isopods), *Palaemon macrodactylus* (shrimp), and *Styela clava* (clubbed tunicate).

Over the past 20 years, the Oregon coast has experienced increased intensity of coastal upwelling. However, OCCRI (2010) suggests that future changes to the coastal surface winds that drive upwelling are likely to be minimal. However, they warn of increased variability in coastal upwelling. For example, Barth and colleagues (2007) found that early season upwelling was delayed and late season upwelling was stronger than average during their 2005 study. This finding was consistent with work done by Snyder and colleagues (2003), who predicted that increases in the contrast between land and ocean temperatures are likely to continue, driving stronger and more variable upwelling conditions.

### *Ocean Upwelling*

*Ocean upwelling is a seasonal wind-driven phenomenon that influences nutrient abundance in coastal waters. Upwelling occurs when strong spring and summertime winds drive surface ocean waters both along the coast and offshore in a process known as "Ekman transport." Ocean bottom waters, typically cold and nutrient-rich, rise to the surface to replace surface waters moved by the wind. Uninterrupted upwelling events can last days to weeks and are characteristic of the Oregon coast.*

*By providing nutrients that promote plankton growth, upwelling reinforces the base of the marine and estuarine food web that supports seabirds, marine mammals, and fisheries, including Dungeness crab, Pacific sardines, Chinook salmon, albacore tuna, halibut and other fin and shellfish species.*

*Source: Peterson et al. 2013, Iles et al. 2011, Dalton et al. 2013*

*Ocean Acidification*

*Since the late 18th century, the average open ocean surface pH levels worldwide have decreased by about 0.1 pH units, a decrease of pH from about 8.2 before the industrial revolution to about 8.1 today. A 0.1 change in pH is significant since it represents about a 30 percent increase in ocean acidity (the pH scale is logarithmic, meaning that for every one point change in pH, the actual concentration changes by a factor of ten). Scientists estimate that by 2100 ocean waters could be nearly 150% more acidic than they are now, resulting in ocean acidity not experienced on earth in 20 million years. The best Pacific Northwest ocean acidification data we have so far are from the Puget Sound area where pH has decreased about as much as the worldwide average (a decrease ranging from 0.05 to 0.15 units).*

*Sources: Feely et al. 2010; NOAA PMEL Carbon Program 2013*

Another effect of increased intensity of coastal upwelling exacerbate ocean acidification's effects on marine and estuarine organisms. Increased coastal upwelling intensity is expected to expose native marine and estuarine communities to low pH ocean waters with limited calcium carbonate (necessary for skeleton and shell formation)- specifically aragonite, the more soluble form of calcium carbonate (Feely et al. 2008). Rising ocean acidity (lowering pH levels) is expected to adversely effect the larvae of many marine invertebrates that incorporate calcite or aragonite into their shells (Orr et al. 2005). If those larvae are unable to mature, competition in estuarine invertebrate communities will diminish, potentially creating opportunities for non-native species to invade more readily (OCCRI 2010).

Increasing Air Temperatures/Decreasing Summer Precipitation

According to the OCCRI (2010), average annual air temperatures are estimated to increase 0.2-1.0$^{o}$ F each decade in Oregon. Summers in particular are expected to become warmer and drier, with an estimated decrease in summer precipitation of 14% by 2080 (OCCRI 2010). While warmer average air temperatures may provide beneficial opportunities to various agriculture industries (e.g., wine grape growers), it will also almost certainly mean new invasive plant pathogens will become more prevalent (Brooks et al. 2004; OCCRI 2010).

Changes to precipitation and air temperature are likely to increase invasive plant species' ranges, further altering native plant ecosystems - with serious economic implications such as increased fire disturbance (by increasing fuel load) and decreased livestock production (OCCRI 2010). Increasing fire events, in turn, will cause openings, providing additional opportunities for the expansion of invasive species (D'Antonio 2000 as cited in OCCRI 2010).

As summer precipitation decreases, the timing of amphibian breeding are likely to shift, possibly causing competition for breeding habitats where none currently exist (OCCRI 2010). For example, the invasive American bullfrog (*Lithobates catesbeianus*) has a later breeding period than native amphibians. As amphibian breeding periods shift to match higher moisture conditions earlier in the year, competition with native species for breeding habitat will increase (Bury and Whelan 1984).

*Uncertainty in Predicting Local Effects of Climate Change*

*There is inherent uncertainty in predicting what the local effects of climate change are likely to be. The uncertainties generally fall into three categories: 1) Natural variability of the earth's climate; 2) Climate sensitivity (how the earth's climate system responds to increases in future greenhouse gas levels); and 3) Future greenhouse gas emissions.*

*To manage for these uncertainties, climate scientists use multiple models ("multi-model ensembles") that incorporate the estimated range of possible natural variability, climate sensitivity, and future greenhouse gas emission values when investigating climate-related change. The models typically generate a range of values for potential future air temperatures, ocean surface temperatures, sea level rise…etc., which naturally become increasingly variable the longer into the future the model predicts. This approach gives communities a range of projections to consider when developing climate change vulnerability assessments and adaptation plans.*

*Sources: Sharp 2012, Hawkins and Sutton 2009*

**References**

Bando, K. J. 2006. The roles of competition and disturbance in a marine invasion. *Biological Invasions*, 8(4): 755-763.

Barth J.A., B.A. Menge, J. Lubchenco, F. Chan, J.M. Bane, A.R. Kirincich, M.A. McManus, K.J. Nielsen, S.D. Pierce, and L. Washburn. 2007. "Delayed upwelling alters nearshore coastal ocean ecosystems in the northern California current". *Proceedings of the National Academy of Sciences of the United States of America*. 104 (10): 3719-24.

Brooks, M. L., C. M. D'Antonio, D. M. Richardson, J. B. Grace, J. E. Keeley, J. M. DiTomaso, R. J.Hobbs, M. Pellant, and D. Pyke. 2004. Effects of invasive alien plants on fire regimes. *BioScience*, 54.

Bury, R. B., and J. A. Whelan. 1984. Ecology and management of the bullfrog, Resource publication 155, United States Fish and Wildlife Service, Washington, D.C.

Carlton, J.T. 2000. Global change and biological invasions in the oceans. In: *Invasive species in a changing world*, H.A. Mooney and R.J. Hobbs (eds), Island Press, New York, New York. pp. 31-53.

Cornu, C.E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Water¬sheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Dalton, M.M., P.W. Mote, and A.K. Snover [eds.]. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Island Press, Wash-ing¬ton, DC.

Davis, A., I.S. Jenkinson, J.H. Lawton, B. Shorrocks, and S. Wood. 1998. Making mistakes when predicting shifts in species range in response to global warming. *Nature*, 391: 783-786.

Eno, N.C., Clark, R.A., and Sanderson, W.G. 1997. Non-native marine species in British waters: a review and directory. Peterborough, UK, Joint Nature Conservation Committee: 133-134.

Environmental Protection Agency (EPA). 2013. Climate change indicators in the United States. Accessed 12 September 2016: https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature

Feely, R. A., S. R. Alin, J. Newton, C. L. Sabine, M. Warner, A. Devol, C. Krembs, and C. Maloy. 2010. The combined effects of ocean acidification, mixing, and respiration on pH and carbonate saturation in an urbanized estuary. *Estuarine, Coastal and Shelf Science*, 88(4): 442-449.

Feely, R.A., C.L. Sabine, J.M. Hernandez-Ayon, D. Ianson and B. Hales. 2008. Evidence for upwelling of corrosive "acidified" water onto the continental shelf. *Science*, 320 (5882): 1490-1492.

Fisher, J. P., T. Bradley, K. Patten. 2011. Invasion of Japanese Eelgrass, Zostera japonica in the Pacific Northwest: A Preliminary Analysis of Recognized Impacts, Ecological Functions and Risks. Prepared for Willipa-Grays Harbor Oyster Growers Association, Ocean Park, WA. 28pp.

Global Invasive Species Database. n.d. ICUN Species Survival Commission. Accessed 20 May 2015: http://www.issg.org/

Grantham, B., F. Chan, K. Nielsen, D. Fox, J. Barth, A. Huyer, J. Lubchenco, and B. Menge. 2004. Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific, *Nature*, 429 (6993): 749-754.

Hawkins, E., and R. Sutton. 2009. The potential to narrow uncertainty in regional climate predictions. *Bulletin of the American Meteorological Society*, 90(8): 1095.

Hesselman, D.J., R.A. Hinrichsen, B.A. Shields, C.C. Ebbesmeyer. 2012. American Shad of the Pacific Coast: A harmful invasive species or benign introduction? *Fisheries*, 37(3):115-122.

Iles, A. C., T. C. Gouhier, B. A. Menge, J. S. Stewart, A. J. Haupt, and M. C. Lynch. 2011. Climate-driven Trends and Ecological Implications of Event-scale Upwelling in the California Current System. *Climate Change Biology*. 18: 783-796.

Jewett, E.B., A.H. Hines and G.M. Ruiz. 2005. Eipfaunal disturbance by periodic low levels of dissolved oxygen: native vs. invasive species response. *Marine Ecology Progressive Series*, 304: 31-44

Konisky, R. A., and D. M. Burdick. 2004. Effects of stressors on invasive and halophytic plants of New England salt marshes: a framework for predicting response to tidal restoration. *Wetlands*, 24:434–447.

Mysak L.A. 1986. El Niño, Interannual Variability, and Fisheries in the Northeast Pacific Ocean. Canadian *Journal of Fisheries and Aquatic Sciences*. 43:464-497.

National Oceanic and Atmospheric Administration (NOAA) Pacific Marine Environmental Laboratory (PMEL) Carbon Program. 2013. What is Ocean Acidification? Accessed 23 February 2016: http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

NOAA Tides and Currents. 2013. Mean Sea Level Trend 9432780 Charleston, Oregon. Accessed 22 June 2015. Accessed 12 September 2016: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9432780

National Research Council (NRC). 2012. Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future. Washington, DC: The National Academies Press. 201 pp.

Norkko, J., D.C. Reed, K. Timmermann, A. Norkko, B.G. Gustafsson, E. Bonsdorff, C.P. Slomp, J. Carstensen and D.J. Conley. 2011. A welcome can of worms? Hypoxia mitigation by an invasive species. *Global Change Biology*, 18(2):422-434.

Oregon Climate Change Research Institute (OCCRI). 2010. Oregon Climate Assessment Report, K.D. Dello and P.W. Mote (eds). College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR http://occri.net/ocar.

Oregon Department of Agirculture (ODA). 2014. Oregon Noxious Weed Profiles. Accessed 31 May 2015: http://www.oregon.gov/oda/programs/weeds/oregonnoxiousweeds/pages/aboutoregonweeds.aspx

Oregon State University (OSU). 2013. Invasive tunicates in the Pacific Northwest. Accessed 25 May 2015: http://seagrant.oregonstate.edu/sites/default/files/sgpubs/onlinepubs/h-13-001-accessible.pdf

Orr, J.C., V.J. Fabry, O. Aumont, L. Bopp, S.C. Doney, R.A. Feely, A. Gnanadesikan, N. Gruber, A. Ishida, F. Joos, R.M. Key, K. Lindsay, E. Maier-Reimer, R. Matear, P. Monfray, A. Mouchet, R.G. Najjar, G.K. Plattner, K.B. Rodgers, C.L. Sabine, J.L. Sarmiento, R. Schlitzer, R.D. Slater, I.J. Totterdell, M.F. Weirig, Y. Yamanaka and A. Yool. 2005. Anthropogenic ocean acidification over the twenty-first century and its impacts on calcifying organisms. *Nature,* 437: 681-686.

Peterson, W.T., C. A. Morgan, J. O. Peterson, J. L. Fisher, B. J. Burke, and K. Fresh. 2013. Ocean Ecosystem Indicators of Salmon Marine Survival in the North California Current. [Prepared by the Northwest Fisheries Science Center of NOAA and Oregon State University]. Accessed 12 September 2016: http://www.nwfsc.noaa.gov/ research/divisions/fe/estuarine/oeip/docu-ments/Peterson_etal_2013.pdf

Rahel, F.J. and J.D. Olden. 2008. Assessing the Effects of Climate Change on Aquatic Invasive Species. *Conservation Biology,* 22 (3): 521-533.

Scavia, D., Field, J.C., Boesch, D.F., Buddemeier, R.W. Burkett, V., Cayan, D.R., Fogarty, M., Harwell, M.A., Howarth, R.W., Mason, C., Reed, D.J., Royer, T.C., Sallenger, A.H., and J.G. Titus. 2002. Climate change impacts on U.S. Coastal and Marine Ecosystems. *Estuaries*, 25 (2): 149-164

Sharp, D. 2012. Climate Change and the Lower Coquille Watershed. Unpublished report. Oregon Climate Change Research Institute/EcoAdapt. Accessed 12 March 2016: http://ecoadapt.org/programs/awareness-to-action/Lower-Coquille-Vulnerability-Project

Shore Stations Program. 1997. [Charleston Station – Salinity and Temperature 1966-1997]. Unpublished raw data.

Snyder, M. A., Sloan, L. C., Diffenbaugh, N. S., & Bell, J. L. 2003. "Future climate change and upwelling in the California Current." *Geophysical Research Letters*, 30(15).

Stachowicz, J.J., Terwins, J.R., Whitlatch, R.B. and R.W. Osman. 2002. Linking climate change and biological invasions: Ocean warming facilitates nonindigenous species invasions. *PNAS*, 99 (24): 15497-15500.

United States Geological Survey (USGS). n.d. Costal Ecosystem Response to Climate Change. [An overview of Coastal Ecosystems Response to Climate Change (CERCC) program of the Western Ecological Research Center].

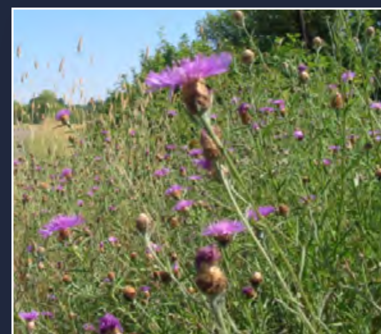
Wells, B.K., C.B. Grimes and J.B. Waldvogel. 2007. Quantifying the effects of wind, upwelling, curl, sea surface temperature and sea level heright on growth and maturation of California Chinook salmon (Oncorchynchus tshawytscha) population. *Fisheries Oceanograph*, 16 (4): 363-382.

Yamada, S.B. 1977. Geographic range limitation of intertidal gastropdods Littorina sitkana and L. planaxis. *Marine Biology,* 39: 61-65.

# Non-native and Invasive Plants in the Lower Coos Watershed

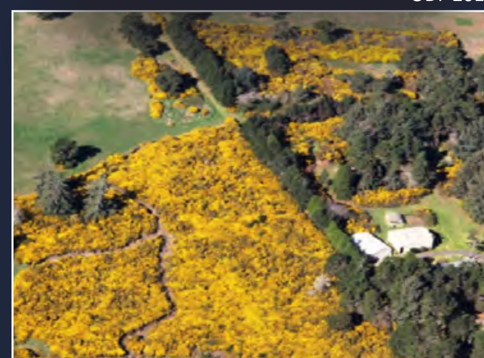

*Summary:*

- *Seven invasive plant species already established in the project area pose imminent environmental or socio-economic threats; 10 species not yet present in the project area are expected to cause problems in the future.*
- *European beachgrass (*Ammophila arenaria*) and gorse (*Ulex europaeus*) are two non-native invasive plant species that have significantly changed the local landscape. Beachgrass is well established in the project area and gorse is common to the south.*

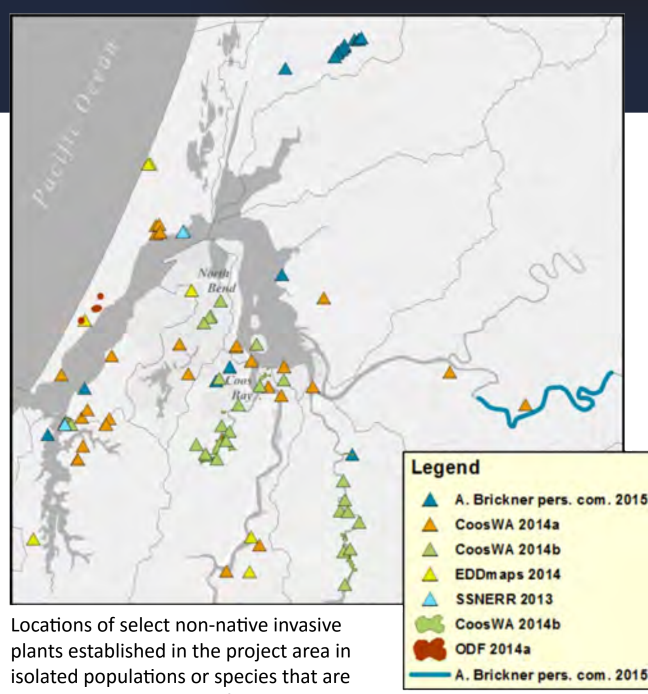
Meadow knapweed Photo: ODA

Gorse Photo: ODF 2014b



**Evaluation**

Many non-native plants threaten local socio-economic or environmental systems; they should be controlled and closely monitored.




Locations of select non-native invasive plants established in the project area in isolated populations or species that are currently being targeted for removal or control actions.

This data summary describes available data for non-native and invasive (see sidebar) vegetation species found locally and is divided, like other data summaries, into two sections: 1) What's happening?; and 2) Background.

The What's happening? section focuses on the presence, distribution, and threat levels associated with priority non-native and invasive plant species, and is divided into three subsections: 1) Predicted Threats; 2) Partially Contained Threats; and 3) Established Threats. The subsections are defined as follows:

1) Predicted threats – invasive vegetation not yet found in the project area but will be in the future.
2) Partially contained threats – invasive vegetation currently found only in isolated populations within the project area.
3) Established threats – invasive vegetation found across much or all of the project area.

The Background section provides detailed descriptions of the specific threats posed by each of the 58 non-native and invasive plant species included in this data summary.

**What's happening?**

The threat status of the non-native and invasive vegetation species discussed in each section is indicated by icons and colors. A butterfly/slash icon indicates plant species with high potential to cause environmental harm; these species outcompete native flora and alter natural ecosystems. The dollar sign icon indicates plant species with high potential to cause serious socio-economic harm (see threat icon graphic). Threat levels are indicated by color codes- red being the greatest threat, pale yellow the lowest threat (see color code graphic).

Each section also includes a summary table listing the species discussed in the section along with general information about their introduction and impacts in Oregon. Species are color-coded using the same icon color codes described above- red being the greatest threat, pale yellow the lowest threat (see color code graphic).


**Threat icon graphic.**


**Color code graphic.**

**Predicted Threats (Table 1)**

These species have nearby established populations (adjoining counties or states) and are imminent threats to the project area. Several species have been introduced in the past but have since been eradicated.

