Crystal Orr

From: Jan Hodder [jhodder111@gmail.com]
Sent: Tuesday, June 18, 2019 2:29 PM
To: Planning Department
Subject: Rebuttal Comments for File No(s) AM-18-010/HBCU-18-002 from Jan Hodder
Attachments: Comments re Public Trust Rights.docx; The Oregon Recreational Dungeness Crab Fishery, 2007-2011.pdf; NewCarissaDARPAppendix4RecreationalLossReport.pdf

Follow Up Flag: Follow up
Flag Status: Completed

Please let me know these have been received. I will mail a copy of the documents on Monday June 24.
Jan Hodder
541 297 0664

Exhibit: 16
Date: 6/18/19

Dr. Janet Hodder
63840 Fossil Point Road
Coos Bay
OR 97420

Jill Rolfe
Coos County Planning
Coos County Courthouse
250 N. Baxter
Coquille, OR 97423

June 18, 2019

Re: County Remand File No. REM-19-001/LUBA Case No. 2016-095

Dear Hearings Officer Stamp,

Please accept these comments from Dr. Janet Hodder regarding the County Remand File No. REM-19-001/LUBA Case No. 2016-095.

I have lived on the shore of lower Coos Bay for over 40 years. From my house I can see the ocean entrance to the bay, the Charleston channel, and all of the lower bay up until approximately river mile 3. Thus I am very familiar with activities that take place in this region of Coos Bay which will be transited by LNG vessels entering and leaving the bay. I have spent considerable time on the water in Coos Bay, both professionally as a marine biology professor, and recreationally as a resident of the area. I regularly kayak and boat in the lower bay, and have caught hundreds of recreational size Dungeness crab from the waters in front of my house.

OAR 141-082-0260 (3) & (6) states that the Department of State Lands must manage submerged and submersible lands to ensure the collective rights of the public to fully use and enjoy this resource for commerce, navigation, fishing, recreation and other public trust values. The Coos Bay Estuary Management Plan's Policy #5 indicates that the County shall support dredge and fill activities in the estuary only if the use or alteration does not unreasonably interfere with Public Trust Rights. The proposed use by LNG tankers associated with the Jordan Cove project will unreasonably interfere with these Public Trust Rights and the County should deny the application.

My principle concern that leads me to conclude that there is unreasonable interference with Public Trust Rights is associated with the movement of LNG tankers to and from the ocean, and the associated encroachment upon the public's right to use the navigable waters in Coos Bay and Jordan Cove for a variety of commercial, fishing, and recreational activities as noted below.

1. LNG ship passage implications for recreational crabbing.

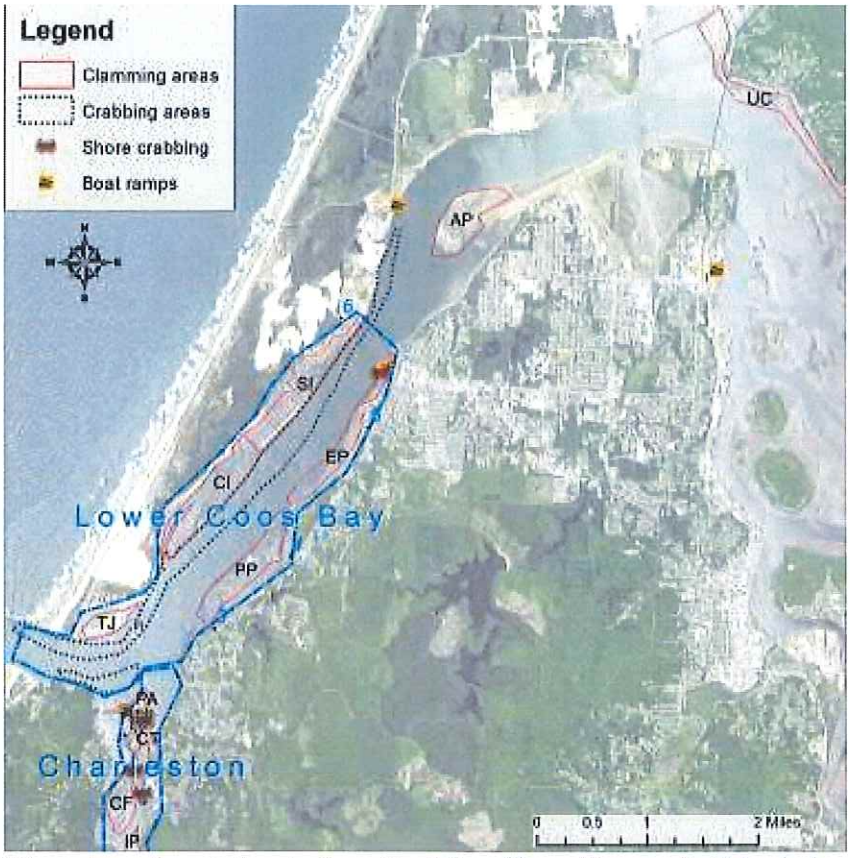
As someone who undertakes significant recreational crabbing activity in Coos Bay I am very concerned about how the passage of LNG ships will restrict my ability to undertake this activity. Two issues associated with the passage of these ships will encroachment upon my right to catch Dungeness crab in Coos Bay:

1. The LNG ships can only transit Coos Bay in the Federal Navigation channel at high tide, due to the need for sufficient depth to ensure safe passage. Prime crabbing time is around high tide when the

current in the bay slows and crabs are walking on the bottom feeding. At mid tide levels tidal currents are much stronger and crabs often bury themselves and are not available for harvest.

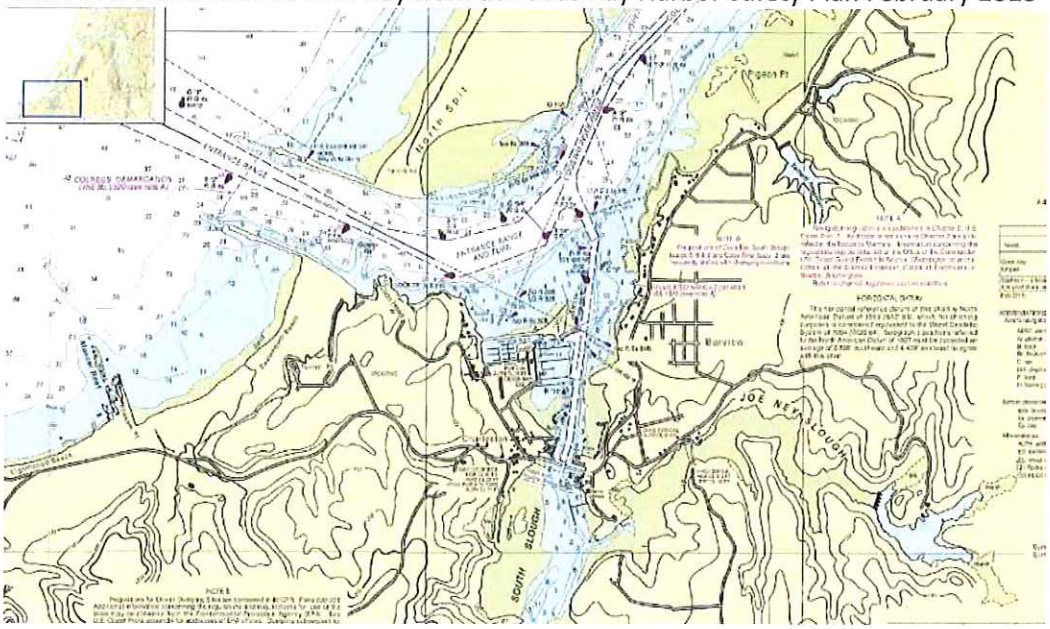
2. The ships, and the tugs that will accompany them, will be required by the Coast Guard to have a safety/security zone of 500 yards around the vessels. When a ship and associated tugs are moving in and out of Coos Bay in the Federal Navigation channel there are a number of regions where it will not be possible for a recreational boat to safely move far enough away from the safety/security zone.

To help understand where crabbing in lower Coos Bay takes place the Oregon Department of Fish and Wildlife's, "*Where to crab and clam in Coos Bay*" information graphic is shown below.
Where to crab and clam in Coos Bay: https://myodfw.com/articles/where-crab-clam-coos-bay
Accessed June 17, 2019.
If you compare these areas with the map of lower Coos Bay sourced from the February 2018 Coos Bay Harbor Safety Plan Accessed June 17, 2019:
https://static1.squarespace.com/static/569e6f1176d99c4f392858c4/t/5abc1b252b6a28c8f42cfd14/1522277173846/Coos+Bay+HSP+2018FEB20+update+2018MAR27.pdf. in which the Federal Navigation Channel is shown in white, (also included below), you can see that many of the prime crabbing spots are adjacent to the navigation channel. If you are crabbing in these areas, and you have to move away because of the LNG ship, in many cases you would not be able to still be in the area you are crabbing. You would be forced to either beach your boat, move to shallow water with the possibility of getting too close to any breaking wave or rock jetties, or grounding the boat, or move to an area away from your crab rings/traps, thus reducing your ability to tend the pots and catch crabs.



Where to crab and clam in Coos Bay https://myodfw.com/articles/where-crab-clam-coos-bay

Chart of the entrance to Coos Bay from the Coos Bay Harbor Safety Plan February 2018



Below, in the outlined box, I submit additional evidence for the assertion that passage of the LNG ships will reduce the ability to successfully undertake recreational crabbing by including the comments I submitted to the Department of State Lands for Jordan Cove Energy Project LP's request for a fill and removal permit APP0060697.

ORS 196.795-990 states that DSL is required to determine whether the project does not unreasonably interfere with the preservation of waters for navigation, fishing, or public recreation.
The application from Jordan Cove energy Project LP to the Division of State Lands (APP0060697) related to fishing and public recreation has many aspects that substantiate a decision to deny the permit. Examples include, but are not limited to:

1. **Reduction of in bay crabbing opportunities**

Coos Bay is a premium site for recreational crabbing. Ainsworth et al. 2012 estimates that in the period 2007 -20011 a minimum of 10,661 to a maximum of 15,023 crabbing trips were made in Coos Bay from April to October each year. Crabbing in Coos Bay is one of the most valuable recreational opportunities in the region and draws considerable number of people to the area. This has a considerable economic impact, especially for the community of Charleston. The permit addresses the issue of restricting access to lower bay crabbing sites because of the LNG transport (PDF page 10). It indicates that as a LNG carrier transits through the bay, the Coast Guard will impose a moving safety/security zone of 500 yards around the carrier and that will limit access to crabbing areas within the safety/security zone. The permit states, "*The sum of the periods in which LNG carriers would have a potential impact on recreational and other boating activity is about 7 hours per week or about 8 percent of all daylight hours (see Appendix C.5 to Resource Report 5*)." It is not possible to corroborate this assumption, as the permit does not appear to have a Resource Report 5. A search of the PDF using Resource Report as the search term does not bring up any results for Resource Reports 5.

The permit further states, "*the USCG will allow LNG carrier transits to occur on a 24-hour basis. This will allow night transit, which will lessen potential impacts on recreational and commercial fishermen to about 4 percent of all hours when LNG carriers can potentially transit LNG carrier transits will be prioritized during nighttime hours to reduce the impact of the moving safety/security zone on recreational and commercial fishing activities in the bay.*" It is not possible to know if the 4% is a legitimate number as no information is given on how it was determined. As noted by the applicant crabbing, and to a lesser extent, fishing tends to occur at high slack tide. Coos Bay experiences a semi-diurnal tide regime meaning that there are two high tides every 24 hours and 50 minutes. There is a difference in the height of these high tides, one being higher than the other is. Due to the depth of the Federal navigation channel it is likely that LNG vessel transit will occur on the higher of the high tides. A search of the 2018 Coos Bay tide tables provides information about the number of nighttime higher high tides. It shows that the number of the nighttime higher high tides, varies considerably during the year due to the tidal regime. On some months there are very few of these higher high tides at night. For example in January, there are nine days, in February twelve, September fifteen, November four and December seven with nighttime higher high tides. Other months have more, for example April has twenty-two and June twenty-seven. Thus the effect on crabbing at slack high tide, the preferred time for this activity will vary considerably. Monthly crab harvest peaks in the fall months in Coos Bay, when catch rates and effort were greatest (Ainswoth et al. 2012). In October and November, a time when there is no option for ocean crabbing, and when crabs are in peak condition for consumption having hardened after their summer moult, almost all LNG transits will take place during daylight high tides, and thus have considerable impact on recreational crabbing.

The permit further states,"*The maximum period for an LNG carrier to pass through the safety and security zone would be 30 minutes, meaning recreational crabbers would not have access to their pots or traps for up to 30 minutes, but the pots or traps would be "soaking" during this time."* It is obvious from this statement that the permit writer has never crabbed in Coos Bay. Consider this scenario: there are three of us crabbing in the boat, which means we can have nine rings. It takes us about 15 minutes to maneuver the boat and set all of the rings in a line from river mile 2 to mile 3. Ring one now has been in the water for at least fifteen minutes. We return to the area of ring one and move to pull the ring. Next the LNG safety/security zone is implemented and we have to move closer to the shore, if there is sufficient water depth, or we have to move to the eastern side of the navigation channel, and at least 500 yards from the LNG tanker. We cannot pull the remaining eight rings for about 30 minutes. By the time the zone has passed and we maneuver back to our ring string and begin to pull the rings they will have been in the water for at least an hour. This is an unacceptable way to undertake recreational crabbing in Coos Bay.

There are no estimates on the effects of the LNG tanker safety/security zone restriction on the public's perception of Coos Bay as a desirable site for in bay crabbing in the permit. Will visitors choose to go elsewhere to crab? The New Carissa Recreational Loss Pre-Assessment Report (Carlson 2001) estimated that at least 100 to 700 fishing and crabbing trips were lost due to the two month fishing and crabbing advisories that resulted from the New Carissa incident.

Ainsworth et al. 2012 and Carlson 2001 are included in this transmittal as exhibit 1 and 2.

Although I am a recreational crab fisher I regularly see the commercial crabbing activity in Coos Bay, especially during the period of the ocean crab closure (September 1 – November 30). This fishery

uses rings to capture crab similar to those used by recreational fishers and thus will be impacted in the same way as recreational fishers by the LNG ship passage, especially in the region of the current and former rock jetties in the lower bay; an area that they consistently use to harvest crab.

2. The LNG ship transits will also impose restrictions on recreation activities other than crabbing.

The lower Coos Bay provides opportunities for a wide variety of recreational activities including fishing, surfing, sailing, kayaking, scuba diving, stand-up paddle boarding, and kite boarding. Additionally the Charleston harbor has berths for both commercial and recreational boats, and provides boat launching access to sports fisherman that trailer their boats from elsewhere. LNG ship movement will impact all these activities, many of which occur at times of high slack water; the time that LNG tankers will transit the bay. LNG tanker safety/security zone restrictions will make it difficult for human powered boats who are not in the Federal Navigation Channel, but are moving up and down the bay, to use the bay during this time. They will be required to pay attention to the safety zone restrictions and move appropriately. Just like when crabbing, boats such as canoes and kayaks will be forced into situations which may be hazardous to their activity. This is bound to discourage people from undertaking these activities because of their concern about when it is safe to be on the water in Coos Bay, or for fear of not being able to move away from the safety zones quickly enough when on the water. Coos Bay is actively promoting itself as a destination for on-the-water recreation. For instance the Bay Area Chamber of Commerce's web site states, *"If it's water activities you crave, Oregon's Bay Area offers a myriad of opportunities from sailing, canoeing, kayaking, water-skiing, swimming, scuba diving and fishing."* From: http://coosbaynorthbendcharlestonchamber.com/bay-area-info/bay-area-more-info/things-to-do/ Accessed: June 18, 2019. And the Coos Bay Visitor Information Center 's web site touts, *"On Oregon's Adventure Coast, water activities abound, from kayaking, paddleboarding, scuba diving and surfing to world-class fishing, crabbing and clamming."* https://oregonsadventurecoast.com/water-recreation/ Accessed: June 18, 2019. Once LNG tanker safety zones start to encroach upon the public's right to use the navigable waters in Coos Bay and Jordan Cove for fishing and other recreational activities one can surmise that some people will no longer see Coos Bay as such an attractive destination for on-the-water activities.

Slack high tide is also the safest time for recreational and commercial fishermen who moor or launch in Charleston to cross the area between the north and south jetties (the area known as the bar) to go fish or crab in the ocean. The 500 ft safety/security zone restriction will have a serious impact on these boats as almost the entire Coos Bay bar will be closed to other vessel movement when a LNG tanker is crossing the bar. This has serious safety consequences as it could mean that boats will have to wait outside of the bar in rough weather until it is clear of an LNG tanker. This is of special concern during the first weeks of the winter commercial crabbing season when crews are taking their pots to sea in a very limited time, and the first few pot pulls of the season are occurring, when over half the commercial crop is harvested.

It is clear that the applicant's proposal to construct an LNG facility in Coos Bay will unreasonably interfere with public trust rights and should be denied by the County.

Sincerely,

Janet Hodder

Janet Hodder Ph.D.

References

Exhibit 1
Justin C. Ainsworth, Mitch Vance, Matthew V. Hunter and Eric Schindler 2012. The Oregon Recreational Dungeness Crab Fishery, 2007-2011. ODFW Informational Report Number 2012-04.

Exhibit 2
Curtis Carlson, 2001. National Oceanic and Atmospheric Administration Damage Assessment Center, Silver Spring, MD, and Robert W. Fujimoto, USDA Forest Service, Portland, OR

INFORMATION REPORTS

NUMBER 2012-04

FISH DIVISION

Oregon Department of Fish and Wildlife

The Oregon Recreational Dungeness Crab Fishery, 2007-2011

The Oregon Recreational Dungeness Crab Fishery, 2007-2011

Justin C. Ainsworth
Mitch Vance
Matthew V. Hunter
Eric Schindler

Oregon Department of Fish & Wildlife
Marine Resources Program
Newport, OR 97365
(541) 867-4741

July 2012

This project was funded in large part by Oregon Recreational Shellfish License fees.

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EXECUTIVE SUMMARY

Recreational crabbing in Oregon bays and offshore waters is one of the most popular shellfishing activities in the state. This report provides a comprehensive review of recreational boat-based crabbing effort and catch in Oregon from 2007 through 2011. Data were analyzed from three different Oregon Department of Fish and Wildlife (ODFW) surveys: (1) the Ocean Recreational Boat Survey; (2) a bay crab fishery survey; and (3) a survey of the Lower Columbia River (LCR) fishery. These three independent assessments utilized unique methods to estimate total effort including counts of empty boat trailers, bar crossing counts, and direct counts of crab pot buoys. Catch rate estimates were generated from on-site interviews representing 104,451 recreational crabbing trips. Effort estimates and catch rate statistics were used to produce estimates of total recreational crab harvest in each of the three fisheries.

Data was summarized by area and month over the five year period, and combined data from all three surveys were used to develop statewide harvest estimates. Recreational harvest statistics were compared to previous studies and with current commercial Dungeness crab harvest levels. Additional data analyzed include:

- Hometown Zip Codes of recreational crabbers to determine straight-line travel distance;
- Biological condition data such as carapace width and shell hardness; and
- Small-scale effort patterns of crabbers within bays.

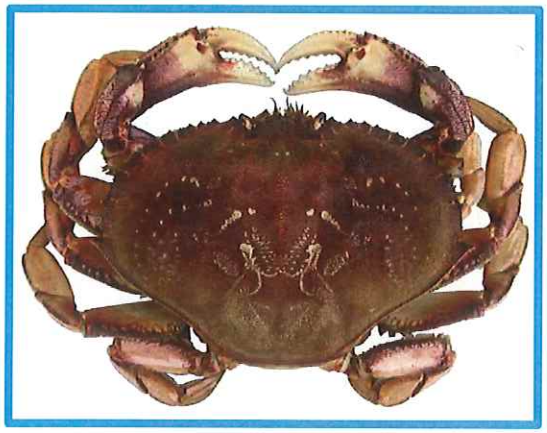
Catch rates for all areas sampled varied seasonally, but catch per unit effort (CPUE) values were typically greatest in the late summer and fall (August-October). The highest CPUE was observed in the LCR fishery during the late fall (October-November), when average monthly CPUE values often exceeded 8 crabs per person. Low monthly catch rates were observed in all areas during the late winter and spring months (February-May).

Seasonal patterns of resource use and harvest were observed in all fisheries. For the five years sampled, the greatest statewide harvest occurred in 2011 when over 1 million pounds of Dungeness crab were harvested by recreational crabbers. The greatest number of crabbing trips occurred in 2009, when an estimated 130,000 crabbing trips occurred. The bay crab fisheries were the greatest component of the statewide harvest, accounting for approximately 60% of the annual total recreational harvest. A regulation change during the Public Process for Angling Regulation Development (2009) extended the ocean recreational crabbing season two months until October 15. After this regulation change, ocean crabbing effort increased 70% and harvest increased 135%, respectively. The harvest and effort statistics detailed in this report will be valuable for managing the recreational Dungeness crab fishery.

INTRODUCTION

Dungeness crab (*Cancer magister*) are the target of recreational and commercial fisheries from Alaska to California. In Oregon, millions of pounds of crab are harvested annually by the commercial fishery, and the recreational fishery is a popular year-round activity occurring in both the offshore waters and in Oregon's estuaries. The commercial and recreational crab fisheries are managed by the Oregon Department of Fish and Wildlife (ODFW), and regulations have been developed over many decades to provide opportunities for harvests and to ensure that populations are maintained at sustainable levels.

Regulations for the crab fisheries are intended to maximize productivity in balance with sustainability, based on what is known of Dungeness crab life history. Minimum size restrictions, for example, ensure that male crabs have the opportunity to participate in at least one mating season before they are vulnerable to the fishery (Butler 1960). In contrast, all females are protected to maximize egg production (Hankin et al. 1997). The ocean commercial fishery is closed following the male molting season in the summer, as a management action intended to minimize the handling mortality of newly-molted crabs from harvest, and to optimize yield from the resource (Kruse et al. 1994). Newly-molted male crabs constitute the majority of new individuals that recruit into the crab population and fishery in any given year.



Dungeness crab (Cancer magister)

Recreational crabbers harvest crab with traps ("pots"), rings ("hoops"), or snares. Traps and rings are attached to buoys, baited, and fished passively by boat- or shore-based crabbers. Snares are small baited traps that are attached to a light line and used by shore-based crabbers. Shore-based crabbers are limited to piers, docks, and jetties within bays, but boat-based crabbers are able to harvest crab in the ocean and bays. All recreational crabbers 14 years or older must hold a current Oregon Shellfish License, and are limited to using three pieces of gear in combination. The current regulations are based on size, sex, and season. The daily limit of Dungeness crabs is 12 males, with a minimum carapace width (CW) of 5 ¾". Bays and beaches are open year-round for recreational crabbing, but the ocean has an annual closure from October 16 through November 30.

Concurrent with the recreational fishery, Dungeness crab are fished commercially in the ocean as well as in some estuaries. Regulations have been developed over time by the Oregon Fish and

Wildlife Commission based on input from industry members, ODFW staff, the Oregon State Police, and other interested parties. The commercial ocean fishery is currently restricted to 427 permitted vessels, each with a specific pot limit of 200, 300, or 500 pots. Commercial crab must be at least 6 ¼" wide and only males are kept. Several rules dictate the specifics of pot design and marking. The season opens on December 1 and closes on August 15, although some season openings are delayed if the crabs are not sufficiently filled out with meat following their previous summer molt. Over the last 10 years, approximately 300-350 vessels have been active in the ocean commercial crab fishery, with seasonal landings between 12-33 million pounds and an ex-vessel value worth $25-50 million per year.

A recreational crabber pulling a pot

A commercial bay crab fishery occurs in some estuaries during the open season (Labor Day to December 31, excluding weekends and state or federal holidays). Like the ocean fishery, crab must be at least 6 ¼" wide and only males are retained. Commercial bay crabbers are limited to 15 rings per boat. Over the past several years, this fishery has only been pursued by a small number of crabbers (20 – 30) that land totals of between 15,000 and 30,000 pounds per year for the entire state.

A large male Dungeness crab and a small female in the premating embrace

While the commercial fishery's effort and landings are strictly monitored, little information has been published on the scope of Oregon's recreational Dungeness crab fishery. Monitoring of the recreational bay crab fishery has occurred intermittently in the past. In 1971, the Fish Commission of Oregon conducted detailed surveys of the recreational use of marine food fish, shellfish, and other miscellaneous invertebrates in 16 Oregon estuaries. Those reports documented the number of angler trips taken, the amount of time spent on each trip, and catch data, including the total number of crabs harvested. In 1988 – 1989, a survey of recreational crabbers in Alsea Bay collected economic and demographic information along with effort and catch data.

The ocean recreational crab fishery has not been surveyed directly, but it is possible to derive estimates of effort and catch from the Ocean Recreational Boat Survey (ORBS) database. The ORBS program is an ongoing survey of all marine recreational fisheries, and operates in all of the major ports along the Oregon coast. Statewide estimates of recreational ocean crab catch and effort have only been generated when needed to address specific management questions.

