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Observed and Estimated Total Bycatch of Green Sturgeon and Pacific Eulachon in the 2002-2010 US West Coast Fisheries

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Table of Contents

List of Tables

List of Figures

Executive Summary

Green sturgeon (*Acipenser medirostris*) and Pacific eulachon (*Thaleichthys pacificus*) bycatch estimates were provided for 2002 through 2010 for all groundfish fishery sectors observed by the West Coast Groundfish Observer Program and the At-Sea Hake Observer Program.

The total green sturgeon bycatch estimate for 2010 was the lowest estimate of all observed years, except 2007. In all years, the Limited Entry California halibut sector constituted the largest source of green sturgeon bycatch among the sectors analyzed.

The Pacific eulachon bycatch estimate for 2010 was the highest estimate of all observed years. The pink shrimp (*Pandalus jordani*) trawl fishery constituted the largest source of eulachon bycatch coast-wide. Observer coverage of the pink shrimp fishery increased in 2010 with increased coverage in California and the initiation of coverage in Washington.

Two methodology and reporting changes were implemented in this report. The first change addressed the need for the presentation of statistical uncertainties in bycatch estimates. This change involved the inclusion of standard error values for bycatch ratios and 95% confidence intervals around bycatch estimates. The second change allowed the estimation of bycatch in strata that had fewer than three vessels observed using non-parametric bootstrapping. This technique involved resampling with replacement all observed hauls within a stratum to produce a representative bycatch ratio for that stratum.

Introduction

The primary objective of this report is to provide bycatch estimates of non-salmonid fish species listed under the Endangered Species Act (ESA) in observed U.S. west coast fisheries from 2002-2010. We present observer bycatch ratios and estimated bycatch (number of individual fish) for two species: green sturgeon (*Acipenser medirostris*) and Pacific eulachon (*Thaleichthys pacificus*).

The southern distinct population segment (DPS) of North American green sturgeon was listed as threatened under the ESA in 2006 (71 FR 17757), and critical habitat was designated in 2009 (74 FR 52300). The North American green sturgeon southern DPS is defined as coastal and Central Valley populations, south of the Eel River in California. The southern DPS is known to only contain a single spawning population in the Sacramento River at present (SWFSC 2005). Preliminary genetic analyses suggest that the majority of green sturgeons encountered by the west coast groundfish fishery are from the southern DPS (Israel and NMFS-SWR, unpublished data).

The southern distinct population segment of Pacific eulachon, hereafter referred to as eulachon, was listed as threatened under the ESA in 2010 (75 FR 13012). The eulachon southern DPS is defined from the Mad River in northern California (inclusive), north to the Skeena River in British Columbia (inclusive).

This report includes estimates for all fisheries observed by the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP) from 2002-2010. These include bycatch in the following commercial fisheries:

Green sturgeon –
- Limited entry (LE) bottom trawl – targeting California halibut
- Open access (OA) bottom trawl – targeting California halibut

Eulachon –
- Shrimp trawl (Washington, Oregon and California)
- At-sea Pacific hake/whiting catcher-processor

Green sturgeon and eulachon -
- LE groundfish bottom trawl
- At-sea Pacific hake/whiting mothership
- At-sea Pacific hake/whiting tribal mothership

Commercial fisheries observed by the WCGOP and A-SHOP that did not have any observed bycatch of green sturgeon or eulachon during this period include:

- LE fixed gear primary sablefish (tier endorsed)
- LE fixed gear non-primary sablefish (non-endorsed)
- OA fixed gear
- Fixed gear state-permitted nearshore (Oregon and California)

Data Sources

Data sources for this report include onboard observer data (from the WCGOP and A-SHOP) and landing receipt data (referred to as fish tickets).

Discard estimation analyses focused on commercial fishery sectors in which the Northwest Fishery Science Center (NWFSC) Fishery Resource Analysis and Monitoring Division (FRAM) has conducted scientific at-sea observation of discards. The WCGOP and the A-SHOP observe distinct sectors of the groundfish fishery. The WCGOP observes a number of different sectors of the groundfish fishery, including the limited entry (LE) groundfish bottom trawl, limited entry and open access (OA) fixed gear, and state-permitted nearshore fixed gear sectors. The WCGOP also observes several fisheries that incidentally catch groundfish, including the California halibut trawl and pink shrimp trawl fisheries. Observations by the A-SHOP are from the federally-permitted sector that targets Pacific hake using mid-water trawl gear and processes catch at-sea. More information on each of these sectors is available in annual reports produced by the A-SHOP and WCGOP (http://www.nwfsc.noaa.gov/research/divisions/fram/observer/). Furthermore, for a list of groundfish sectors that are not covered by either program see the description of observer coverage provided by Bellman et al. (2011) in the annual report on estimated mortality of groundfish species.

The WCGOP's goal is to improve total catch estimates by collecting information on the discarded catch (fish returned overboard at-sea) of west coast groundfish species. For more details about WCGOP goals, vessel selections, and data collection, see the WCGOP website at http://www.nwfsc.noaa.gov/research /divisions/fram/observer/. The website also provides estimates of observer coverage, observed catch, and a summary of observed fishing depths for each sector. A list of fisheries, in order of coverage priority and detailed information on data collection methods employed in each observed fishery can be found in the WCGOP manual (NWFSC 2010).