**Non-native species –** *Plants or animals introduced either intentionally or accidentally to locations outside their native ranges.*

**Invasive Plant –** *Non-native plants or animals that aggressively outcompete native vegetation causing significant economic loss and/or environmental harm. Not all non-native species are invasive.*

**Noxious Weeds –** *Invasive plant species listed at the county, state or federal level as particularly harmful to public health, wildlife, agricultural activities, or public and private property.*

**Cordgrasses (*Spartina spp.*)**

Three invasive cordgrass species are considered serious potential economic and environmental threats to the Coos estuary:

Smooth cordgrass (*Spartina alterniflora*), considered the most aggressive of the invasive cordgrass species, has been found once in the Coos estuary at the Oregon Department of Transportation's (ODOT) Barview Wayside wetland mitigation site near Barview (Figure 1). This population was accidentally transplanted during the wetland mitigation re-vegetation work. Because they never produced seed heads, the mysterious plants, growing into two large clones in the middle of the wetland, were very hard to positively identify (Figure 2). What was later identified using genetic techniques as smooth cordgrass was manually removed from the site over the course of seven years, both before and after the plant was positive identified. Helped immeasurably by the absence of seed production, smooth cordgrass is now considered completely eradicated at the Barview Wayside site. Aside from a site in the Siuslaw estuary (where the Barview Wayside infestation


Figure 1: Locations of historic cordgrass infestations in the Coos estuary. All known plants have since been eradicated. Data: SSNERR 2013

**Predicted Threats**

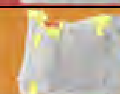
| Common name | Species name | ODA listing* | | $ | Distribution in project area | Native location | Year Oregon introduction | Location Oregon introduction | Vector Oregon introduction | Oregon range** | References |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Common cordgrass | *Spartina anglica* | A | x | x | Not known to be present | England | n/a | n/a | n/a | n/a | |
| Dense-flowered cordgrass | *Spartina densiflora* | T and A | x | x | Near Jordan Cove; eradicated 2013 | Southern South America | 2013 | Coos estuary | Most likely ocean currents | n/a | |
| Saltmeadow cordgrass | *Spartina patens* | T and A | x | x | Not known to be present | Eastern North America | c1930 | Siuslaw River | Most likely contaminated oyster spat | n/a | Howard et al. 2007 |
| Smooth cordgrass | *Spartina alterniflora* | T and A | x | x | Barview (South Slough); eradicated 2005 | Eastern U.S. | c1970 | Siuslaw River | Intentional planting |  | Howard et al. 2007 |
| Garlic mustard | *Alliaria petiolata* | T and B | x | x | Not known to be present | Europe | 1959 | Multnomah County | Most likely intentional |  | ODA 2014a |
| Portuguese Broom | *Cytisus striatus* | T and B | x | x | Not known to be present | Spain and Portugal | c1980 | south of Florence | Intentional planting |  | ODA 2014a |
| Diffuse Knapweed | *Centaurea diffusa* | B | | x | Not known to be present | Mediterranean | early 1900's | | Contaminated alfalfa seeds |  | ODA 2014a |
| Giant hogweed | *Heracleum mantegazzianum* | T and A | x | x | Not known to be present | Caucasus Mt., Asia | 2001 | Eugene | | | Savonen 2003 |
| Herb Robert | *Geranium robertianum* | B | x | | Not known to be present | Eurasia, northern Africa | | | |  | |
| Woolly Distaff Thistle | *Carthamus lanatus* | T and A | | x | Limited | Mediterranean | 1987 | Douglas County | Imported California livestock |  | OSU 2006 |

Table 1. Predicted non-native and invasive vegetation species threats. * Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program. ** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a).

Figure 2. Top left: Smooth cordgrass (*Spartina alterniflora*) clones (black arrows) at Barview Wayside in 1995. Top right: close-up of a flowering smooth cordgrass seed head which never developed at Barview Wayside. Middle left: Dense-flowered cordgrass (*Spartina densiflora*) in Coos Bay near Jordan Cove (2013). Middle right: Close-up of dense-flowered cordgrass flowering head. Bottom left: Saltmeadow cordgrass (*Spartina patens*). Bottom right: Common cordgrass (*Spartina anglica*).

originated), and a site at the mouth of the Columbia River, the Barview Wayside infestation is the only documented case of smooth cordgrass becoming established in Oregon. According to Howard et al. (2007), regional invasions occur in San Francisco, CA, which has a large (~1,000 acres in 2006) smooth cordgrass population, and to the north, in Willapa Bay, WA where populations peaked in 2003 with 8,500 acres affected, costing Washington state over $3 million from 2005-07.

Dense-flowered cordgrass (*Spartina densiflora*) plants were found in the Coos estuary in 2013 near Jordan Cove, the first time this species has been found in Oregon (Figures 1 and 2). Five individual clones were found and subsequently removed. According to Howard et al. (2007), over 1,500 acres of marsh habitat in Northern California have been converted to dense flowered cordgrass-dominated systems. For example, dense-flowered cordgrass now occupies 94% of Humboldt Bay's remaining salt marsh habitat.

Saltmeadow cordgrass (*Spartina patens*) is only known to occur in Oregon on Cox Island in the Siuslaw River (Howard et al. 2007)(Figure 2). Present since the 1930's, eradication of this population began in 1996 and is still ongoing. As of 2006, San Francisco (California) had a small (< 1 acre) population of this species (Howard et al. 2007).

Common cordgrass (*Spartina anglica*) has never been found in Oregon, but has established populations in both the Puget Sound to the north and San Francisco to the south (Howard et al. 2007)(Figure 2).

### Garlic mustard (*Alliaria petiolata*)

Although not known to occur in Coos County, the Coos County Weed Advisory Board has determined that garlic mustard can cause harm to the local forest ecosystems by dominating forest understory plant communities (Coos Weed Board 2011)(Figure 3). The Oregon Department of Agriculture (ODA) reports that the nearest county known to have garlic mustard is Josephine, just southeast of Coos County (ODA 2014).

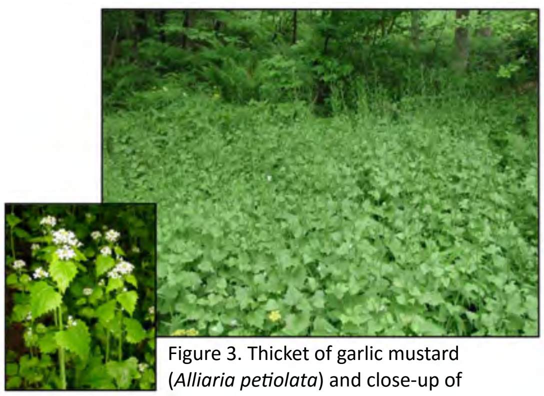


Figure 3. Thicket of garlic mustard (*Alliaria petiolata*) and close-up of flowers. Photos: ODA 2014a; EDDMapS 2014.

### Portuguese Broom (*Cytisus striatus*)

Portuguese Broom infestations in Oregon are only known in Lane and Douglas Counties, with the closest documented location just south of Florence (ODA 2014a)(Figure 4). In North America, it only occurs in California and Oregon (Zouhar 2005a). The Coos County Weed Advisory Board has listed this species as a species of high concern due to its detrimental economic impacts and the likelihood of this species to infest Coos County (Coos Weed Board 2011). The California Invasive Plant Council lists Portuguese broom as one of the most invasive wildland pest plants in regional areas of the state (Zouhar 2005a).

Figure 4. Portuguese Broom (*Cytisus striatus*) plant and close up of seed pods. Photos: ODA 2014a

### Diffuse Knapweed (*Centaurea diffusa*)

Diffuse knapweed, which occurs in all surrounding counties but not yet in Coos County, is listed by the Coos County Weed Advisory Board as a species expected to be extremely damaging to the local economy if allowed to take hold (Coos Weed Board 2011)(Figure 5). This species cannot tolerate flooding or shading, therefore it is most likely to be found in drier pasture or cropland areas (Beck 2013). Duncan (2001 as cited in Zouhar 2001a) reports that Oregon had nearly one million acres of diffuse knapweed infesting it in 2000.

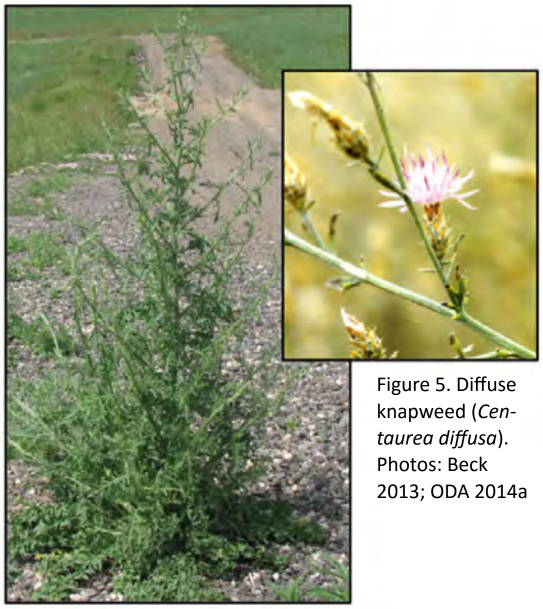


Figure 5. Diffuse knapweed (*Centaurea diffusa*). Photos: Beck 2013; ODA 2014a

**Giant Hogweed (*Heracleum mantegazzianum*)**

Giant hogweed has yet to be found in the project area, but has limited distribution along the northern Oregon coast (ODA 2014a). Moist wooded riparian areas of the project area would provide perfect habitat for this species and allow it to reach its full reproductive potential (Figure 6)(Forney 2013).

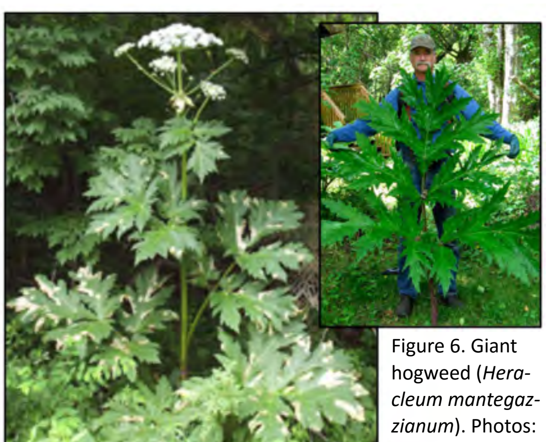


Figure 6. Giant hogweed (*Heracleum mantegazzianum*). Photos: ODA 2014a

**Herb Robert (*Geranium robertianum*)**

Herb Robert is not known to occur in the project area, but there has been positive identification of this species in Coos County by the United States Forest Service (USFS) in 2002 (Figure 7)(EDDMapS 2014). According to ODA (2014a), Herb Robert has the potential to become the most common woodland invader in Western Oregon.

Figure 7. Herb Robert (*Geranium robertianum*). Photo: ODA 2014a

**Woolly Distaff Thistle (*Carthamus lanatus*)**

Wooly distaff thistle is not known to occur in Coos County, but it can be found in all surrounding counties (ODA 2014a; OSU 2006). According to Burrill (1994), Wooly distaff thistle is a federally listed noxious weed considered one of the worst pasture weeds in North America and Australia.

**Partially Contained Threats (Table 2)**

Species described in this section have become established in the project area in isolated pockets, and whose populations are either being actively managed or were just recently discovered.

### Old Man's Beard (*Clematis vitalba*)

So far, old man's beard has limited distribution in the project area. It is, however, fairly widespread along the South Fork Coos River (Figures 8 and 9)(ODA 2014a; A. Brickner, pers. comm. 2014). Old man's beard is much more common in northwestern Oregon and is expected to become widespread throughout most of the state due to this species' highly effective seed dispersal strategy (ODA 2014a).

### False Brome (*Brachypodium sylvaticum*)

Identified in the South Slough watershed in 2006 by ODA, Oregon is considered the "epicenter for false brome" in the U.S. (Figures 8 and 9)(EDDMapS 2014, ODA 2014a). First discovered in North America (specifically, in Eugene) in 1939, this perennial grass has been naturalized (a self-sustaining population) in the Corvallis/Albany area since at least 1966 and has now taken over an estimated 10,000 acres in Oregon (Chambers 1966; Davi 2009; ODA 2014a). Distribution of false brome is expected to become more widespread since the species has had time to genetically evolve and adapt (Holmes et al. 2010).

### Policeman's Helmet (*Impatiens glandulifera*)

Until recently, infestations of policeman's helmet have been restricted to northwestern Oregon. However, in 2014 this species was found in the project area (Figures 8 and 9) (ODA 2014a; A. Brickner, pers. comm. 2015). Oregon invasions have come from expansion of established populations in western Washington and lower British Columbia (ODA 2014a).

### Spanish Heath (*Erica lusitanica*)

Within the project area, Spanish heath occurs along Cape Arago Highway (Figures 8 and 9) (A. Brickner, pers. comm. 2015). First introduced at a rare plant nursery near Langlois OR, Spanish heath has become established in seven Oregon locations, mainly in Coos and Curry counties. It's well adapted to the moist acidic soils of coastal Oregon and is a prolific seed-bearer. Spanish heath is expected to spread exponentially in the coming years. High costs associated with controlling established populations make Spanish heath a high priority for early eradication (French 2009).

**Partially Contained Threats**

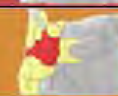
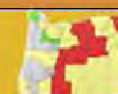
| Common name | Species name | ODA listing* | | $ | Distribution in project area | Native location | Year Oregon introduction | Location Oregon introduction | Vector Oregon introduction | Oregon range** | References |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Old man's beard | *Clematis vitalba* | B | x | x | Currently limited to Coos River | England | c1950 | | Intentional planting |  | A. Brickner pers. com. 2015 |
| False brome | *Brachypodium sylvaticum* | B | x | | South Slough | Eurasia, northern Africa | 1939 | Eugene | |  | ODA 2014a |
| Policeman's helmet | *Impatiens glandulifera* | B | x | | North Slough 2014 | Himalayas | | | |  | A. Brickner pers. com. 2015 |
| Spanish heath | *Erica lusitanica* | B | | x | Cape Arago Hwy | Western Europe | 1970 | Langlois | |  | A. Brickner pers. com. 2015 |
| Spurge species | *Euphorbia* spp. | A or B | x | x | Three known locations | Eurasia | 1991 | Salem | | | A. Brickner pers. com. 2015; ODA 2014a |
| Dalmatian toadflax | *Linaria dalmatica* | T and B | | x | South Slough (Barview) in 2014 | Mediterranean | | | |  | A. Brickner pers. com. 2015 |
| Yellow flag iris | *Iris pseudacorus* | B | x | | Mingus park | Eurasia, northern Africa | | | |  | A. Brickner pers. com. 2015 |

Table 2. Partially contained non-native and invasive vegetation species threats. * Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program. ** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a).

Figure 8. Partially contained species. Clockwise from top: Policeman's helmet (*Impatiens glandulifera*)(inset: flower); Yellow flag iris (*Iris pseudacorus*); Old man's beard (*Clematis vitalba*)(inset: leaves and flower); Spanish heath (*Erica lusitanica*); Dalmatian toadflax (*Linaria dalmatica*). Middle: False brome grass (*Brachypodium sylvaticum*). Photos: ODA 2014a; Stone 2009; Lincoln county soil water conservation district; kingcounty.gov; wikipedia.

**Spurge Species (*Euphorbia spp.*)**

Approximately 12 spurge plants whose identification have not been finalized can be found at three locations in the project area. These spurge species are most likely leafy spurge (*E. esula*) or oblong spurge (*E. oblongata*)(Figure 9). The plants will be positively identified and pulled in the summer of 2015 (A. Brickner, pers. comm. 2015). Oblong spurge is only known to occur in three Oregon counties, Lane County being closest to the project area (ODA 2014a). Rare along coastal Pacific

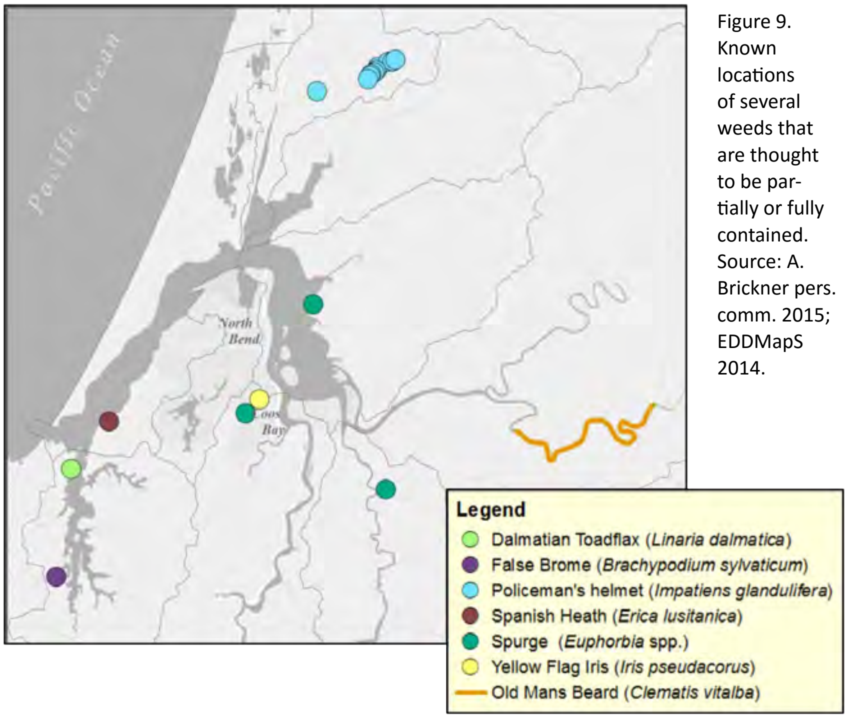



Figure 9. Known locations of several weeds that are thought to be partially or fully contained. Source: A. Brickner pers. comm. 2015; EDDMapS 2014.

Northwest in 1994, leafy spurge is more common in eastern Oregon counties, but occurs in Curry County to the south (Pojar and MacKinnon 1994; USDA 2015).

**Dalmatian Toadflax (*Linaria dalmatica*)**


Dalmatian toadflax was positively identified in Charleston in 2014 for the first time within the project area (Figures 8 and 9)(A. Brickner, pers. comm. 2015). Many Oregon counties east of the Cascades have widespread infestations of this species (ODA 2014a).

**Yellow Flag Iris (*Iris pseudacorus*)**

Yellow flag iris is an aquatic plant found sporadically within the project area and is more common further north (e.g., Umpqua River) (Figures 8 and 9)(A. Brickner, pers. comm. 2015; ODA 2014a).

**<u>Established Species (Table 3)</u>**

The following list of priority, already established non-native and invasive plant species (listed in Table 3 which spans two pages), are found throughout the project area, either in widespread or limited populations.

Figure 10. Top: Oblique sand dunes before beachgrass (*Ammophila spp.*) invasion. Middle: Inspection of intentional plantings of beachgrass in the Oregon Dunes Recreation Area c1930's. Dunes were planted to stabilize the highly mobile sand. Bottom: Bulldozer taking down a foredune north of Reedsport. The foredune was largely created by beachgrass (seen behind the bulldozer). Sources: University of Oregon Libraries; Siuslaw National Forest (bottom two photos); Coos Bay BLM (inset)

**Beachgrass (*Ammophila spp.*)**

Two related invasive beachgrass species occur in Oregon: 1) European beachgrass (*Ammophila arenaria*)(native to Europe); and 2) American beachgrass (*A. breviligulata*)(native to the east coast of North America )(Figure 10). European beachgrass was introduced to Oregon in 1910 near Coos Bay for dune stabilization and now dominates the dune system (Crook 1979). American beachgrass was intentionally planted near the mouth of the Columbia River in the 1930s and has since spread south. According to Hacker et al. (2012), American beachgrass was only found in isolated patches in Coos County, where the dunes are dominated by European beachgrass. Since their introduction in Oregon, beachgrasses have created a nearly continuous barrier from the foredunes inland to Highway 101, completely changing the formerly dynamic dune system (Crook 1979). Aerial photography of Oregon dunes from 1939 show 20% vegetative coverage; 50 years later over 80% of dunes in the same region were covered by vegetation (USFS n.d.).