Pacific rock crab (top) and red rock crab (bottom) are sometimes caught by recreational crabbers

The purpose of this report is to provide a comprehensive review of boat-based recreational crabbing in Oregon from 2007 through 2011. Effort and catch were estimated using data from three different sources: (1) the ORBS program; (2) a bay crab fishery survey; and (3) a separate survey of the Lower Columbia River (LCR) fishery. These three independent assessments adopted unique methods to estimate total effort, varying from counts of empty boat trailers, enumeration of bar crossing counts, and counting the number of buoys. All of these effort assessment techniques were complemented with on-site interviews of recreational crabbers to estimate catch rates. Data were summarized by area and month over the five year period, and combined data were used to develop statewide estimates. Seasonal patterns of resource use and harvest were observed in all fisheries, providing valuable information for future management decisions.

This report provides the most thorough examination of the Oregon recreational crab fishery ever completed. While the survey results represent the majority of the statewide fishery, it was not possible to generate monitoring information in some areas. For example, the Oregon coast contains at least 9 bays where recreational crabbing occurs but it was only possible to sample the five most utilized bays (Figure 1). Additionally, this report contains data only from boat-based crabbing effort; land-based effort and harvest has been surveyed in some bays but will be reported in a separate report. Recreational crabbers also harvest red rock crab (*Cancer productus*) and Pacific rock crab (*Cancer antennarius*) while targeting Dungeness crab, but estimates for this fishery are also not reported here. Finally, the ocean recreational fishery was monitored in some ports only during the major effort periods in the summer and fall. Due to these unsampled areas and/or times, the overall

total effort and catch data reported are likely underestimates.

METHODS

Bay Crab Survey

Figure 1. Location of nine Oregon bays that support a recreational crab fishery; five of the largest and most utilized were selected to be included in the bay crab fishery survey from 2007-2011.

Effort estimates

Two inherent qualities of the Oregon bay crab fishery were used to develop a model for estimation of total crabbing effort. First, surveyors were able to visually count all buoys within a bay from several shoreline vantage points over a relatively short period of time. These instantaneous counts provide an unbiased snapshot of crabbing effort that would be impossible for the ocean or lower Columbia River crab fisheries. Second, the "tidal-centric" characteristic of the bay crab fishery allowed surveyors to concentrate their observations to restricted periods when crabbing activity was greatest. Most bay crabbers focus their effort to within an hour or two of the high or low tide, a time when the current slackens and catch rates may be higher. Therefore, the level of crabbing effort on any given day increases as the tidal currents slow, and effort decreases as the ebb or flow returns following the tide change.

The bell-shaped distribution of crabbing effort around the time of the tide was used to create a model that enabled surveyors to estimate whole-day effort (*WDE*) from a single instantaneous count (*IC*). An area-under-the-curve model (AUC) was generated from multiple instantaneous counts of buoys in Yaquina Bay at 30 minute intervals for an entire day. Each 30 minute count represented the total effort during that 30 minute interval. The AUC counts began early in the day before any bay crabbers began setting pots, and concluded 12-16 hours later as the effort waned to zero again. The AUC effort model of recreational crabbing in Yaquina Bay was assumed to be typical for bay crabbing in general, and was therefore applied to the other bays sampled.

The AUC counts describe how the crabbing effort is distributed around the time of the tide change, and also yield estimates of total daily effort in terms of hours, termed pot-hours. One pot-hour is defined as one piece of gear (pot or ring) fished for one

WDE = Whole-Day Effort (pot-hours)

IC = Instantaneous Count (# of buoys)

CF = Correction Factor

AUC = Area-Under-the-Curve effort model

PhP = Pot-hours per Person

hour. If the AUC counts were made once an hour instead of every thirty minutes, the estimate of *WDE* would be the sum of every *IC* conducted that day. However, since the AUC counts were conducted at time *t* every 30 minutes, the *WDE* is one-half the summed 30 minute counts over period *i*, or

$$WDE_{pot-hours} = 0.5 * \sum_{t=1}^{i} IC_t.$$

Estimates of *WDE* can also be made from an *IC* at time *t* using a correction factor (*CF*) for time *t*,

$$WDE_{pot-hours} = IC_t * CF_t,$$

and solving for *CF* gives

$$CF_t = \frac{WDE}{IC_t}.$$

Correction factor values were generated for every time *t*, relative to the time of high or low tide, for estimating whole day effort from instantaneous counts (see Appendix for an example).

Multiple AUC count days were completed to generate confidence intervals for each *CF* value. Mean *CF* values among all AUC count days *n* were obtained with

$$CF_t = \frac{\sum_{t=1}^{i} CF_t}{n},$$

and standard errors (*SE*) for each *CF* value around the mean were estimated by dividing the standard deviation (*s*) by the square root of the number of days (*n*):

$$SE(CF_t) = {s(CF_t)}/{\sqrt{n}}.$$

The 95% confidence interval for each *CF* value, with *n*=11 (10 degrees of freedom), is

$$\overline{CF_t} \pm 2.228 * SE(CF_t).$$

The upper and lower limits of the 95% confidence interval for each *CF* estimate were used to estimate upper and lower crabbing effort estimates for every day sampled.

Once the AUC model was completed, bay-wide instantaneous buoy counts could be expanded with the appropriate correction factor to estimate crabbing effort for the whole day. Surveyors were instructed to perform bay-wide buoy counts at or near the time of high or low tide, termed a "peak" count.

Peak counts were stratified by day-type (weekday/weekend) since effort in recreational fisheries will increase during weekends and holidays. Sampling goals were to randomly schedule eight weekday and 2-4 weekend peak count days per month per bay. Surveyors could complete peak counts in as little as twenty minutes in smaller bays like Alsea Bay and Netarts Bay, but could take up to one hour in larger

bays (Coos Bay and Yaquina Bay). Surveyors adapted the timing of their peak counts to coincide with the tide time, based on the time requirement to complete the counts for each bay.

Each sampled bay was divided into zones to facilitate counting and to compare spatial effort patterns within a bay. The extent of the zones approximated the total recreational use areas from the mouth of the bay to the upstream extent. Recreational crabbing above the upstream limit of the survey could occur in some bays, but effort in these marginal areas was rarely observed.

The spatial extent and configuration of zones were created out of convenience utilizing vantage points from which surveyors could find unobstructed views of boats and crabbing gear. The zonal boundaries were marked by permanent landmarks such as navigation buoys. Surveyors counted buoys and the numbers of boats using binoculars, recorded the time of the count, moved to the next adjacent zone, and repeated the peak count taking care not to double-count or miss any buoys. If commercial bay crab buoys were present, surveyors were usually able to exclude them from the count of recreational crab buoys.

To expand peak counts into estimates of whole-day effort, buoy count times from each zone within a bay were compared to the tide time. For example, if high tide occurred at 10:30 AM and a count was conducted at 10:10 AM, the count was (-20) minutes from the tide time. The time difference between the peak count and tide time was then compared to the *CF* values generated from the AUC model. Each peak count was multiplied by the appropriate *CF* value to estimate the pot-hours of effort in that zone. Once each zone was expanded, all the effort estimates from within each zone were summed for each sampled day.

Monthly estimates for effort were calculated from the sample of daily effort counts, stratified by day-type, and applied to unsampled days. Weekend and holidays within each month sampled received one estimate of total pot-hours of effort, and weekend days received another. Thus, the overall monthly effort, in pot-hours, is

$$WDE_{monthly} = [WDE_{weekday} * (number\ of\ weekdays)] + [WDE_{weekend} * (number\ of\ weekend\ days)].$$

Monthly mean, upper, and lower estimates of WDE were generated using the mean, upper, and lower CF values to estimate a 95% confidence interval of total crabbing effort.

Occasionally, sampling goals were not met due to time and schedule limitations, in which case missing values were inferred using data from similar months. This was necessary on some weekend effort estimates when a surveyor was unable to make a peak weekend buoy count within a month. The missing value was inferred, using a statistical technique known as imputation, with either the mean of nearest monthly values (e.g. if a July value was missing, it was estimated with the mean of June and August values), or the mean of the nearest yearly values (e.g. if the July 2009 value was missing, it was estimated with mean of

July values from 2007, 2008, 2010, and 2011).

While the variable for expressing effort for the bay crab survey is pot-hours, the total number of people participating in the bay crab fishery is also useful. Both the LCR and ORBS projects directly estimate crabbing effort as the number of trips (where one "trip" equals one person crabbing for one day). To convert the bay crab survey effort units (pot-hours) to comparable "trip" units, a conversion must first be done by incorporating the creel survey estimates of soak time (defined as the number of hours crabbing gear was actively fished during a trip) and total gear used. Using these terms, a new variable, pot-hours/person (*PhP*), is calculated with the following equation:

$$PhP = \frac{(total\ gear) * (soak\ time)}{(number\ of\ people)}.$$

Monthly mean *PhP* values were calculated from all interviews conducted in each bay. Because pot-hours is defined as

$$WDE_{pot-hours} = (total\ gear) * (soak\ time),$$

then to convert pot-hours to people is

$$WDE_{people} = \frac{WDE_{pot-hours}}{PhP},$$

$$= \frac{(total\ gear) * (soak\ time)}{(total\ gear) * (soak\ time) \Big/ (number\ of\ people)}$$

$$= (number\ of\ people).$$

Catch rate estimates

The Oregon bay crab survey is an on-site, access point survey (Pollock et al. 1994). Crabbers were intercepted upon completion of their trip at boat ramps or slips within a marina. Interview data were used to estimate catch-per-unit-effort (*CPUE*) in terms of crabs per pot-hour. *Catch*, for the purposes of this survey, is defined as the number of Dungeness crab caught and retained per person. The creel surveys occurred in close association with the peak count effort surveys, and most interviews were conducted in the hours after the effort survey.

Data collected during the creel survey included: (1) the total hours spent crabbing; (2) the type and number of pieces of gear used; (3) the number of people crabbing on the vessel; and (4) the number of Dungeness, red rock, and Pacific rock crab harvested. In addition, hometown ZIP Code of the interviewee was recorded for analyzing fishery participation. Subsamples of crabs were measured for carapace width and several other measures of biologic condition.

Monthly *CPUE* (crabs/pot-hour) estimates were calculated for each bay:

$$CPUE_{monthly} = \frac{\sum(crab\ retained)}{\sum[(total\ gear) * (soak\ time)]}.$$

As with the effort survey, due to resource limitations or lack of crabbing effort, surveyors were sometimes unable to complete interviews within a month to generate an estimate of *CPUE*. When this occurred, inferences using an imputation process replaced missing values with mean values from the other years of the survey for the same month and bay.

Harvest estimates

Harvest is defined as the total number of Dungeness crab caught and retained during a period of time (daily, monthly, or yearly). Harvest is a simple function of how successful crabbers were (*CPUE*) and how many pot-hours of effort were expended (*WDE*). Harvest (H) was estimated monthly with the equation:

$$H_{monthly} = CPUE_{monthly} * WDE_{monthly}.$$

Biological condition

During interviews with recreational crabbers, surveyors measured a subsample of retained crabs and collected other measures of biological condition. When crabbing effort was slow and/or catch rates were low, surveyors were able to measure a greater percentage of crabs than when effort and/or catch rates were high. Performing interviews was a priority over measuring crab, so surveyors managed their time to reduce missed interviews. Therefore, the crabs selected for measures of biological condition were collected haphazardly but without any known bias.

When a boat's catch of crab was selected for collecting biological data, a random sample of up to 10-15 crab was measured. Carapace width (CW) was measured to the nearest millimeter just anterior of the tenth anterolateral spine (the legal method of measuring minimum size of 146 mm or 5 ¾ inches), sex was recorded along with condition data such as missing limbs, presence of barnacles, etc. Crab shell hardness was measured on a ranked scale; "A" crabs were hard, "C" crab were soft and had likely molted recently, and "B" crabs had shells that only gave slightly when pressed. Hardness was measured by squeezing with the thumb and forefinger at the "shoulder" of the crab, an area of the carapace just posterior to the spines. Presence of "needle disease", an infection of the microsporidian *Nadelspora canceri,* was recorded (Olson et al. 1994, Childers et al. 1996). The muscle tissue of infected crabs is opaque when viewed through the periarticular membrane at the base of the legs.

Weight was estimated for each crab with a width-weight model derived from 5,268 male Dungeness crab captured during research sampling in Yaquina and Alsea bays from 2007 to 2009 (ODFW, unpublished data), where

$$weight(g) = 0.00011207 * CW^{3.076262}.$$

Annual mean weights were estimated for each bay. Mean weights were then used to estimate the total weight of crabs harvested such that, for each month *i*,

$$Kg_i = H_i * \overline{weight},$$

and

$$Lb_i = \frac{Kg_i}{0.453592}.$$

Fishery participation

Interviewees were asked to provide their hometown ZIP Code to examine the distances people travel to go crabbing. Data from crabber interviews were compared to a database of ZIP Code latitude and longitude coordinates, and the results were mapped in ArcMap (ESRI 2011).

For the purposes of the fishery participation survey only, interviews of land-based crabbers were included with boat-based crabbers. This increased the sample size and represents a sample of all crabbers traveling to Oregon bays to participate in the recreational crab fishery.

Lower Columbia River Survey

Figure 2. The Lower Columbia River, located between Washington and Oregon, is surveyed using different methods than other estuaries due to its much greater size.

Effort estimates

Participants in the Lower Columbia River crab fishery focus their effort around the time of high tide, similar to the bay crab fishery. However, because the LCR crab fishery occurs in an area much larger than the other estuaries along the coast, a different approach to estimating effort was employed. Surveyors were unable to count buoys from shore to estimate daily pot-hours of effort, and therefore an effort expansion model based on counts of empty boat trailers was developed.

Durham and Hunter (2008) describe counting empty boat trailers for determining the timing of peak effort in the LCR recreational crab fishery in Hammond, Oregon. Each empty trailer was assumed to represent a single boat participating in the crab fishery because no other fishery was co-occurring during the late fall and winter when effort in the LCR fishery is greatest. During the model development, trailer counts were conducted hourly throughout the day. Hourly trailer counts (*TC*) were integrated over the count period *i* to estimate the whole-day effort (*WDE*), in terms of boat-hours,

$$WDE_{boat-hours} = \sum_{t=1}^{i} TC_t.$$

The units for CPUE are boat-hours when using the trailer count method, and these CPUE values must be converted to crabs/person for compatibility with the other creels surveys in this report. To accomplish this, a method was first developed to estimate the total number of boats crabbing based on the average trip length, and then expand the boat estimate by the average number people crabbing per boat. First, *WDE* in boat-hours is converted to the total number of boats, using the average trip length (TL), in hours, from the creel survey, where:

$$WDE_{boats} = \frac{WDE_{boat-hours}}{TL},$$

$$= \frac{(total\ boats) * (hours)}{(hours)},$$

$$= (total\ boats).$$

Second, while the model was being developed, the peak trailer counts (TC_{peak}) were found to be greatest, on average, at two hours before high tide. After the $WDE_{boat-hours}$ for each model development day was converted to WDE_{boats}, the following comparison was made:

$$TC_{peak} = WDE_{boats} * E_{peak},$$

or

$$E_{peak} = \frac{TC_{peak}}{WDE_{boats}}.$$

In other words,

$$E_{peak} = \frac{(\#\ trailers\ two\ hours\ before\ high\ tide)}{(total\ boats\ crabbing\ the\ whole\ day)},$$

where E_{peak} is a constant which measures the efficiency of the peak trailer counts in estimating the total daily number of boats crabbing. Once the E_{peak} value was developed for the model, surveyors of the LCR crab fishery were able to complete trailer counts at the peak effort time (two hours before high tide), and convert the value directly to estimated boats. The total number of boats was estimated by:

$$WDE_{boats} = \frac{TC_{peak}}{E_{peak}}.$$

The third step necessary to express daily effort in terms of people (WDE_{people}) is to expand the boat estimate, using the mean number of people per boat ($\bar{P}$) from the creel survey, so that

$$WDE_{people} = WDE_{boats} * (\bar{P}).$$

Weekly survey goals were to make at least one TC_{peak} on a weekday, and one TC_{peak} on a weekend. Monthly total estimates of the number of people crabbing ($WDE_{monthly}$) were estimated by extrapolating daily effort estimates from sampled days to unsampled days. The sampling frequency among months varied; weather and/or staff availability occasionally prevented surveyors from meeting minimum goals. The annual LCR survey targeted the highest use months in the fall and winter, typically October through February but as late as March in some years.

Catch rate estimates

Like the bay crab survey, the Lower Columbia River crab survey is an on-site, access point survey. Crabbers were intercepted upon completion of their trip at boat ramps or slips within Hammond boat basin. Interview data were used to estimate catch-per-unit-effort (*CPUE*) in terms of crabs per person.

The creel survey collected data including: (1) the hours spent crabbing; (2) the pieces of gear used; (3) the number of people crabbing on the vessel; and (4) the number of Dungeness crab harvested. Monthly *CPUE* (crabs/person) estimates were calculated throughout the sampling period:

$$CPUE_{monthly} = \frac{\sum(crab\ retained)}{\sum(people)}.$$

Harvest estimates

Monthly harvest ($H_{monthly}$), in numbers of crab, was estimated using the formula:

$$H_{monthly} = CPUE_{monthly} * WDE_{monthly}.$$

Biological data

A subsample of at least 50 crabs per week, spread out among interviews, was selected for measures of biological condition. Carapace width, shell hardness, and other condition data were recorded in in a similar manner as the bay crab survey. Total weight was estimated using the width-weight formula and process described above for the bay crab survey.

Ocean Recreational Boat Survey

Figure 3. Ports surveyed for the Ocean Recreational Boat Survey.

The Ocean Recreational Boat Survey (ORBS) relies on a number of different methods to estimate effort and catch, depending on the port and/or fishery. ORBS currently operates in all Oregon ports where recreational ocean fishing occurs. Schindler et al. (2008) describes in detail the sampling methodology.

Effort estimates are derived from contacting charter vessel operators, bar crossing counts, and trailer/slip counts. Effort counts are expanded for the time outside the count period based on interview data. Weekly and monthly estimates are derived for private and charter boats, and for each target fishery.

Dockside interviews are conducted in conjunction with effort counts to generate unbiased estimates of anglers per boat and catch. Interview results are stratified by several strata including week, port, trip type, etc. The interview data yielded estimates of the number of crabs harvested per person (*CPUE*). Estimates of total crab harvest (number of crabs) and effort (number of angler-trips) for each month and port were calculated using expansion methods detailed in Schindler et al. (2008).

RESULTS

Bay Crab Effort Modeling

The AUC model to estimate bay crabbing effort was developed from whole day buoy counts on eleven days between March 2007 and June 2008 in Yaquina Bay (Figure 4). Observations of crabbing effort during the development of the AUC model for Yaquina Bay illustrate that the instantaneous buoy counts are closely aligned with the timing of the flood and ebb tides. Maximum instantaneous buoy counts are generally greatest about 30 minutes before the slack tide, and indicate that

recreational crabbers expend their greatest effort during the period of slowest tidal currents.

For each day the AUC counts were conducted, the total daily effort (pot-hours) was calculated by integrating the area under each curve. *CF* values were then calculated for each 30 minute count within each day. Mean *CF* values 95% confidence intervals for each count time in relation to the time of the tide were then calculated (Figure 5). Variability in the CF values was low immediately before and after the slack tide, and increased substantially about 2 hours before and after slack tide. These results are consistent with the observations that peak recreational bay crabbing effort occurs during the transitions between the flood and ebb tides.

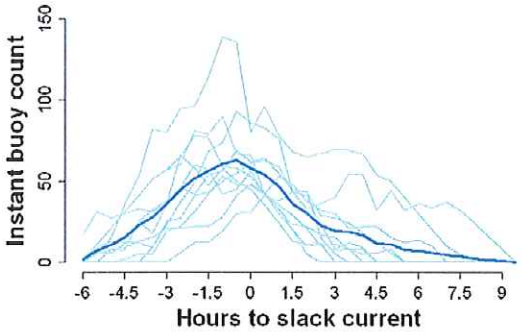


Figure 4. Results of AUC model buoy counts (light blue) conducted every 0.5 hours on eleven days between March 2007 and June 2008 in Yaquina Bay. The dark blue line is the mean buoy count for each buoy count time in reference to the high or low tide time on each sampling day.

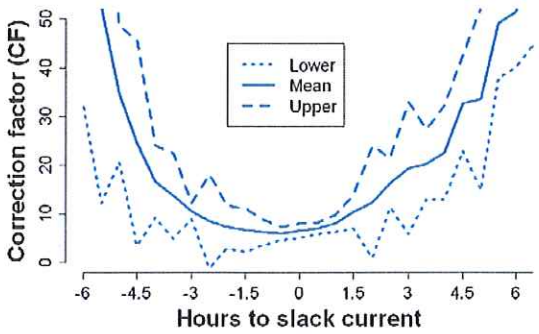


Figure 5. Correction factor values and 95% confidence intervals developed with the AUC model.

A Fish Commission of Oregon biologist checks a crab pot during a research project in the 1960s

Tillamook Bay

Effort estimates

Tillamook Bay was divided into three zones for counting buoys and understanding the spatial patterns of crabbing effort (Figure 6). Crabbing effort was surveyed in Tillamook Bay for 5-7 months between April and October for four years (Table 1). The westernmost zone, TJ (Tillamook Jetty), was consistently utilized most frequently during all years sampled (Table 2). Crabbers in this area typically set their gear on each side of the channel along the jetties. The central zone, KC (Kincheloe), was the second most popular area. This area is closest to the Garibaldi Marina, with calmer waters than TJ near the bay mouth. The remainder of the crabbing effort occurred in Crab Harbor (CH). Bay crabbing effort peaked in the late summer to early fall (Table 3), when up to 2,000 crabbing trips per month were estimated to occur. Bay crabbers in Tillamook Bay typically preferred to use pots and typically fished their gear around 4 hours (Table 4).

Recreational crabbers in Yaquina Bay

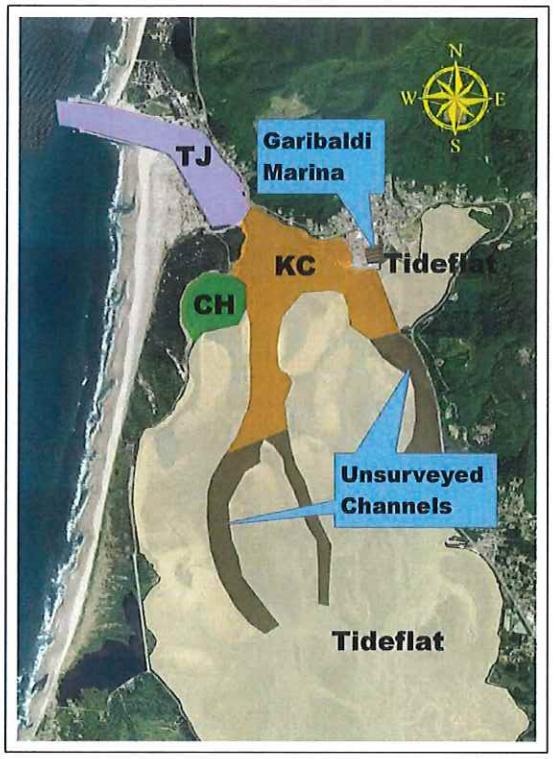


Figure 6. Recreational crabbing areas of Tillamook Bay (see text for explanation of areas and codes).

Table 1. Sampling days in Tillamook Bay (2008-2011).

	Weekday		Weekend	
	Days	Interviews: boats (people)	Days	Interviews: boats (people)
2008	55	117 (322)	9	39 (111)
2009	38	70 (194)	4	13 (40)
2010	38	121 (317)	14	78 (225)
2011	35	118 (318)	5	85 (248)

Table 2. Spatial patterns of recreational crabbing effort in Tillamook Bay: each number represents the percent of total observed effort that occurred in each zone for each year. The zone codes correspond to the crabbing areas in Tillamook Bay (Figure 6).

Area	CH 52 ha	KC 247 ha	TJ 126 ha
2008	16.5	29.2	54.3
2009	13.2	25.7	61.1
2010	6.2	39.1	54.7
2011	4.6	38.4	57.0
Ave.	10.1	33.1	56.8

Table 3. Estimated monthly recreational crabbing trips in Tillamook Bay (NS = not sampled).

	2008	2009	2010	2011
April	89	663	451	320
May	229	1,108	814	641
June	378	479	630	203
July	575	1,958	788	631
August	1,373	1,721	1,589	1,330
September	1,426	1,536	1,531	2,512
October	2,370	NS	1,276	NS
Total (95% conf. interval)	6,440 (4,635-8,245)	7,465 (5,829-9,102)	7,080 (5,503-8,657)	5,637 (4,355-6,919)

Table 4. Average gear usage and soak time by recreational crabbers in Tillamook Bay.

	Number of pots	Number of rings	Soak time (hours)	Pot-hours per person
2008	1.49	0.35	4.11	8.25
2009	1.67	0.25	4.07	7.47
2010	1.83	0.24	3.69	7.61
2011	1.67	0.27	3.68	7.33
Ave.	1.67	0.28	3.89	7.67

Catch rate estimates

Catch rates varied throughout the sampling period within each year, but followed a similar pattern among all years (Figure 7). The lowest *CPUE*, in terms of crabs/pot-hour or crabs/person, occurred in May or June. Catch rates typically increased over the summer to reach the peak values in August or September. Catch rates then slowly decreased over the fall and early winter months.