Observer and fish ticket data processing steps are described in detail on the WCGOP website under Data Processing, and in prior reports produced annually by the WCGOP at http://www.nwfsc.noaa.gov/research/divisions/fram/observer/. All data processing steps specific to this report are described in the methods section below.

When green sturgeon are encountered on vessels observed by the WCGOP, observers document length and general condition, take photographs, scan for scute markings and tags, and take a tissue sample. If the specimen is obviously dead, the observer will also take a fin ray sample and determine sex. All but one green sturgeon observed between 2002 and 2010 by the WCGOP have been fish that are not obviously dead.

When green sturgeon are encountered in a species composition sample on an observed vessel by the A-SHOP, observers document length and weight, determine sex if possible, take photographs, visually scan for tags, and take a pectoral fin ray sample. All three green sturgeon observed by the A-SHOP between 2002 and 2010 were dead at the time of sampling, due to the nature of the fishery and fishing vessel operations. At-sea hake observers follow protocols detailed in the A-SHOP manual and additional materials provided by the A-SHOP program related to sturgeon sampling (NWFSC 2011a).

Fleet-wide landing receipts (fish tickets) are the cornerstone of retained catch information for all sectors of the commercial groundfish fishery on the U.S. west coast. Fish tickets are trip-aggregated sales receipts issued

to vessels by fish-buyers in each port for each delivery of fish. They are provided to fish-buyers by a state agency and must be returned to the agency for processing. Fish tickets are designed by the individual states, and Washington, Oregon, and California each have a slightly different format of receipt. In addition, each state conducts species-composition sampling for numerous market categories that are reported on fish tickets. Market categories represent either a single species or a mixture of species. Fish ticket and species-composition data are submitted by state agencies to the Pacific Fisheries Information Network (PacFIN) regional database, which is maintained by the Pacific States Marine Fisheries Commission (PSMFC). Percentages for the species composition within market categories were applied to the fish ticket data used in our analyses. As such, landed weights from sampled market categories were distributed to individual species to the greatest extent possible.

Annual fish ticket landings data were retrieved from the PacFIN database and subsequently divided into various sectors of the groundfish fishery as indicated in Figure 1. All additional data processing steps are described in the methods section below.

Methods

Bycatch Estimation Methods

All vessels fishing in the at-sea hake fishery carry two A-SHOP observers for every fishing day, and thus further estimation to expand bycatch to the fleet-wide level was not necessary. Data were provided directly from the A-SHOP and incorporated into Table 5 for green sturgeon bycatch and Table 6 for eulachon bycatch. The number of individual fish caught was reported by each at-sea hake fishery sector: tribal and non-tribal motherships, and catcher-processors.

A deterministic approach was used to estimate green sturgeon and eulachon bycatch for all WCGOP observed sectors of the groundfish fishery. Through this approach, observed bycatch rates for green sturgeon and eulachon were directly expanded to the fleet-wide level. First, bycatch ratios were computed from observer data as the catch (in number of fish) of green sturgeon or eulachon divided by the retained weight of either groundfish species included in the groundfish fishery management plan (FMP) (excluding Pacific hake), California halibut, or pink shrimp, depending on the fishery. Denominators differed for each fishery based on the targeting behavior of that fishery. Bycatch ratios were then multiplied by the fleet-wide landed weight of either FMP groundfish, California halibut, or pink shrimp, depending on the fishery. This calculation provided an expanded estimate of total fleet-wide green sturgeon or eulachon bycatch (in number of fish). Because of differences in data availability and management structure among the various fisheries, this approach was applied with slight modifications for each fishery. Each of these modifications is detailed in the methodology for each fishery below. In addition, non-parametric bootstrap resampling was used to estimate bycatch ratios per stratum when fewer than three vessels were observed within a stratum.

In all cases where a FMP groundfish species grouping was used to compute discard ratios, any retained weights that were recorded by the observer but that did not appear on fish tickets were excluded from the denominator. This was necessary to prevent double-counting associated with differences in the species codes used by observers and processors. For instance, while observers may record rockfish catch at the species level, various species of rockfish are often grouped, weighed, and recorded together on the fish ticket under a grouped species code such as NUSP - northern unspecified slope rockfish. By using only the retained

groundfish weight from fish tickets in bycatch ratio denominators, we prevent double-counting of retained weights. This is not an issue when using a single species in the denominator, such as California halibut, as any retained weights in observer and fish ticket data that share the same species code will match and adjust properly.

Species were defined and/or grouped for this report according to the WCGOP Data Processing Appendix, which can be found at: http://www.nwfsc.noaa.gov/research/divisions/fram/observer/data_processing.cfm. A complete listing of groundfish species is defined in the Groundfish Fishery Management Plan (http://www.pcouncil.org/wp-content/uploads/fmpthru19.pdf).

Standard errors (SE) of bycatch ratios were calculated based on the method presented by Pikitch et al. (1998) and are provided in Tables 1-4.