**Gorse (*Ulex europaeus*)**

So far, gorse is found only in relatively small, isolated patches around the Coos estuary (Figures 11 and 12)(SHN 2013; A. Brickner,

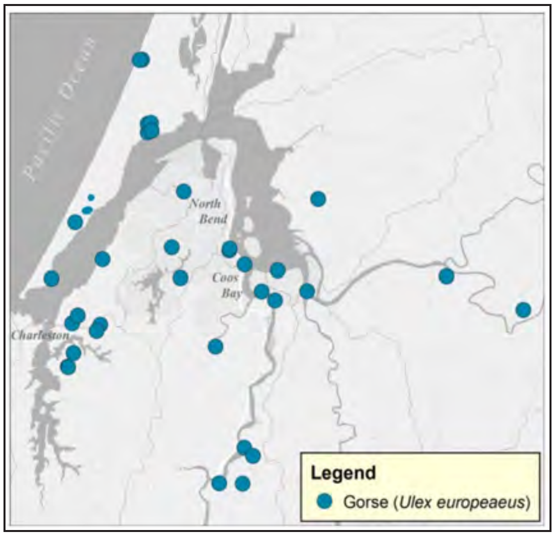



Figure 11. Known locations of gorse (*Ulex europeaeus*) infestations in the project area. Sources: ODF 2014a; EDDMapS 2015; CoosWA 2014a




Figure 12. Established species with limited distribution in the project area that have the greatest potential impacts to the project area (clockwise from top left): gorse (*Ulex europaeus*); Himalayan knotweed (*Polygonum polystachyum*); giant knotweed (*Polygonum sachalinense*); and Eurasian watermilfoil (*Myriophyllum spicatum*). Photos: ODA 2014a

pers. comm. 2015; OR Dept. of Forestry [ODF] 2014a; CoosWA 2014a; EDDMapS 2014). Infestations at many of these locations are controlled by the Coos Watershed Association (CoosWA) and in some cases herbicide (Garlon 3A or triclopyr)(A. Brickner, pers. comm. 2015). Just south of the project area, gorse has completely overtaken native vegetation in many expansively infested landscapes. ODF conducted an aerial survey of 300,000 acres in coastal Coos and Curry counties in the spring of 2014; they recorded over 6,200 acres of gorse, nearly 4,400 acres of which were heavily infested (ODF 2014a).

### French broom (*Genista monspessulana*)

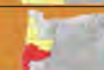
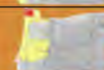
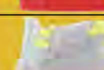
Widespread on the southern Oregon coast, this plant prefers warm, moist, low elevation areas (ODA 2014a)(Figure 13). French broom is the most widespread broom in California (Zouhar 2005b).

### Knotweeds (*Polygonum spp.*)

There are four knotweeds known in the project area: Himalayan (*P. polystachyum*), Japanese (*P. cuspidatum*), giant (*P. sachalinense*), and Bohemian (*P. bohemica*)(a hybrid between giant and Japanese knotweeds) (Figure 12). Himalayan knotweed is the least common of the three non-hybridized species

Table 3 (continued next page). Established non-native and invasive vegetation species threats.

**Established Threats**

| Common name | Species name | ODA listing* | (no-insect icon) | $ | Distribution in project area | Native location | Year Oregon introduction | Location Oregon introduction | Vector Oregon introduction | Oregon range** | References |
|---|---|---|---|---|---|---|---|---|---|---|---|
| European beachgrass | *Ammophila arenaria* | | x | x | Widespread | Europe; northern Africa | 1910 | near Coos Bay | Intentional planting | | Russo et al. 1988 |
| Gorse | *Ulex europaeus* | T and B | x | x | Limited | Europe | c1870 | Bandon | Intentional planting |  | |
| Armenian blackberry | *Rubus armeniacus* | B | x | x | Widespread | Armenia; northern Iran | 1922 | Marion County | Intentional planting |  | ODA 2014a |
| Bohemian knotweed | *Polygonum bohemica* | | x | | Limited | hybrid between giant and Japanese | | | | | |
| Brazilian waterweed | *Egeria densa* | B | x | x | Widespread | South America | | | |  | |
| English ivy | *Hedera helix* | B | x | x | Widespread | Eurasia | | | |  | |
| Eurasian watermilfoil | *Myriophyllum spicatum* | B | x | x | Limited | Eurasia; northern Africa | | | |  | |
| French broom | *Genista monspessulana* | B | x | x | Widespread | Mediterranean | 1924 | Curry County | |  | |
| Giant knotweed | *Polygonum sachalinense* | B | x | | limited (1st found in Coos County in 1937) | northeastern Asia and Japan | 1937 | Coos County | |  | ODA 2014a |
| Himalayan knotweed | *Polygonum polystachyum* | B | x | | Limited | Asia | 1934 | Polk County | |  | |
| Japanese knotweed | *Polygonum cuspidatum* | B | x | | Limited | eastern Asia | 1965 | Lane County | |  | ODA 2014a |
| Jubata grass | *Cortaderia jubata* | B | x | x | Widespread | northern Andes | | | |  | |
| Purple loosestrife | *Lythrum salicaria* | B | x | | Widespread | Eurasia; northwest Africa | | | |  | |
| Reed canary grass | *Phalaris arundinacea* | | x | | Widespread | Mediterranean; possibly North America | | | | | |
| Scotch broom | *Cytisus scoparius* | B | x | x | Widespread | Europe | 1892 | Benton County | |  | |
| Butterfly bush | *Buddleja davidii (B. variabilis)* | B | | x | Widespread | China; Japan | | | Intentional planting |  | ODA 2014a |
| Canada thistle | *Cirsium arvense* | B | | x | Widespread | Eurasia | | | |  | |
| Creeping buttercup | *Ranunculus repens* | | x | x | Widespread | Eurasia; northern Africa | | | | | NPSO 2008 |
| English holly | *Ilex aquifolium* | | x | | Widespread | Eurasia | | | | | Gray 2005; NPSO 2008 |
| Field bindweed (morning glory) | *Convolvulus arvensis* | T and B | | x | Widespread | Eurasia | | | |  | |
| Meadow knapweed | *Centaurea pratensis* | B | | x | Limited | Europe | | | |  | |

* Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program.

** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a)

*** Non-native species not considered to be invasive.

**Established Threats (continued)**

| Common name | Species name | ODA listing* | | $ | Distribution in project area | Native location | Year Oregon introduction | Location Oregon introduction | Vector Oregon introduction | Oregon range** | References |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Milk thistle | *Silybum marianum* | B | | x | Widespread | Eurasia | | | |  | |
| Parrot's feather | *Myriophyllum aquaticum* | B | x | | Widespread | Amazon | c1940 | | |  | ODA 2014a |
| Poison hemlock | *Conium maculatum* | B | | x | Limited | Europe; Mediterranean | 1919 | Multnomah County | |  | ODA 2014a |
| Slender flowered thistle | *Carduus tenuiflorus* | B | | x | Widespread | Europe; northern Africa | | | |  | |
| Spiny cocklebur | *Xanthium spinosum* | B | | x | Limited | South America | | | |  | |
| Spotted knapweed | *Centaurea stoebe (C. maculosa)* | T and B | | x | Limited | central/eastern Europe | | | |  | |
| Tansy ragwort | *Senecio jacobaea* | T and B | | x | Widespread | northern Eurasia | 1922 | | |  | OSU 2008b |
| Velvetleaf | *Abutilon theophrasti* | B | | x | Limited | southern Asia | | | |  | |
| Yellow starthistle | *Centaurea solstitialis* | B | | x | Limited | Mediterranean | | | |  | |
| Biddy-biddy | *Acaena novae-zelandieae* | B | x | | Limited | New Zealand | 1951 | Curry County | possibly imported sheep wool |  | ODA 2014a |
| Bull thistle | *Cirsium vulgare* | B | | x | Widespread | Eurasia; northwest Africa | pre 1900 | | |  | OSU 2006 |
| Cherry laurel | *Prunus laurocerasus* | | | | Widespread | eastern Europe; southwestern | | | | | |
| Cotoneaster | *Cotoneaster spp.* | | x | | Widespread | Eurasia; northern Africa | | | | | NPSO 2008 |
| Japanese eelgrass | *Zostera japonica* | | x | | | eastern Asia | | | | | |
| Pennyroyal | *Mentha pulegium* | | x | x | Limited | Europe; northern Africa; Middle | | | | | |
| St. Johnswort | *Hypericum perforatum* | B | | x | Widespread | Europe | | | |  | |
| Sweet fennel | *Foeniculum vulgare* | | x | | Widespread | Mediterranean | | | | | |
| Yellow glandweed | *Parentucellia viscosa* | | | | Limited | Europe | | | | | |
| Brass buttons*** | *Cotula coronopifolia* | | | | | Southern Africa | | | | | Heutte and Bella 2003 |
| Redtop grass*** | *Agrostis gigantea* | | | | | Eurasia | | | | | Carey 1995 |

Table 3 (continued from previous page). Established non-native and invasive vegetation species threats.

* Listed species are considered noxious weeds by the state of Oregon (Oregon Department of Agriculture). A-listed species: Economically threatening weed which occurs in small enough infestations to make eradication or containment possible; or is not known to occur in the state, but its presence in neighboring states make future occurrence in Oregon imminent. B-listed species: Economically threatening weed which is regionally abundant, but may have limited distribution in some counties; T-listed species: Weeds annually selected from A or B listed species as the focus of prevention and control by Oregon's Noxious Weed Control Program.

** Weed distribution color key: Yellow: limited; Red: widespread; Green: historical; Gray: not known to be present. (ODA 2014a)

*** Non-native species not considered to be invasive.

Figure 13. Established species with widespread distribution in the project area that pose the greatest threats to the project area. Top row: reed canary grass (*Phalaris arundinacea*); French broom (*Genista monspessulana*); Scotch broom (*Cytisus scoparius*); Middle row: Brazilian waterweed (*Egeria densa*); jubata grass (*Cortaderia jubata*); purple loosestrife (*Lythrum salicaria*). Photos: ODA 2014a; U of FL (Brazilian waterweed); and OSU (reed canary grass).

in the Pacific Northwest, while Japanese knotweed has the most widespread distribution, especially in western Oregon (ODA 2014a).

CoosWA provides free herbicide application to knotweed infestations for any landowner within the Coos watershed. Because of this effort, between 2008 and 2012, knotweed infestation in the Coos watershed was reduced from 12 acres to three (Cornu et al. 2012).

**Purple loosestrife (*Lythrum salicaria*)**

Found along moist sites in most subsystems of the project area, purple loosestrife populations are especially dense along Catching Slough and near the Libby area of Coalbank Slough (Figures 13 and 14)(CoosWA 2014b).

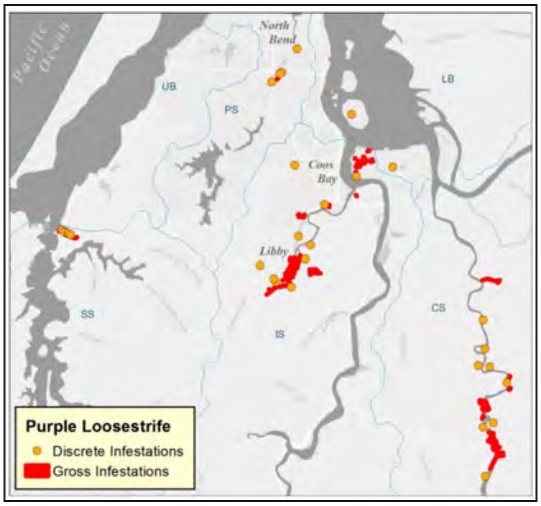



Figure 14. Discrete (small, isolated) and Gross (large, dense) infestations of purple loosestrife (*Lythrum salicaria*) in the project area as surveyed by Coos Watershed Association staff in 2014. Subsystems: SS = South Slough; LB = Lower Bay; UB = Upper Bay; PS = Pony Slough; IS = Isthmus Slough; CS = Catching Slough. Source: CoosWA 2014b

**Reed canary grass (*Phalaris arundinacea*)**

Reed canary grass (Figure 13) commonly occurs in freshwater wetlands and on agricultural lands in the project area. However, distribution of the species and the extent of invasion have not been documented locally. Magee et al. (1999) evaluated 96 freshwater wetland sites in the Portland (OR) area and found that the most frequently found invasive species was reed canary grass (93% of sites). In a related study by Magee and Kentula (2005), freshwater wetlands (43 study plots in seasonal, perennial, and open water wetlands within the Portland, OR urban growth boundary) where reed canary grass was present averaged 67% cover.

**Butterfly bush (*Buddleja davidii,* formerly *B. variabilis*)**


Out of all Oregon counties, butterfly bush is most widespread in Coos and Lane counties (ODA 2014a). In the project area, it's been most frequently reported along Cape Arago Hwy, Isthmus Slough, and the mouth of the Coos River (EDDMapS 2015).

**Buttercup (*Ranunculus spp.*)**


There are numerous native and non-native buttercup species in Oregon. Introduced buttercups include: *R. arvensis, R. bulbosus, R. ficaria, R. sardous, R. muricatus, R. parviflorus,* and *R. repens*. The latter three occur in Coos County (USDA 2015). Of these three, creeping buttercup (*R. repens*) is considered the most problematic both environmentally and economically (Burrill 1996).

**Knapweed or starthistle (*Centaurea spp.*)**


There are three knapweed/starthistle species known to occur in the project area – spotted knapweed (*C. stoebe*, formerly *C. maculosa*), meadow knapweed (*C. pratensis*) and yellow starthistle (*C. solstitialis*). A fourth invasive species, diffuse knapweed, (*C. diffusa*) has not been found locally and is described under Predicted Threats above.

Because yellow starthistle, already infesting nearly one million acres of Oregon rangeland (Duncan 2001 as cited in Zouhar 2002), prefers dry conditions with full sunlight, it's not likely to heavily infest the project area. Meadow knapweed, on the other hand, favoring moist conditions (e.g. riverbanks or irrigated pastures), can become established in a wide range of local environments (ODA 2014a; OSU 2006; Zouhar 2002). Spotted knapweed tolerates both wet and dry conditions, but prefers areas that receive summer rainfall (Beck 2013; PCA 2005). According to Zouhar (2001b), nearly 800,000 acres of Oregon lands were infested with spotted knapweed in 2000.

**Tansy ragwort (*Senecio jacobaea*)**

Already widespread in Coos County, tansy ragwort thrives in cool, wet, cloudy weather, like that seen along the Oregon coast (OSU 2008b).

**Biddy-biddy (*Acaena novae-zelandiae*)**

Biddy-biddy's distribution is limited in Coos County and in the project area. It's been reported in the lower Coos estuary near Empire and in the upper South Slough estuary (C. Cornu, pers. comm. 2015; EDDMapS 2014; ODA 2014a).

**Cotoneaster (*Cotoneaster spp.*)**

Multiple cotoneaster species have been introduced in Oregon including *C. simonsii* which is found in Coos County including the project area. Other species found elsewhere may pose threats in the future: *C. franchetii* , *C. lacteus* (Lane and Curry counties)*; C. horizontalis, C. divaricatus, C. nitens* (Lane County); *C. acuminatus* (Benton County); and *C. pannosus* (Jackson County)(USDA 2015).

**Japanese eelgrass (*Zostera japonica*)**

Japanese eelgrass coverage has not been quantified in the Coos estuary, but it commonly occupies previously unvegetated mudflat areas (Shafer et al. 2011). Japanese eelgrass was first observed in the Coos estuary in the mid-1970's in South Slough. By the mid-1980's it had spread throughout the South Slough and to middle portions of the Coos estuary (Posey 1988). This eelgrass invader has since increased its distribution and density in the Coos estuary (Rumrill 2006). Japanese eelgrass grows on the Coos estuary's mid-intertidal mudflats (0.6-1.2 m

[2.0-4.0 ft] above mean lower low water) and generally does not compete with the native eelgrass (*Z. marina*), which grows on lower intertidal mudflats and in subtidal channels (Posey 1988). In Yaquina Bay, Japanese eelgrass coverage has increased by 400% in just over nine years (Young et al. 2008).

**Sweet Fennel (*Foeniculum vulgare*)**

Fennel is considered only moderately invasive. Expansive populations can be found in coastal southern Oregon (NPSO 2008).

**Background**

Below are detailed descriptions of the specific threats posed by each of the non-native and invasive plant species included in this data summary (species listed alphabetically):

**American Beachgrass (*Ammophila breviligulata*)**: See "Beachgrasses" below.

**Armenian blackberry (*Rubus armeniacus*) (formerly Himalayan blackberry, *Rubus discolor*)**
According to ODA (2014a), this invasive blackberry is the most economically damaging non-native species in western Oregon due to control costs on public and private rights-of-way, agricultural pasture and crop lands, and timberlands. The estimated economic impact of Armenian blackberry infestations and associated control costs in Oregon is over $40 million. When all susceptible acres of land are considered, this estimate could rise to $268 million (ODA 2014b). Armenian blackberry, which severely alters native ecosystems, can grow 20 feet per year and reproduces with prolific berry production, or vegetatively by rooting the tip of the cane when it touches the ground (ODA 2014a). Commonly found in open riparian areas, blackberry thickets provide little shade for streams and prevent native shade-producing trees and shrubs to colonize stream banks.

**Beachgrasses (*Ammophila spp.*)**
Non-native European and American Beachgrasses are well adapted to seasonal sand burial (up to 1 m per year according to Ranwell 1959 as cited in Russo et al. 1988), which allows them to outcompete the native dune grass, *Elymus mollis* (a.k.a. *Leymus mollis*). Invasive beachgrasses spread via rhizomes (i.e., rootstock), the fragments of which are dispersed along the shore by winter storms (Russo et al. 1988). Once established, these species are very difficult to control, much less eradicate.

Since the introduction of beachgrasses to the Oregon dunes, populations of native plant and animal species adapted to once dynamic Oregon dune habitats (including pink sand verbena, wolf's evening primrose, silvery phacelia, and the endangered western snowy plover), have declined precipitously (Figure 10)(Julian 2012, Kaye 2004, Kalt 2008, Russo et al. 1988).

Russo et al. (1988) attributed native dune species decline largely to changes in the orientation of the Oregon dune field's valleys (technically referred to as "slacks") and to the reduction in sand supply to interior dune habitats, both caused by the establishment of non-native beachgrasses. Historically, beaches associated with the Oregon dunes were characterized by the absence of foredune habitat running parallel to the ocean shore. Dunes and associated slacks were instead oriented obliquely to the shore, shifting with seasonal changes in prevailing winds. The Coos Bay dune field (stretching from Haceta Head in the north and Cape Arago in the south, the largest dune sheet in North America) contains the only "oblique-ridge dunes"' in the world, which are expected to disappear in the foreseeable future due to non-native beachgrass stabilization (Cooper 1958; Crook 1979).

According to a draft environmental impact statement by Siuslaw National Forest (1993 as cited in Wiedemann and Pickart 1996), the unique open dunes will completely disappear by 2040, a process which can only be reversed by removing the foredune, a cost-prohibitive solution.

Wiedemann and Pickart (1996) temper the threat by providing evidence for the long-term cyclical nature of Oregon dune stabilization and rejuvenation over the course of the past 3,000 years; a recurring process in which vegetation-induced dune stabilization creates a foredune, which is then eliminated during major natural disturbances (e.g., subduction zone earthquake, tsunami, sea level rise), releasing interior dunes once again to wind-driven sand movement. They suggest that non-native beachgrasses may only be hastening a natural cyclical process.

**Biddy-biddy (*Acaena novae-zelandiae*)**
Biddy-biddy is a low-growing perennial forb (non-grass herbaceous plant) that prefers disturbed open sites (e.g., stablilized dunes or open scrub communities) and competes poorly with established native vegetation (ODA 2014a). Its seed exteriors feature barbed burs that cling tenaciously to almost anything, allowing the seeds to spread far and wide by mobile species including mammals, birds and humans. Biddy-biddy can also spread vegetatively by the growth of above-ground "stolons" (horizontal stems)(ODA 2014a).

**Brass Buttons (*Cotula coronopifilia*)**
Brass buttons is a non-native, non-invasive species commonly found in disturbed wetlands and beaches in every Oregon coastal county. Brass buttons is easily outcompeted by native vegetation.

**Brazilian waterweed (*Egeria densa*)**
Exported from South America for use in aquariums, Brazilian waterweed has escaped to infest local lakes, ponds, and slow moving rivers where it forms dense mats on the water's surface. Once established, Brazilian waterweed slows or stops water flow, traps sediments, displaces native aquatic species, and interferes with recreational activities (e.g., swimming, boating)(Figure 13). Inter-

estingly, all Brazilian waterweed plants in the U.S. are male, but they still manage to spread vegetatively (WSDE n.d.).