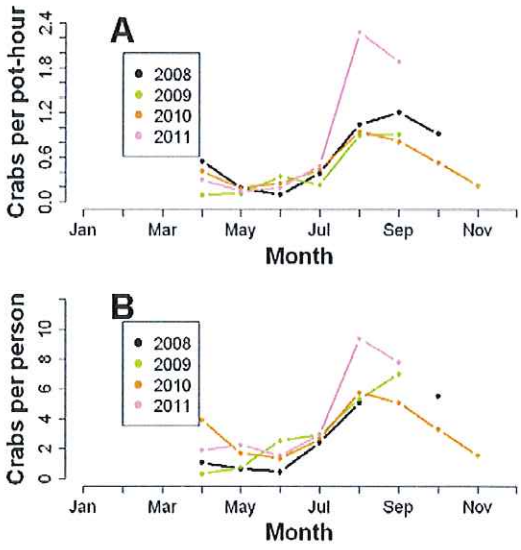


Figure 7. Monthly CPUE estimates for recreational crabbers in Tillamook Bay; A) crabs per pot-hour, and B) crabs per person.

Harvest estimates

The monthly harvest of crabs for all years sampled was the greatest in September 2011, when close to 35,000 crabs were harvested (Figure 8). Harvest in April through July in all years was low due to a combination of low effort and decreased catch rates. The cumulative number of crab

harvested annually was converted to pounds using the average estimated weight per crab. The estimated annual harvest of Dungeness crab in Tillamook Bay during the period sampled was 66,200 pounds in 2008, 45,600 pounds in 2009, 49,400 pounds in 2010, and 85,300 pounds in 2011. Due to limited staff availability, crabs harvested after the sampling period are not included in these estimates. However, estimates during unsampled periods are provided in the "Bay Crab Fishery Off-Season Estimates" section later in this report.

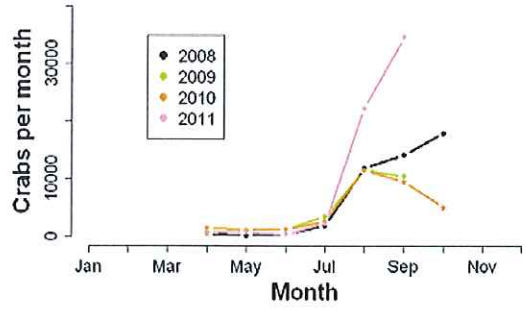


Figure 8. Estimated number of crab harvested each month by recreational crabbers in Tillamook Bay.

Biological data

Crabs sampled for biological data had an average carapace width of between 156-163 mm among all years sampled (Table 5, Figure 9). The rate of sublegal-sized crabs (<146 mm CW) was highest in the first year sampled, with sublegal crabs encountered less frequently from 2009-2011. The frequency of crabs observed with observed with medium and soft shells was low in 2009, and soft shelled crabs were not observed in 2010. These observations indicate that substantial variability may occur in the molt cycle and the behavior of newly molted crab, or among surveyors measuring crab.

Table 5. Mean carapace width (CW), percent sublegal (<146 mm CW), and estimated mean weight of crab harvested by recreational crabbers in Tillamook Bay.

	Crabs measured	Mean CW (mm)	Percent sublegal	Mean weight (g)
2008	391	156.5	13.0	644.8
2009	76	163.2	1.3	732.7
2010	158	160.4	3.2	692.5
2011	145	156.4	2.1	636.0

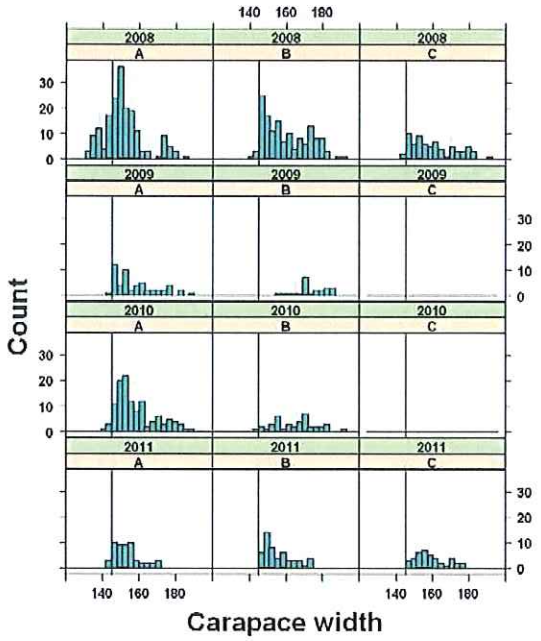


Figure 9. Size frequency and shell grade (A=hard, B=medium, C=soft) of Dungeness crab in Tillamook Bay; the vertical line represents the minimum legal size of 146 mm.

Fishery participation

About half of the recreational crabbers interviewed in Tillamook Bay traveled less than 50 miles, but over 11% traveled over 150 miles (Table 6). Almost 85% of all crabbers interviewed were

Oregon residents, and nearly 10% traveled from Washington. Most crabbers in Tillamook Bay traveled from the northern Willamette Valley area or were local residents from the northern Oregon coast (Figure 10).

Table 6. Distances traveled (staight line, in miles) by recreational crabbers interviewed in Tillamook Bay, 2008-2011.

Distances traveled	Percent of total trips
0-50 miles	52.8
51-100 miles	33.3
101-150 miles	2.4
>150 miles	11.5

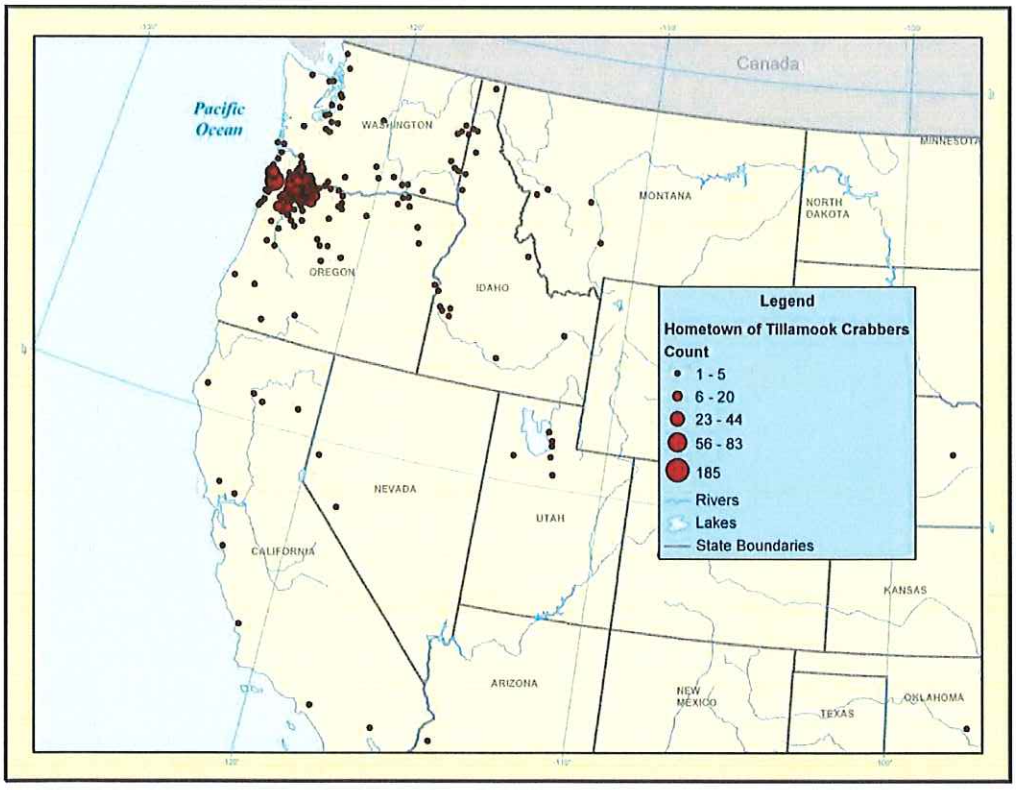


Figure 10. Hometown of recreational crabbers interviewed in Tillamook Bay, 2008-2011.

Netarts Bay

Effort estimates

The crabbing effort in Netarts Bay is limited to the narrow channel that snakes between the bay's vast tideflats. The crabbing areas were divided into four zones for counting buoys (Figure 11). Sampling in Netarts Bay occurred during the summer and early fall for four years (Table 7). The majority of the crabbing effort occurred in the Lower Netarts area (LN) and the area near Netarts Bay RV Park (RV) (Table 8). The remainder of the crabbing effort occurred in Central Netarts (CN) and Upper Netarts (UN). Total monthly crabbing trips were lowest in April-June, and increased through the summer (Table 9). Crabbers favored using pots, and typically soaked their gear for 3-4 hours (Table 10).

Recreational crab buoys at the mouth of Alsea Bay

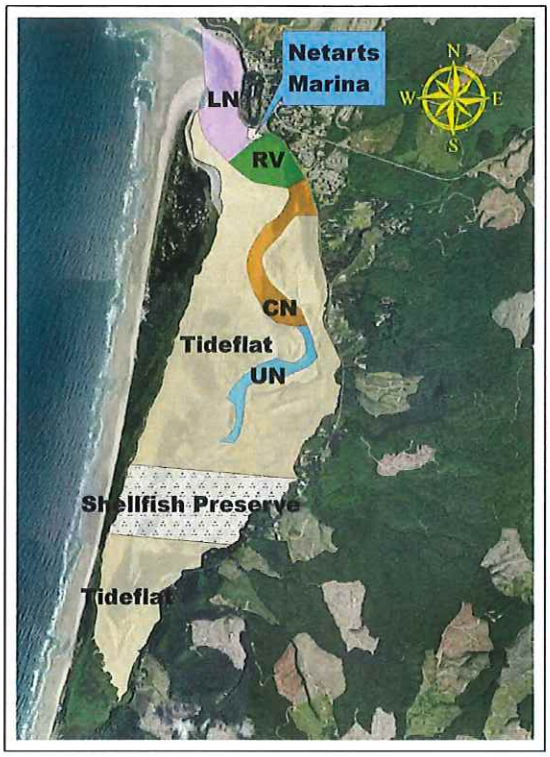


Figure 11. Recreational crabbing areas of Netarts Bay (see text for explanation of areas and codes).

Table 7. Sampling days in Netarts Bay (2008-2011).

	Weekday		Weekend	
	Days	Interviews: boats (people)	Days	Interviews: boats (people)
2008	43	158 (425)	14	66 (218)
2009	37	133 (376)	5	27 (82)
2010	39	188 (477)	10	115 (343)
2011	34	212 (604)	8	94 (265)

Table 8. Spatial patterns of recreational crabbing effort in Netarts Bay: each number represents the percent of total observed effort that occurred in each zone for each year. The zone codes correspond to the crabbing areas in Netarts Bay (Figure 11).

Area	CN 45 ha	LN 58 ha	RV 34 ha	UN 26 ha
2008	13.2	47.5	32.2	7.1
2009	18.5	55.0	20.9	5.7
2010	18.2	56.9	22.7	2.3
2011	11.4	58.7	27.9	1.9
Ave.	15.3	54.5	25.9	4.2

Table 9. Estimated monthly recreational crabbing trips in Netarts Bay (NS = not sampled).

	2008	2009	2010	2011
April	299	333	434	553
May	406	559	467	694
June	285	267	455	510
July	360	1,928	1,240	1,042
August	801	1,612	2,745	1,297
September	930	1,664	2,767	1,924
October	1,871	NS	2,140	NS
Total (95% con. interval)	4,951 (3,485-6,418)	6,363 (5,001-7,724)	10,248 (8,131-12,364)	6,020 (4,666-7,375)

Table 10. Average gear usage and soak time by recreational crabbers in Netarts Bay.

	Number of pots	Number of rings	Soak time (hours)	Pot-hours per person
2008	1.57	0.39	4.44	9.67
2009	1.39	0.57	3.63	7.40
2010	1.64	0.56	3.63	8.29
2011	1.28	0.65	2.85	5.62
Ave.	1.47	0.54	3.64	7.75

Catch rate estimates

The best months for crabbing in Netarts Bay were August and September (Figure 12). Catch rates were low (around 2 crabs per person) in April-June and peaked in the late summer (6-8 crabs person).

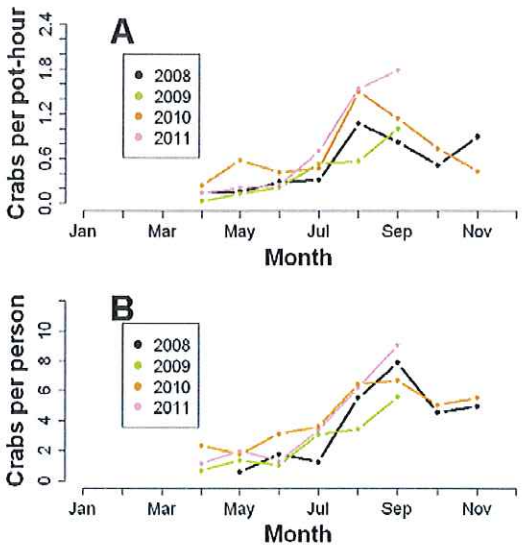


Figure 12. Monthly CPUE estimates for recreational crabbers in Netarts Bay; A) crabs per pot-hour, and B) crabs per person.

Harvest estimates

Total monthly harvest of crabs was greatest in August 2010 when approximately 30,000 crabs were taken (Figure 13). The lowest overall harvest was in 2008. For all years sampled, the lowest monthly harvests occurred in April through June. The estimated annual harvest of Dungeness crab in Netarts Bay during the period sampled was 31,900 pounds in 2008, 43,500 pounds in 2009, 118,300 pounds in 2010, and 70,000 pounds in 2011. Projections of the harvest during unsampled periods are

provided in the "Bay Crab Fishery Off-Season Estimates" section.

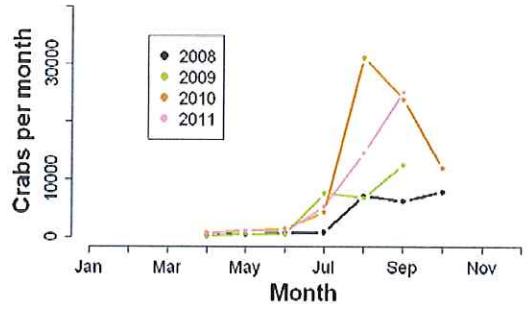


Figure 13. Estimated number of crab harvested each month by recreational crabbers in Netarts Bay.

Biological data

Carapace width of crabs sampled from the recreational catch in Netarts Bay varied among the years sampled (Table 11, Figure 14). Crabs were the smallest in 2008 (155 mm mean CW), and the largest crabs were observed in 2010 (162 mm mean CW). Compliance with the minimum size limit was lowest in 2008 when almost 16% of the crabs were undersized (<146 mm CW). Less than 1% of crabs measured in 2011 were less than the minimum size. Crabs with soft shells were not observed in 2009 and 2010, possibly due to the variability between surveyors in judging shell hardness.

Table 11. Mean carapace width (CW), percent sublegal (<146 mm CW), and estimated mean weight of crab harvested by recreational crabbers in Tillamook Bay.

	Crabs measured	Mean CW (mm)	Percent sublegal	Mean weight (g)
2008	483	154.7	15.7	618.1
2009	234	161.1	3.0	702.8
2010	262	162.1	7.3	718.7
2011	533	158.6	0.6	666.3

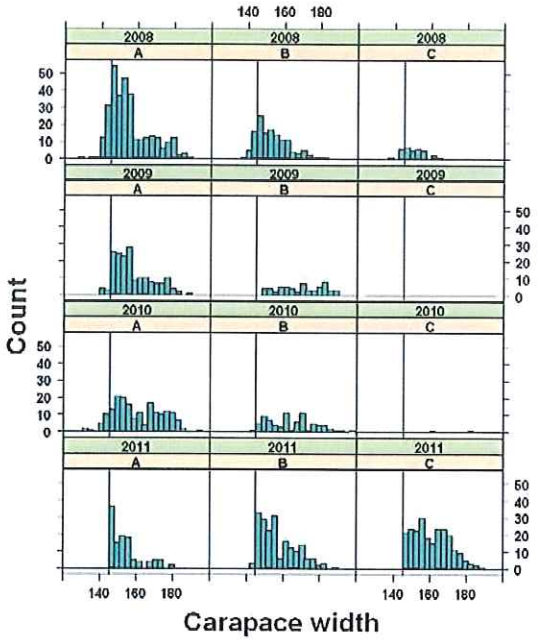


Figure 14. Size frequency and shell grade (A=hard, B=medium, C=soft) of Dungeness crab in Tillamook Bay; the vertical line represents the minimum legal size of 146 mm.

Fishery participation

Most of the recreational crabbers that were interviewed in Netarts Bay had traveled over 50 miles, and 24% had traveled over 150 miles (Table 12). Over 75% of the crabbers interviewed were Oregon residents. Like Tillamook Bay crabbers, most people participating in the Netarts Bay crab fishery originated from either the northern Willamette Valley area or were local north coast Oregon residents (Figure 15).

Table 12. Distances traveled (staight line, in miles) by recreational crabbers interviewed in Netarts Bay, 2008-2011.

Distances traveled	Percent of total trips
0-50 miles	33.1
51-100 miles	40.6
101-150 miles	2.3
>150 miles	24.0

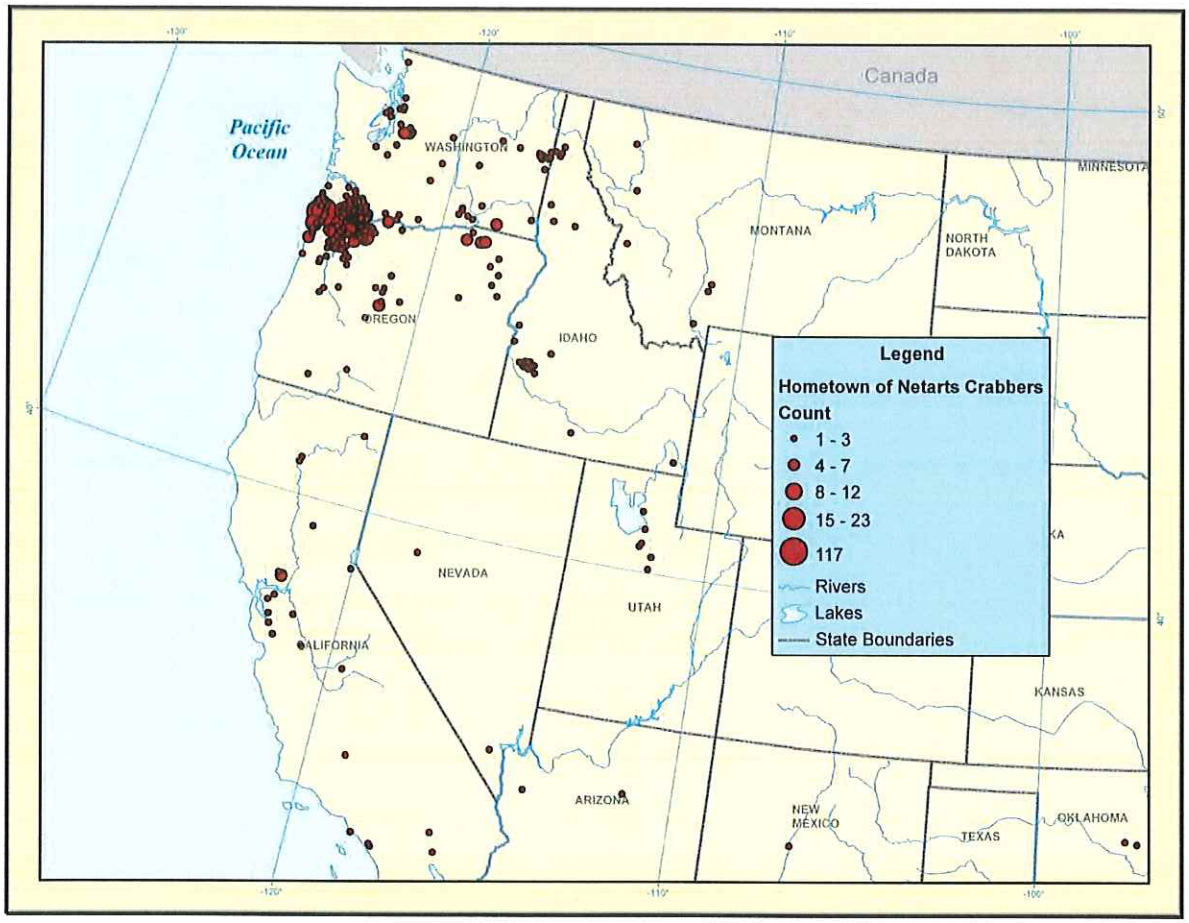


Figure 15. Hometown of recreational crabbers interviewed in Netarts Bay, 2008-2011.

Yaquina Bay

Effort estimates

The crabbing effort within Yaquina Bay was divided into four zones to facilitate counting buoys (Figure 16). Effort counts were conducted year-round from 2007-2011 (Table 13). Crabbing effort was focused on the margins of the main navigational channel. Overall, for all years sampled, the GP (Gas Plant) zone in the central part of the bay was the most utilized (Table 14). This area provides protection for the small boat crabber, with much calmer conditions on most days than the South Jetty (SJ) zone. In addition, there is less boat traffic than in the sometimes congested Coast Guard (CG) zone. The Upper Bay (UB) area was the least popular area. Crabbing effort was variable within each year sampled, but generally was highest in the fall and lowest in the late winter and spring (Table 15). Like most of the other bays sampled, crabbers typically used pots and fished their gear for around four hours (Table 16).

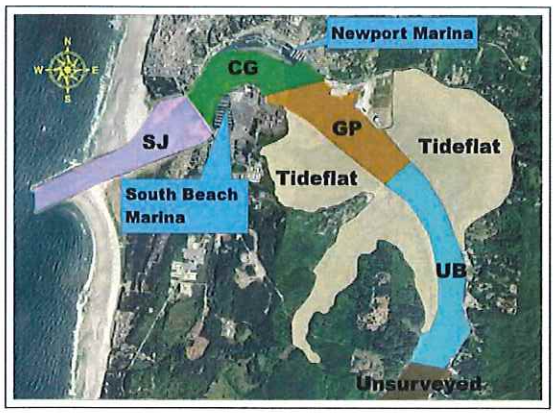


Figure 16. Recreational crabbing areas of Yaquina Bay (see text for explanation of areas and codes).

Table 13. Sampling days in Yaquina Bay.

	Weekday		Weekend	
	Days	Interviews: boats (people)	Days	Interviews: boats (people)
2007	63	351 (950)	4	352 (1,001)
2008	82	388 (1,099)	21	327 (962)
2009	77	224 (619)	26	256 (752)
2010	63	304 (850)	18	241 (705)
2011	58	297 (846)	19	296 (901)

Table 14. Spatial patterns of recreational crabbing effort in Yaquina Bay: each number represents the percent of total observed effort that occurred in each zone for each year. The zone codes correspond to the crabbing areas in Yaquina Bay (Figure 16).

Area	SJ 99 ha	CG 75 ha	GP 93 ha	UB 107 ha
2007	9.2	14.3	64.5	12.0
2008	17.1	18.8	55.5	8.6
2009	14.5	20.9	57.8	6.7
2010	15.0	22.1	54.8	8.1
2011	17.7	14.9	62.1	5.3
Ave.	14.7	18.2	58.9	8.1

Table 15. Estimated monthly recreational crabbing trips in Yaquina Bay.

	2007	2008	2009	2010	2011
Jan.	927	251	1,435	656	684
Feb.	923	644	1,127	1,397	645
Mar.	1,264	658	1,031	1,054	578
April	738	601	1,061	1,154	423
May	1,181	1,040	869	497	853
June	1,301	976	1,084	1,311	716
July	4,210	2,599	1,817	2,307	2,169
Aug.	2,617	2,285	1,966	2,240	1,927
Sept.	1,356	3,658	2,572	2,144	2,065
Oct.	4,038	3,506	2,161	3,730	2,125
Nov.	972	3,390	1,335	695	596
Dec.	406	474	1,126	566	936
Total (95% conf. inter-val.)	19,934 (13,879 - 25,988)	20,081 (15,628 - 24,535)	17,586 (13,851 - 21,321)	17,752 (13,927 - 21,577)	13,716 (10,648 - 16,748)

Table 16. Average gear usage and soak time by recreational crabbers in Yaquina Bay.

	Number of pots	Number of rings	Soak time (hours)	Pot-hours per person
2007	1.60	0.50	4.08	8.48
2008	1.58	0.44	3.98	8.34
2009	1.71	0.45	4.15	9.27
2010	1.75	0.37	3.83	8.37
2011	1.72	0.35	4.16	8.70
Ave.	1.67	0.42	4.04	8.63

Catch rate estimates

With some exceptions, the trend in *CPUE* followed a similar seasonal pattern each of the five years sampled (Figure 17). Starting with the lowest *CPUE* in the spring, catch rates increased in the summer before peaking in the fall. Catch rates then declined over the winter. The highest catch rates observed in Yaquina Bay were in the late fall of 2008 and 2011, when crabbers averaged approximately 6 crabs per person.

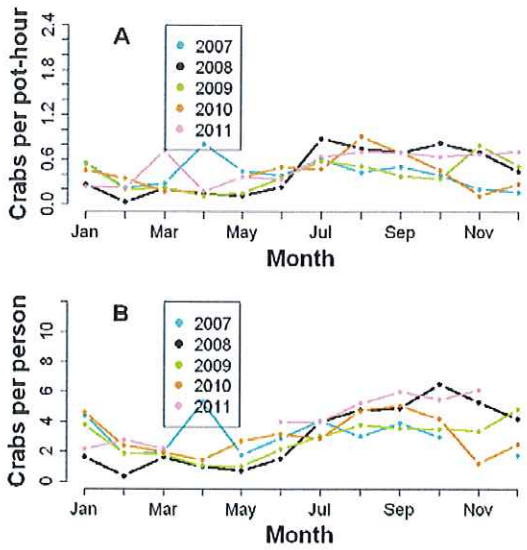


Figure 17. Monthly CPUE estimates for recreational crabbers in Yaquina Bay; A) crabs per pot-hour, and B) crabs per person.

Harvest estimates

Monthly harvest of crabs in Yaquina Bay generally did not increase until July (Figure 18). Harvest then either plateaued (2009-2011), was variable (2007), or continued to increase later in the season (2008). However, in all years sampled, the overall harvest was lowest for the months of February through June. When the total number of crab harvested was converted to pounds, the estimated annual harvest in Yaquina Bay was 103,000 pounds in 2007, 141,700 pounds in 2008, 84,400 pounds in 2009, 93,800 pounds in 2010, and 81,400 pounds in 2011.

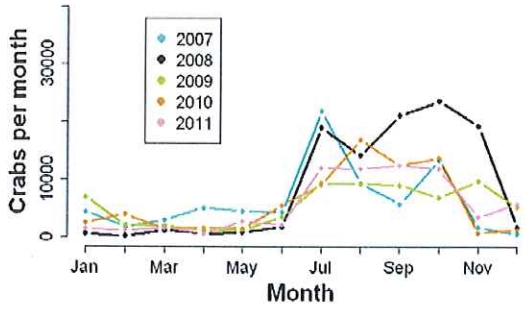


Figure 18. Estimated number of crab harvested each month by recreational crabbers in Yaquina Bay.

Biological data

Recreational crabbers in Yaquina Bay were not very compliant with the minimum size limit (Table 17, Figure 19). For all years of this study (2007-2010), sublegal crabs (<146 mm CW) represented at least 10% of the catch.

Table 17. Mean carapace width (CW), percent sublegal (<146 mm CW), and estimated mean weight of crab harvested by recreational crabbers in Yaquina Bay (estimates for 2011 are missing due to small sample size).

	Crabs measured	Mean CW	Percent sublegal	Mean weight (g)
2007	66	155.1	10.6	571.1
2008	359	154.7	15.6	618.6
2009	301	151.2	18.9	542.1
2010	60	153.3	15.0	575.0
2011	-	-	-	-

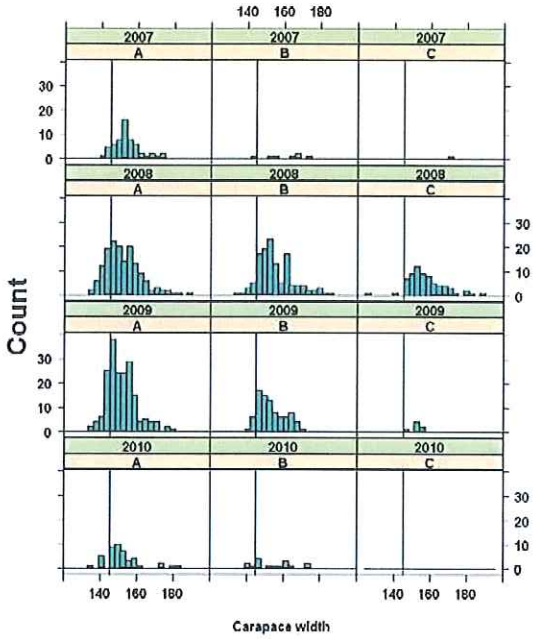


Figure 19. Size frequency and shell grade (A=hard, B=medium, C=soft) of Dungeness crab in Yaquina Bay; the vertical line represents the minimum legal size of 146 mm (2011 data are missing due to small sample size).

Fishery participation

Recreational crabbers interviewed in Yaquina Bay were a mix of local and long distance travelers (Table 18). Overall, 87% of recreational crabbers in Yaquina Bay were Oregon residents. Most of the crabbers interviewed in Yaquina Bay originated from either the Willamette Valley or the central coast (Figure 20). A significant number of crabbers also originated from the Bend area.

Table 18. Distances traveled (staight line, in miles) by recreational crabbers interviewed in Yaquina Bay, 2007-2011.

Distances traveled	Percent of total trips
0-50 miles	30.9
51-100 miles	46.7
101-150 miles	9.0
>150 miles	13.4

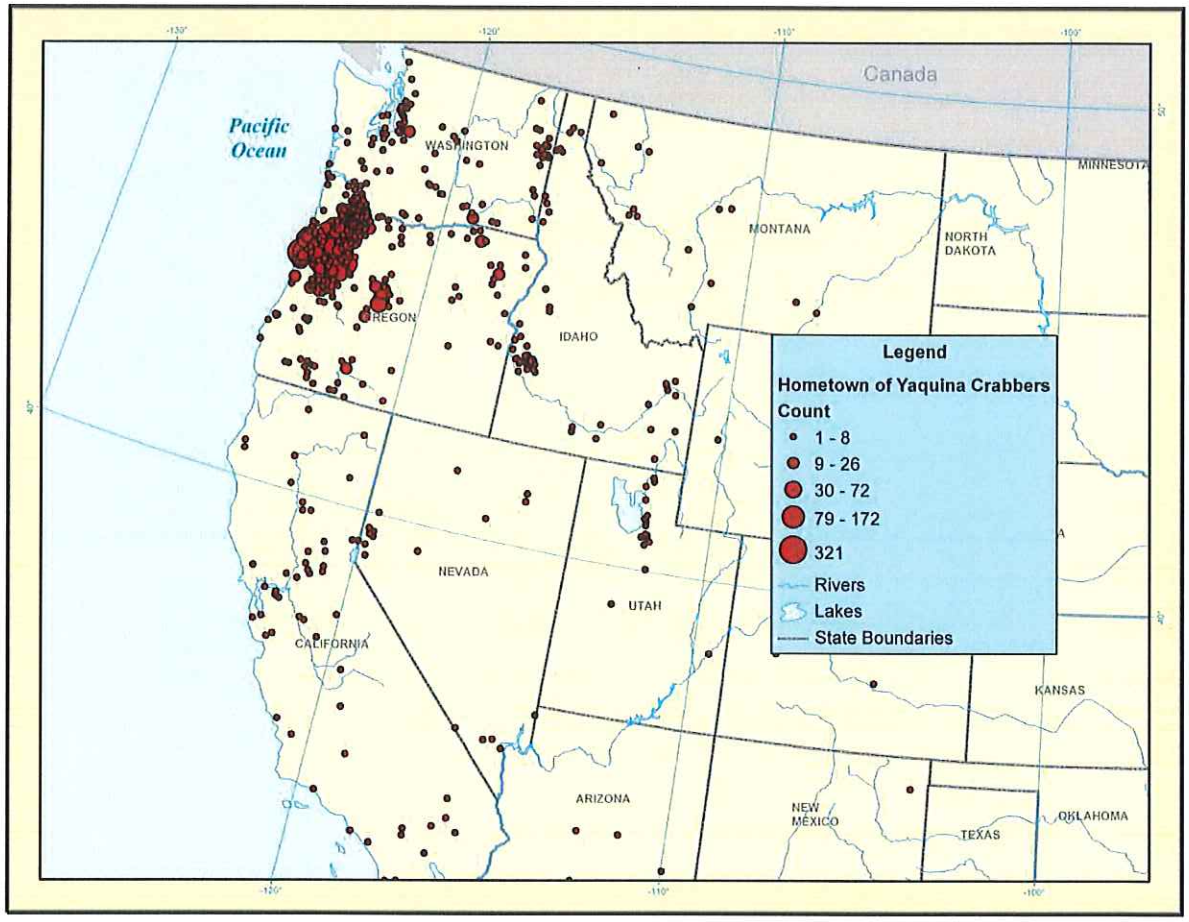


Figure 20. Hometown of recreational crabbers interviewed in Yaquina Bay, 2007-2011.

Alsea Bay

Effort estimates

Recreational crabbing effort within Alsea Bay was divided into three zones to facilitate counting buoys (Figure 21). Effort counts were conducted year-round from 2007-2011 (Table 19). Crabbing effort was focused on the margins of the main river channel. Overall, for all years sampled, the Interpretive Center (IC) zone in the western part of the bay was the most utilized (Table 20). This area is nearest the mouth of the bay, and crabbers preferred to set their gear as close to the ocean as conditions permit. The central Port of Alsea (PA) zone was also popular, particularly for smaller boats due to the relatively calmer conditions in this area. Crabbing effort near McKinley's Marina (MM) was usually low. Monthly crabbing effort for all years was relatively low from January through June, and peaked in the fall (Table 21). Although crabbers typically used pots, rings were a popular choice, and on average crabbers fished their gear for periods between three and four hours (Table 22).

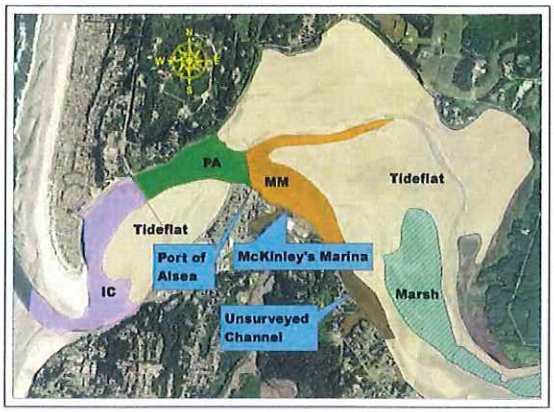


Figure 21. Recreational crabbing areas of Alsea Bay (see text for explanation of areas and codes).

Table 19. Sampling days in Alsea Bay.

	Weekday		Weekend	
	Days	Interviews: boats (people)	Days	Interviews: boats (people)
2007	60	145 (391)	5	19 (56)
2008	72	175 (444)	17	74 (209)
2009	71	145 (371)	25	92 (246)
2010	57	111 (304)	17	71 (185)
2011	61	169 (427)	14	54 (145)

Table 20. Spatial patterns of recreational crabbing effort in Alsea Bay: each number represents the percent of total observed effort that occurred in each zone for each year. The zone codes correspond to the crabbing areas in Alsea Bay (Figure 21).

Area	IC 57 ha	PA 35 ha	MM 49 ha
2007	56.3	40. 7	3.0
2008	62.2	36.2	1.6
2009	60.0	34.6	5.4
2010	57.5	37.6	4.9
2011	54.0	39.5	6.5
Ave.	58.0	37.0	8.6

Table 21. Estimated monthly recreational crabbing trips in Alsea Bay.

	2007	2008	2009	2010	2011
Jan.	300	169	553	54	252
Feb.	400	163	275	295	90
Mar.	286	276	209	48	80
April	180	133	168	99	64
May	292	145	500	191	497
June	460	437	380	161	299
July	2,519	1,455	1,462	1,077	1,312
Aug.	2,613	3,724	2,109	2,721	2,055
Sept.	3,296	3,715	3,363	2,913	2,136
Oct.	3,077	3,306	2,821	1,719	2,503
Nov.	901	2,418	1,314	896	1,048
Dec.	486	675	773	577	1,221
Total (95% conf. inter-val.)	14,810 (9,698 - 19,923)	16,615 (13,059 - 20,171)	13,929 (10,775 - 17,082)	10,752 (8,318 - 13,186)	11,558 (8,951 - 14,269)

Table 22. Average gear usage and soak time by recreational crabbers in Alsea Bay.

	Number of pots	Number of rings	Soak time (hours)	Pot-hours per person
2007	1.19	1.14	3.61	8.30
2008	1.54	0.71	3.39	7.75
2009	1.43	0.96	3.36	8.08
2010	1.47	0.86	3.58	8.41
2011	1.42	0.90	3.47	7.97
Ave.	4.41	0.91	3.48	8.10

Catch rate estimates

The trend in *CPUE* followed a similar seasonal pattern during each of the five years sampled (Figure 22). Starting with the lowest *CPUE* in the spring, catch rates in Alsea Bay consistently increased in the summer before peaking in the fall. Catch rates then declined over the winter.

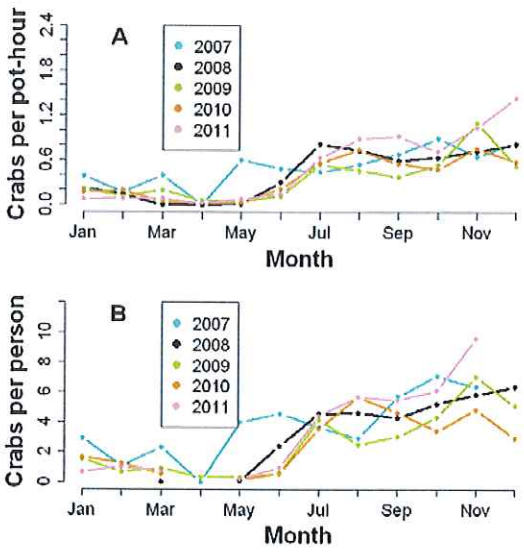


Figure 22. Monthly CPUE estimates for recreational crabbers in Alsea Bay; A) crabs per pot-hour, and B) crabs per person.

Harvest estimates

The peak monthly harvest of crabs in Alsea Bay for all years sampled coincided with the higher effort and catch rates in the fall (Figure 23). In all years sampled, the overall harvest was lowest for the months January through June. When the total number of crab harvested was converted to pounds, the estimated annual harvest in Alsea Bay was 102,500 pounds in 2007, 110,800 pounds in 2008, 69,200 pounds in 2009, 74,800 pounds in 2010, and 97,600 pounds in 2011.

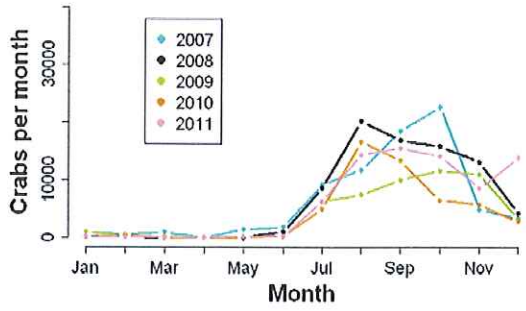


Figure 23. Estimated number of crab harvested each month by recreational crabbers in Alsea Bay.

Biological data

Recreational crabbers in Alsea Bay were not very compliant with the minimum size limit (Table 23, Figure 24). Except for 2010, sublegal crabs (<146 mm CW) represented at least 10% of the catch. Soft shelled crabs were rarely observed in Alsea Bay of the period 2007-2011.

Table 23. Mean carapace width (CW), percent sublegal (<146 mm CW), and estimated mean weight of crab harvested by recreational crabbers in Alsea Bay.

	Crabs measured	Mean CW (mm)	Percent sublegal	Mean weight (g)
2007	276	155.1	14.5	610.8
2008	771	154.7	10.1	625.1
2009	853	151.2	12.5	608.7
2010	363	153.3	7.7	668.3
2011	285	148.8	15.8	600.7

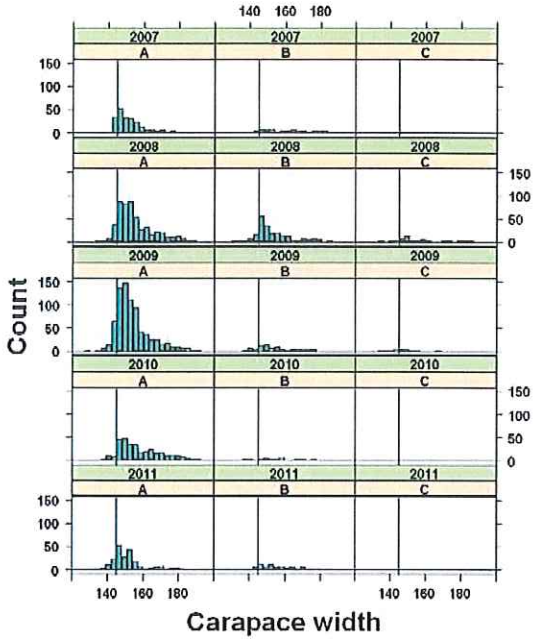


Figure 24. Size frequency and shell grade (A=hard, B=medium, C=soft) of Dungeness crab in Alsea Bay; the vertical line represents the minimum legal size of 146 mm.

Fishery participation

Although most of the recreational crabbers interviewed in Alsea Bay traveled less than 100 miles, over 18% of them traveled over 150 miles (Table 24). Overall, 82.7% of the crabbers interviewed in Alsea Bay were Oregon residents. A significant number of crabbers also originated from the Bend area. Most of the crabbers interviewed in Alsea Bay originated from either the Willamette Valley or the coast (Figure 25).

Table 24. Distances traveled (staight line, in miles) by recreational crabbers interviewed in Alsea Bay, 2007-2011.

Distances traveled	Percent of total trips
0-50 miles	44.0
51-100 miles	26.7
101-150 miles	10.9
>150 miles	18.4

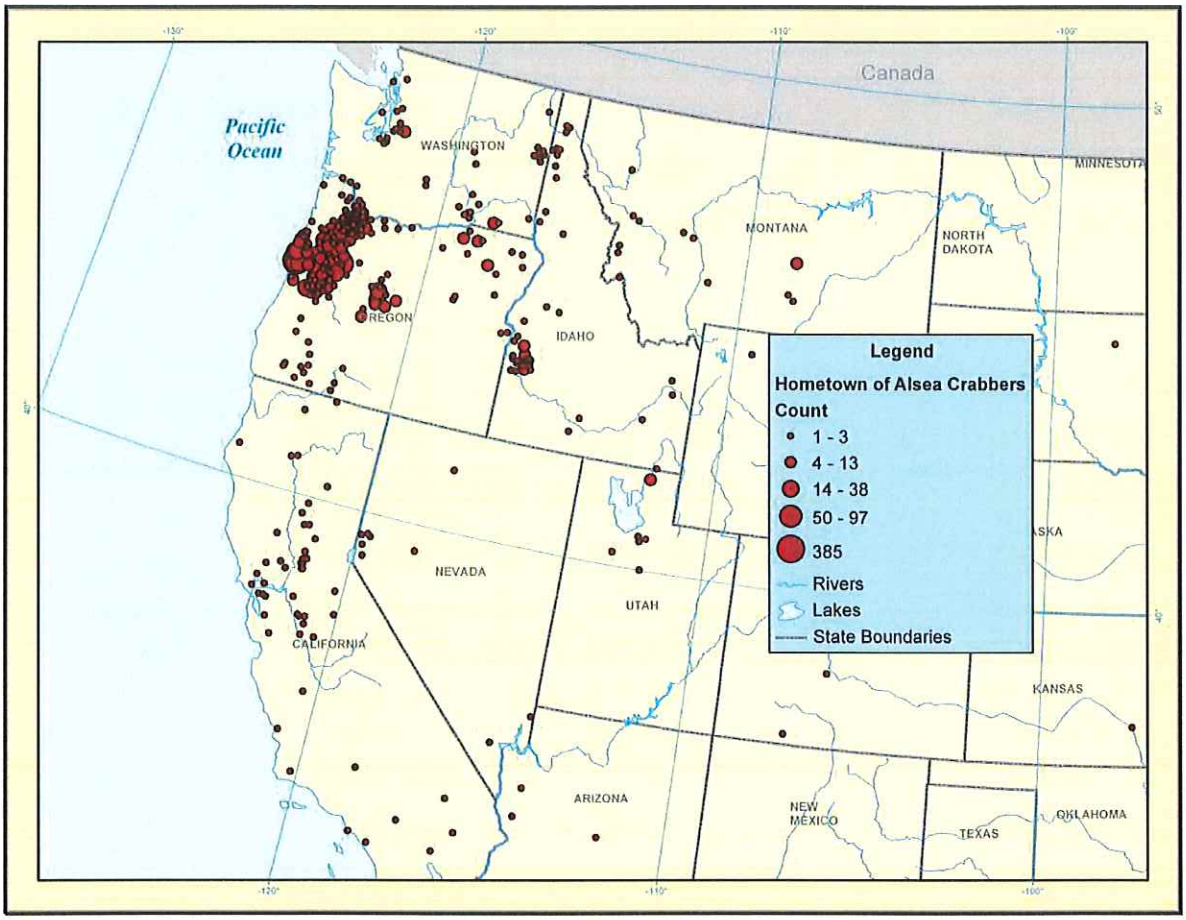


Figure 25. Hometown of recreational crabbers interviewed in Alsea Bay, 2007-2011.

Coos Bay

Effort estimates

The crabbing effort within Coos Bay was divided into four zones to facilitate counting buoys (Figure 26). Effort counts were conducted nearly year-round from 2008-2011, except for some winter months when staff was not available (Table 25). Crabbing effort was focused on two main locations: near the Training Jetty (TJ) by the bay entrance, and the western side of the main navigation channel near Clam Island (CI) (Table 26). Less utilized areas where the region near Point Adams (PA), and Strawberry Island (SI). A small portion of crabbing effort was observed outside of these main zones. Crabbing effort was variable within each year sampled, but generally was highest in the fall and lowest in the late winter and spring (Table 27). Like most of the other bays sampled, crabbers typically used pots and fished their gear for around three hours (Table 28).

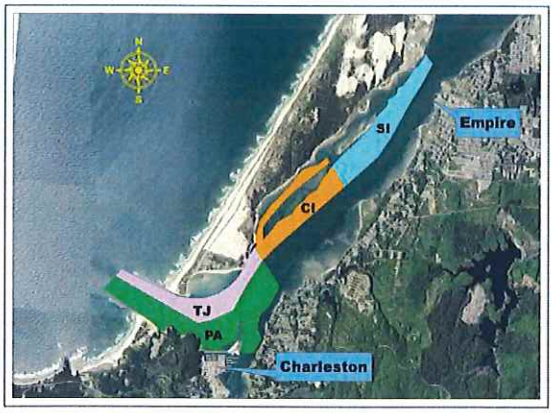


Figure 26. Recreational crabbing areas of Coos Bay (see text for explanation of areas and codes).

Table 25. Sampling days in Coos Bay.

	Weekday		Weekend	
	Days	Interviews: boats (people)	Days	Interviews: boats (people)
2008	75	269 (617)	13	16 (44)
2009	65	163 (364)	2	0 (0)
2010	59	126 (328)	3	2 (5)
2011	46	104 (249)	8	8 (23)

Table 26. Spatial patterns of recreational crabbing effort in Coos Bay: each number represents the percent of total observed effort that occurred in each zone for each year. The zone codes correspond to the crabbing areas in Coos Bay (Figure 29).

Area	TJ 95 ha	PA 178 ha	CI 98 ha	SI 108 ha	Other
2008	34.4	8.5	39.3	16.3	1.4
2009	32.6	9.1	41.7	12.4	4.2
2010	28.3	9.7	45.7	14.5	1.9
2011	22.4	10.3	48.9	17.6	0.8
Ave.	29.4	9.4	43.9	15.2	2.1

Table 27. Estimated monthly recreational crabbing trips in Coos Bay (NS = not sampled).

	2008	2009	2010	2011
Jan.	NS	1,845	NS	1,530
Feb.	NS	NS	NS	NS
Mar.	351	1,329	319	928
April	683	1,143	359	375
May	877	864	1,000	920
June	638	663	1,153	874
July	1,834	2,033	2,021	2,000
Aug.	6,155	2,136	3,085	2,481
Sept.	3,468	2,572	2,476	2,671
Oct.	3,616	NS	2,126	2,431
Nov.	1,886	NS	NS	NS
Dec.	NS	NS	NS	NS
Total (95% conf. inter-val.)	19,507 (14,076 - 24,939)	12,584 (8,264 - 17,106)	12,540 (8,657 - 16,422)	14,209 (10,337 - 18,081)

Table 28. Average gear usage and soak time by recreational crabbers in Coos Bay.

	Number of pots	Number of rings	Soak time (hours)	Pot-hours per person
2008	2.07	0.27	2.82	6.60
2009	2.09	0.32	3.07	7.31
2010	2.02	0.30	3.16	7.29
2011	2.11	0.25	3.15	7.24
Ave	2.07	0.29	3.05	7.11

Catch rate estimates

Catch rates in Coos Bay were variable within each year, but were generally highest in the late summer and early fall (Figure 27). Coos Bay crabbers had the highest *CPUE* overall compared to other bays surveyed in this report, with over 8 crabs per person observed in some months.