**Bull thistle (*Cirsium vulgare*)**
Reaching 5 ft (1.5 m) tall and 3 ft (0.9 m) in diameter, bull thistle is made up of many spiny branches and can develop taproots that extend 28 inches (71 cm) into the soil (OSU 2008a; USFS 2005a). Seeds are wind dispersed and can remain viable for up to 10 years (OSU 2008a). This thistle is most commonly found in disturbed areas such as along roadsides and in pastures in poor conditions, though it can also be found in cleared forestland (OSU 2006; USFS 2005a). Bull thistle can reduce agricultural productivity by forming large, dense stands in pastures. Bull thistle also grows in native plant communities, out-competing these plants for water, nutrients and space.

**Buttercup (*Ranunculus spp.*):** Of all the non-native plant species found in Coos County, creeping buttercup (*R. repens*) is the most invasive, spreading by stolons and forming thick carpets in wet meadows (Burrill 1996). In buttercup-infested pasture lands this plant can poison and sometimes kill livestock (Burrill 1996). Creeping buttercup is also highly invasive in moist riparian terraces and wetlands, dominating streamside plant communities (NPSO 2008)

**Butterfly bush (*Buddleja davidii* formerly *B. variabilis*)**
Similar to Scotch broom (below), butterfly bush dominates open disturbed habitat, and is especially problematic to re-forested lands where it smothers tree seedlings (ODA 2014a). Butterfly bush can grow to 12 ft (3.6 m) in height and 15 ft (4.6 m) across and produces an abundance of wind-dispersed seeds (USFS 2005b).

**Canada thistle (*Cirsium arvense*)**
Canada thistle spreads aggressively through agricultural lands, riparian areas, wet meadows, and roadsides both vegetatively and from seed (up to 5,000 per plant)(USFS 2006a). Control of established populations can be difficult because even small root segments can form new plants (OSU 2006).

**Cherry laurel (*Prunus laurocerasus*)**
Also known as English laurel, cherry laurel can “escape” from cultivated hedges, spreading into nearby forest lands. Cherry laurel is a shade tolerant plant that can grow to 30 ft (9 m) tall and is toxic (especially the seeds) if ingested (USDA 2010).

**Cordgrasses (*Spartina spp.*)**
Except where otherwise noted, the following information is provided by Howard et al. (2007). Only one *Spartina* species (*S. foliosa*) is native to the U.S. West Coast. Four other *Spartina* species found in the region are non-native and considered particularly invasive: Common cordgrass (*S. anglica*), smooth cordgrass (*S. alterniflora*), dense-flowered cordgrass (*S. densiflora*), and saltmeadow cordgrass (S. patens). Common cordgrass is a hybrid between the European cordgrass (*S. maritima*, not found on the U.S. West Coast) and smooth cordgrass. Common and smooth

cordgrasses colonize West Coast estuaries, converting widespread unvegetated low intertidal mudflats to marsh habitat. These marshes are dominated entirely by *Spartina* since no native marsh plants are adapted to grow in the low intertidal zone. This dramatic habitat shift affects native plant and animal species that rely on intertidal mudflats (e.g., shore birds, native clams, eelgrass), and severely limits recreational and commercial uses of those same mudflats (e.g., commercial oyster cultivation, recreational clamming). Smooth cordgrass is the most aggressively spreading of the four species and is also able to occupy the broadest elevation range (mudflat to high marsh). Dense-flowered and saltmeadow cordgrasses are better adapted to local marsh habitats where they aggressively outcompete native salt marsh species.

All four non-native *Spartina* species can reproduce both sexually (seeds), flowering late summer into early fall, and by vegetative means (i.e. rhizome fragments).

**Cotoneaster (*Cotoneaster spp.*)**
Cotoneaster species frequently escape garden plantings and are considered moderately invasive in coastal Oregon woodlands and prairies (NPSO 2008). On occasion, populations can become dense enough to crowd out native vegetation (DiTomaso et al. 2013).

**Dalmatian Toadflax (*Linaria dalmatica*)**
Dalmatian toadflax is a potentially serious weed that invades agricultural lands. It is resistant to many herbicides, hosts several viruses that can transfer to crops, outcompetes

***Vectors of invasion***

*Not being aware of some plants' aggressive potential, people intentionally introduce what turn out to be invasive terrestrial vegetation to their local areas:*

- *As garden ornamentals (e.g., butterfly bush, Scotch broom, gorse)*
- *For agriculture land enhancements (e.g., false brome, reed canary grass)*
- *For use in aquariums or water features (e.g. Eurasian watermilfoil, Brazilian waterweed)*
- *For use as bank or dune stabilization (e.g., European beach grass)*

*Accidental invasive species introductions also occur, often the result of seeds or vegetative parts hitchiking on:*

- *Internationally traded goods (e.g., biddy-biddy in sheep's wool)*
- *The boots or clothing of individuals traveling from infested regions*
- *Migrating animals*

*Animals can also spread non-native and invasive plants by ingesting seeds and dropping seed-laden feces in areas with hospitable growing conditions (e.g., cotoneaster, English ivy).*

desirable forage plants while having no forage value itself, and is difficult to eradicate once established (Figure 8). Control costs are currently estimated at over $250,000 per year. If all Oregon lands susceptible to infestation were covered by this species, annual control costs could reach over $20 million (ODA 2014b). Toadflax vegetative budding roots can extend up to six feet (1.8 m) deep and spread laterally up to 12 ft (3.6 m). Mature toadflax plants can produce as many as 500,000 seeds each year. This species commonly invades open disturbed areas such as roadsides and cultivated fields but rarely occurs in intact natural areas. Toadflax is not known to be used by local animals except as cover for small animals (Zouhar 2003).

**Diffuse knapweed (*Centaurea diffusa*)**
See 'Knapweeds and Starthistle' below.

**English holly (*Ilex aquifolium*)**
A common ornamental, English holly frequently escapes garden plantings and is considered moderately invasive in Oregon woodlands and prairies (NPSO 2008). English holly is a shade tolerant species that is frequently associated with increasing forest stand density. English holly populations in Oregon are expected to spread significantly in coming years (Gray 2005).

**English ivy (*Hedera helix*)**
English ivy is a perennial evergreen climbing vine that covers trees to canopy height, sometimes creating enough biomass that its weight topples trees. English ivy also spreads horizontally along the forest floor, displacing all native vegetation in its path (ODA 2014a). It is considered a threat to native plant communities in Oregon and has been placed on ODA's 2010 list of quarantine species (Waggy 2010). English ivy has a high tolerance to varying light conditions, thriving in both full shade and full sun. It can survive in early to late successional forests (Waggy 2010).

**Eurasian watermilfoil (*Myriophyllum spicatum*)**
See 'Watermilfoil' below.

**European Beachgrass (*Ammophila arenaria*)**
See "Beachgrasses" above.

**False Brome (*Brachypodium sylvaticum*)**
Brought to Oregon in the late 1930's by USDA as one of several grasses for range enhancement experiments, false brome has since escaped into Oregon's landscape (Figure 8). False brome is a perennial grass that thrives in both shady and sunny conditions, creating thick monoculture (single-species) mats that can outcompete native herbaceous vegetation and prevent native tree species' seeds from germinating. Further, false brome does not provide good forage, reducing pasture productivity (Davi 2009).

**Field bindweed (morning glory)(*Convolvulus arvensis*)**
Competing with crops for nutrients and water and extremely difficult to remove, field bindweed can reduce crop yields by as much as 50% (ODA 2014a). One plant can produce up to 500 seeds, which remain viable in the soil for up to 20 years (USFS 2006b). This

climbing vine has lateral roots that can sprout new plants from small root or vine fragments, greatly complicating eradication measures (USFS 2006b; Zouhar 2004a).

**French Broom (*Genista monspessulana*)**
An aggressive pioneer species that displaces native early colonizing plants in disturbed areas, French broom can drive up invasive species control costs in timber harvest areas and create a severe fire hazard during the dry season (Figure 13)(ODA 2014a). A medium sized French broom shrub can produce over 8,000 seeds per year, which are explosively ejected by the pod up to 13 ft (4 m) from the parent shrub (Bossard 2000, Zouhar 2005b). Over half the seeds from these dense woody shrubs are dormant upon dispersal. Germination takes place only under specific environmental conditions (e.g., scarification of the seed shell); seeds remain viable in the soil for up to 5 years (Adams et al. 1991, Bossard 2000b).

**Garlic Mustard (*Alliaria petiolata*)**
Extremely difficult to control once established, garlic mustard thrives in partial shade and forms dense thickets in forest understories, displacing native species (Figure 3). It can also infest riparian zones, roadsides, trails and agricultural lands and is almost totally reliant on seed production to spread (ODA 2014a). Garlic mustard can grow as tall as 3.5 feet (1 m)(USFS 2005c) and does not tolerate acidic soil, likely explaining its absence from conifer-dominated communities. This invader appears to negative affect native butterfly populations by fatally inhibiting larval development in butterfly eggs deposited on its leaves (Munger 2001).

**Giant Hogweed (*Heracleum mantegazzianum*)**
Unlike its native relative, cow parsnip (*H. maximum*), giant hogweed adversely affects both local economies and native plant communities (ODA 2014a). Most common in partial shade or full sun, giant hogweed readily invades riparian areas where it outcompetes native species, provides poor winter groundcover for animals, and leads to increased bank erosion during winter rains (Thiele and Otte 2006, DiTomaso and Healy 2007, Forney 2013). Forney (2013) describes giant hogweed as a human health hazard, since its sap contains a chemical that can cause severe burns on UV exposed skin, prompting the need for targeted control programs in public spaces. Although this plant is currently only found in very limited areas in Oregon, potential economic impact to the state (in lost agricultural production and control costs) if it was to infest all susceptible habitat would be over $1 million per year (ODA 2014b).

Giant hogweed is a large plant, growing approximately 15 ft (4.5 m) tall with flower heads and leaves that can be 3 ft (0.9 m) or more in diameter (ODA 2014a). It grows from a single hollow stem that can be 6 inches (15 cm) in diameter (Figure 5)(Page et al. 2006). Seeds can float in water for two days and remain viable, allowing this plant spread via waterways (Gucker 2009). Because of its size and prolific seeding ability (each flower head can produce 1,500 seeds), giant hogweed easily outcompetes native species (USFS 2005d). According to Gucker (2009), giant hogweed seeds are capable of germinating within the first year of dispersal; the plants generally flower in three years and then die.

**Gorse (*Ulex europaeus*)**

Gorse is considered one of the most unmanageable weeds in the world, significantly affecting both native habitats and local economies (e.g., managed forestland) by forming impenetrable thickets that persist and thrive for many years (Figure 12)(ODA 2014a). A perennial, densely spiny shrub that can live for over 40 years, gorse colonization results in the development of large seed banks in underlying soils, which severely complicate eradication efforts. Gorse seeds, which can remain dormant but viable for up to 30 years, require scarification (damage to outer seed case) in order to germinate (Zouhar 2005c). Gorse currently infests less than 0.2% of possible area it could inhabit in Oregon but still costs the state an estimated $441,000 in lost economic activity and control measures. If it were to cover all susceptible lands, it would cost over $205 million to control.

**Herb Robert (*Geranium robertianum*)**

Herb Robert can affect native flora, with localized densities of 250 plants/$m^2$. Herb Robert's roots, however, are shallow, allowing for easy manual control. According to ODA (2014a), herb Robert can invade open forest or forest edge habitat, and can also thrive in shady conditions, allowing it to directly compete with native understory plant communities (Figure 7).

**Japanese eelgrass (*Zostera japonica*)**

The invasive status of Japanese eelgrass is debated. Evidence supports both its potential benefits and harmful effects. The following describes Japanese eelgrass's positive, negative and neutral effects on the local ecosystem.

<u>Positive</u>: Waterfowl (e.g., mallards) prefer grazing on Japanese eelgrass over native eelgrass, possibly due to the higher caloric value and easier foraging accessibility of the former (Baldwin and Lovvorn 1994).

According to Ferraro and Cole (2012), benthic macroinvertebrates species richness, abundance, and biomass are greater in Japanese eelgrass beds compared with native eelgrass beds.

Posey (1988) demonstrated that species diversity was higher in Japanese eelgrass beds than in adjacent unvegetated areas in the South Slough. Supporting Posey's results, Javier (1987), also studying Japanese

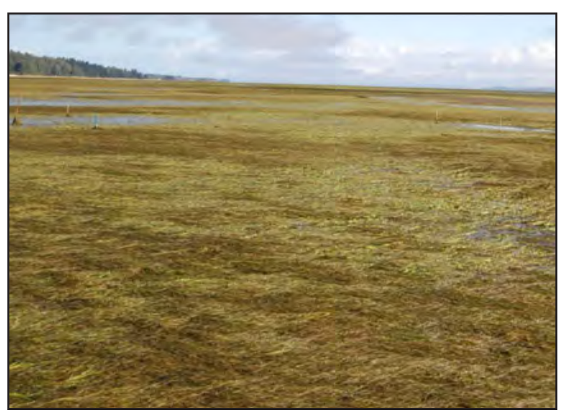


Figure 15. Continuous coverage of invasive Japanese eelgrass (*Z. japonica*) in Willipa Bay, WA at a site that was unvegetated mudflat 10 years prior. Source: Fisher et al. 2011

eelgrass habitats in the South Slough, found that the four most common spionids (worm species considered prey resources for various animals) were found in significantly higher densities in Japanese eelgrass beds compared to surrounding mudflats. This result supports the theory that Japanese eelgrass provides refuge for prey resources.

Negative: Able to spread through both seed production and vegetatively, Japanese eelgrass roots create a dense sodlike matrix, able to completely cover substrate surfaces (Fisher et al. 2011, Posey 1988).

In Willapa Bay, WA, Japanese eelgrass populations remained relatively confined for 50 years after introduction until 1998 when they began to greatly expand (likely surpassing some critical population/reproductive threshold), covering large swaths of formerly unvegetated estuarine mudflat (Figure 14). Japanese eelgrass then began to outcompete native eelgrass (in the transition zone where the two species overlap) and spread into existing low salt marsh habitat (Fisher et al. 2011). Coverage of unvegetated mudflats by Japanese eelgrass and its heavily matted root structures may also adversely affect burrowing benthic macroinvertebrates that colonize open mud habitats (Posey 1988).

Rumrill and Kerns (1991) found that juvenile Dungeness crabs (*Cancer magister*) accidentally settle in Japanese eelgrass beds, at higher intertidal elevations than they normally would, leaving the young crabs more susceptible to predators and desiccation.

Neutral: Known to overlap with native eelgrass (*Z. marina*) in other estuaries, Japanese eelgrass in the Coos estuary thus far colonizes discretely higher intertidal elevations (Dudoit 2006). Fisher et al. (2011) explain that native eelgrass can often suppress the density of Japanese eelgrass in beds where the species co-occur. However, a critical Japanese eelgrass population threshold may not yet have been reached in the Coos estuary (see Willipa Bay example in the Japanese eelgrass "Negative" section above).

Like the native eelgrass, Japanese eelgrass traps and stabilizes sediments and slows tidal currents to the benefit of smaller fish and crustaceans. Its senesced leaves contribute to the estuary's detrital food web, and it radically changes the character of formerly unvegetated mudflats. Long-term Japanese eelgrass colonization can result in significantly smaller mean sediment grain size, significantly higher levels of volatile organics (an indicator of detritus), and higher benthic macroinvertebrate density and species richness compared with adjacent unvegetated mudflats (Posey 1988).

Finally, in Oregon, Pacific herring use both Japanese eelgrass and the native eelgrass as spawning substrate (Matteson 2004).

**Jubata grass (*Cortaderia jubata*)**

Frequently confused with the related invasive pampas grass (*C. selloana*), the perennial jubata grass can grow to 7 m (23 ft) tall. A single plant can grow roots that spread 3.5 m (11 ft) deep and 4 m (13 ft) wide, easily crowding out native vegetation (especially in native grasslands) and out-competing seedling trees in timber managed areas (Figure 13) (ODA 2014a; Marriott et al. 2013). Damaging even in small populations because of its rapid growth and formidable size, the large clumping grass once established can be very difficult to remove (Peterson and Russo 1988). Jubata grass is a prolific seeder (millions of seeds per plant) that does not require pollination. These giant grass plants can spread quickly because their numerous seeds are light and can travel easily on the wind (Peterson and Russo 1988).

**Knapweed or starthistle (*Centaurea spp.*)**
Diffuse knapweed (*C. diffusa*) is a highly prolific plant (18,000 seeds per plant) that forms dense thickets in a wide range of conditions, including gravel banks, sandy riparian areas, rock outcrops, and agricultural pasture lands. (Figure 5). Health hazards associated with this species include skin irritation due to plant juices and bites from associated mites (ODA 2014a, 2014b). It is an extremely difficult plant to manage once established. The expense associated with controlling and eradicating diffuse knapweed can often exceed the income potential of the pasture or forage lands it invades (Beck 2013, USFS 2014, Zouhar 2001a).

Meadow knapweed (*C. pratensis*) is a hybrid of brown knapweed (*C. jacea*) and black or common knapweed (*C. nigra*). According to ODA (2014a), this invader prefers moist open conditions such as wet pastures and riverbanks where it frequently outcompetes native and forage grasses, causing declines in pasture productivity. They add that once established, this plant is difficult to eradicate. Hand-pulling is a challenge due to the plant's woody root crown, and long-term herbicide regimens are only effective if maintained for many years.

Meadow knapweed's current annual economic impact to the State of Oregon is estimated at $146,000. However, at present it only covers 1% of possible habitats. If it were to infest all potential habitats, it could cost the state over $15 million per year (ODA 2014b).

Spotted knapweed (*C. stoebe* formerly *C. maculosa*), one of the most dominant weeds in the western US, spreads primarily by seed but can also spread vegetatively by sprouting lateral shoots (Beck 2013; Zouhar 2001b). This species releases a toxin into the soil that hinders growth of neighboring vegetation, reducing competition from native species (USFS 2006d). Considered a serious threat to Oregon rangelands, this perennial plant is able to live nine years (Zouhar 2001b). Spotted knapweed's estimated economic impact to Oregon thus far is limited ($33,000) but could grow. Luckily for Oregon's coastal communities, however, habitat suitability for spotted knapweed west of the coast range is scarce (ODA 2014b).

Yellow starthistle (*C. solstitialis*) is a prolific seed producer, thrives in full sunlight in areas of summer drought, and can grow 3-6 ft (0.9-1.8 m) tall (OSU 2008c). A single plant is able to produce 150,000 seeds (OSU 2006) which can remain viable in the soil for 10 years

(Callihan et al. 1993). According to Zouhar (2002), yellow starthistle taproots can grow deep enough (more than 3 ft) so that heavy infestations can lower the local soil water table below the root zone of most native plants, adversely affecting those plant communities.

Yellow starthistle can cause livestock injury (chewing disease) especially in horses. Currently this plant costs Oregon an estimated $775,000 per year to control. Costs could reach nearly $28 million if this species covered all possible lands in Oregon with suitable habitat (ODA 2014b).

**Knotweeds (*Polygonum spp.*)**
There are four knotweeds known in the project area: Himalayan (*P. polystachyum*), giant (*P. sachalinense*), Japanese (*P. cuspidatum*) and Bohemian (*P. bohemica*), which is a hybrid between giant and Japanese knotweeds (Figure 12). Knotweeds form dense thickets along water edges, outcompeting native riparian species (ODA 2014a). According to ODA (2014a), knotweeds can grow new plants vegetatively from any part of the plant, above or below ground, making proper disposal of cuttings imperative for preventing its spread. Once established, knotweeds are extremely costly and time consuming to control, much less eradicate. Giant, Japanese and Bohemian knotweeds all produce extensive rooted mats that hinder any kind of growth from other plant species (Steiger 1957, Weber 1987, Lema 2007).