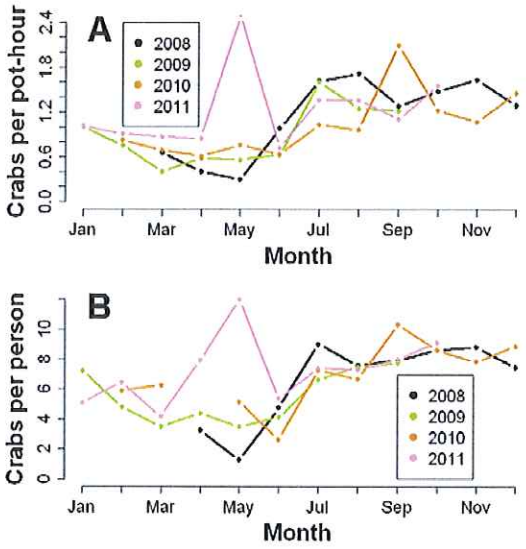


Figure 27. Monthly CPUE estimates for recreational crabbers in Coos Bay; A) crabs per pot-hour, and B) crabs per person.

Harvest estimates

Monthly crab harvest peaked in the fall months in Coos Bay, when catch rates and effort were greatest (Figure 28). When the Coos Bay Dungeness crab catch was converted to pounds, the annual harvest during the periods sampled was 193,200 pounds in 2008, 119,800 pounds in 2009, 139,700 in 2010, and 181,900 pounds in 2011. Projections of the harvest during unsampled periods are provided in the "Bay Crab Fishery Off-Season Estimates" section.

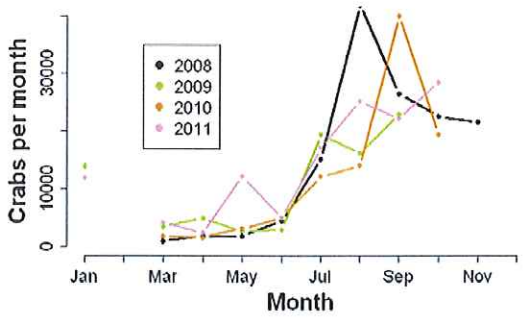


Figure 28. Estimated number of crab harvested each month by recreational crabbers in Coos Bay.

Biological data

Crabs measured in Coos Bay were among the largest found in all of the bays surveyed (Table 29, Figure 29). In addition, compliance with minimum size limits was much better than was observed in other bays, with only around 2.5% of crabs measured less than the minimum size. Nearly all Dungeness crab measured in Coos Bay had hard shells.

Table 29. Mean carapace width (CW), percent sublegal (<146 mm CW), and estimated mean weight of crab harvested by recreational crabbers in Coos Bay (estimates for 2011 are missing due to small sample size).

	Crabs measured	Mean CW	Percent sublegal	Mean weight (g)
2008	755	156.8	2.7	643.3
2009	318	155.9	2.5	631.6
2010	134	157.6	2.2	655.5
2011	-	-	-	-

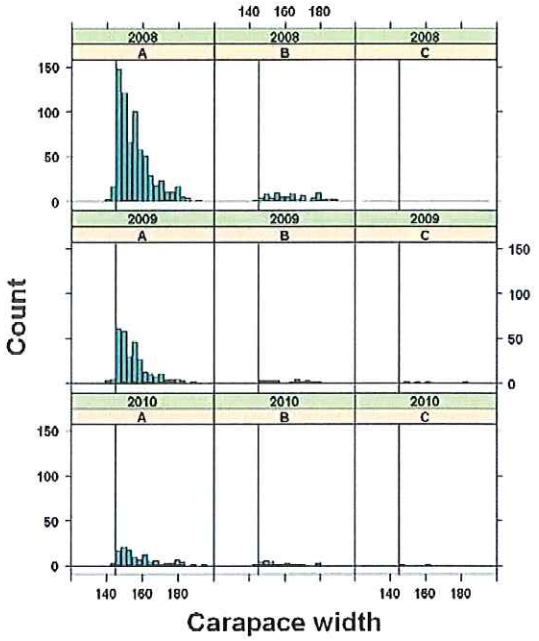


Figure 29. Size frequency and shell grade (A=hard, B=medium, C=soft) of Dungeness crab in Coos Bay; the vertical line represents the minimum legal size of 146 mm.

Fishery participation

Most of the recreational crabbers interviewed in Coos Bay travelled less than 75 miles (Table 30). Overall, 83% of recreational crabbers in Coos Bay were Oregon residents. Most of the crabbers interviewed originated from either the south coast or from towns along the Interstate 5 corridor between Medford and Eugene (Figure 30). A significant number of crabbers were visiting Coos Bay from California.

Table 30. Distances traveled (staight line, in miles) by recreational crabbers interviewed in Coos Bay, 2008-2011.

Distances traveled	Percent of total trips
0-50 miles	61.7
51-100 miles	14.4
101-150 miles	4.5
>150 miles	19.4

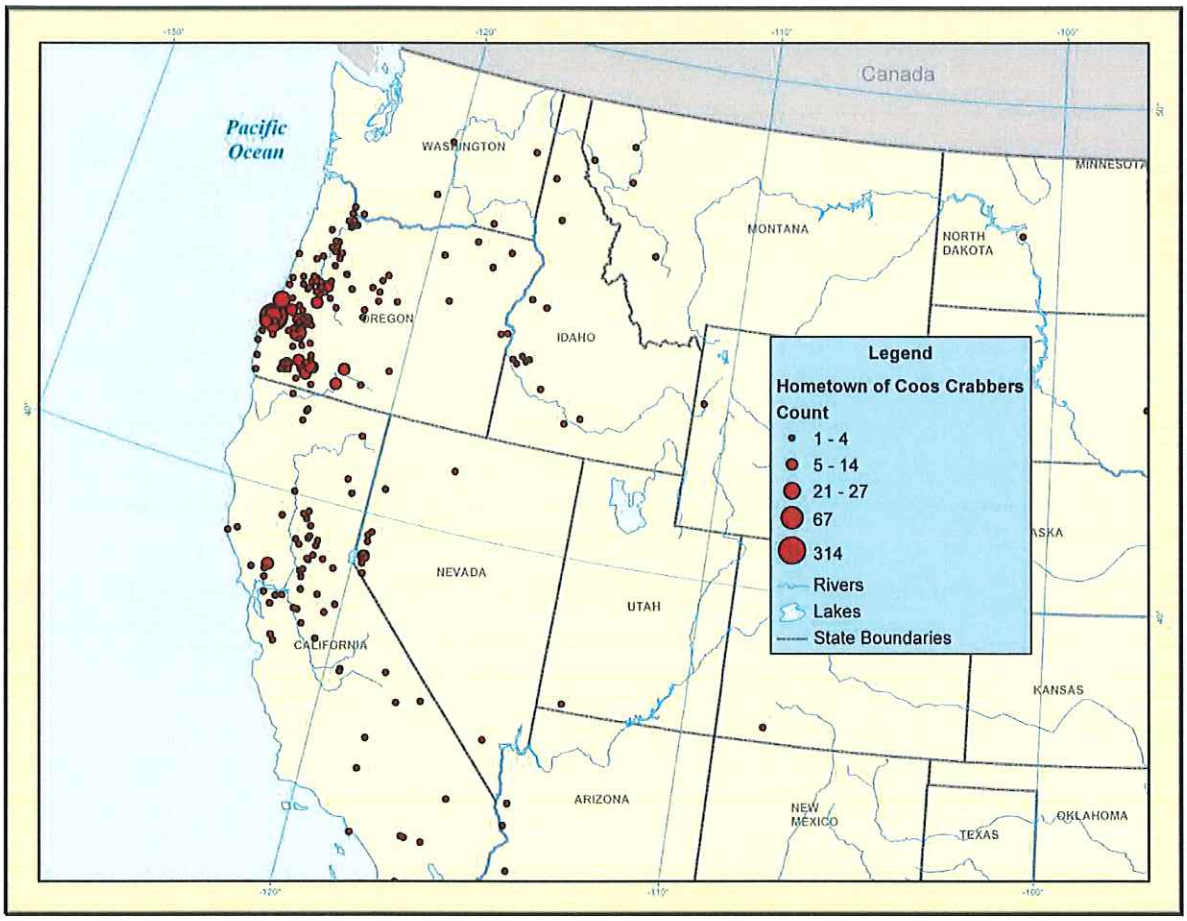


Figure 30. Hometown of recreational crabbers interviewed in Coos Bay, 2008-2011.

Bay Crab Fishery Off-Season Estimates

Sampling in Tillamook, Netarts, and Coos bays was limited to the highest use months in the summer and early fall due to staff availability. However, Yaquina and Alsea bays were sampled year-round. Results generated by the Yaquina and Alsea surveys during the winter were used to infer the effort and catch in the bays that were only surveyed seasonally.

First, a comparison was made between the harvest of crabs in Yaquina and Alsea bays (Figure 31). The harvest in each bay followed a similar pattern, peaking in the fall and falling to the lowest levels in the late winter-early spring. In Yaquina Bay, however, the harvest was slightly higher during the spring. The pattern of utilization of these two bays likely represents the pattern found in the other bays that are only seasonally sampled.

The next step was to develop a proportional model of effort and harvest based on the datasets for Yaquina and Alsea bays. For each month sampled, a value was calculated that represented the proportion of the annual effort or harvest that occurred in that month. Monthly mean values were calculated for each bay, and the monthly values for Yaquina and Alsea were averaged to create a composite proportional model of annual bay crab effort and harvest (Figure 32). Each monthly value represents the theoretical proportional contribution of effort or harvest to the annual totals.

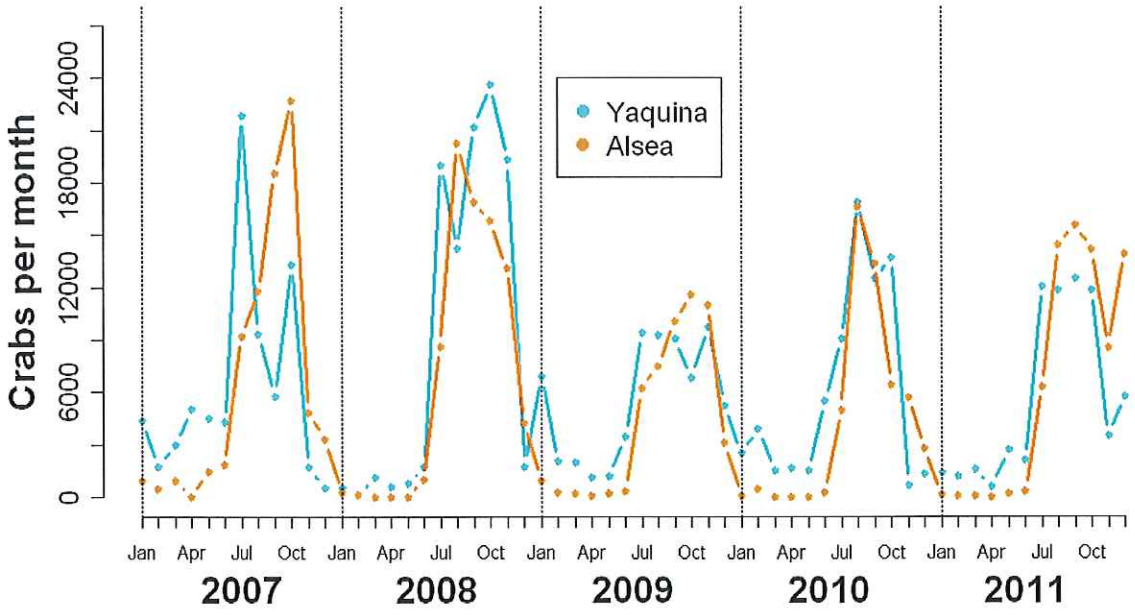


Figure 31. Comparison of Yaquina and Alsea bays' monthly landings, 2007-2011.

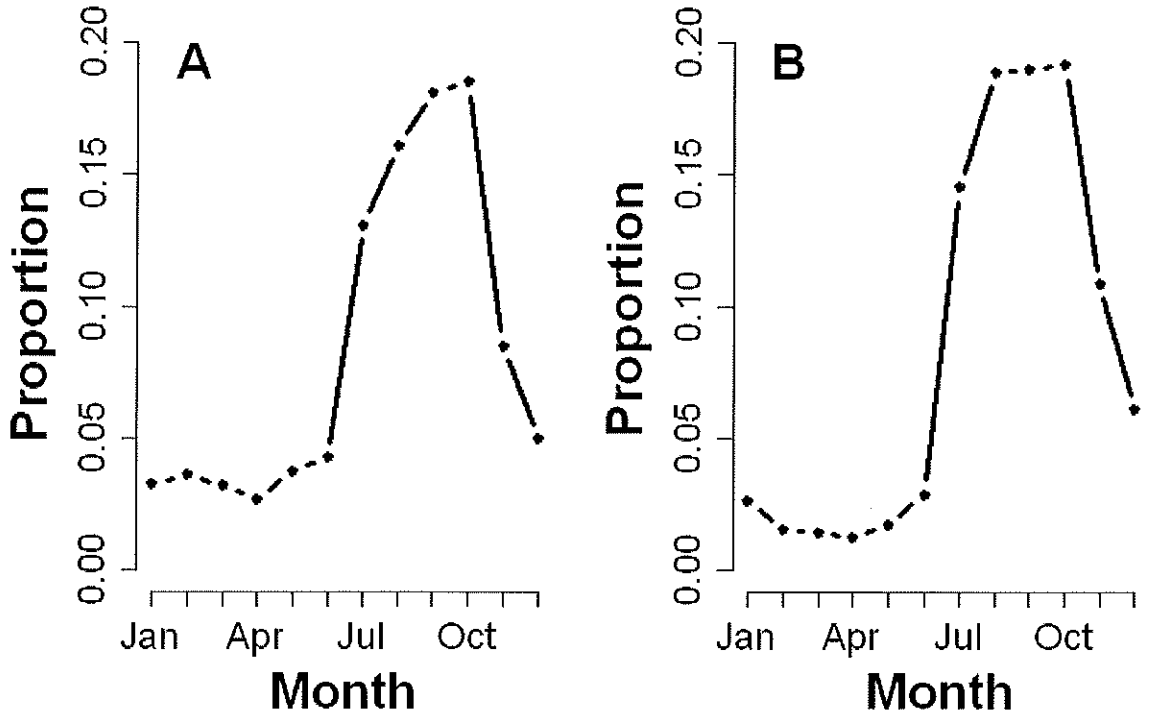


Figure 32. Proportion of annual trips (A) and pounds harvested (B) for each month based on analysis of Yaquina and Alsea bay harvest, 2007-2011.

Finally, effort and harvest were estimated for the unsampled months in Tillamook, Netarts, and Coos bays. This was accomplished by summing the effort or harvest values from the months sampled and dividing by the sum of proportional values from the model for the months sampled. For example, in 2009, Tillamook Bay was sampled from April through September and an estimated 45,635 pounds of crab were harvested. The sum of proportional values from the model for the months April through September is 0.583 (e.g. the model predicts that 58.3% of the annual harvest occurs during these months). The 2009 annual harvest estimate is therefore 45,635/0.583 = 78,258 pounds. Expanded estimates of effort and harvest are presented in the "Statewide Summary" section.

Effort and harvest expansions using this method are provided using the mean estimates of effort. Confidence intervals could be estimated using the upper and lower estimates of monthly effort presented in previous sections, but are omitted from the "Statewide Summary" section for the purpose of clarity.

Lower Columbia River

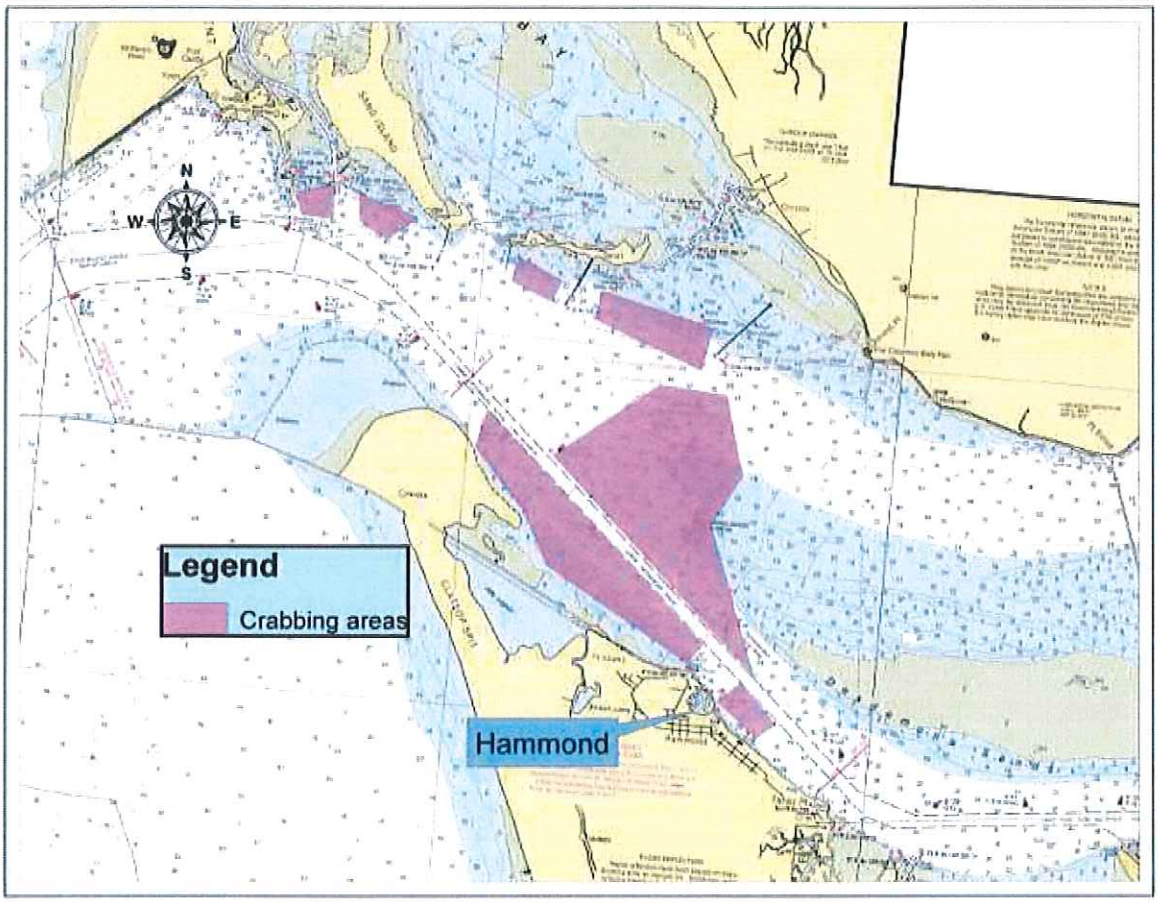


Figure 33. The primary crabbing areas of the Lower Columbia River.

Effort estimates

Recreational crabbing in the Lower Columbia River occurs in a number of areas near Hammond, Oregon (Figure 33). The LCR fishery cannot be observed directly like the other estuarine crab fisheries of Oregon, so an alternative model of estimating effort was developed that did not rely on counting buoys. When generating a model of crabbing effort, staff counted empty boat trailers parked at the basin every hour during the interview process. Peak effort timeframes were determined from these counts to determine the total effort profile. Due to limited staff availability, the LCR fishery could only be surveyed during the traditional highest use periods in the late fall and winter. The lowest use months, typically March through August, were not sampled and estimates could not be provided for this report.

Expansion factors were derived by using the area under the curve calculation of hourly effort counts, integrating sampling harvest time interview data and converting from harvester time to harvester numbers.

From these data, a correction for effort efficiency (E_{peak}) of 0.85 was calculated. Once the E_{peak} was calculated, future peak counts were divided by 0.85 to estimate total daily effort. Monthly crabbing trips in the LCR were highest in October and November (Figure 38).

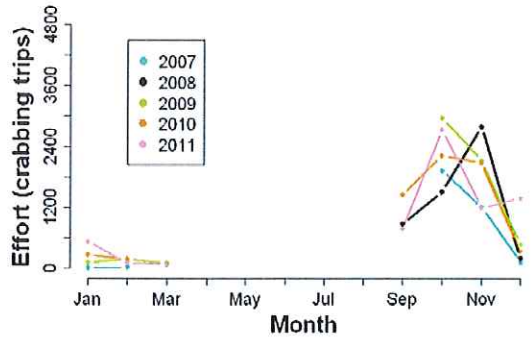


Figure 34. Estimated monthly recreational crabbing trips in the Lower Columbia River.

Catch rate estimates

Between 2007 and 2011, a total of 3,566 interviews of recreational crabbers in the LCR revealed a high *CPUE* in the late fall months, with many crabbers harvesting their daily limit of 12 Dungeness (Figure 35). Catch rates declined most years in February and March.

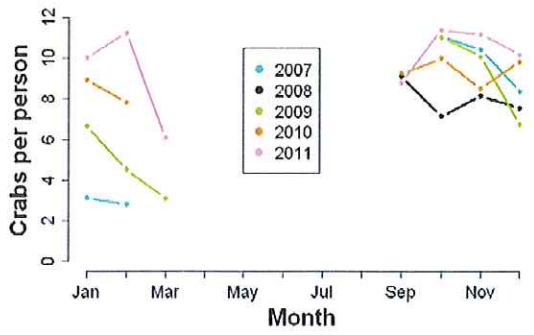


Figure 35. Monthly CPUE (crabs per person) estimates for recreational crabbers in th Lower Columbia River.

Harvest estimates

Because effort and catch was highest in October and November, the total crab harvest was highest in these months (Figure 36).

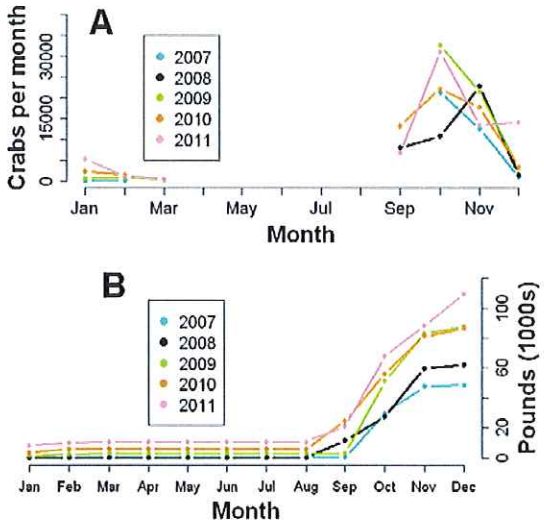


Figure 36. Estimated number (A) and cumulative pounds (B) of crab harvested each month by recreational crabbers in the Lower Columbia River.

Biological data

Crabs measured in the LCR fishery were large and the occurrence of undersized crab was low (Table 31, Figure 37).

Table 31. Mean carapace width (CW), percent sublegal, and estimated mean weight of crab harvested by recreational crabbers in the Lower Columbia River.

	Crabs measured	Mean CW (mm)	Percent sublegal	Mean weight (g)
2007	422	156.1	4.0	631.8
2008	657	157.7	2.1	651.5
2009	675	159.1	1.5	671.8
2010	1192	157.1	2.9	645.1
2011	632	160.0	0.7	681.9

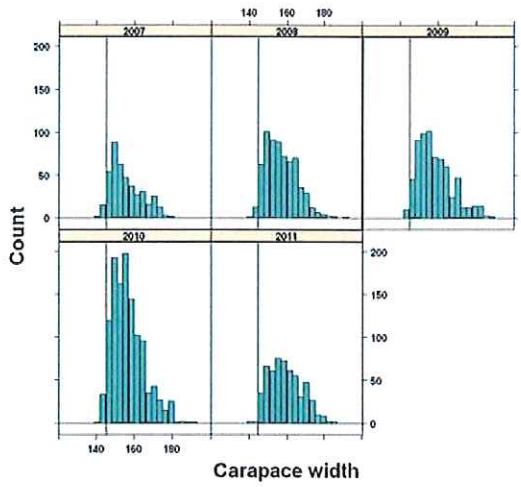


Figure 37. Size frequency of Dungeness crab in the Lower Columbia River recreational fishery; the vertical line represents the minimum legal size of 146 mm.

Ocean Recreational Boat Survey

Effort estimates

The Ocean Recreational Boat Survey (ORBS) was conducted year-round in Newport, Depoe Bay, and Brookings (2007-2011), and seasonally in most of Oregon's 12 major ports (Table 32). Sampling timeframes within the seasonally sampled ports were chosen to coincide with the highest utilization periods by ocean anglers. Although ocean crabbing effort estimates are not available for the winter and spring for many ports, the sampling timeframe accounts for the majority of ocean crabbing effort in these ports.

Annual ocean recreational crabbing trips increased from almost 30,000 trips in 2007 and 2008 to approximately 50,000 trips in 2009, 2010, and 2011 (Table 33). A "crabbing trip" is defined as one person crabbing for one day; a single boat can have multiple daily crabbing trips depending on the number of people on board. The increase in effort can be attributed to the regulatory change in 2009 that extended the season end date from August 15 to October 15. From 2009 to 2011, the highest monthly effort estimates occurred in August and September (Figure 38), particularly in Newport, Garibaldi, and Depoe Bay. This time frame also coincides with a general seasonal increase in recreational ocean fishing for other species. The lowest monthly effort estimates occurred in winter and spring when weather conditions are unfavorable for most recreational crabbers.

Table 32. Months sampled and total crabbers interviewed by the ORBS program, by port, 2007-2011.

	2007	2008	2009	2010	2011
Astoria	May-Sept	May-Sept	May-Sept	May-Sept	May-Sept
Garibaldi	Mar-Oct	Mar-Oct	Mar-Oct	Mar-Oct	Mar-Dec
Pacific City	June-Sept	June-Sept	June-Sept	June-Sept	June-Dec
Depoe Bay	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec
Newport	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec
Florence	June-Sept	June-Sept	June-Sept	June-Sept	June-Dec
Winchester Bay	May-Sept	May-Sept	May-Sept	May-Sept	May-Sept
Charleston	Mar-Oct	Mar-Oct	Mar-Oct	Mar-Oct	Mar-Dec
Bandon	June-Sept	June-Sept	June-Sept	June-Dec	Jan-Dec
Port Orford	-	-	-	-	Apr-Dec
Gold Beach	June-Sept	June-Sept	Apr-Oct	June-Dec	Jan-Dec
Brookings	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec
TOTAL INTERVIEWS	12,877	13,452	18,620	18,710	19,268

Table 33. Estimated annual ocean recreational crabbing trips by port and trip type, 2007-2011.

	Trip Type	2007	2008	2009	2010	2011
Astoria	Private	1,097	465	1,391	1,365	1,092
	Charter	123	11	115	82	107
Garibaldi	Private	3,859	2,761	8,761	7,132	6,095
	Charter	1,761	2,347	2,187	3,478	2,976
Pacific City	Private	1,224	1,085	2,111	2,917	2,914
	Charter	110	36	169	405	443
Depoe Bay	Private	441	827	1,307	1,096	763
	Charter	3,302	3,160	4,861	5,186	7,028
Newport	Private	2,918	4,195	6,006	8,303	6,546
	Charter	6,369	6,086	8,417	9,113	10,500
Florence	Private	701	301	1,083	633	492
	Charter	0	0	0	0	0
Winchester Bay	Private	2,786	1,541	2,815	2,179	2,066
	Charter	257	28	20	NA	NA
Charleston	Private	2,367	2,548	3,782	3,280	2,866
	Charter	0	8	35	31	27
Bandon	Private	144	165	190	340	266
	Charter	132	168	268	460	408
Port Orford	Private	NA	NA	NA	NA	204
	Charter	NA	NA	NA	NA	73
Gold Beach	Private	116	107	600	482	181
	Charter	306	336	574	638	704
Brookings	Private	1,792	2,324	5,263	3,080	4,040
	Charter	12	27	6	0	12
TOTAL	**Combined**	**29,816**	**28,526**	**49,960**	**50,200**	**49,801**

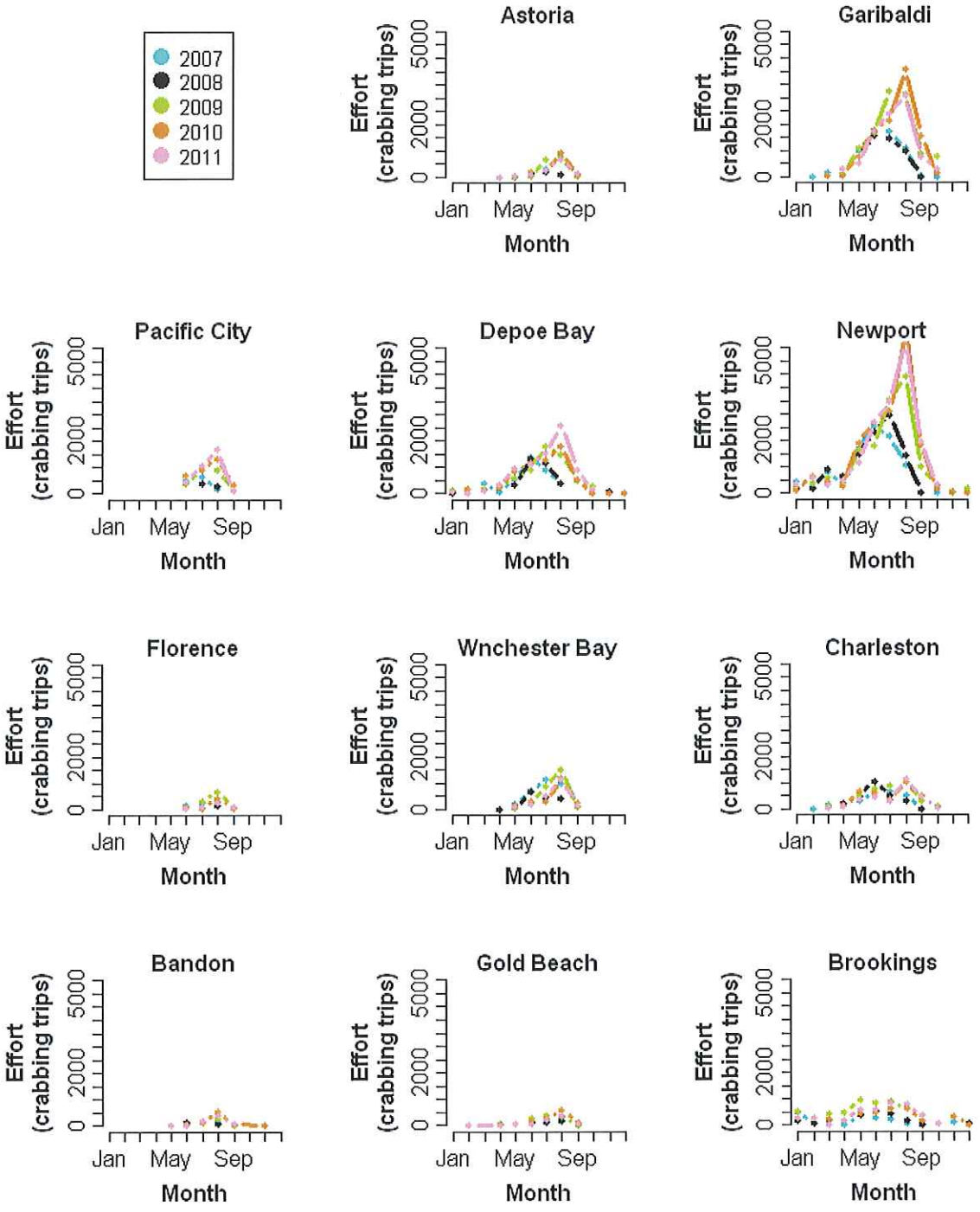


Figure 38. Estimated monthly recreational ocean crabbing trips, including both charter and private boats.

Catch rate estimates

Catch rates for all ports sampled varied within the season (Figure 39, Figure 40, and Figure 41). In general, *CPUE* was highest in August through October when mean *CPUE* reached 6 crabs per person in many ports, and was lowest in the spring.

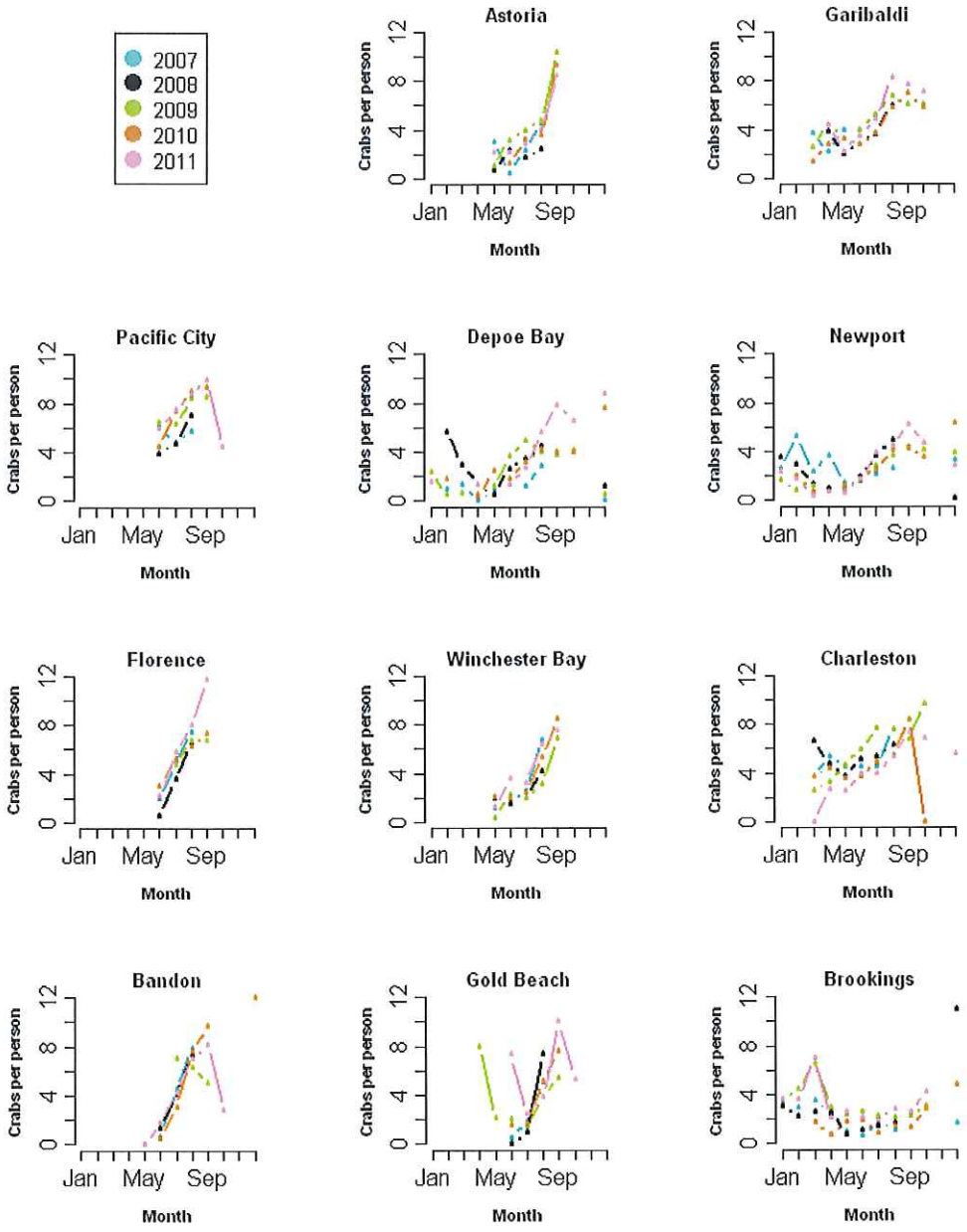


Figure 39. Monthly CPUE (crabs per person) estimates for private recreational ocean crabbers in Oregon ports.

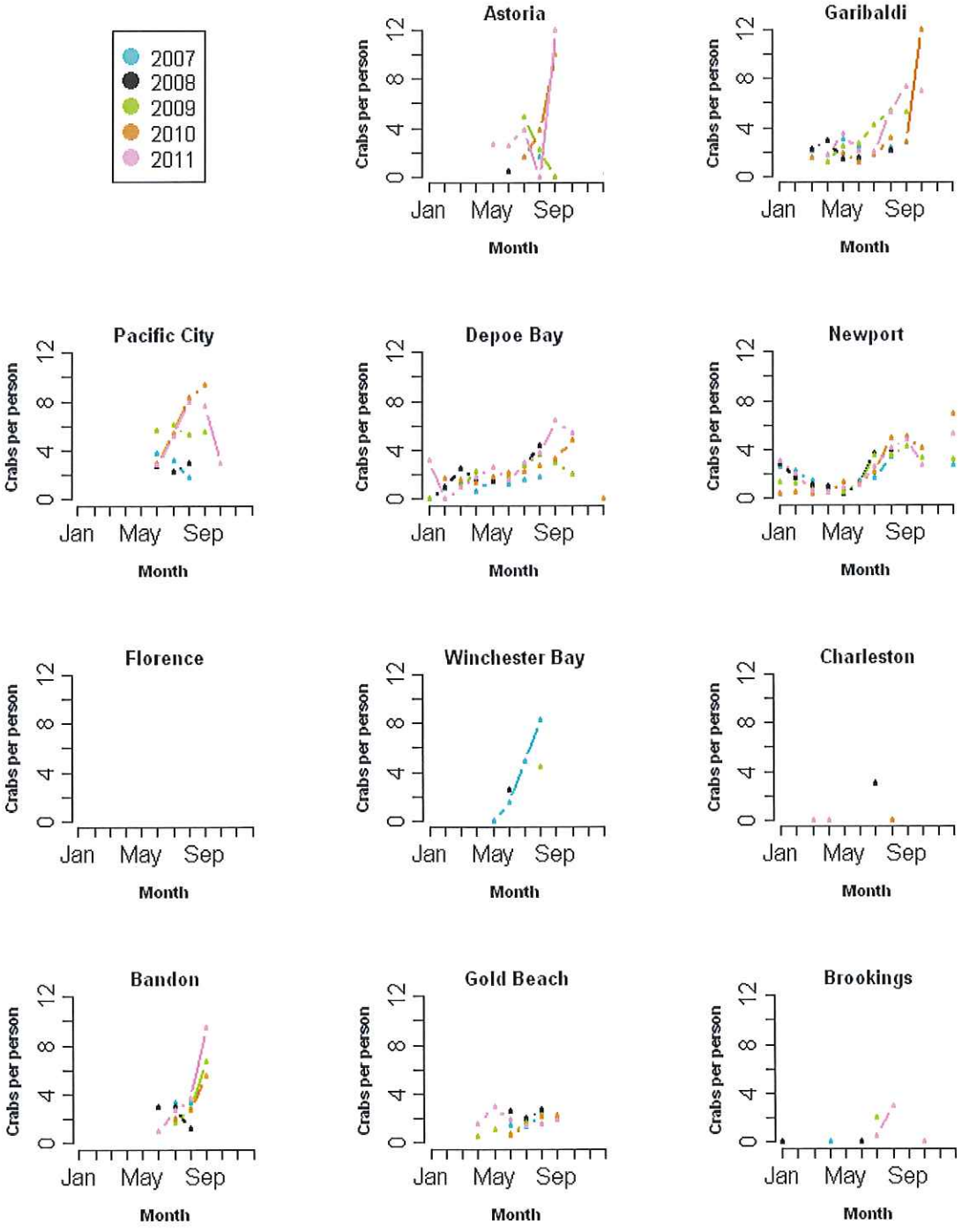


Figure 40. Monthly CPUE (crabs per person) estimates for charter recreational ocean crabbers in Oregon ports.

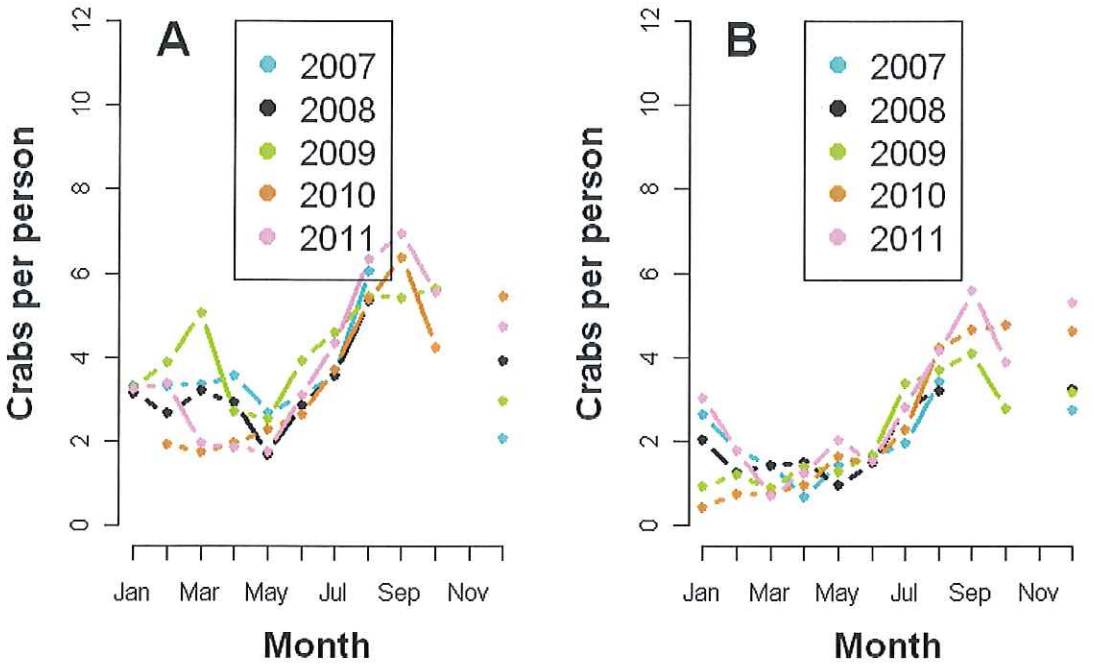


Figure 41. Monthly CPUE (crabs per person) estimates for recreational ocean crabbers with all Oregon ports combined; A) private boats, and B) charter boats. Sampling was limited to three ports during the winter months (see Table 32).

Harvest estimates

Monthly harvest estimates of Dungeness crab in the ocean were highest in the fall, when both effort and *CPUE* were greatest (Figure 42). For the 2009-2011 seasons, after the regulatory change to extend the season, approximately 60,000 crabs per month were harvested in August of each year by private boats. An additional 20,000 were harvested by charter boats.

Crabs retained by ocean recreational crabbers were not measured for carapace width by the ORBS program, so converting the number of crabs to pounds using a mean size required making some assumptions. Based on comparing *CPUE*, and observations from recreational crabbers and staff, the size of crabs captured in the ocean fishery was assumed to be similar to crabs captured in the lower Columbia River. The mean carapace width of crabs measured in the lower Columbia River fishery for the years 2007 and 2011 was between 156.1 and 160.0 mm, corresponding to an estimated weight of between 631.8 and 681.9 grams. Therefore, the harvest of crabs in the ocean fishery was estimated using the mean of these weights (656.4 g/crab, or 1.447 lb/crab). Using this conversion factor, the total annual harvest of crab from the ocean was just over 110,000 pounds for the years 2007 and 2008, and was between 250,000 and 300,000 pounds for 2009, 2010, and 2011 (Figure 43). The reason for larger harvests in 2009-2011 can be attributed to the two-month extension of the ocean crab season beginning in 2009.

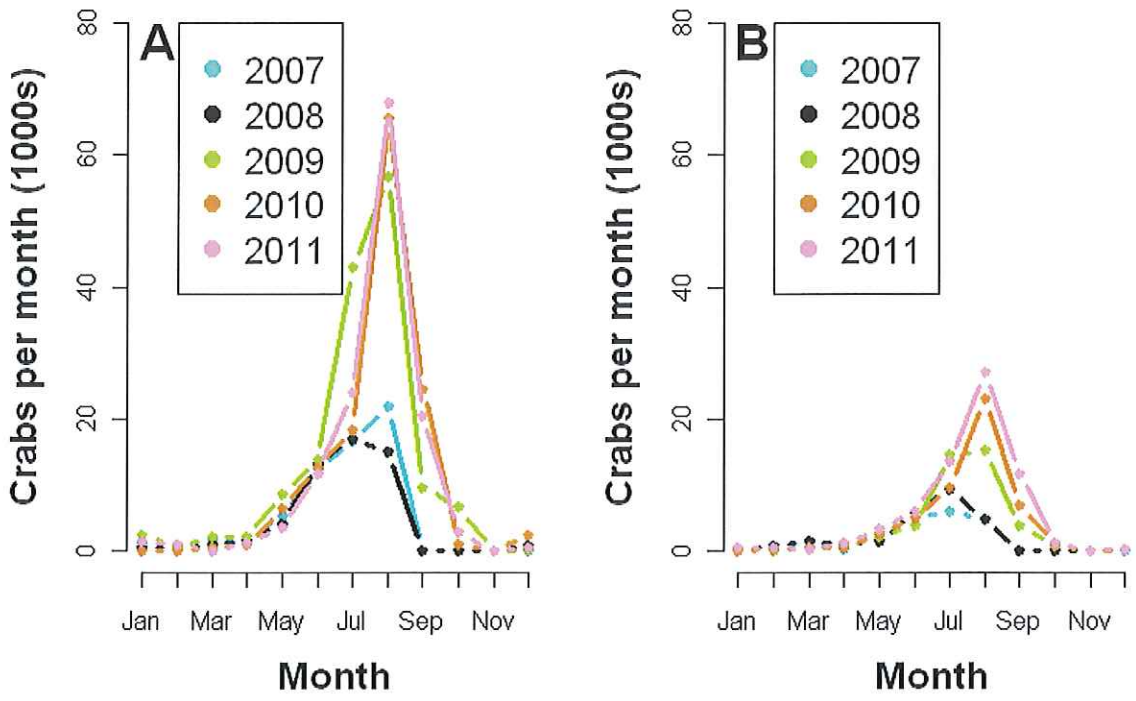


Figure 42. Estimated number of crabs harvested each month by ocean recreational crabbers with all ports combined; A) private boats, and B) charter boats. Beginning in 2009, the ocean recreational crab season was extended two months until October 15, resulting in an increased level of effort in 2009-2011. Sampling was limited to three ports during the winter months (see Table 32).

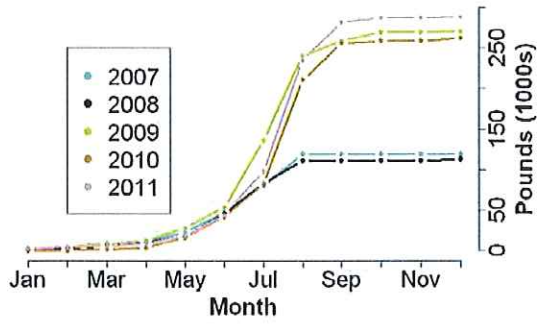


Figure 43. Estimated cumulative pounds of crab harvested by ocean recreational crabbers (private and charter) with all ports combined. The 2009 season extension until October 15 resulted in an increased harvest 2009-2011.

Statewide Summary

Effort estimates

The statewide estimate of total crabbing trips can be derived from the sum of all bay, ocean, and LCR monthly trips. Monthly estimates of total statewide trips were highest in August for the years 2009, 2010, and 2011, when 2,400-3,000 estimated crabbing trips occurred (Figure 44). This effort was higher than 2008 due to the extended ocean crabbing season beginning in 2009 (Yaquina Bay and Alsea Bay were the only bays surveyed in 2007, so statewide estimates for 2007 are omitted). Overall, seasonal effort was highest in the late summer-early fall.

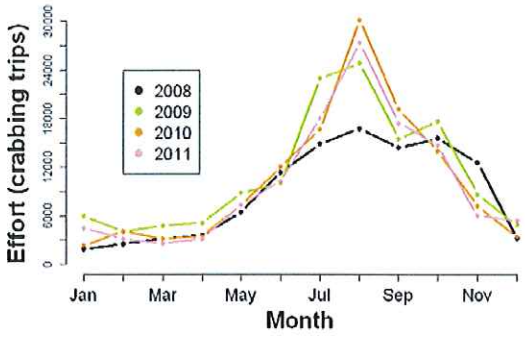


Figure 44. Estimated number of crabbing trips each month by recreational crabbers in the ocean, all bays sampled, and the lower Columbia River combined for 2008-2011. Included are estimates of bay crab effort in Tillamook, Netarts, and Coos bays during the winter-spring using the proportional analysis of Yaquina and Alsea winter-spring effort.

Harvest estimates

The overall statewide harvest of Dungeness crab peaked in the late summer-early fall months (Figure 45), when effort and catch rates were highest. Peak harvest reached 250,000 pounds in August 2010 and 2011 (Yaquina Bay and Alsea Bay were the only bays surveyed in 2007, so statewide estimates for 2007 are omitted). The lowest monthly harvests occurred from January to June, corresponding to low effort and catch rates in all of the fisheries.

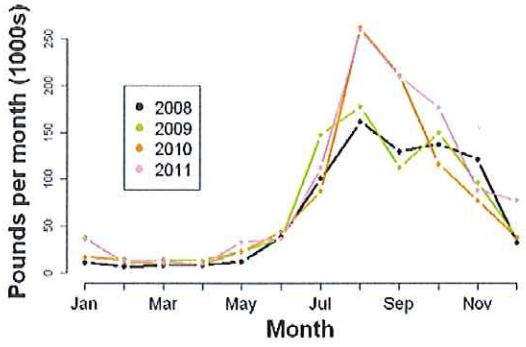


Figure 45. Estimated pounds of crabs harvested each month by recreational crabbers in the ocean, all bays sampled, and the lower Columbia River combined for 2008-2011. Included are estimates of bay crab harvest in Tillamook, Netarts, and Coos bays during the winter-spring using the proportional analysis of Yaquina and Alsea winter-spring harvest.

For all of the five years sampled, the greatest statewide harvest occurred in 2011, when over 1 million pounds of Dungeness crab were harvested by the recreational fleet (Table 34). However, the greatest overall estimated number of crabbing trips occurred in 2009, when over 130,000 crabbing trips occurred. For all years sampled, the bay crab fisheries were the major component of statewide harvest, accounting for around 60% of the annual totals. Ocean recreational crabbing effort and harvest increased after 2008 due to the two month season extension. Effort and harvest increased 70% and 135%, respectively.