Giant knotweed is the largest of the knotweeds, growing to 13 ft (4 m) tall, with 1 ft (0.3 m) long leaves, and able to spread via rhizomes (i.e., rootstock) up to 65 ft (20 m) laterally (ODA 2014a). Slightly smaller, Japanese knotweed grows up to 10 ft (3 m) tall with 6 inch (15 cm) long leaves and can tolerate adverse conditions such as high temperature, salinity, drought, or full shade (USFS 2004). Himalayan knotweed, the least shade tolerant species, is even smaller growing to 6 ft (1.8 m) tall and has narrow leaves 4-8 inches (10-20 cm) long (ODA 2014a).

**Meadow knapweed (*Centaurea pratensis*)**
See 'Knapweeds and Starthistle' above.

**Milk thistle (*Silybum marianum*)**
A large thistle, milk thistle can grow 10 ft (3 m) tall and 5 ft (1.5 m) in diameter (OSU 2006). Since it can grow so large and spread so rapidly, OSU (2006) notes that livestock can be entirely displaced in pastures that are heavily infested with milk thistle.

**Old Man's Beard (*Clematis vitalba*)**
Similar to English ivy, old man's beard is a woody climbing vine that can grow up to 100 ft (30 m) long, and can blanket entire trees or smother native ground cover (Figure 8). Individual plants can produce over 100,000 seeds per year, which are then easily transported by wind, water or animal. Further enhancing its ability to spread, small vine sections can regenerate into entirely new plants (ODA 2014a).

**Parrot's feather (*Myriophyllum aquaticum*)**
See 'Watermilfoil' below

**Pennyroyal (*Mentha pulegium*)**
Pennyroyal, member of the mint family, occurs in most coastal Oregon counties (Cal-IPC n.d.). Thought to be widespread and invasive in some Oregon freshwater wetlands, it is difficult to control once established (NPSO 2008). Found primarily in seasonally flooded, disturbed sites (e.g. pastures or riparian areas), pennyroyal's capacity to displace native plants is uncertain, but it is considered a problem species for ranchers since it can poison livestock (Cal-IPC n.d.).

**Poison hemlock (*Conium maculatum*)**
A member of the carrot family, poison hemlock is an extremely poisonous plant that inhabits pastures and irrigation ditches, growing 3-7 ft (0.9-2.1 m) tall (ODA 2014a).

**Policeman's Helmet (*Impatiens glandulifera*)**
Policeman's helmet can form dense stands in moist open areas (e.g., riparian zones)(Figure 8)(ODA 2014a). Individual plants can release up to 800 seeds per seed capsule, which explode when mature; in riparian areas, seeds are then easily transported downstream (ODA 2014a).

**Portuguese Broom (*Cytisus striatus*)**
Portugese broom outcompetes native scrub/shrub vegetation (particularly in commercial timberland) and provides no food for native wildlife. Individuals can reach sizes of 20 ft (6 m) in width, with trunk diameters of 14 inches (35.5 cm). Easy to confuse with the much more common Scotch broom, Portuguese broom seed pods are covered in thick white hair, similar to willow buds (ODA 2014a). See "Scotch Broom" below for more information on broom species.

**Purple loosestrife (*Lythrum salicaria*)**
Purple loosestrife is a perennial plant that spreads vegetatively by rhizomes (i.e., rootstock), or with seeds that disperse in water (Figure 13). This highly invasive freshwater wetland plant quickly colonizes disturbed areas and can create dense single-species thickets in wetlands and riparian edges, adversely affecting habitat availability for waterfowl and songbirds (Munger 2002, ODA 2014a).

A prolific seeder, Purple loosestrife seed capsules burst at maturity projecting two to three million seeds per year per plant that disperse by water or wind and can remain viable for up to three years (Munger 2002, USFS 2005e). Rhizome spread is about a foot per year and long-established plants can be shrubby, growing up to 10 ft (3 m) tall and 5 ft (1.5 m) wide (USFS 2005e, Munger 2002).

Purple loosestrife currently costs the state an estimated $12,000 to control. Luckily, this wetland invader is unlikely to reach its full biological potential in Oregon due to successful (achieves 50-95% reduction in established populations) and approved biological control measures (ODA 2014b).

Locally, CoosWA has since 1999 released over 41,000 biological control agents (two beetle species and two weevil species) at 23 of 70 purple loosestrife-infested sites in the project area. The release sites ranged in size from 0.5 to over 5 acres, large enough to support viable beetle and weevil populations for effective purple loosestrife control. Each biological control release consists of 500-1000 beetle or weevil species which the USDA and ODA carefully selected over many years to ensure they only attack purple loosestrife (A. Brickner, pers. comm. 2015).

CoosWA partners with ODA and USDA Animal and Plant Health Inspection Service to obtain the beetles and weevils, which attack many parts of the plant including leaves, buds, roots, and seeds. The insects are released in the late summer and monitored by CoosWA staff each season for effectiveness. Several releases and many years may be required before results are evident but the beetles and weevils have proven to be effective for controlling and sometimes eradicating purple loosestrife locally and throughout the country. So far, these insects have helped CoosWA staff nearly eradicate purple loosestrife from a two-acre site. At Coos WA's other release sites, the insects have controlled purple loosestrife populations to varying degrees; the insects' effectiveness is oftentimes influenced by the presence of tidal flooding at the site (A. Brickner, pers. comm. 2015).

**Redtop grass (*Agrostis gigantean*)**
This non-native perennial grass has been widely introduced as pasture grass and thrives in meadows and grasslands, but also frequently occurs in open riparian areas (Carey 1995). Red top grass is common and can create single species patches but is not considered an invasive grass (Huang and del Moral 1988).

**Reed canary grass (*Phalaris arundinacea*)**
There is some confusion as to the native status of this perennial grass. It's likely native to parts of North America, but has been cultivated for livestock fodder with non-native strains and is now considered an invasive plant that is a major threat to natural freshwater wetlands (Figure 13)(Apfelbaum and Sams 1987, Lavergne and Molofsky 2007).

An aggressive invader, reed canary grass quickly spreads both vegetatively (by creeping rhizomes (i.e., rootstock)) and by seed (individual seed heads can produce up to 600 seeds). Reed canary grass seeds can germinate immediately after dropping with no dormancy requirements (Apfelbaum and Sams 1987, Tu 2004).

Associated with a reduction in native plant species richness, reed canary grass often approaches 75-100% cover in the areas is invades (Houlahan and Findlay 2004, Mulhouse and Galatowitsch 2003). As an example, an Oregon study by Schooler et al. (2006) found that native species abundance declined exponentially with increasing cover of reed canary grass. Likewise, along the Willamette River in Oregon, Fierke and Kauffman (2006) found that reed canary grass abundance was negatively correlated with species richness and understory species diversity in established riparian forest stands.

Perkins and Wilson (2005), found a strong negative correlation between native plant community diversity in beaver-dammed wetlands along the Oregon coast and reed canary grass infestations. They suggest that the cyclical nature of disturbance associated with beaver dam abandonment/beaver pond draining provides ideal opportunities for reed canary grass invasions, chronically suppressing natural wetland communities.

Animals are also adversely affected by reed canary grass. In a study by Spyreas et al. (2010), wetland plant diversity and abundance of *Homoptera* insects (true bugs such as shield bugs and leafhoppers) decreased as reed canary grass populations increased. Reed canary grass is extremely difficult to completely eradicate once established. Mechanically removed red canary grass stands quickly grow back from seed stocks and rhizomes remaining in the soil. Apfelbaum and Sims (1987) describe how reed canary grass continued to persist even as test plots were clipped to ground level and covered with black plastic for two growing seasons. However, since this species requires full sunlight, Kim et al. (2006) found that reed canary grass populations decreased 68% within two years by being shaded by willow plantings.

**Scotch broom (*Cytisus scoparius*)**
Scotch broom is a perennial shrub that can grow to 8 ft (2.5 m) tall in almost any soil type. It is considered the worst nuisance plant on Oregon forest lands, substantially increasing costs associated with timber land re-forestation (Figure 13). Once established, scotch broom is difficult to control, costing an estimated $47 million dollars annually in lost timber production and control costs (ODA 2014a). In Oregon and Washington, complete stand failure of Douglas-fir plantings has occurred due to Scotch broom infestations (Peterson and Prasad 1998). Scotch broom also displaces native colonizing species in multiple habitat types (e.g., forestlands or dunes), in both disturbed and undisturbed areas (ODA 2014a).

Scotch broom spreads by seed. Typically, a handful of seeds are projected from its seed pods, dispersing an average of 3 ft (0.9 m) from the parent plant (Zouhar 2003). Bossard (2000a) estimates seeds can remain viable in the soil for 30 years. They add that nearly 100% of seeds are viable but dormant when released from the pod, requiring scarification (damage to the seed coat) in order to allow water to penetrate and the seed to germinate. The environmental conditions required to release dormancy are not yet understood.

Along with seed production, brooms can sprout from root stumps following damage (e.g., from mowing or fire)(Zouhar 2005a).

**Slender flowered thistle (*Carduus tenuiflorus*)**
Slender flowered thistle can grow to 6 ft (1.8 m) tall, invade disturbed areas (e.g., vacant lots, old fields) and reduce forage productivity of less healthy pastures. However, it rarely overtakes healthy grasslands or native vegetation (DiTomaso and Healy 2007). Plants can produce as many as 20,000 seeds annually, which can remain dormant but viable in the soil for up to 10 years (Marriott et al. 2013).

**Spanish Heath (*Erica lusitanica*)**
Spanish heath is extremely prolific, able to produce nine million seeds per plant. It can create thick single-species stands in disturbed areas, potentially affecting Coos County timber and pasture lands (Figure 8). Since mowing has no lasting effect on controlling Spanish heath (plants do not die, just re-vegetate horizontally, creating dense mats), costly herbicide applications are expected to be the only method available for effectively controlling this invasive species (French 2009).

**Spiny cocklebur (*Xanthium spinosum*)**
Found in a variety of disturbed habitats, ingestion of Spiny cocklebur seedlings can be fatally toxic to livestock. Spiny burs can cling to animals and humans or float on water in order to disperse (DiTomaso et al. 2013).

**Spotted Knapweed (*Centaurea stoebe* formerly *C. maculosa*)**
See 'Knapweeds and Starthistle' above.

**Spurge (*Euphorbia spp.*)**
Both oblong and leafy spurges (*E. oblongata* and *E. esula*) are highly toxic to livestock and irritating to human skin and eyes. The spurges' milky sap contains the toxin ingenolis (St. John and Tilley 2014). Ingenolis is potent enough to cause blistering and hair loss around horses' hooves put in recently mowed pastures infested with leafy spurge (Gucker 2010).

Leafy spurge's massive root system can vegetatively reproduce (even when pieces are very small, partially dried and deeply buried), and can extent to nearly 15 ft (4.5 m) deep (Gucker 2010). This, along with its highly prolific seeding capability and its ability to establish itself in both disturbed and undisturbed sites in a variety of habitats, allows leafy spurge to successfully outcompete native vegetation (Gucker 2010, St. John and Tilley 2014).

Once established, leafy spurge is very difficult to eradicate. In fact, the Canadian Botanical Association ranked leafy spurge as 6th of 81 invasive species seriously affecting natural habitats in Canada (St. John and Tilley 2014, Catling and Mitrow 2005 as cited in Gucker 2010). Cattle will not graze in areas where leafy spurge is 10% cover or greater, degrading pasture carrying capacity by 50-75%. Leafy spurge currently costs the state an estimated $17,000 per year to control, but has only just gained a foothold (0.2% of likely habitats are currently infested). If it spread to its maximum potential, leafy spurge control measures could cost the state over $65 million per year (ODA 2014b).

Well adapted to a wide variety of habitats, in western Oregon, oblong spurge thrives in moist grassy bottomlands (including pastures) and sunny riparian areas, out-competing native vegetation. Oblong spurge is also a showy perennial herb cultivated commercially as an ornamental plant (ODA 2014a).

**St. John's wort (*Hypericum perforatum*)**
St. John's wort is commonly found growing on disturbed lands (e.g., roadsides, agricultural sites). Once established, St. John's wort will decrease forage productivity in pasture lands

and poison livestock with a photosynthesizing chemical (hypericin) that causes blisters, blindness or swelling of the animal's mouth, preventing them from grazing or drinking (Crompton et al. 1988, Zouhar 2004b). St. John's wort is a prolific seeder (up to 34,000 seeds per plant)(Crompton et al. 1988). However, seedlings are slow growing, especially during summer drought conditions, making them susceptible to competition from other plant species (Tisdale et al. 1959, Campbell 1985).

Perhaps this plant's most problematic effects are loss of grazing capacity in pastures where it takes over. Sampson and Parker (1930) reported that St. John's wort shades out desirable pasture vegetation and removes large quantities of moisture from the soil. Seedling survival of St John's wort for most years is extremely low, because the plant is unable to tolerate summer drought conditions. However, due to the sizable and persistent seed banks associated with St. John's wort infestations, this plant's populations can remain dormant for many years, only to expand rapidly through seed germination to cover large areas during wetter years.

**Sweet Fennel (*Foeniculum vulgare*)**
Sweet fennel is a perennial that invades open disturbed areas like roadsides and coastal scrub land, sometimes developing into dense stands that can displace native flora. It can grow to 10 ft (3 m) tall (DiTomaso et al. 2013).

**Tansy Ragwort (*Senecio jacobaea*)**
Tansy Ragwort is a poisonous member of the sunflower family. All parts of tansy ragwort are poisonous, causing lethal liver damage to most livestock if consumed. Normally biennial (lives 2 years), mowed or damaged plants will continue to regrow until seeds are produced. A prolific seed producer (200,000 seeds per plant), tansy ragwort seeds can last 15 years in the soil and still remain viable. Tansy ragwort is able to grow 6 ft (1.8 m) tall with a taproot that penetrates the soil up to 1 ft (0.3 m) deep, and requires open, disturbed habitat to become established (OSU 2008b). Prior to an extremely successful biological control program begun in the 1960's using the cinnabar moth, tansy ragwort flea beetle, and a seed head fly, Oregon lost over $5 million per year in control and lost productivity costs. Since then, cattle losses from tansy ragwort poisoning have become rare and lost productivity costs have decreased to an estimated $115,000 per year (ODA 2014b). It should be noted, however, that changing climate conditions may favor tansy ragwort growth while limiting productivity of the beneficial insects used to control the plant, thus helping tansy ragwort populations rise once again in western Oregon (OSU 2011).

**Velvetleaf (*Abutilon theophrasti*)**
Generally only invasive in very disturbed areas, velvetleaf has become a serious threat to orchard and croplands (USFS 2006e). Seeds from this species can lie dormant in soil for over 50 years (USFS 2006e).

**Watermilfoil (*Myriophyllum spp.*)**
Eurasian watermilfoil (*M. spicatum*) and Parrot's feather (*M. aquaticum*) are two freshwa-

ter aquatic plants that colonize slow moving water (e.g., lakes, ponds), forming dense mats on the water's surface (Figure 12). Both species can thrive in eutrophic (excessive nutrient) conditions.

Parrot's feather can grow up to a foot above the surface of the water, resembling small fir trees, while Eurasian watermilfoil forms long (up to 5 ft [1.5 m]) intertwining stems that grow near the water's surface. Infestation of either species reduces fish production and native plant diversity, helps increase mosquito populations, and is a general nuisance for recreational users (e.g., swimmers and boaters) (ODA 2014a).

**Woolly Distaff Thistle (*Carthamus lanatus*)**
An especially significant nuisance in pasture lands, woolly distaff thistle can grow to 4 ft (1.2 m) tall and remain rigid and upright even after it dies, creating a formidable barrier to grazing livestock (OSU 2006). French (2010) notes that dense infestations can also clog harvesting equipment. Woolly distaff thistle seeds remain viable for up to 10 years, creating the need for aggressive control measures in established populations and prevention strategies on susceptible lands to maintain productive grazing lands (French 2010).

In the 1980s, the ODA Weed Program successfully implemented a woolly distaff thistle prevention campaign, which has kept the wooly distaff thistle infestation to less than four acres in Oregon. This success translates to an estimated economic impact of less than $500 per year. In the absence of the sustained state-wide early-detection program, woolly distaff thistle control measures are estimated to cost over $164 million per year (ODA 2014b).

**Yellow Flag Iris (*Iris pseudacorus*)**
Yellow flag iris is an aquatic plant that can thrive in a wide range of environmental conditions (e.g., fresh to brackish waters, wetlands, rocky shores, stream banks or ditches) and can form dense impenetrable thickets that displace native vegetation and alter habitat for animals (Figure 8)(USFS 2006c). Its buoyant seeds allow widespread dispersal by water. Yellow flag iris can also propagate vegetatively by rhizome (i.e., rootstock), creating laterally spreading clones that displace native aquatic vegetation (Stone 2009; USFS 2006c).

**Yellow Glandweed (*Parentucellia viscosa*)**
This annual hemiparasite (obtains some nutrients from a host plant) invades coastal wetland prairies and pastures, thriving especially in dune wetlands (Pickart and Wear 2000). A 1996 study in Humboldt Bay dunes habitat by Pickart and Wear (2000) found that yellow glandweed is a prolific seeder (12,000 seeds per plant) allowing an extensive seed bank to build in underlying soils. However, native plant species did not appear to be affected by the presence of yellow glandweed, suggesting that this non-native plant is not particularly invasive.

**Yellow Starthistle (*Centaurea solstitialis*)**
See 'Knapweeds and Starthistle' above.

**References**

Apfelbaum, S. I., and Sams, C. E. 1987. Ecology and Control of Reed Canary Grass *(Phalaris arundinacea* L.). Natural Areas Journal. 7(2): 69-74.

Baldwin, J. R., and J. R. Lovvorn. 1994. "Habitats and tidal accessibility of the marine foods of dabbling ducks and brant in Boundary Bay, British Columbia". Marine Biology. 120 (4): 627-638.

Beck, K. G. 2013. Diffuse and Spotted Knapweed. Colorado State University Extension. Viewed 13 March 2015: http://www.ext.colostate.edu/pubs/natres/03110.pdf

Bossard, C. 2000a. "*Cytisus scoparius* (L.) Link." In: Bossard, Carla C.; Randall, John M.; Hoshovsky, Marc C. (eds.) Invasive plants of California's wildlands. Berkeley, CA: University of California Press: 203-208.

Bossard, C. 2000b. "*Genista monspessulana* (L.) L. Johnson." In: Bossard, Carla C.; Randall, John M.; Hoshovsky, Marc C. (eds.) Invasive plants of California's wildlands. Berkeley, CA: University of California Press: 203-208.

Burrill, L. C. 1994. Distaff thistle (*Carthamus lanatus*), A "Weeds" Pacific Northwest Extension Publication. PNW 420, reprinted May 1994.

Burrill, L. C. 1996. 'Weeds: Creeping Buttercup *Ranunculus repens L.'* Pacific Northwest Extension Publications. Viewed 26 March 2015: https://ir.library.oregonstate.edu/xmlui/handle/1957/16924

California Invasive Plant Council (Cal-IPC). n.d. Invasive Plants of California's Wildland: *Mentha pulegium.* Viewed 27 March 2015: http://www.cal-ipc.org/ip/management/ipcw/pages/detailreport.cfm@usernumber=62&surveynumber=182.php

Callihan, R. H., T. S. Prather, and F. E. Northam. 1993. "Longevity of Yellow Starthistle (*Centaurea solstitialis*) Achenes in Soil". Weed Technology. 7 (1): 33-35.

Campbell, M. H. 1985. Germination, emergence and seedling growth of *Hypericum perforatum* L. Weed Research. 25(4): 259-266.

Carey, J. H. 1995. *'Agrostis gigantea'*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 1 April 2015: http://www.fs.fed.us/database/feis/plants/graminoid/agrgig/all.html

Catling, Paul M. and Gisele Mitrow. 2005. A prioritized list of the invasive alien plants of natural habitats in Canada. Canadian Botanical Association Bulletin. 38(4): 55-57. [71460]

Chambers, K. L. 1966. Notes on Some Grasses of the Pacific Coast. Madroño 18(8): 250-251.

Cooper, W. S. 1958. Coastal Sand Dunes of Oregon and Washington. Geological Society of America, New York.

Coos County Weed Advisory Board (Coos Weed Board). 2011. Coos County Noxios Weed List. Viewed 13 March 2015: http://www.co.coos.or.us/Portals/0/Board%20and%20Committees/Weed/2011noxiousweedlist.pdf

Coos Watershed Association (CoosWA). 2014a. [Gorse Treatment Sites]. Unpublished spatial data.

Coos Watershed Association (CoosWA). 2014b. [2014 Purple Loosestrife Sites]. Unpublished spatial data.

Cornu, C.E., J. Souder, J. Hamilton, A. Helms, R. Rimler, B. Joyce, F. Reasor, T. Pedersen, E. Wright, R. Namitz, J. Bragg, and B. Tanner. 2012. Partnership for Coastal Watersheds State of the South Slough and Coastal Frontal Watersheds. Report prepared for the Partnership for Coastal Watersheds Steering Committee. South Slough National Estuarine Research Reserve and Coos Watershed Association. 225 pp.

Crompton, C. W.; Hall, I. V.; Jensen, K. I. N.; Hilderbrand, P. D. 1988. "The biology of Canadian weeds. 83. *Hypericum perforatum* L." Canadian Journal of Plant Science 68(1): 149-162.

Crook, C. S. 1979. A system of classifying and identifying Oregon's coastal beaches and dunes. Oregon Coastal Zone Management Association, Inc., Newport, OR.

Davi, R. 2009. Invasive Grass Called False Brome, Threatens Oregon Native Plant Diversity. Oregon State University Extension Service. Viewed 16 March 2015: http://extension.oregonstate.edu/gardening/node/952

DiTomaso, J. M. and E. A. Healy. 2007. Weeds of California and Other Western States. Univ. California, DANR. Publ. #3488, 1808 pp.

DiTomaso, J. M., G. B. Kyser, S. R. Oneto, R. G. Wilson, S. B. Orloff, L. W. Anderson, S. D. Wright, J. A. Roncoroni, T. L. Miller, T. S. Prather, C. Ransom, K. G. Beck, C. Duncan, K. A. Wilson, and J. J. Mann. 2013. Weed Control in Natural Areas in the Western United States. Weed Research and Information Center, University of California, Davis, CA. 544 pp.

Dudoit, C. M. 2006. The distribution and abundance of a non-native eelgrass, *Zostera japonica*, in Oregon estuaries. B.S. Senior Thesis. Oregon State University, Corvallis, OR. http://ir.library.oregonstate.edu/jspui/handle/1957/5055

Duncan, Celestine Lacey. 2001. Knapweed management: another decade of change. In: Smith, Lincoln, ed. Proceedings, 1st international knapweed symposium of the 21st century; 2001 March 15-16; Coeur d'Alene, ID. Albany, CA: U.S. Department of Agriculture, Agricultural Research Service: 1-7. [37824]

Early Detection and Distribution Mapping System (EDDMapS). 2014. Species Found in Coos County, Oregon. University of Georgia, Center for Invasive Species and Ecosystem Health. Viewed 13 March 2015: http://www.eddmaps.org/tools/countyplants.cfm?id=us_or_41011

Ferraro, S. P., and F. A. Cole. 2012. "Ecological periodic tables for benthic macrofaunal usage of estuarine habitats: Insights from a case study in Tillamook Bay, Oregon, USA". Estuarine, Coastal and Shelf Science. 102-103: 70-83.

Fierke, M. K. and J. B. Kauffman. 2006. 'Invasive Species Influence Riparian Plant Diversity Along a Successional Gradient, Willamette River, Oregon.' Natural Areas Journal. 26(4): 376-382.

Fisher, J. P., T. Bradley, K. Patten. 2011. Invasion of Japanese Eelgrass, *Zostera japonicda* in the Pacidific Northwest: A Preliminary Analysis of Recognized Impacts, Ecological Functions and Risks. Prepared for Willipa-Grays Harbor Oyster Growers Association, Ocean Park, WA. 28pp.

Forney, T. 2013. Plant Pest Risk Assessment for Giant Hogweed, *Heracleum mantegazzianum* 2009 (Revised 2013). Oregon Department of Agriculture. Viewed 20 March 2015: http://www.oregon.gov/ODA/shared/Documents/Publications/Weeds/PlantPestRiskAssessmentGiantHogweed2013.pdf

French, K. 2009. Plant Pest Risk Assessment for Spanish Heath, *Erica lusitanica* 2009. Oregon Department of Agriculture. Viewed 16 March 2015: http://www.oregon.gov/ODA/shared/Documents/Publications/Weeds/PlantPestRiskAssessmentSpanishHeath2013.pdf

French, K. 2010. Plant Pest Risk Assessment for Wooly Distaff Thistle, Smooth Distaff Thistle *Carthamus lanatus, C. baeticus* 2010. Oregon Department of Agriculture. Viewed 20 March 2015: http://www.oregon.gov/ODA/programs/Weeds/OregonNoxiousWeeds/Pages/RiskAssessments.aspx

Gray, A. N. 2005. "Nonnative Plants in the Inventory of Western Oregon Forests." U.S. Department of Agriculture Forest Service General Technical Report. NC 252:11-16.

Gucker, C. L. 2009. *'Heracleum mantegazzianum'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 24 March 2015: http://www.fs.fed.us/database/feis/plants/forb/herman/all.html

Gucker, C. L. 2010. *'Euphorbia esula'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 8 April 2015: http://www.fs.fed.us/database/feis/plants/forb/eupesu/all.html

Hacker, S. D., P. Zarnetske, E. Seabloom, P. Ruggiero, J. Mull, S. Gerrity, and C. Jones. 2012. "Subtle Differences in Two Non-Native Congeneric Beach Grasses Significantly Affect their Colonization, Spread, and Impact". Oikos. 121(1): 138-148.

Heutte, T., and E. Bella. 2003. Invasive Plants and Exotic Weeds of Southeast Alaska. USDA Forest Service, State and Private Forestry and Chugach National Forest, Anchorage, AK. 79 pp.

Holmes, S. E., B. A. Roy, J. P. Reed, and B. R. Johnson. 2010. 'Context-dependent Pattern and Process: The Distribution and Competitive Dynamics of an Invasive Grass, *Brachypodium sylvaticum'.* Biological Invasions. 12 (7): 2303-2318.

Houlahan, J. E., and C. S. Findlay. 2004. "Effect of invasive plant species on temperate wetland plant diversity." Conservation Biology 18(4): 1132-1138.

Howard, V., M. Pfauth, M. Sytsma, and D. Isaacson. 2007. Oregon Spartina Response Plan. Portland State University, Portland, ORn. 80 pp.

Huang, C., and R. del Moral. 1988. "Plant-environment relationships on the Montlake wildlife area, Seattle, Washington, USA". Vegetatio. 75 (1-2): 103-113.

Javier, S.N. 1987. Predator-prey Interrelationships and the Introduced Eelgrass, *Zostera japonica* (Acshers. and Graebn.) in the South Slough of Coos Bay, Oregon, U.S.A. Thesis (M.S.) – University of Oregon.

Julian, L. S. 2012. A Comparison of Bee Fauna in Two Northern California Coastal Dune Systems. Thesis (M.S.)--Humboldt State University.

Kalt, J. 2008. Status Review and Field Inventory for Silvery phacelia: *Phacelia argentea* (Hydrophyllacease). McKinleyville, CA. 13pp.

Kaye, T. N. 2004. 'Reintroducing the Endangered Pink Sand-Verbena to Pacific Coast Beaches: Direct Seeding and Out-Planting', in Brooks, M.B., S.K. Carothers, and T. LaBanca (eds.), The Ecology and Management of Rare Plants of Northwestern California: Proceedings from a 2002 Symposium of the North Coast Chapter of the California Native Plant Society, California Native Plant Society, Sacramento, CA, p131-139.

Kim, K. D., K. Ewing, and D. E. Giblin. 2006. Controlling *Phalaris arundinacea* (reed canarygrass) with live willow stakes: a density-dependent response. Ecological Engineering. 27(3): 219-227.

Lavergne S, and J. Molofsky. 2007. "Increased genetic variation and evolutionary potential drive the success of an invasive grass". Proceedings of the National Academy of Sciences of the United States of America. 104 (10): 3883-8.

Lema, Erik B. 2007. Evaluation of operational control efforts for Japanese knotweed (*Polygonum cuspidatum* Sieb & Zucc.) along roadside rights-of-way in central Adirondack State Park, New York. Syracuse, NY: State University of New York, College of Environmental Science and Forestry. 71 p. Thesis.

Magee, T. K., T. L. Ernst, M. E. Kentula, and K. A. Dwire. 1999. "Floristic Comparison of Freshwater Wetlands in an Urbanizing Environment." Wetlands. 19:517-534.

Magee, T. K. and M. E. Kentula. 2005. "Response of Wetland Plant Species to Hydrologic Conditions". Wetlands Ecology and Management. 13:163-181.

Marriott, M., R. Tertes, and C. Strong. 2013. South San Francisco Bay Weed Management Plan. U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Fremont, CA. 82pp.

Matteson K. 2004. Commercial Pacific herring fishery Yaquina Bay Oregon Summary Report. Marine Resources Program,Oregon Department of Fish and Wildlife, Newport, Oregon. 18pp.

Mulhouse, J. M. and S. M. Galatowitsch. 2003. Revegetation of prairie pothole wetlands in the mid-continental US: twelve years post-reflooding. Plant Ecology, 169, 143–159.

Munger, G. T. 2001. '*Aliaria petiolata'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 23 March 2015: http://www.fs.fed.us/database/feis/plants/forb/allpet/all.html

Munger, G. T. 2002. *'Lythrum salicaria'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 24 March 2015: http://www.fs.fed.us/database/feis/plants/forb/lytsal/all.html

Native Plant Society of Oregon (NPSO). 2008. Exotic Gardening and Landscaping Plant Invasive in Native Habitats of the Southern Willamette Valley. Viewed 26 March 2015: http://emerald.npsoregon.org

Oregon Department of Agriculture (ODA). 2014a. Oregon Noxious Weed Profiles. Viewed 13 March 2015: http://www.oregon.gov/oda/programs/weeds/oregonnoxiousweeds/pages/aboutoregonweeds.aspx

Oregon Department of Agriculture (ODA). 2014b. Economic Impact from Selected Noxious Weeds in Oregon. 186p.

Oregon Department of Forestry (ODF). 2014a. Gorse Aerial Survey GIS Data, GIS data files, viewed 10 March 2015: http://www.oregon.gov/odf/privateforests/pages/fhinvasives.aspx

Oregon Department of Forestry (ODF). 2014b. Mapping the Invasive Plant Gorse: An aerial Survey Special Project. Oregon Department of Forestry, Salem, OR. 2 pp.

Oregon State University (OSU). 2006. Problem Thistles of Oregon. Oregon State University Extension Service. Viewed 20 March 2015: https://catalog.extension.oregonstate.edu/sites/catalog.extension.oregonstate.edu/files/project/pdf/ec1288.pdf

Oregon State University (OSU). 2008a. Bull Thistle *Cirsium vulgare.* Oregon State University Extension Service. Viewed 20 March 2015: https://catalog.extension.oregonstate.edu/ec1588

Oregon State University (OSU). 2008b. Tansy Ragwort *Senecio jacobaea.* Oregon State University Extension Service. Viewed 20 March 2015: https://catalog.extension.oregonstate.edu/ec1599

Oregon State University (OSU). 2008c. Yellow Starthistle *Centaurea solstitalis.* Oregon State University Extension Service. Viewed 20 March 2015: https://catalog.extension.oregonstate.edu/ec1600

Oregon State University (OSU). 2011. After three decades, invasive tansy ragwort once again threatening Oregon. OSU News and Research Communications web page. Viewed 1 July 2015: http://oregonstate.edu/ua/ncs/archives/2011/aug/after-three-decades-control-invasive-tansy-ragwort-once-again-threatening-oregon

Page, N. A., R. E. Wall, S. J. Darbyshire, and G. A. Mulligan. 2006. "The biology of invasive alien plants in Canada. 4. *Heracleum mantegazzianum* Sommier & Levier." Canadian journal of plant science 86(2): 569-589.

Perkins, T. E. and M. V. Wilson. 2005. 'The Impacts of *Phalaris arundinacea* (Reed Canarygrass) Invasion on Wetland Plant Richness in the Oregon Coast Range, USA Depend on Beavers'. Biological Conservation. 124(2): 291-295.

Peterson, D. J. and R. Prasad. 1998. "The biology of Canadian weeds. 109. *Cytisus scoparius* (L.) Link." Canadian Journal of Plant Science 78(3): 497-504.

Peterson, D. L. and M. Russo. 1988. Element Stewardship Abstract for *Cortaderia jubata.* The Nature Conservancy, Arlington, Virginia. 8 pp.

Pickart, A. and K. Wear. 2000. "*Parentucellia viscosa* Invades Dune Wetlands of Northern California". CalEPPC News. 8: 11.

Plant Conservation Alliance (PCA). 2005. Spotted Knapweed. Bureau of Land Management, viewed 20 March 2015: http://www.nps.gov/plants/alien/fact/cest1.htm

Pojar, J. and A. MacKinnon. 1994. Plants of the Pacific Northwest coast: Washington, Oregon, British Columbia and Alaska. Redmond, WA: Lone Pine Publishing. 526 pp.

Posey, M. H. 1988. "Community Changes Associated with the Spread of an Introduced Seagrass, *Zostera japonica".* Ecology. 69 (4): 974-983.

Ranwell, D. 1959. Newborough Warren, Anglesey. I. The dune system and dune slack habitat. Journal of Ecology. 47:571-601.

Rumrill, S. S. and J. Kerns. 1991. Settlement of Dungeness crab (*Cancer magister*) megalopa larvae within beds of native and non-native eelgrass (*Zostera marina* and *Z. japonica*): potentially negative effects of recruitment into non-native habitat. South Slough NERR / Apprentice in Science and Engineering, summer project. 28 pp.

Rumrill, S. 2006. The Ecology of the South Slough Estuary, Oregon: Site Profile of a National Estuarine Research Reserve. South Slough National Estuarine Research Reserve, Charleston, OR. 258pp.

Russo, M., A. Pickart, L. Morse, and R. Young. 1988. Element Stewardship Abstract for *Ammophila arenaria.* The Nature Conservancy, Arlington, Virginia. 12 pp.

Sampson, A. W. and K. W. Parker. 1930. St. Johns wort on range lands of California. Bulletin 503. Berkeley, CA: University of California, College of Agriculture, Agriculture Experiment Station. 47 p.

Savonen, C. 2003. Huge New Noxious Weed Invading Oregon. Oregon State University, Extension Service. Viewed 9 March 2015: http://extension.oregonstate.edu/gardening/huge-new-noxious-weed-invading-oregon

Schooler, S. S., P. B. McEvoy, and E. M. Coombs. 2006. "Negative per capita effects of purple loosestrife and reed canary grass on plant diversity of wetland communities". Diversity and Distributions. 12 (4): 351-363.

Shafer, D. J., J. E. Kaldy, T. D. Sherman, and K. M. Marko. 2011. "Effects of Salinity on Photosynthesis and Respiration of the Seagrass *Zostera japonica*: A Comparison of Two Established Populations in North America". Aquatic Botany. 95 (3): 214-220.

SHN Consulting. 2013. Botanical Resources Assessment Report – Jordan Cove Energy Project Coos County, Oregon. Prepared for Jordan Cove Energy. 56 pp.

Siuslaw National Forest. 1993. Draft Environmental Impact Statement for the Oregon Dunes National Recreation Area Management Plan. Siuslaw National Forest, Corvallis, OR.

South Slough National Estuarine Research Reserve (SSNERR). 2013. [Coos Spartina locations]. Unpublished spatial data.

Spyreas, G., B. W. Wilm, A. E. Plocher, D. M. Ketzner, J. W. Matthews, J. L. Ellis, and E. J. Heske. 2010. "Biological consequences of invasion by reed canary grass *(Phalaris arundinacea)*". Biological Invasions. 12 (5): 1253-1267.

Steiger, A. J. 1957. Russians find new way to fight forest fire with fireproof underbrush. Forests and People. 7(3): 17, 46-47.

St. John, L., and D. Tilley. 2014. Plant Guide for Leafy spurge (*Euphorbia esula*). US Department of Agriculture-Natural Resources Conservation Service, Plant Materials Center, Aberdeen, Idaho.

Stone, K. R. 2009. *'Iris pseudocorus'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 16 March 2015: http://www.fs.fed.us/database/feis/plants/forb/iripse/all.html

Tisdale, E. W., M. Hironaka, and W. L. Pringle. 1959. "Observations on the Autecology of *Hypericum perforatum*". Ecology. 40 (1): 54-62.

Tu, M. 2004. Reed canarygrass (*Phalaris arundinacea* L.) control and management in the Pacific Northwest. The global invasive species team (GIST). Arlington, VA: The Nature Conservancy (Producer). Accessed 24 June 2015: http://www.invasive.org/gist/moredocs/phaaru01.pdf

United States Department of Agriculture (USDA). 2010. Cherry Laurel: *Prunus laurocerasus* L. Center for Invasive Species and Ecosystem Health. Viewed 26 March 2015: http://www.invasive.org/browse/subinfo.cfm?sub=14124

United States Department of Agriculture (USDA). 2015. Plants Database. US Department of Agriculture Natural Resources Conservation Service. Viewed 26 March 2015: http://plants.usda.gov/java/

United States Forest Service (USFS). 2004. Weed of the Week: Japanese Knotweed. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/japanese-knotweed.pdf

United States Forest Service(USFS). 2005a. Weed of the Week: Bull Thistle. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/bull-thistle.pdf

United States Forest Service (USFS). 2005b. Weed of the Week: Butterfly Bush. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/butterfly_bush.pdf

United States Forest Service(USFS). 2005c. Weed of the Week: Garlic Mustard. Viewed 13 March 2015: http://www.invasive.org/weedcd/pdfs/wow/garlic_mustard.pdf

United States Forest Service (USFS). 2005d. Weed of the Week: Giant Hogweed. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/giant-hogweed.pdf

United States Forest Service (USFS). 2005e. Weed of the Week: Purple Loosestrife. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/purple-loosestrife.pdf

United States Forest Service (USFS). 2006a. Weed of the Week: Canada Thistle. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/canadian-thistle.pdf

United States Forest Service (USFS). 2006b. Weed of the Week: Field Bindweed. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/field_bindweed.pdf

United States Forest Service (USFS). 2006c. Weed of the Week: Yellow Iris. Viewed 16 March 2015: http://www.invasive.org/weedcd/pdfs/wow/yellow-iris.pdf

United States Forest Service (USFS). 2006d. Weed of the Week: Spotted Knapweed. Viewed 23 March 2015: http://www.invasive.org/weedcd/pdfs/wow/spotted-knapweed.pdf

United States Forest Service (USFS). 2006e. Weed of the Week: Velvetleaf. Viewed 23 March 2015: http://www.na.fs.fed.us/fhp/invasive_plants/weeds/velvetleaf.pdf

United States Forest Service (USFS). 2014. Field Guide for Managing Diffuse, Meadow, Spotted, and Squarrose Knapweekds in the Southwest. USDA Forest Service, Albuquerque, NM. Viewed 13 March 2015: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5410116.pdf

United States Forest Service (USFS). n.d. Siuslaw National Forest: Overlook Dunes Restoration Project. Viewed 10 April 2015: http://www.fs.usda.gov/detail/siuslaw/landmanagement/resourcemanagement/?cid=fsbdev7_007301

Waggy, M. A. 2010. *'Hedera helix'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 24 March 2015: http://www.fs.fed.us/database/feis/plants/vine/hedhel/all.html

Washington State Department of Ecology (WSDE). n.d. Non-native, Invasive, Freshwater Plants: *Egeria densa* (Brazilian Elodea) Technical Information. Viewed 18 March 2015: http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua002.html

Weber, William A. 1987. Colorado flora: western slope. Boulder, CO: Colorado Associated University Press. 530 p.