Table 34. Statewide estimates of effort and catch of recreational crab from the ocean, Columbia River, and sampled bays.

		Total trips (1000s)	Total pounds harvested (1000s)
2007	Bays*	37.8	205.5
	Columbia**	3.3	48.8
	Ocean	29.8	119.2
	Total	**70.9**	**373.5**
2008	Bays***	72.4	594.5
	Columbia	5.4	62.0
	Ocean	28.5	112.7
	Total	**106.3**	**769.2**
2009	Bays	77.2	498.6
	Columbia	6.0	87.8
	Ocean	50.0	270.7
	Total	**133.1**	**857.0**
2010	Bays	66.2	562.2
	Columbia	6.5	86.1
	Ocean	50.2	262.7
	Total	**123.0**	**910.9**
2011	Bays	63.3	668.5
	Columbia	6.8	109.3
	Ocean	49.8	288.9
	Total	**120.0**	**1,066.7**

*(2007)Yaquina and Alsea bay only

**(2007-2011): Lower Columbia River survey typically Jan-Feb and Sept-Dec.

*** (2008-2011): Yaquina and Alsea surveyed year-round; bay crab harvest in Tillamook, Netarts, and Coos bays surveyed in the summer-fall and also include winter-spring estimates using the proportional analysis of Yaquina and Alsea winter-spring harvest.

DISCUSSION

Recreational crabbing in Oregon bays and offshore waters is one of the most popular shellfishing activities in the state. To comprehensively estimate total statewide effort and catch, combining the results of three independent fishery surveys was necessary. Five years of data from the bay, lower Columbia, and ocean fisheries was analyzed for estimating the number of crabbing trips and total crabs harvested.

During the five years the recreational crab fishery was monitored, up to 133,000 crabbing trips were made annually. Participants in these fisheries were primarily Oregon residents (84% of the bay crabbers interviewed), but crabbing is a popular activity for visitors from other states as well. Recreational crabbing plays an important role in the economy of coastal Oregon communities, contributing to the estimated $36 million in travel expenditures generated annually by all shellfishing in Oregon (Runyan 2009). Equipment related expenses (gear, fuel, bait, and boats) for all recreational shellfishing in Oregon makes an additional estimated $136 million contribution to the economy, and recreational crabbing is an important component of these expenses as well.

An ODFW study of recreational resource use in Oregon estuaries estimated the total number of trips and crabs harvested in 1971 (Gaumer et al. 1973a, 1973b, 1973c, 1974a, 1974b). When compared with data from the current survey (Table 35), the total effort in the estuaries sampled has not changed significantly. The current estimated number of trips in Tillamook Bay and Coos Bay is less than the estimates from 1971, but the other bays are very similar. However, there has been a significant increase in the number of crab harvested in these bays. Possible explanations for this could be the availability of larger and more efficient boats used by crabbers in the last 40 years, availability of commercially produced gear (pots are more widely used

now), and/or a change in bait use (chicken, a common bait used by today's crabbers, is cheap and readily available). There are no available past estimates of ocean recreational crabbing effort, but as recreational boats have become larger over the past few decades, the levels of ocean crab harvest seen today are likely much greater than in the past.

Table 35. Comparison of recreational bay crab harvest in select estuaries using data from the current study and the 1971 ODFW resource use study.

	1971		2007-2011 (min-max)	
	Trips[1]	Crabs[1]	Trips[2]	Crabs[2]
Tillamook	11,109	32,731	5,637-7,465	28,251-60,830
Netarts	10,165	19,092	4,951-10,248	23,436-74,656
Yaquina	22,075	43,278	15,029-23,837	66,377-104,108
Alsea	11,918	23,462	10,752-16,615	50,788-80,370
Coos	25,548	40,065	10,661-15,023	86,019-136,263

1) Yaquina data from October 1970 to October 1971. Data for all other estuaries is for March-October 1971 only.

2) Yaquina and Alsea data are annual estimates. Data for all other estuaries are for the sampling season typically April-October.

The current study shows harvest of crab in the ocean, bay, and lower Columbia fisheries peaked in the late summer, when weather and catch rates are favorable. For the ocean fishery, crabbers can only set gear on days when boats can safely operate. To a degree, this is also true in the lower Columbia and bay fishery. The high effort in the ocean crab fishery in late summer also coincides with the high effort times in other fisheries, and crab are often targeted in combination with salmon, halibut, or groundfish.

Although weather and other fisheries explain most of the increased harvest in the late summer, Dungeness crab molting and growth also contribute to the peak harvests of late summer. Male Dungeness crabs that are legal sized, and male crabs within one molt of legal size, typically molt only once a year. Molt timing is somewhat synchronous, occurring in the summer months (June-August) following the spring female molt (March-June). The supply of harvestable crab is therefore greatest after the male molt, conveniently coinciding with favorable weather conditions. As the newly-molted male crabs grow inside their new shell, the yield of crab meat per crab improves over the fall months.

The harvestable male crab population from each year's molt is a finite supply that recreational and commercial crabbers harvest until the next male molt season. As the resource of male crabs is harvested, the supply dwindles, and catch rates decline. The commercial ocean fishery experiences this effect the most, as each month fewer and fewer crab are available.

During the winter and spring, recreational crab harvest is low because effort is reduced due to unfavorable weather conditions. Catch rates decline as the supply decreases. Catch rates in the bay fisheries also decline dramatically in the spring when the rainy months bring increased river flow. In the lower Columbia, the same phenomenon occurs following releases from

the Bonneville Dam in the late winter. The freshwater input reduces salinity, which stresses the crab's physiology, and results in either the crabs exiting the estuary or cessation of feeding.

Following the winter-spring wet season, the months of April-June can be the most frustrating months for the recreational crabber. Effort in the bay and ocean fisheries increases as favorable weather conditions return to coastal Oregon. Catch rates, however, do not improve until the males molt in the summer and the supply of harvestable crabs is replenished. The total available population of crabs is dependent on a number of environmental and other factors, and population levels can vary widely year to year.

Widely fluctuating crab populations result in fluctuating annual harvests, particularly in the commercial ocean fishery. There are no annual assessments of the crab population, and there is no allocation system between the commercial and recreational fisheries either. Current regulations provide assurances that the recreational crabber will have a share of the total harvest, such as a smaller size limit and longer open seasons in the bays and ocean fisheries. Without these protections, the recreational Dungeness crab harvest would be heavily impacted by the commercial fishery.

The ocean commercial fishery takes the largest share of the total annual Dungeness crab harvest (Table 36). This fishery is capped by the number of permitted vessels and the amount of gear they can use, but it is the available resource that determines the total annual catch. Total commercial harvest estimates in some fisheries may exceed 90% of the total available population (Gotshall 1978, Methot and Botsford 1982, Hankin 1985, Smith and Jamieson 1989).

Table 36. Comparison of recreational and commercial bay and ocean Dungeness crab fisheries, 2007-2011 (all data is summarized by calendar year).

		Total pounds harvested (1000s)	Percent of annual harvest
2007	Recreational*	373.5	2.15
	Comm. Bay	20.2	0.12
	Comm. Ocean	17,005.4	97.74
	Total	**17,399.1**	**100**
2008	Recreational	769.2	5.25
	Comm. Bay	18.7	0.13
	Comm. Ocean	13,869.4	94.62
	Total	**14,657.3**	**100**
2009	Recreational	857.0	3.77
	Comm. Bay	24.2	0.11
	Comm. Ocean	21,824.3	96.12
	Total	**22,705.5**	**100**
2010	Recreational	910.9	5.43
	Comm. Bay	36.2	0.22
	Comm. Ocean	15,831.3	94.36
	Total	**16,778.4**	**100**
2011	Recreational	1,066.7	5.82
	Comm. Bay	25.6	0.14
	Comm. Ocean	17,225.0	94.04
	Total	**18,317.3**	**100**

* (2007-2011) Yaquina and Alsea surveyed year-round; Lower Columbia River surveyed typically Jan-Feb and Sept-Dec; (2008-2011) bay crab harvest in Tillamook, Netarts, and Coos bays surveyed in the summer-fall and also include winter-spring estimates using the proportional analysis of Yaquina and Alsea winter-spring harvest.

In contrast to the commercial fishery, the recreational fishery is more likely limited by effort. After the ocean crab season was extended to October 15 in 2009, for example, the number ocean recreational

crabbing trips reached 50,000 and showed very little variation over the next two years. The resulting harvest during these years showed little variation as well, averaging around 270,000 pounds. Recreational harvest would only increase if more effort were put into this fishery. Although the ocean recreational fishery has not increased since 2009, there has been a noticeable increase in the harvest from the bays. However, the total number of bay crabbing trips has actually declined.

The opportunities to increase participation in recreational crabbing are limited. The bays and Lower Columbia River are already open year-round, and the ocean crab fishery has only a brief six week closure. The ocean crab fishery experiences a high *CPUE* in the winter months with little participation, but ocean conditions are usually unsafe for recreational crabbers at this time.

Recreational crabbing is a popular fishery in the ocean, bays, and lower Columbia River. Success rates in these fisheries varied depending on the availability of crab and weather conditions. The surveys estimated effort and catch year-round in some areas, and during the high effort periods in others.

Because recreational crabbing occurs in so many areas, there were some crab fisheries which unfortunately could not be surveyed. For example, the bay crab fisheries in places like the Nehalem, Siuslaw, and Umpqua rivers could not be sampled due to limited staff availability. Combined, these unsampled fisheries could add several hundred thousand pounds of crab to the estimated bay crab harvest reported in this report. The bay red rock crab fishery, minor in comparison to Dungeness, is monitored but is not included in this report.

Additionally, land-based crabbing is another popular fishery in some bays, where public crabbing piers often see heavy use by recreational crabbers in the summer months. The land-based crab fishery has been monitored alongside the boat-based fishery, and the results will be presented in a separate report.

Together, the recreational crab fisheries of Oregon have supported annual harvests of over 1 million pounds in recent years. These fisheries provide important recreational opportunities, and benefit the coastal Oregon economy. The fishery surveys presented here will continue to provide valuable data for managing and protecting these fisheries.

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Appendix: Worksheet for calculating total pot-hours

A series of instantaneous buoy counts (IC) every 0.5 hours were recorded during the development of the AUC model of recreational crabbing effort. In this example, the first buoy counts in Yaquina Bay on 14 June 2008 were completed 5 hours before high tide. The total whole-day effort (WDE) is $0.5 * \sum_{t=1}^{i} IC_t$, or 379 pot-hours. The correction factor for the count at the time of high tide (t), where $CF_t = \frac{WDE}{IC_t}$, is 379/56 = 6.767857.

Hours to High Tide	Instantaneous Counts (IC)	Pot-hours (0.5*IC)	Correction Factor (WDE/IC)
-6	0	0	0
-5.5	0	0	0
-5	8	4	47.375
-4.5	7	3.5	54.14286
-4	25	12.5	15.16
-3.5	18	9	21.05556
-3	35	17.5	10.82857
-2.5	46	23	8.23913
-2	60	30	6.316667
-1.5	57	28.5	6.649123
-1	42	21	9.02381
-0.5	45	22.5	8.422222
0	56	28	6.767857
0.5	42	21	9.02381
1	53	26.5	7.150943
1.5	48	24	7.895833
2	38	19	9.973684
2.5	32	16	11.84375
3	30	15	12.63333
3.5	21	10.5	18.04762
4	22	11	17.22727
4.5	22	11	17.22727
5	15	7.5	25.26667
5.5	12	6	31.58333
6	14	7	27.07143
6.5	10	5	37.9
7	0	0	0
		Sum = 379 pot-hours	

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New Carissa Recreational Loss Pre-Assessment Report

October 2001

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1. Introduction

The objectives of this report are to document the nature and extent of recreation site closures and to document the historical recreation use levels at locations affected and potentially affected by the *1999 New Carissa* groundings. This information is based on ephemeral data collected during and after the initial stages of the incident. This report also provides a preliminary estimate of the economic value of recreational losses resulting from this incident, which will help determine if a recreational lost use damage assessment is necessary. No original recreation valuation studies or visitor counts were undertaken.

Incident Background

On February 4, 1999, the 600-ft. bulk freighter, the New Carissa, ran aground approximately 3.3 miles north of Coos Bay channel entrance in the North Spit, just south of the Oregon Dunes National Recreation Area (ODNRA). On February 11, the vessel's hull broke into two sections. The bow section was towed to sea and a towline separation resulted in re-grounding of the bow section of the vessel in Waldport, Oregon on March 3, 1999. See Figure 1 for a map of the grounding sites. The bow section was again towed to sea on March 9, 1999 and scuttled several days later. It is estimated that at least 70,000 gallons of oil were released during this incident. The nature of the releases, however, makes accurate estimates of releases difficult. Currently the stern section of the vessel remains grounded along the beach in the North Spit. As of July 27, 2001, tar balls associated with the New Carissa were still being recovered on the beach near the stern section.

As a result of the initial grounding, both the North Spit area and the Horsfall recreation area, which is located within the ODNRA, were closed to the public on February 4, 1999. See Figure 2 for a map of the areas in the ODNRA affected by the incident and Figure 3 for a map of the area in the North Spit affected by the incident. Subsequent oil releases and response operations closed the beach and Coast Guard Road north of the Horsfall recreation area and south of Ten Mile creek from February 12th through February 20th. The Umpqua Beach area, located within the ODNRA, was closed on February 21st and remained closed until April 16th due to snowy plover response actions. Although the Horsfall recreation area reopened on March 5th, the North Spit area remained completely closed until March 26th. At this time, only the side of the North Spit adjacent to Coos Bay was reopened. On August 2nd, the rest of the North Spit was reopened to the public under certain restrictions, which lasted through the end of the snowy plover nesting season (September 15th). See Figure 4 for a map of the North Spit access restrictions during this time.

In addition to the closure of recreation sites, shellfishing closures were issued for the beaches of Coos and Douglas Counties and portions of Coos Bay on February 11th and February 12th, respectively. On February 12th, shellfishing advisories were issued for Winchester Bay and the Umpqua Estuary. Fishing and crabbing advisories were also issued at this time for Coos Bay, Winchester Bay and the Umpqua Estuary. For most of these areas, the advisories and closures were lifted on March 4th. See Figures 5 and 6 for a map of shellfishing closure areas and fishing and crabbing advisory areas.

As a result of the second grounding of the New Carissa, Governor Patterson State Beach was closed to the public on March 3rd and not reopened until March 10th. In addition, recreational shellfishing closures were announced for Yaquina Bay and Alsea Bay on March 4th. These areas did not reopen until March 8th and March 22nd, respectively. Recreational shellfishing advisories were announced for all beaches and bays in Lincoln and Lane Counties on March 3rd.[1]

Valuing Lost Recreation Services

Economists generally agree that the correct measure of the net economic value of a recreation trip is the average consumer surplus per trip. Consumer surplus is the measure of an individual's value for a good, in this case recreation, above and beyond any payments that are necessary to obtain that good. The change (net) in consumer surplus as a result of a policy change or environmental impact is the consumer's measure of economic loss. This concept of net consumer surplus is applied in economics to measure losses under a wide range of circumstances; for example, impacts on consumers from changes in food prices, losses from outages in water or power supply, as well as disruptions of outdoor recreation due to oil spills. In the case of recreation, net consumer surplus per trip is the monetary measure of a consumer's loss of enjoyment of recreational opportunities because of changes in the quality of recreation sites or site closures. With oiled recreation sites, losses can occur if a site is closed and an individual forgoes recreation trips. Losses can also occur if an individual is forced to incur extra costs in terms of time and money to travel to an alternative location, or if an individual must recreate at a less valued site due to a spill. A less valued site could either be the now oiled area or an alternative non-oiled location with less desirable characteristics (e.g., more crowded, different amenities, etc.).

Although the available data is limited to initial collection efforts, the analysis presented for this report presents the two main components needed to make a preliminary estimate of the loss of consumer surplus resulting from the *New Carissa* incident: (1) an estimate of the number of recreation trips affected either through lost trips or trips of reduced quality; and (2) an estimate of the unit value (consumer surplus) per trip for each of these affected recreational activities. The estimate of the aggregate lost recreational use value caused by the *New Carissa* is computed as the product of the number of trips affected times the unit value per trip, summed over the recreational activities considered.

[1] Lincoln County beaches were already closed for shellfish harvesting due to the presence of the toxin domoic acid. This closure did not affect Yaquina Bay and Alsea Bay.

Historical counts of individuals recreating in areas affected by the incident are used to estimate the number of trips affected by the oil spill. To estimate the consumer surplus loss resulting from the oil spill, the benefits transfer approach is used in this analysis. With the benefits transfer approach, one transfers an existing estimate of consumer surplus developed in another situation for a similar resource to the current problem of concern. When the resources and users being studied are similar to the resources being assessed, the benefits transfer approach is well accepted as a method to estimate losses in the context of natural resource damage assessments and has been found reliable through its admission in past court proceedings. The Department of Interior (DOI) uses the benefits transfer method in its Type A model to value the loss of natural resources (including beach recreation) resulting from the release of oil and other substances. The use of benefits transfer in the Type A model was upheld by the U.S. Court of Appeals, District of Columbia Circuit *in National Association of Manufactures v. U.S. Department of the Interior*.[2] In addition, the benefits transfer method has been used to value the lost recreation resulting from several oil spill incidents, including the 1990 *American Trader* oil spill in Southern California, where the use of benefits transfer was upheld in court.[3]

2. A Description of Affected Recreation Trips and An Estimate of the Number of Affected Recreation Trips

North Spit Area

Description of Affected Areas

The Bureau of Land Management (BLM) and the United States Army Corps of Engineers (ACOE) administer almost 1,770 acres of public land in the North Spit.[4] The spit provides significant area for lightly constrained recreational use in a rural setting where the public engages in a variety of recreational activities. Off-highway vehicle use, beach combing, boating, bay-shore clamming and crabbing, day hiking, picnicking and wildlife viewing are popular activities in the area. The area is also used for surfperch and striped bass fishing. See BLM (1995) for a more detailed description of the area and activities taking place on the North Spit.

Public access to the North Spit area was blocked on February 4, 1999 near the intersection of Horsfall Road and the Transpacific Highway. County sheriffs manned a checkpoint at this location to enforce the closure. The North Spit area remained completely closed to the public until March 26, 1999. At this time, the area east of the Transpacific Parkway and the Bay-Side Road were re-opened to the public. Blockades were built along the Bay-Side road on Army Corps of Engineers land in the SW 1/4 of Section 25 of Township 25 South Range 14 West to prevent entry to the inner part of the North Spit and to the south on the bay beach side of the North Spit (see Figure 3). All other BLM lands on the North Spit remained closed to public

[2] 134 F.3d 1095 (D.C. Cir. 1998)

[3] People ex rel. Department of Fish and Game v. ATTRANSCO Inc., et al., Orange County Superior Court Case Number 64 63 39.

[4] The beaches along the North Spit and the ODNRA are under the jurisdiction of the Oregon State Parks.

access and use. This precluded access to the ocean beaches (both wet sand and dry sand), the North Jetty and other areas within the North Spit.[5]

Signs indicating that the west side of the North Spit was closed to the public were posted at the Horsfall beach parking lot, at the ocean beach at the BLM and the US Forest Service (USFS) property line as well as other key entry locations. BLM rangers also patrolled the area to enforce the restrictions. Spinreel DuneBuggy Rental and Tours, a private company, ran tours to the grounding site from the parking lot near the boat ramp on the east side of the spit from March 12, 1999 through mid-August, 1999. Tourists visiting the grounding site were only allowed to get off the vehicle transporting them to view the *New Carissa* at a single turn-around site. Individuals were not allowed to engage in any recreational activities on the spit until the partial reopening of the area on March 26th. See Appendix A for monthly counts of individuals taking the tours.

On August 2, 1999 the North Spit was reopened to the public with the exception of the following areas, where recreational activity was restricted or limited to certain uses. The ocean beach, both wet and dry sand, from a line approximately 200 yards north of the North Jetty to the Federal Aviation Administration (FAA) tower was completely closed to the public to protect potential snowy plover nesting sites. In addition, the dry sand portion of the ocean beach from the FAA facility north to the BLM/USFS boundary remained closed to the public. In addition to these access restrictions, vehicular traffic was only allowed on the foredune road and the Bay-Side road, and off-highway vehicles were prohibited on the North Spit during the 1999 snowy plover nesting season. At the end of the snowy plover nesting season on September 16, the management of the North Spit returned to normal operations. See Figure 4 for a map of the areas affected after August 2, 1999.

In order to reopen the North Spit to public access, the BLM was required to prepare a new plan to manage public use of the spit (BLM, 1999) and submit it to the Fish and Wildlife Service for concurrence (DOI, 1999.) These documents describe in more detail the effect of the *New Carissa* incident on the management practices in the North Spit during the 1999 snowy plover nesting season.

Historical Use Rates and Estimated Number of Affected Trips

Historical use rates at the BLM boat ramp parking area are shown in Table 1, which shows the number of people using the restroom facilities from January through August in 1998 and counts of vehicles entering the area. A counter on the restroom facilities at the boat ramp makes individual counts. This counter only captures the individuals who use the restroom facilities; therefore, it provides a very conservative estimate of the number of visitors to the parking lot area. In addition, the vehicle counter also provides a conservative estimate of the total number of visits to the North Spit, due to the fact that some visitors may never enter into the parking lot area.

[5] Off-highway vehicle use was precluded in the North Spit from March 26th through September 15th.

Table 1: Number of Visitors to BLM Facilities										
1998	January	February	March	April	May	June	July	August	September	October
People	700	900	1,000	1,575	930	1,200	2,790	897	903	565
Vehicles	659	845	1,066	913	803	942	935	1,130	1,421	1,786

Examining the level of recreational use in the North Spit in 1998 can be used to make an estimate of the number of recreational visits affected by the New Carissa incident in 1999. The average number of vehicles counted per day in the North Spit in February and March of 1998 equaled 32.39. Using this average daily count to measure losses in 1999, the forty-nine days of complete closure of the spit, from February 5th through March 25th, would lead to a loss of 1,587 vehicle trips to the area.

It is necessary to determine the total number of individual trips, rather than the number of vehicle trips, in order to calculate the total lost consumer surplus resulting from the incident. Consumer surplus can be calculated at an individual or household level. Assuming 2.5 persons per vehicle, there would have been a loss of 3,968 person trips during the time of complete closure of the North Spit.

The assumption of 2.5 persons per vehicle is based on a surveys conducted by the U.S. Forest Service at the Horsfall recreation area within the ODNRA in May and July of 1996. The average number of people per vehicle during a given day ranged from 2.23 to 4.17 with an average of 2.55. Given the proximity of the North Spit to Horsfall and the similar nature of the recreation activities taking place at these locations, it is assumed that the average number of people per vehicle visiting these areas would be similar. See Appendix B for the counts of persons per vehicle at Horsfall during the U.S. Forest Service surveys.

For approximately four months, from March 26, 1999 to August 1, 1999, only the bayside of the spit was open to the public. From April through July of 1998 there were 3,593 vehicles counted at the North Spit. BLM personnel estimate that during the partial re-opening the visitation level to the entire spit was approximately 50% of normal levels. Based on this reduction in use and assuming 2.5 people per vehicle, there would be a loss of 4,491 person trips to the North Spit for the approximately four months of partial re-opening.

From August 2, 1999 to September 15, 1999 the remaining areas of the North Spit were open with the exceptions noted above. During August 1998 there were 1,130 vehicle trips to the North Spit and in September 1998 there were 1,421 vehicle trips. BLM personnel estimate that during the month and a half of restricted use of the North Spit visitation levels fell by 15% to 20% over the normal levels. Based on this reduction in use and assuming 2.5 people per vehicle, there would be a loss of 690-920 person trips to the North Spit for the month and a half of restricted use in the North Spit. It is important to note that in addition to the losses mentioned above, individuals who recreated in the North Spit after March 26, 1999 may have also suffered losses due to the continued presence of the stern section and the salvage operations.

In addition to the oil spill incident, weather is an additional factor that could have had a significant effect on the level of recreation in the area. As described later in this report, there is no reason to believe that the weather in 1999 would have significantly affected the number of trips relative to 1998 levels. In addition, there are no known additional factors, outside of the *New Carissa* incident, that would have caused visitation levels to the North Spit to change between 1998 and 1999.

Horsfall, Oregon Dunes National Recreation Area

Description of Affected Areas

Like the BLM managed areas, sheriff deputies closed the Horsfall recreation area in the ODNRA to the public on February 4, 1999. Popular recreational activities in the Horsfall area include camping, off-highway vehicle use, horse riding, shellfishing, day hiking, beach combing, fishing and wildlife viewing. From February 12, 1999 to February 21, 1999, the beach and Coast Guard Road between the Horsfall recreation area and 10-Mile Creek were also closed due to the presence of oil and to keep individuals from attempting to reach the grounding site. The areas to the east of Coast Guard Road remained open to the public. In addition to these two areas, Umpqua Beach Parking Lot #2 and locations south of this at Umpqua Beach were closed to the public from February 21, 1999 to April 16, 1999 due to the release of snowy plovers that had been oiled earlier in the incident.