Wiedemann, A. M and A. Pickart. 1996. "The *Ammophila* problem on the Northwest Coast of North America". Landscape and Urban Planning. 34 (3/4): 287-300.

Young, D. R., P. J. Clinton, D. T. Specht, T. H. DeWitt, and H. Lee. 2008. "Monitoring the expanding distribution of nonindigenous dwarf eelgrass *Zostera japonica* in a Pacific Northwest USA estuary using high resolution digital aerial orthophotography." Journal of Spatial Science 53 (1): 87-97.

Zouhar, K. 2001a. '*Centaurea diffusa*'. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 23 March 2015: http://www.fs.fed.us/database/feis/plants/forb/cendif/all.html

Zouhar, K. 2001b. *'Centaurea maculosa'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 23 March 2015: http://www.fs.fed.us/database/feis/plants/forb/censtom/all.html

Zouhar, K. 2002. *'Centaurea solstitialis'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 23 March 2015: http://www.fs.fed.us/database/feis/plants/forb/censol/all.html

Zouhar, K. 2003. *'Linaria spp.'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 16 March 2015: http://www.feis-crs.org/beta/

Zouhar, K. 2004a. *'Convolvulus arvensis'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 24 March 2015: http://www.fs.fed.us/database/feis/plants/vine/conarv/all.html

Zouhar, K. 2004b. *'Hypericum perforatum'*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 26 March 2015: http://www.fs.fed.us/database/feis/plants/forb/hypper/all.html

Zouhar, K. 2005a. *'Cytisus scoparius, C. striatus'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 24 March 2015: http://www.fs.fed.us/database/feis/plants/shrub/cytspp/all.html

Zouhar, K. 2005b. *'Genista monspessulana'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 24 March 2015: http://www.fs.fed.us/database/feis/plants/shrub/genmon/all.html

Zouhar, K. 2005c. *'Ulex europaeus'.* In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, viewed 26 March 2015: http://www.fs.fed.us/database/feis/plants/shrub/uleeur/all.html

# Invasive and Non-native Vertebrates in the Lower Coos Watershed

*Summary*


- *Monitoring of striped bass and American shad in the Coos estuary have largely been suspended since populations of both non-native fishes has sharply declined since their height in the 1940s and 1950's.*
- *Invasive nutria cause substantial economic and ecological harm to coastal communities. All indications suggest populations are strong in the project area.*



Striped bass


Nutria

**Evaluation**

Available evidence suggests that sizable populations of striped bass and American shad no longer occur in the Coos estuary.

**Evaluation**

More data are needed to fully evaluate local nutria status. But available evidence suggests local populations are strong.

**! DATA GAP**

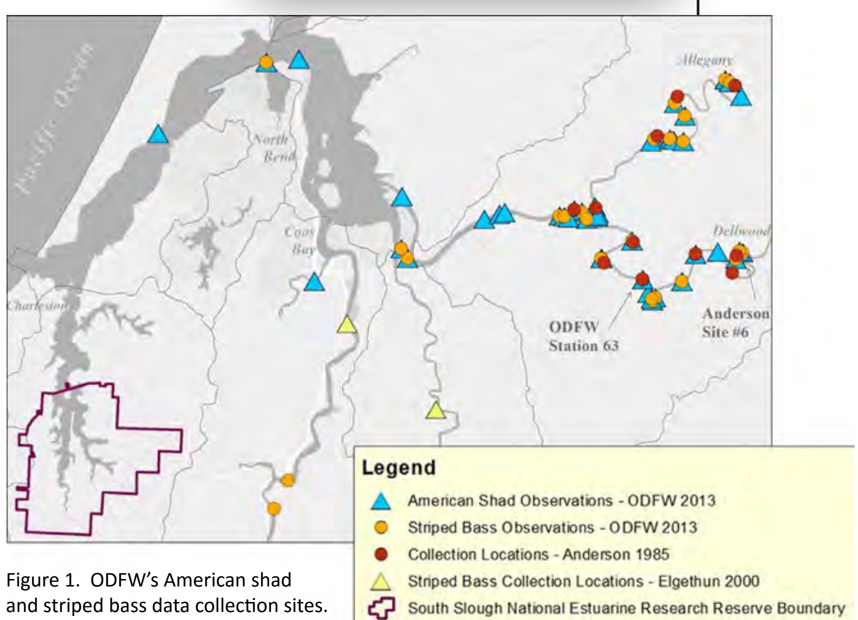



Figure 1. ODFW's American shad and striped bass data collection sites. Figure shows fewer sites than were actually sampled since not all ODFW sites included lat/long information.

**What's Happening?**

This data summary describes available information regarding the three most economically and ecologically important non-native vertebrate species found in the project area: two fish species, American shad (*Alosa sapidissima*) and striped bass (*Morone saxatilis*), and one large rodent, nutria (Myocastor coypus).

American shad
*Alosa sapidissima*
The Coos basin once supported major yearly runs of American shad each spring; large enough to support a commercial fishery in southwestern Oregon (Rothman 1968). Shad populations have now dwindled to the point that the run does not occur every year. Starting in the late 1950's, a large bacterial outbreak began infecting American shad populations during the spawning season in southern Oregon coastal streams (including the Coos watershed), causing large adult shad population losses (Rothman 1968). Rothman suggests this was the beginning of the sharp decline in American shad populations along the southern Oregon coast. A very small recreational fishery (several anglers/year) still exists for shad in the Coos watershed (G. Vonderohe, pers. com. 2015).

By contrast, in the Columbia River, American shad still represent the largest anadromous spawning run, outnumbering all native salmon (wild and hatchery combined), with spawning adults estimated at 4-8 million in recent years (Hasselman et. al. 2012b).

For nearly 30 years (1965-present), the Oregon Department of Fish and Wildlife (ODFW) conducted long-term fish monitoring, initially targeting both juvenile American shad and striped bass. Emphasis on those species ended in 2006 as their populations declined; monitoring efforts were re-focused to Chinook salmon populations. However, incidental catch data on the two non-native fishes are still recorded when caught. Due to the shift in focus, it should be noted that seining efforts were not identical in all years (e.g., sites were missed at different years).

According to the ODFW database (2013), American shad were found throughout the estuary, most often and in the highest numbers at Station 63 on the South Fork Coos River (Figure 1). They were most recently captured in 2008 at the same station. The age class most frequently captured was juveniles, often in exceedingly high numbers (500 – 1,000 in one seine was not uncommon, with a high of 2,500 juvenile shad caught in a single seine). Some (generally two or less per seine) intermediates and adults were also caught.

A related ODFW study (2009) monitored American shad and striped bass over-wintering populations in Catching and Isthmus Sloughs from 1979 to 1998. Researchers set overnight gillnets in late spring (April-June) at four sites in Catching and five sites in Isthmus Sloughs. Small numbers (<10) of shad were found each year.

Other American shad population information:

Carlton (1989) listed shad as "abundant" in the South Slough National Estuarine Research Reserve (SSNERR)(Figure 1). Although no targeted studies have reassessed the SSNERR population since that report, it's likely the populations in South Slough have declined like the rest of the Coos estuary. This is supported by preliminary findings from a fish assemblage study of the South Slough estuary. Between July 2015 and June 2016 only 15 American shad have been caught.

An older study by Anderson (1985) found that American shad larvae outnumbered striped bass larvae 10 to one, and that American shad juveniles outnumbered those of striped bass 335 to one in 1983, and 585 to one the following year in the Coos River (Figure 1).

American shad were intentionally introduced from their native US east coast habitats to the Pacific coast habitats in 1871 when 10,000 fry were released into the Sacramento River, CA (Hasselman 2012b). Subsequent introductions to the Sacramento River occurred over the next 10 years, totaling 574,000 fry (Hasselman 2012b).

Five years after their initial introduction to the Sacramento River, shad were being found in the Columbia River, (Hasselman 2012b). Numbers soon increased when nearly 1 million shad fry were transplanted to the Columbia River basin in the mid 1880's (Hasselman 2012b). By the late 1800's, shad were found throughout Oregon estuaries.

***Background***

***Non-native species*** *– also called "alien" species, this is a species that has been introduced (either intentionally or accidentally) to a location outside its native range.*

***Invasive species*** *– a non-native species that aggressively outcompetes native species or causes significant economic loss.*

***Source: Clinton 1999***

Like salmon, American shad are anadromous. They spend a year in the estuary as juveniles and adults spend 3-6 years in the ocean before returning to their natal stream to spawn (Pearcy and Fisher 2011). In the Coos estuary, adults return to spawn in May and June, and juveniles use the rivers and estuary as nursery habitat (August-November) before returning to the ocean (Monaco and Emmett 1990). As a zooplankton-consuming species with a similar diet to Chinook salmon, American shad compete with native species for food and space (Hasselman 2012a). Large numbers of shad on the Columbia River have created migratory delays for native fish due to shad's dense accumulation at the base of hydroelectric dam fish ladders (Hasselman 2012a). In addition, shad are parasitic hosts that can inadvertently increase population densities and ranges of parasites that also infect native fish species (Hasselman 2012a). For example, Hasselman (2012a) describes how a parasitic nematode was historically restricted to marine waters where its native herring host lived, until shad caused an ecological expansion of the parasite into freshwater systems.

On the other hand, American shad, can also alleviate avian and mammalian predation on native fish, including salmon, by virtue of the attractiveness of their population densities to predators (Hasselman 2012a).

Striped bass
*Morone saxatilis*
In 1914, some 35 years after striped bass were intentionally released in the San Francisco estuary as a commercial fish species imported from the US east coast, the first striped bass were caught in the Coos estuary. By the mid-1920's striped bass populations were robust enough to support a commercially fishery here (Parks 1978, Waldman et al. 1998). By 1945, adult striped bass populations peaked at an estimated 69,000 individuals in southwestern Oregon (Parks 1978, Waldman et al. 1998).

Since then, striped bass populations have declined drastically; fewer than 1,000 adults were counted during monitoring in the 1990's (Waldman et al. 1998).

According to Moyle (2002), San Francisco continues to maintain the highest striped bass breeding population on the west coast. In southwestern Oregon, striped bass populations are the greatest in the Umpqua and Coquille river estuaries (based on angler effort and catch data)(G. Vonderohe, pers. com. 2015).

Although they are considered an anadromous fish on the west coast, striped bass spend much of their life in the estuary. Striped bass are also opportunistic and voracious predators, feeding on juvenile salmon and other small native fish (e.g., anchovies) and invertebrates (e.g., bay shrimp)(Moyle 2002).

Striped bass are still a highly regarded sport fishing species in Oregon despite the commercial fishery having closed years ago.

During ODFW's long-term fish monitoring program (2013)(described above under American shad), striped bass (both hatchery and wild) were found throughout the estuary, most often and in the highest numbers at station 63 on the South Fork Coos River (Figure 1). Striped bass were most recently captured in 2000 at the same station. After 2000, no striped bass were caught, despite the same stations being sampled specifically for striped bass and shad until 2006. The age class most frequently captured was juveniles (sometimes by the hundreds), followed by intermediates and then adults.

Winter gillnetting by ODFW (also described above) found that overwintering striped bass in Catching and Isthmus Sloughs fluctuated by year and month captured. Striped bass generally represented a higher catch rate compared to American shad.

Anderson (1985) examined striped bass populations in the Coos River and estimated 912 wild striped bass in the Coos River system in 1983 and 1,003 in 1984. Anderson also found that American shad larvae outnumbered striped bass larvae 10 to one and American shad juveniles outnumbered striped bass 335 to one in 1983 and 585 to one in 1984. The majority of striped bass juveniles (hatchery and wild) were found in the South Fork Coos River – the majority of those at site #6 (Figure 1). No wild juveniles were found on the Millicoma River.

Curiously, the Coos population of striped bass has unprecedented high levels of hermaphroditism (one individual has both male and female reproductive organs), a condition that is exceedingly rare in striped bass populations in their native range. (Waldman et al. 1998). Waldman and colleagues (1998) speculate that this anomaly is likely due to a genetic bottleneck from the few founders that strayed to the Coos estuary from San Francisco Bay. This, along with subsequent declines in the Coos population caused rare genes (which expressed themselves through hermaphroditism) carried by the remaining individuals to pass on their genes to offspring, which subsequently caused the gene to spread throughout the population.

However, Elgethun and colleagues (2000) postulate that elevated levels of contaminants such as tributyltin accumulate in striped bass (a higher order predator), causing reproductive anomalies. Elgethun's team measured butyltin exposure of fish in the Coos estuary and found that striped bass caught in Catching Slough had elevated concentrations of tributyltin (110 µg/kg) and total butyltins (130 µg/kg)(Figure 1). Striped bass from Isthmus Slough were also measured and had lower concentrations the same sampling year (1992) at 40 µg/kg and 50 µg/kg respectively.

<u>Nutria</u>
<u>Myocastor coypus</u>
There is very little information currently available with which to estimate nutria status and trends in the project area.  Resource managers understand from anecdotal observation and the studies described below that nutria continue to be a growing problem on Oregon's south coast.  One contributing factor to nutria's spread especially in western Oregon is their preference for regions with mild winters such as the Oregon coast. According to LeBlanc (1994), summer densities in Oregon can range as high as 56 animals per acre.

The US Geological Survey's (USGS) Nonindigenous Aquatic Species program, consider nutria to be established in the following project area subsystems at least since 2007: Coos River, Isthmus Slough, Haynes Inlet, South Slough, Upper Bay, and in the  Lower Bay along the North Spit (USGS 2015).

While there's currently no standard protocol used to assess nutria distribution or abundance in Oregon, Sheffels and Sytsma (2007) created a distribution map based on ODFW wildlife biologists' best estimates for nutria density at the 6th field HUC watershed scale (Figure 2). According to Sheffels and Sytsma, nutria densities in the project area subwatersheds are considered to be medium (11-100 individuals/subsystem) in North Slough, Haynes Inlet, Coos River, Catching Slough, Isthmus Slough, and South Slough subsystems and high (>100 individuals/subsystem) in Pony Slough, Upper Bay, and Lower Bay subsystems.

Witmer and Lewis (2001) describe nutria as a large semi-aquatic rodent, first introduced in Lincoln and Tillamook Counties, in the late 1930's for fur farming. Due to nutria fur farming's low economic returns, it was a short-lived industry with lasting consequences. Many failed nutria farmers released their nutria stock into the wild where they soon became naturalized. With the ability of female nutria to produce 2-3 litters per year and 4-5 offspring per litter, nutria have become

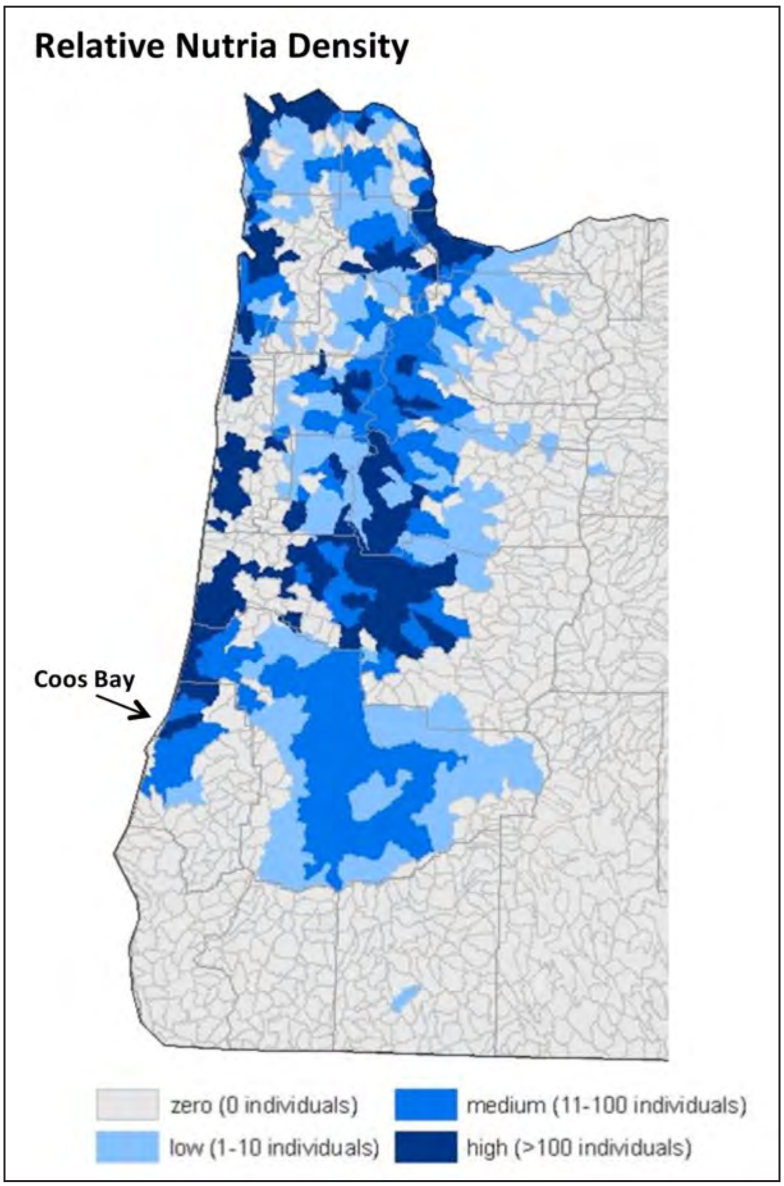



Figure 2. Estimated relative nutria densities in Oregon watersheds. Modified from: Sheffels and Sytsma 2007.

exceedingly abundant in the wild, especially in central and western Oregon (Sheffels and Sytsma 2007, Wentz 1971, citations within Sheffels 2013).

Nutria cause numerous ecological and socio-economic problems. They cause soil erosion, reduced water quality, damage to native flora, structural damage to channel banks and levees, and are carriers of diseases and parasites that can pass to humans, livestock and pets (e.g., rabies)(Witmer and Lewis 2001).

Nutria can denude vast areas of vegetation through foraging and creating grooming platforms, trails, and dens (citations within Witmer and Lewis 2001). Meyer (2006) found that nutria selectively feed on forbs (non-grass herbaceous vegetation) in coastal Oregon wetland habitats and have denuded large areas of both natural and restored tidal wetlands in South Slough (Cornu, pers. com. 2015).

Meyer also documented considerable bank erosion in areas with nutria populations compared to areas without nutria. The associated excess turbidity in adjacent waters, affecting fish species.

Perhaps most importantly to coastal economies, nutria significantly destabilize and ultimately destroy waterway structures (e.g., dikes and levees) when they burrow into banks (Sheffels and Sytsma 2007). These sometimes extensive burrows can extend up to 18’ in length and 2’ in diameter, and include complex interconnecting passages (Link 2004).

**References**


Anderson, D. A. 1985. *A Study of the Early Life History of the Striped Bass, Morone saxatilis, in Coos River Estuary, Oregon. Thesis (M.S.)--University of Oregon*, 1985.

Carlton, J. T. 1989. “Man’s Role in Changing the Face of the Ocean: Biological Invasions and Implications for Conservation of Near-Shore Environments.” *Conservation Biology*. 3(3): 265-273.

Clinton, W. B. 1999. Invasive Species. *Federal Register.* 64(25): 6183-6186.

Elgethun K, C Neumann, and P Blake. 2000. “Butyltins in Shellfish, Finfish, Water and Sediment from the Coos Bay Estuary (Oregon, USA)”. *Chemosphere*. 41 (7): 953-64.

Hasselman, D. J., R. A. Hinrichsen, B. A. Shields, and C. C. Ebbesmeyer. 2012a. “American Shad of the Pacific Coast: A Harmful Invasive Species or Benign Introduction?.” *Fisheries*. 37(3): 115-122.

Hasselman, D. J., R. A. Hinrichsen, B. A. Shields, and C. C. Ebbesmeyer. 2012b. “The Rapid Establishment, Dispersal, and Increased Abundance of Invasive American Shad in the Pacific Northwest.” *Fisheries*. 37(3): 103-114.

LeBlanc, D. J. 1994. *Nutria*. Internet Center for Wildlife Damage Management, viewed 1 May 2015: http://icwdm.org/handbook/rodents/nutria.asp

Link, R. 2004. *Living with Wildlife in the Pacific Northwest*. University of Washington Press, Seattle, WA.

Meyer, A. 2006. *The Impacts of Nutria on Vegetation and Erosion in Oregon.* Thesis (M.A.)--University of Colorado at Boulder, 2006.

Monaco, M. E. and R. L. Emmett. 1990. Distribution and abundance of fishes and invertebrates in West Coast estuaries. Volumes 1 and 2. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Rockville, MD.

Moyle, P. B. 2002. *Inland Fishes of California.* Berkeley: University of California Press. Oregon Department of Fish and Wildlife (ODFW). 2009. [Coos Bay spring gillnetting]. Unpublished raw data.

Oregon Department of Fish and Wildlife (ODFW). 2009. [Coos spring gillnetting]. Unpublished raw data.

Oregon Department of Fish and Wildlife (ODFW). 2013. [Coos fish monitoring seine program]. Unpublished raw data.

Parks, N. B. 1978. "The Pacific Northwest Commercial Fishery for Striped Bass, 1922-74." Marine Fisheries Review. 40(1): 18-20.

Pearcy, W. G., and J. P. Fisher. 2011. "Ocean distribution of the American Shad (Alosa sapidissima) along the Pacific coast of North America." *Fishery Bulletin*. 109(4): 440-453.

Rothman, S. 1968. *A Bacterial Disease of the American Shad (Alosa sapidissima).* Thesis (MS) – Oregon State University.

Sheffels, T. 2013. Status of Nutria (Myocastor coypus) Populations in the Pacific Northwest and Development of Associated Control and Management Strategies, with an Emphasis on Metropolitan Habitats. Thesis (Ph.D.) ---Portland State University.

Sheffels, T. and M. Sytsma. 2007. Report on Nutria Management and Research in the Pacific Northwest. Center for Lakes and Reservoirs, Portland State University. 57pp.

U.S. Geological Survey (USGS). 2015. Nonindigenous Aquatic Species Database. Gainesville, Florida. Accessed: 5 May 2015: http://nas.er.usgs.gov/queries/huc8.aspx?state=OR

Waldman, J. R., R.E. Bender, and I.I. Wirgin. 1998. "Multiple Population Bottlenecks and DNA Diversity in Populations of Wild Striped Bass, Morone saxatilis." *Fishery Bulletin*. 96: 614-620.

Wentz, W. A. 1971. *The Impact of Nutria (Myocastor coypus) on Marsh Vegetation in the Willamette Valley, Oregon.* Thesis (M.S.) – Oregon State University, 1971.

Witmer, G. W. and J.C. L.ewis. 2001 Introduced Wildlife of Oregon and Washington . USDA National Wildlife Research Center - Staff Publications. Paper 656. Retrieved from: http://digitalcommons.unl.edu/icwdm_usdanwrc/656

# Invasive and Non-native Terrestrial Invertebrates in the Lower Coos Watershed

*Summary:*

- *Although no invasive terrestrial invertebrate populations are currently established in the project area, experts have identified the forests of western Oregon as a high risk ecosystem for invasion; continued monitoring is needed.*

- *Invasive terrestrial invertebrates are potentially costly economic and ecological threats to the project area even beyond potential threats to locally harvested tree species.*

Emerald ash borer Photo: emeraldashborer.info

Asian long-horned beetle deposits eggs in firewood. Photo: Environmental News

**Evaluation**

There are currently no established invasive terrestrial invertebrate populations in the project area.

**Evaluation**

Project area forests are considered high risk for future invasive species invasions. Continued monitoring is needed.

**What's Happening?**

While many benign non-native terrestrial invertebrates (insects) are established in the project area, none are currently considered invasive; that is, no non-native insects are known to be responsible for local ecological or economic damage, or threaten human health. However, it's important to note that the risk of future invasive insect introductions is very real. In part because, like any community, the Coos Bay area is exposed to invasive species introduction through any number of "vectors." These include the transport of firewood, living plants, and freight packed wooden packaging material (see sidebar below).

Due to the abundance of tree cover and the economic importance of the local timber industry, this section focuses on non-native wood boring insects that represent the largest potential economic and ecological threats to the project area. These species include the emerald ash borer (*Argrilus planipennis*), Asian long-horned beetle (*Anoplophora glabripennis*), gypsy moth (*Lymantria dispar spp*.), and balsam woolly adelgid (*Adelges piceae*)(Table 1). None of these species are currently established in the project area. However, should they become established locally, they would pose significant threats.

Emerald Ash Borer
*Argrilus planipennis*
The emerald ash borer, native to eastern Russia, northern China, Japan, and Korea (McCullough and Usborne 2011; OSU 2011), was first detected in Detroit, Michigan in 2002. Since detection, the emerald ash borer has spread gradually and is now found in 25 states and two Canadian provinces. The westerly extreme of its range has reached Colorado. Although the emerald ash borer is not currently found in Oregon, experts believe that the future introduction of this species could result in potentially tremendous economic and ecological costs (OSU 2011).

Experts believe that the emerald ash borer was inadvertently introduced to North America when infested wood was used in crates or stabilizing cargo in ships (McCullough and Usborne 2011; Carlson and Verschoor 2006). Adult emerald ash borers deposits eggs in the crevices of true ash trees (i.e., *Fraxinus spp.*).

***How Invasive Insects Are Spread***

*Invasive insects can spread through a variety of mechanisms, including the long-distance transport of wooden goods, plants, or trees. For example, the interstate transportation of firewood and other wooden goods (e.g., patio furniture, pallets) can spread invasive wood-boring insects. Similarly, the use of wooden packaging materials (e.g., crates, wood shavings, wooden supports) may encourage the spread of these same species. In addition to the transport of wooden goods, the spread of insects may be facilitated by the movement of ornamental plant species and nursery stock.*

*Source: USDA 2006, 2015; OSU 2011*

After emergence, insect larvae damage or kill their host trees by consuming the tree's cambium (i.e., layer of live inner bark), interrupting the flow of nutrients throughout the tree (Carlson and Verschoor 2006; OSU 2011).

Emerald ash borer damage has been extensive in the eastern United States. Kovacs and colleagues (2010) estimate that emerald ash borer infestations have caused approximately $10.7 billion in damage, resulting on the removal or replacement of approximately 17 million ash trees by 2019 in the Midwest, Mid-Atlantic, and Northeast states alone. In Oregon, the introduction of the emerald ash borer could jeopardize native populations

| Common Name | Scientific Name | Photo | Detection Date | Native Range |
|---|---|---|---|---|
| Emerald Ash Borer | *A. planipennis* |  Photo: KS Dept. of Agriculture | 2002 | Russia, China, Japan, Korea |
| Asian Long-horned Beetle | *A. glabripennis* |  Photo: Lampuneuleh | 1996 | China, Korea |
| Gypsy Moth | *Lymantria dispar spp.* |  Photo: NC Dept. of Agriculture | European: 1869<br>Asian: 1991 | Most of temperate Europe and Asia |
| Balsam Woolly Adelgid | *A. piceae* |  Photo: USDA Forest Service | 1900 | Central Europe |

Table 1. Summary of potential invasive insect threats to the lower Coos watershed.

of Oregon ash (*Fraxinus latifolia*), the only species of true ash that occurs in the project area (Pojar and MacKinnon 1994; OSU 2011). Williams (pers. comm. 2015) explains that although the emerald ash borer does not target commercially harvested species, its introduction represents potentially substantial economic costs to the timber industry if introduction is accompanied by additional regulation (e.g., quarantine, mandatory inspection of mobile equipment such as trucks). He adds that the use of pesticides to control emerald ash borer infestations could also potentially affect water quality. In addition to these possible costs, the introduction of the emerald ash borer to Oregon could also decrease habitat complexity by threating the viability of Oregon ash populations in ecologically important areas (e.g., riparian zones) (OSU 2011).

<u>Asian Long-horned Beetle</u>
<u>*Anoplophora glabripennis*</u>

The Asian long-horned beetle, native to China and Korea (Haack et al. 2010), was likely first introduced to Brooklyn, New York in 1996. It has since spread to several eastern states, including New Jersey, Massachusetts, Ohio, and Illinois as well as Ontario, Canada. Although its spread has been contained to the eastern United States, experts suggest that an Asian long-horned beetle invasion of western Oregon forests would result in extensive ecological and economic damage (OSU 2011).

The Asian long-horned beetle was inadvertently introduced to the eastern United States in wood packing materials (Haack et al. 2010; OSU 2011). It damages hardwood tree species, including, but not limited to, maples (*Acer spp.*), birch (*Betula spp.*), ash (*Fraxinus spp.*), poplars (*Populus spp.*), willows (Salix spp.), and elm (*Ulmus spp.*)(Haack et al. 2010). Similar to other invasive wood boring species, Asian long-horned beetle larvae damage healthy trees by consuming their vascular tissues, resulting in structural weakness and tree death (OSU 2011; Haack et al. 2010).

Since its introduction to North America, Asian long-horned beetle damage has been extensive and costly in the eastern United States. If allowed to proliferate, the estimated magnitude of nationwide damage is significant. According to Nowak et al. (2001), from 1997 to 2008, Asian long-horned beetle infestations caused $373 million of damage to forests in Illinois, Massachusetts, New Jersey, and New York alone. They estimate that Asian long-horned beetle infestations could cause a loss of 1.2 billion trees nationwide (valued at $669 billion) if the insects are allowed to continue spreading.

In Oregon, the potential ecological effects of Asian long-horned beetles are also significant. Although this species would not affect Oregon's dominant conifer species (e.g., Douglas fir, Port Orford cedar, hemlock), the insect is likely to infest native hardwood species (e.g., Oregon ash, big leaf maple, alder)(OSU 2011). These hardwood species provide important ecosystem services, including nutrient cycling, erosion control, and habitat complexity. They add that Asian long-horned beetle infestations could also result in significant economic costs where extensive beetle damage may necessitate the removal of large trees in urban settings (OSU 2011). Similar to the emerald ash borer, the Asian long-horned beetle may also result in significant costs to the timber industry if infestation within or in proximity to the project area results in additional regulatory measures (Williams pers. comm. 2015).

European Gypsy Moth
*Lymantria dispar Linnaeus*
The European gypsy moth was first introduced in the late 1860s, when the species was brought to Massachusetts from Europe for the purposes of silk production (USDA 2003b). Quickly realizing the alarming potential for damage, the Massachusetts State Board of Agriculture began attempts to eradicate European gypsy moths using methods that ranged from manual removal of egg masses to systematic forest burning and application of primitive pesticides (Figure 1) (USDA 2003b).

The United States Department of Agriculture (2008) explains that gypsy moths cause a substantial amount of damage by defoliating, weakening, and ultimately killing host trees, including broad-leafed hardwood species (i.e., oak, apple, alder, willow, birch, madrone, cottonwood) as well as coniferous species that

Figure 1. Two workers attempting eradicate European gypsy moth by burning the forest with kerosene (c. 1890). Photo: USDA 2003b

are abundant and harvested commercially within the project area (i.e., Douglas fir, pine, and western hemlock) . They add that gypsy moth infestations reduce the forests' ability to defend against disease, fire, and erosion, deteriorating the quality of habitat for other forms of plant and animal life.

Despite early control efforts, the European gypsy moth continued to spread and established populations throughout New England by the 1920s (Sadof 2009).  Attempts to eradicate European gypsy moths began again in the 1940s following the discovery of the use dichloro-diphenyl-tirchloroethane (DDT) as an extremely effective pesticide. But the application of DDT for pest control was limited in the 1960s and banned in the 1970s due to public concern about the severe environmental affects associated with DDT use (Sadof 2009). In the past 20 years, efforts to control European gypsy moths via the aerial application of alternative pesticides have once again been reestablished (Sadof 2009; USDA 2003a). European gypsy moth infestations remain a serious forest management issue throughout New England, the Mid-Atlantic, and the Midwest (ODA 2015).

Although isolated populations of European gypsy moths have occurred in Oregon since the 1970s (including seven moths found in Grants Pass in 2015) there are currently no established populations in the state. This is in part due to Oregon's early detection rapid response protocol, which include a large-scale trapping program throughout the state (Figure 2) (ODA 2015).

Figure 2. A delta trap, used to detect European and Asian gypsy moths, to facilitate early detection of these species. Source: ODA 2015.

<u>Asian Gypsy Moth</u>
<u>*Lymantria dispar asiatica*</u>
The Asian gypsy moth is similar to European gypsy moths in many ways, but Asian gypsy moths are known to feed on a wider range of host species and cover much larger distances in flight (USDA 2015).

Asian gypsy moths were first  introduced to North America near the Port of Vancouver, British Columbia in 1991, likely from ships infested with egg masses arriving from eastern Russia. Since its arrival, the Asian gypsy moth has spread to parts of the Pacific Northwest, including Washington and Oregon. A secondary inadvertent introduction (again from infested cargo ships) occurred on the east coast of North Carolina shortly thereafter (1993). Since then, Asian gypsy moths have been detected and largely eradicated on at least 20 separate occasions in locations across the United States. Though still intermittently detected in Oregon, local Asian gypsy moth eradication efforts have been successful thus far due to early detection and rapid response (USDA n.d., USDA 2015).

Figure 3. Asian gypsy moth egg masses on the inside of a vehicle wheel. Photo: Australian Department of Agriculture 2015

Beginning in 2009, the United States Department of Agriculture has taken preventative measures against the Asian gypsy moth by requiring foreign trading partners to participate in rigorous inspections of ships at the time of departure from foreign ports and again during entry at domestic ports. Although these preventative measures have been effective, Asian gypsy moths continue to be detected periodically in the United States, spread by a variety of means (e.g., Figure 3)(USDA 2015).

Balsam Woolly Adelgid
*Adelges piceae*
Common throughout fir forests in central Europe (Arthur and Hain 1984), the balsam wooly adelgid first appeared on the US west coast in 1929, most likely as a result of the transportation of infected fir saplings to be used as nursery stock (USDA 2006). Populations appear to be established throughout the range of "true firs" (*Abies* spp.) in Oregon and Washington. While not yet detected in the project area, this insect does affect local tree species, including grand fir (*Abies grandis*) (USFS n.d.).

Balsam woolly adelgids affect true fir species by injecting a hormone into the host tree that disrupts normal growth and inhibits cone production. Balsam woolly adelgid populations in the Willamette Valley have limited the reproductive success of grand fir (*Abies grandis*), and may ultimately cause the eventual disappearance of this species from Willamette Valley ecosystems if current trends continue. The ability to control balsam woolly adelgid infestations by applying areal pesticides is limited due to the species' ability to excrete a proactive waxy coating. Although alternative methods (e.g., treatment of individual trees) have proven effective, these methods require additional resources and are generally limited to accessible areas supporting high-value trees (USDA 2006).

Other Invasive Terrestrial Invertebrates: Exotic Mollusks

According to Casper (2008), experts have identified nearly 50 invasive mollusk species in the Pacific Northwest. Some of these species have caused substantial damage to agricultural crops in western Oregon, including for example, the gray field slug (*Deroceras reticulatum*), a species native to Europe (Gavin et al. 2012). Although it's apparent that non-native slugs and snails are present and causing damage in Oregon, experts are unable to determine the exact number of invasive terrestrial mollusk species statewide because little is known about the presence of these species and the extent of their actual or potential to cause economic and/or ecological damage within the project area (Casper 2008).

## References

Arthur, F. H., and F. P. Hain. 1984. Seasonal history of the balsam woolly adelgid (Homoptera: Adelgidae) in natural stands and plantations of Fraser fir. *Journal of Economic Entomology*, 77(5), 1154-1158.

Australian Department of Agriculture. 2015. Forests and timber: a field guide to exotic pests and diseases. Accessed 7 July 2015: http://www.agriculture.gov.au/pests-diseases-weeds/plant/forestry/forests-timber

Carlson, J. and K. Verschoor. 2006. Insect Invasion! Accessed 7 July 2015: http://www.eaglelake1.org/envirnonmental_issues/invasive_species/terrestrial/trees/EAB/Emerald%20Ash%20Bore.PDF

Casper, B. 2008. Non-native slugs and snails are a slimy scourge in Mid-Valley gardens, landscapes. [Online publication of the Statesman Journal].

Gavin, W. E., G. W. Mueller-Warrant, S. M. Griffith, and G. M. Banowetz. 2012. Removal of molluscicidal bait pellets by earthworms and its impact on control of the gray field slug (Derocerus reticulatum Mueller) in western Oregon grass seed fields. *Crop Protection,* 42, 94-101.

Haack, R. A., F. Hérard, J. Sun, and J.J. Turgeon. 2010. Managing invasive populations of Asian longhorned beetle and citrus longhorned beetle: a worldwide perspective. *Annual Review of Entomology*, 55, 521-546.

Kovacs, K. F., R. G. Haight, D. G. McCullough, R. J. Mercader, N. W. Siegert, and A. M. Liebhold. 2010. Cost of potential emerald ash borer damage in U.S. communities, 2009-2019. *Ecological Economics* 69: 569-578.

McCullough, D. and R. Usborne. 2011. Emerald Ash Borer: Frequently Asked Questions. Accessed 6 July 2015: http://www.emeraldashborer.info/faq.cfm#sthash.yjteBsNX.dpbs.

Nowak, D. J., Pasek, J. E., Sequeira, R. A., Crane, D. E., and Mastro, V. C. 2001. Potential effect of Anoplophora glabripennis (Coleoptera: Cerambycidae) on urban trees in the United States. *Journal of Economic Entomology,* 94(1), 116-122.

Oregon Department of Agriculture (ODA). 2015. Gypsy Moth Fact Sheet. Accessed 12 September 2016: https://www.oregon.gov/ODA/shared/Documents/Publications/IPPM/GypsyMothFactSheet.pdf

Oregon State University (OSU). 2011. Oregon Forest Pest Detectors. [Online informational modules from the Department of Forestry at Oregon State Univ.]. Accessed 2 July 2015: http://pestdetector.forestry.oregonstate.edu

Pojar, J. and MacKinnon, A. (eds.). 1994. *Plants of the Pacific Northwest Coast: Washington, Oregon, British Columbia and Alaska*. Lone Pine Publishing, Vancouver, British Columbia.

Sadof, C. 2009. History of Gypsy Moth in North America. [Online Publication of the Extension Entomology Department at Purdue University]. Accessed 7 July 2015: http://extension.entm.purdue.edu/GM/index.php?page=history

United States Department of Agriculture (USDA). 2003a. Gypsy Moth in North America. Accessed 7 July 2015: http://www.fs.fed.us/ne/morgantown/4557/gmoth/

United States Department of Agriculture (USDA). 2003b. Gypsy Moth in North America: E. Leopold Trouvelot, Perpetrator of our Problem. Accessed 7 July 2015: http://www.fs.fed.us/ne/morgantown/4557/gmoth/trouvelot/

United States Department of Agriculture (USDA). 2006. Balsam Woolly Adelgid. Forest, Insect, and Disease Leaflet 118. Accessed 2 July 2015: http://www.na.fs.fed.us/pubs/fidls/bwa.pdf

United States Department of Agriculture (USDA). 2015. Asian Gypsy Moth. [Publication of the Animal and Plant Health Inspection Service]. Accessed 7 July 2015: http://www.aphis.usda.gov/publications/plant_health/content/printable_version/fs_phasiangm.pdf

United States Department of Agriculture (USDA). n.d. Success Story- Gypsy Moth. Accessed July 6 2015: http://www.fs.usda.gov/detail/r6/forest-grasslandhealth/invasivespecies/?cid=fsbdev2_027210

United States Forest Service (USFS). n.d. Balsam Woolly Adelgid. Accessed 2 July 2015: http://www.fs.fed.us/r6/nr/wildlife/decaid/IandDSpecies/Balsam%20woolly%20adelgid.html

Williams, Wyatt. 2015. Personal Communication July 2, 2015.