Historical Use Rates and Estimated Number of Affected Trips

Table 2 shows the historical number of vehicles that have entered into the Horsfall recreation area from January through March for the last 5 years. In February 1998, 4,362 vehicles entered the area. With the same average visitation rate over a 29-day period, which is the number of days the area was closed, there would be approximately 4,500 vehicles entering the area. Managers from the ODNRA estimate that approximately 10 percent of the vehicles enter the park in February for administrative purposes. Subtracting the administrative vehicles and assuming that there were between 2.5 individuals per vehicle, there would be 10,125 lost visits to Horsfall in a 29 day period in 1999, if 1999 visitation rates were similar to 1998 rates. See Appendix C for a more complete list of vehicle counts at the ODNRA.

Table 2: Vehicle Counts at Horsfall Recreation Area

	January	February	March
1995	5922	5799	7822
1996	5711	6315	9587
1997	5503	5980	8744
1998	4687	4362	7850
1999	4649	Closed Feb 4th	6884
Average 1995-1998	5456	5614	8501

Access to the beach and Coast Guard road from Horsfall to 10-Mile Creek was blocked from February 12, 1999 to February 21, 1999. There are three main entry points to this area of the ODNRA: Horsfall, Hauser, and Spinreel. There was no car counter at Hauser in 1999 or 1998 but there were 1,298 vehicles counted in February 1997 at this location. The car counter at Spinreel indicated that 1,447 vehicles entered this area in February of 1999. Assuming that 10 percent of the vehicle traffic is for administrative purposes, the average number of vehicles entering Spinreel and Hauser over a nine-day period in February equals approximately 800. This figure is derived from the 1997 and 1999 counts at these two sites respectively. Although there does not appear to be a large drop in visits to this location (there were 1,610 vehicles counted at Spinreel in 1998), visitors wishing to enter the beach area from either Spinreel or Hauser would have been precluded from doing so. It is believed that at least half of those entering the ODNRA from these sites usually spend at least part of their time recreating in the beach area that was closed. Based on these assumptions, the estimated number of trips of diminished value to this area is 1,000.

The Umpqua Beach area was closed from February 21, 1999 to April 15, 1999 due to response actions and emergency restoration actions for snowy plovers. Snowy plovers that had been oiled were released into the area after the initial incident. This area was also closed due to high water levels in February and March so the New Carissa incident only affected recreation visits from April 1, 1999 to April 15, 1999. The average daily number of vehicles that entered this area in April 1998 was approximately 105. Assuming 2.5 people per vehicle and 10 percent of the traffic is for administrative purposes, the total number of visits lost at this location for a 15-day period in April 1999 would be approximately 3,550, based on 1998 visitation levels.

The losses described above do not take into account the potential losses of individuals who encountered oil during times not discussed above. Due to the ongoing releases of oil, recreational losses could have occurred throughout the summer.

Governor Patterson State Park

Description of Affected Areas

The grounding of the bow section of the New Carissa near Alsea Bay resulted in the closure of Governor Patterson State Beach from March 3, 1999 to March 9, 1999. Governor Patterson State Park is a sandy beach just south of Alsea Bay. This beach is used mainly by local residents from the Waldport area for beach combing, walking, wildlife viewing and other beach activities.

Historical Use Rates and Estimated Number of Affected Trips

Table 3 shows the March traffic counts from Governor Patterson State Park in March for 1996 through 1998. The average daily vehicle count for March 1998 is approximately 225. Based on this number and assuming that there are 2.5 individuals per vehicle, there would have been approximately 3,950 lost visits to the park during the week in March 1999 based on 1998 visitation levels.

Table 3: Governor Patterson State Park Vehicle Counts

	March 1996	March 1997	March 1998
Vehicle Count	8,534	7,306	7,015

Shellfishing Closures and Advisories

After the initial grounding of the New Carissa, shellfishing closures were issued by the Oregon Department of Agriculture for Coos and Douglas County Beaches on February 11, 1999. On February 12, 1999, the estuaries in lower Coos Bay and the area north of the Charleston Bridge were closed to recreational shellfish harvesting. See Figure 5 for dates and locations of official shellfish closures. The public was informed of the closures through press releases, recorded telephone messages and signs in key shellfishing areas. The closures were not strictly enforced and some individuals continued to harvest shellfish during this period of time. With the exception of the area near the grounding site and Bastendorf Beach, these closings were lifted on March 4, 1999. Recreational shellfish closures were lifted at Bastendorf Beach on March 22nd and due to the continued presence of the stern section of the New Carissa, the area near the initial ground site remained closed to all recreational activity including shellfish harvesting and fishing through September 1999.

Data on the number of individuals engaged in shellfish harvesting is limited. The last official census of shellfish harvesters for selected areas of Coos Bay counted 145 individuals at peak clam digging times in the spring and summer of 1991 (Johnson and Wood, 1996). This number only represents a fraction of those shellfishing. The census would have missed anyone not harvesting at the selected areas and harvesting during non-peak times. In addition, the census also did not attempt to count individuals shellfish harvesting along the coast.

It should also be noted that the census of shellfish harvesters was taken during the spring and summer, when the water level during low tides can fall to minus 2 feet. The two lowest water level heights that occurred during the closing of shellfishing in Coos Bay were on Sunday, February 14th at approximately 5:30 p.m. and on Monday, March 1st at 6:00 p.m. The water level heights were minus 0.59 feet and minus 0.35 feet, respectively. During the closure of Bastendorf beach, which lasted until March 22nd, the lowest water level height measured in Coos Bay occurred on Tuesday, March 16th at approximately 5:30 p.m. The water level at this time was minus 0.66 feet. There was also a minus tide of minus 0.34 feet on March 17th near 6:00 p.m. See Figure 7 for tide level charts for Coos Bay from February 4th through March 24th.

After the second grounding of the New Carissa, recreational shellfish closures were issued for Alsea Bay and Yaquina Bay on March 4, 1999. Shellfish advisories for these two bays had been issued a day earlier. Yaquina Bay reopened on March 8, 1999 and Alsea Bay reopened on March 22, 1999. Counts of shellfish harvesters in Yaquina Bay and Alsea Bay for selected areas in the spring and summer of 1996 found 229 individuals and 128 individuals at peak times, respectively. There were no negative tides in Yaquina Bay during its closure period and during the closure of Alsea Bay the largest negative tides occurred late at night on March 17th and March 18th. See Figure 8 for tide level charts for Yaquina Bay from March 4th through March 24th. It should be noted that during the advisories against shellfish harvesting in Lincoln County, which followed the second grounding, the beaches were already closed for shellfish harvesting due to the presence of the toxin domoic acid.

Given the limited data on recreational shellfish harvesting and the uncertain level of compliance with the recreational shellfish harvesting closures, it is difficult to make precise estimates of the *New Carissa* incident's effect on shellfish harvesting. However, access to several popular shellfishing areas near the North Spit would have been prevented as a result of the closure of the spit. Oil booms placed near Charleston prevented people from accessing popular shellfish harvesting areas. In addition, the shellfish harvesting restrictions and advisories were imposed for an extended period of time and covered a wide geographic area. Based on the extended period of closures and advisories, which covered many popular shellfish harvesting locations, and the available data on the number of recreational shellfish harvesting trips, it is estimated that between 100 and 500 recreational shellfish harvesting trips were lost due to the *New Carissa* incident.

Fishing and Crabbing Advisories

In addition to the shellfish closures and advisories, fishing and crabbing advisories were also issued after the two grounding incidents. See Figure 6 for dates and locations of official advisories. These advisories did not specifically restrict these activities but likely lead to a decrease in the number of fishing and crabbing trips taken along the coast and estuaries in Oregon. Data from the Pacific States Marine Fisheries Commission from 1993 to 1998, show that approximately 750 coastal shore based fishing trips per month (not including crabbing trips) were taken on average in Coos and Douglas county during the first two months of the year. Based on this figure and the relative popularity of crabbing in the area it is estimated that at least 100 to 700 fishing and crabbing trips were lost due to the fishing and crabbing advisories that resulted from the *New Carissa* incident.

Other Areas

It would be difficult to determine with certainty if the New Carissa incident had a significant impact on other areas in the vicinity of the groundings, including other locations in the ODNRA. Although the total number of visitors to the ODNRA fell in February of 1999 (not including Horsfall), when compared to the same time period in 1998, a similar fall was seen in January of

1999 before the spill occurred. Total February 1999 vehicle counts outside of Horsfall were 68% of the February 1998 counts but similar number can be seen for the month before the grounding. The January 1999 counts were only 50% of the January 1998 counts.

See Table 4 for a summary of the estimated number of recreation trips affected by the *New Carissa* incident.

Table 4: Preliminary Estimate of the Number of Recreational Trips Affected the *New Carissa* Incident				
Affected Area	Closure Date	Opening Date	Types of Activities	Estimated Number of Affected Trips
North Spit (Full Closure)	February 4th	March 25th	Off Hwy Vehicles Wildlife Viewing Horse Riding Target Shooting Day Hiking Clamming Crabbing/Fishing	3,968 Lost Trips
North Spit (Partial Re-opening)	March 26th	August 1st	See Above	4,491 Lost Trips
North Spit (Limited Access)	August 2nd	September 15th	See Above	690-920 Lost Trips
ODNRA Horsfall	February 4th	March 5th	Camping Off Hwy Vehicles Horse Camping / Horse Riding Shellfish Harvesting Beach Combing Wildlife Viewing	10,125 Lost Trips
ODNRA Beach and Coast Guard Road between Horsfall and 10-mile Creek	February 12th	February 21st	Off Hwy Vehicles Shellfish Harvesting Beach Combing	1,000 Diminished Trips
ODNRA Umpqua Beach Parking Lot #2 and south	February 21st	April 16th [6]	Wildlife Viewing Beach Combing Off Hwy Vehicles Picnicking Sight-seeing Shellfish Harvesting	3,550 Lost Trips
Governor Patterson State Beach	March 3rd	March 10th	Beach Combing Picnicking Sight-seeing	3,950 Lost Trips

[6] Area was also closed due to high water in February and March.

Recreational Shellfish Harvesting Losses				
Coos and Douglas Co. Beaches Closure	February 11th	March 3rd		100-500 Lost Trips
Bastendorf Beach Closure	February 11th	March 22nd		
North Spit - Grounding Site Closure (access through BLM areas)	February 11th	Ongoing		
Lower Coos Bay (Downstream of railroad bridge) and Charleston Boat Basin (downstream of Charleston Bridge)	February 12th	March 4th		
Yaquina Bay Closure	March 4th	March 8th		
Alsea Bay Closure	March 4th	March 22nd		
Winchester Bay Advisory	February 12th	March 4th		
Bays and Beaches in Lane and Lincoln Co. Advisory	March 3rd	March 22nd (Lincoln Co. Beaches also closed due to presence of domoic acid)		
Alsea Bay and Yaquina Bay Advisory	March 3rd	March 3rd (Changed to closure on the 4th)		
Recreational Fishing and Crabbing Losses				
Coos Bay and Winchester Bay	February 12th	March 4th		100 – 700 Lost Trips
Total Estimated Number of Lost Trips				**26,974 – 28,204**
Total Estimated Number of Diminished Trips				**1,000**
Total Estimated Number of Affected Trips				**27,974 – 29,204**

Weather

Rainfall and temperature data collected at the North Bend airport indicate that the weather in early 1999 was similar to early 1998 (see Table 5 for 1998 and 1999 February data). Temperatures during the two time periods were also similar. Average rainfall was slightly lower in 1999; slightly lower on weekends and slightly higher on weekdays. Therefore, it appears that visitation rates in 1999 would not have been significantly different than the 1998 rates as a result of weather.[7] Newport, Oregon weather data indicate that during the seven days that Governor Patterson State Park was closed in March, the weather was fairly typical for a week in March. The average daily rainfall totals for March 1988 and for the closed days in March 1999 were 0.30 inches and 0.33 inches respectively. See Appendix D for more detailed weather data from North Bend Airport and Newport, Oregon.

Table 5: 1998 and 1999 Weather Data at North Bend Air Port

Time Period		Feb. 1998 High Temp.	Feb. 1998 Low Temp.	Feb. 1999 High Temp.	Feb. 1999 Low Temp.	Feb. 1998 Daily Rainfall (Inches)	Feb. 1999 Daily Rainfall (Inches)
Month	Average	55.07	43.00	52.61	40.68	0.45	0.43
	Median	54.50	43.50	52.00	39.50	0.29	0.33
Weekend and Holidays	Average	53.78	44.00	53.56	41.89	0.63	0.46
	Median	53.00	44.00	53.00	42.00	0.38	0.32
Weekday	Average	55.68	42.53	52.16	40.11	0.37	0.41
	Median	55.00	43.00	52.00	39.00	0.28	0.34
3-Day Weekend	Average	52.00	43.67	53.33	40.00	0.47	0.21
	Median	53.00	44.00	53.00	39.00	0.38	0.11

3. Value of Recreational Losses

As stated earlier in this report, the correct measure of the net economic value of a recreation trip is the average consumer surplus per trip. The net lost consumer surplus (or value) associated with each affected trip will vary by the type of recreational activity. Therefore, to estimate the total lost economic value resulting from the *New Carissa* incident, it is first necessary to consider the consumer surplus associated with each type of recreational activity affected by the incident. The main activities affected by the *New Carissa* incident include off-highway vehicle use, day-hiking, picnicking, wildlife viewing, fishing, crabbing and shellfish harvesting. The following section provides a brief summary of the economic literature valuing these types of activities. See

[7] This analysis does not take into account the time of day in which rain fell. The timing of the rainfall could also cause daily visitation rates to vary.

Table 6 for a summary of the consumer surplus values associated with these recreational activities.

Off-Highway Vehicle Use

The areas affected by the *New Carissa* incident provide some of the most unique off-highway vehicle use in the nation. From expansive beaches to towering dunes the area provides a highly valued riding experience. It is likely that the experience of off-highway vehicle use in this area is valued as highly here as anywhere in the nation. Two economic studies that have attempted to value the consumers' surplus from off-highway vehicle use are Bergstrom and Cordell (1991) and Walsh and Olienyk (1981). Bergstrom and Cordell (1991) estimate values for 37 different activities at parks and recreation areas throughout the United States. The data were collected between 1985 and 1987 as part of a national survey of recreational users. More than 26,000 on-site interviews were conducted at national and state parks, lakes, reservoirs and community recreation areas. Using a zonal travel cost model, Bergstrom and Cordell (1991) provides broad, U.S. population-level estimates for the values typical users ascribe to common recreational activities. They estimate that the expected consumer surplus per day from off-highway vehicle use is $22.31 (December, 1999 $). Walsh and Olienyk (1981) applied the contingent valuation method to estimate the value of off-highway vehicle driving in front range national forests of Colorado. Their estimated value of driving off-highway vehicles was $15.60 (December, 1999 $).[8]

Camping

The consumer surplus for a camping trip in the area affected by the *New Carissa* will depend on the characteristics of the campers as well as the characteristics of the camping facilities and recreational experiences. The campgrounds located within the ODNRA, provide excellent camping facilities located close to the beach, sand dunes and hiking trials. Campers who are avid off-highway vehicle users use these campgrounds. Horsfall campground provides one of the few equestrian camping areas in the nation. Camping in this area is a highly valued recreational experience and the value of this experience would likely be comparable to the value of many camping experiences throughout the country. Walsh *et al.* (1992) conducted a nation wide meta-analysis of user day values for recreational activities and find that the average consumer surplus per camping day is $28.54 (December, 1999 $). Bergstrom and Cordell (1991), in the study mentioned above, estimate that the consumer surplus per day of a camping trip is $13.39 (December, 1999 $).

Day-Hiking and Picnicking

Although other studies have estimated the consumer surplus associated with hiking, many of these studies have looked at lengthy or multi-day hiking trips. Most of the hiking taking place in the areas affected by the *New Carissa* incident would involve day hikes along paths or along the beaches affected by the incident. Based on their national study, Bergstrom and Cordell (1991)

[8] This value is taken from Walsh *et al.* (1988), which adjusted the estimated consumers surplus by 20 percent to convert total trip values to on-site activity.

estimate that the consumer surplus per day for day hiking is $18.24 (December, 1999 $). Picnicking is also an important recreational activity within the areas affected by the New Carissa incident. alsh *et al.* (1992), which looks at several economic studies in different areas within the United States, find that the average value per picnicking day is $25.36 (December, 1999 $).

Fishing

The value of a fishing trip varies widely depending on the type of fish targeted and the fishing mode. Freeman (1995) provides a review of the value of a saltwater recreational fishing. The values he cites range from approximately $10 per trip to $100 per trip. The larger values are usually based on sites that include a fairly substantial geographic area. In studies that specify smaller geographic areas, it is more likely that the availability of close substitute sites will result in lower values for access to the site in question. During the month of February, the area along the North Spit and the ODNRA is known as an excellent fishing area for the highly prized striped bass (Fishing & Hunting News, 1999). Given the limited time of the striped bass migration near the beach and the limited areas available for striped bass fishing, there would be relatively few, if any, close substitutes for this recreational experience.

General Beach Activity

Although the activities normally taking place in the areas affected by the New Carissa incident are varied, many of these activities might be considered part of normal activities taking place at a beach.[9] Table 7 summarizes the existing literature on the value of a beach visit for general beach recreation. The first seven studies were relied upon the Department of Interior (DOI) to develop its damage assessment regulations under the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. § 9601 *et seq.*). The average value per beach trip from these studies is $14.39 (December, 1999 $).

Table 6: Consumer Surplus Values for Activities Affected by New Carissa Incident

Activity	Study	Consumer Surplus Value (December, 1999 $)
Off-Highway Vehicle Use	Bergstrom and Cordell (1991) Walsh and Olienyk (1981)	$22.31 $15.60
Camping	Walsh *et al.* (1992) Bergstrom and Cordell (1991)	$28.54 $13.39
Day Hiking	Bergstrom and Cordell (1991)	$18.24
Picnicking	Walsh *et al.* (1992)	$25.36
Fishing	Freeman (1995)	$10-$100
General Beach Activities	DOI Average	$14.39

[9] It is likely that off-highway vehicle use, camping (especially equestrian camping), shellfish harvesting, crabbing and fishing are activities that are not well represented in studies of the consumer surplus associated with beach trips. However, the literature values for the consumer surplus values associated with a general beach trips fall within the range of values estimated for these individual activities.

Table 7: General Beach Recreation: Value of a Beach Day from the Literature			
Authors	**Date of Study**	**State**	**Value (December, 1999 $)**
Curtis & Shows	1982	FL	$3.93
Curtis & Shows	1984	FL	$7.50
Dornbush et al.	1986	CA	$10.64
Tyrrell	1982	RI	$15.95
Bell and Leeworthy	1986	FI	$17.37
Meta Systems, Inc.	1985	MA	$17.81
Leeworthy and Wiley	1991	NJ	$27.56
Kouru	1993	MA	$21.04
Hanemann	1997	CA	$14.16-$51.51

4. Preliminary Estimate of the Total Lost Consumer Surplus

The general DOI beach value ($14.39 December, 1999 $) falls within the lower range of values for recreational activities taking place within the affected area and therefore provides a conservative estimate of the average lost consumer surplus for each trip lost by the *New Carissa* incident. Multiplying $14.39 times the estimated number of trips lost gives the estimated economic loss resulting from lost recreational trips. The total preliminary estimated lost use value associated with the oil spill is approximately $388,156 to $405,856. Further economic studies could be made to attempt to lessen the uncertainty of the estimated losses but it is likely that they would yield similar estimated losses.

This lost use value does not account for the estimated 1000 trips to the area from Horsfall to 10-Mile Creek between from February 12, 1999 to February 21, 1999 that were affected by the beach closure in this location. Although visitors would have been able to recreate in non-beach areas of the ODNRA, they would have been precluded from accessing the beach at this time. It is assumed that individuals recreating in this area did not lose all of the value associated with their trips. Therefore, we apply a value reduction of 50 percent to the general beach day value as a reasonable approximation of the diminished use value associated with the closure of this area. This reduction factor is based on the geographic extent of the affected area and the importance of beach recreation to the general experience of visiting the ODNRA. The total preliminary estimated diminished use value for this area is $7,200.

The total preliminary estimated loss in consumer surplus from the *New Carissa* incident ranges from $395,356 - $413,056. Table 8 presents a summary of these losses.

Table 8: Preliminary Estimate of the Recreational Losses Resulting from the *New Carissa* Incident			
	Number of Trips	**Consumer Surplus Loss Per Trip**	**Total Losses**
Lost Trips	26,974 – 28,204	$14.39	$388,156 to $405,856
Diminished Trips	1,000	$7.20	$7,200
Total			**$395,356-$413,056**

4. Compensatory Restoration Alternatives

The goal of the Oil Pollution Act of 1990 (OPA), 33 U.S.C. 2701 *et seq.*, is to make the environment and public whole for injuries to natural resources and services resulting from an incident involving a discharge of oil (incident). This goal is achieved through the return of the injured natural resources and services to baseline and compensating for interim losses of such natural resources and services from the date of the incident until recovery. (OPA Natural Resource Damage Assessment Regulations,15 C.F.R. § 990.10).

Determining the Feasibility of Compensatory Restoration Project Alternatives

The trustees are currently considering the feasibility of alternative compensatory projects to address the potential recreational losses resulting from the *New Carissa* incident. The nature and scale of appropriate compensatory projects will ultimately depend on the final estimated value of the lost recreational use resulting from the incident. Below is a preliminary list of potential restoration projects and preliminary cost estimates. Additional projects may be considered in the future.

Gov. Patterson State Park Beach trail and parking lot - $44,000. There are two parts to this project.

Beach Trail. The beach trail at Governor Patterson was in a state of disrepair prior to the *New Carissa* incident; however, additional deterioration occurred during this time. The scope of this project would include digging out and repairing uneven surfaces with crushed rock and placing a 2" compacted overlay of class "C" asphalt and placing a 6 inch wide band of 3/4 minus "shoulder rock" after installation of the asphalt.

Parking Lot. Resurfacing the parking lot with a 2-inch lift of class "C" asphalt beginning at an east west line drawn approximately at the north beach trail, continuing north to include the remainder of the parking lot. This project would also include replacing the curbs in this area and re-stripping of the lot.

North Spit and Horsfall area entry kiosk and 2 satellite kiosks - $60,000.

This project would place an entry kiosk with a pull-off for vehicles near the Horsfall/North Spit turn-off, with information and directions about the Horsfall and North Spit areas. Two satellite kiosks would be strategically in the area.

North Spit and Horsfall area beach closure signs - $30,000.

This project would place 3 beach closure boundary signs, with pilings as posts, at the following locations: one at the USFS/BLM boundary near Horsfall, one at Horsfall, and one near the FAA tower.

Horsfall Day Use Area expansion - $200,000.

This project would expand the existing day use area used for OHV staging to 61 sites, increasing persons at one time (PAOT) capacity from 48 to 152. Including a short, paved access road, preliminary costs are $250,000. The balance of the funds would most likely come from matching funds from the OHV community. The Horsfall corridor is heavily used by OHV recreationists and includes one of the two most heavily used OHV campgrounds on the Oregon Dunes NRA. This expansion is in accordance with the Management Plan and the NEPA work has been completed.

Horsfall area accessible viewing deck - $35,000.

This project would address the need for accessible near-ocean viewing places along the central Oregon coast. The fore dune blocks access for the mobility-challenged. This project would build an accessible ramp and viewing platform on the fore dune at Horsfall Beach. The parking area and restroom are already accessible.

North Spit (interior) trail rehab - $30,000.

This project would rehab existing trails within the interior of the North Spit, to create a connected trail system for foot and horse traffic, with signs, to encourage hikers and horse users, and discourage vehicle users in the interior of the spit.

Horsfall Campground accessible sites - $30,000.

This project would add ten fully accessible campsites by reconstructing existing sites.

North Spit-Weyco trail expansion - $160,000.

This project would expand the existing loop trail across BLM and/or FS (ODNRA) land and allow for ocean access. The trail will follow existing sand trails as much as possible and will maintain natural surfaces, i.e., sand and dirt except in areas needing elevation and boardwalk. Some seasonal wetlands must be crossed; a

boardwalk is necessary for these low areas. The scope of this project will include a cooperative EA process, trail marking and creation of boardwalks. Trail uses will include hiking and possibly equestrian.

North Spit equestrian staging area - $60,000

This project would create an equestrian staging facility on BLM land across the road from the existing BLM boat ramp. It would create the only facility to specifically accommodate equestrian users on the North Spit. The basic concept is a specialized parking lot with access roads and appropriate signage. Size could range from accommodating 8 to 16 truck/horse trailers. Also, surface type could range from all blacktop to all gravel. By locating the facility at this site, horseback riders would be able to come in with their vehicles, unload their horses, and ride directly from the parking lot over to the fore dune road without having to cross the Transpacific Parkway. The project was not previously analyzed in the Coos Bay Shorelands Plan, so NEPA work would have to be done for this, as would consultation with U.S. Fish and Wildlife Service. Cost would vary depending on the size and surface type selected for the project with a range of $30,000- $100,000.