Although bycatch ratios were calculated directly using observer data when there were three or greater observed vessels in a stratum, bycatch ratios were produced using bootstrap methods in instances when less than three vessels were observed within a stratum. To provide a bootstrapped bycatch ratio where an inadequate sample occurred, a non-parametric bootstrap model was developed in R (www.r-project.org). The model re-sampled observer data within a single stratum (across all years) at the haul level with replacement (10,000 iterations), producing a bycatch ratio from each iteration. A mean bycatch ratio was then calculated from the 10,000 iterated bycatch ratios to produce an average bycatch ratio estimate used to expand bycatch amounts to the fleet level. A 95% confidence interval was calculated to estimate error in the mean bycatch ratio.

Limited Entry Bottom Trawl Fishery

Fleet-wide green sturgeon and eulachon bycatch estimates for the LE bottom (non-midwater) trawl fishery were derived from WCGOP observer data and fish ticket landings data (Figure 1).

LE bottom trawl vessels can hold a California halibut bottom trawl permit and participate in the state-permitted California halibut fishery. California halibut tows can occur on the same trip as tows targeting groundfish and were identified based on the following criteria: 1) the reported tow target was California halibut or 2) the tow target was nearshore mix, sand sole, or other flatfish, and the tow took place in less than 30 fathoms and south of 40°10' N. latitude. All tows in the observer data that met at least one of the above requirements were removed from the LE bottom trawl data and included as data for the California halibut fishery (see below). Tow targets are typically determined by the vessel captain.

Several additional filtering steps were then applied to the data to ensure that data for the LE bottom trawl sector was defined appropriately. We investigated tows and landings with more than 2 mt of Pacific hake, to exclude effort that was targeted exclusively towards this species. On the basis of the Pacific hake catch criterion, nine observed tows between 2002 and 2010 met the criterion and were removed.

Observer data were then stratified by state of landing and season. Bycatch of green sturgeon and eulachon typically occurs in a shallow and limited depth range, therefore making additional stratification by fishing depth unnecessary (Figure 2 and 3). Once the data set had been stratified, bycatch ratios were computed from

the observer data and multiplied by fleet-wide fish ticket landing weights in each stratum. This expansion was done according to the following equation:

$$D_{as} = \frac{\sum\limits_{t} d_{ast}}{\sum\limits_{t} r_{ast}} \times \sum\limits_{t} R_{ast}$$

where:

a: state of landing (Washington, Oregon or California)
s: season (winter: Nov - Apr / summer: May - Oct)
t: tows in observer data
d: observed number of green sturgeon or eulachon
r: observed retained weight of all FMP groundfish except Pacific hake
R: weight of retained FMP groundfish (except Pacific hake) recorded on fish tickets
D: bycatch estimate for state a and season s

Note that the denominator of observed bycatch ratios and the fish ticket expansion factor included weight from all retained FMP groundfish except Pacific hake. Pacific hake was excluded from the denominator because vessels that target or land large amounts are considered to be part of Pacific hake mid-water trawl sectors, which are distinct from the LE groundfish bottom trawl fishery.

Observed number of fish, bycatch ratios, and estimated fleet-wide bycatch by state of landing and season in the LE bottom trawl fishery are presented for green sturgeon in Table 1 and for eulachon in Table 3.

California Halibut Bottom Trawl Fishery

Fleet-wide green sturgeon bycatch estimates in the California halibut bottom trawl fishery were derived from WCGOP observer data and fish ticket landings data. Although all California halibut vessels are permitted by the state of California, we consider this fishery to consist of both a limited entry (LE) and an open access (OA) component (i.e. vessels that do not have federal limited entry groundfish permits). The WCGOP provides observer coverage for both of these components. The WCGOP provides observer coverage under the LE groundfish bottom trawl sector and isolates data for the LE component of the California halibut fishery based on the following criteria: 1) the tow target was California halibut or 2) the tow target was nearshore mix, sand sole or other flatfish, and took place in less than 30 fathoms, south of 40°10' N. latitude. All tows in the observer data set that met at least one of the above requirements were included in the LE California halibut bottom trawl dataset. The WCGOP randomly samples the OA California halibut sector separately. The LE and OA components of the California halibut trawl fishery remain separate in this report, with bootstrapped bycatch ratios used when fewer than 3 vessels were observed by WCGOP in a given component.

Bycatch ratios were computed for this fishery using the retained weight of California halibut in the denominator. The fleet-wide landed weight of California halibut was then used as a multiplier to expand observed green sturgeon bycatch ratios to the fleet level. To isolate fish tickets from trips on which California halibut was targeted, landings were only compiled from fish tickets that had greater than 150 lbs of California halibut during the period 2002-2006.

Starting in 2007, the state of California required that vessels participating in the LE and OA trawl fisheries landing more than 150 lbs of California halibut to possess a California halibut bottom trawl permit. While all OA vessels that landed more than 150 lbs of CA halibut in 2007 possessed a permit, not all LE vessels did. To account for all California halibut fishing in 2007, the permit list was used to identify California halibut vessels in the OA fishery, while the 'more than 150 lbs' guide was used to isolate California halibut trips in the LE fishery.

By 2008, California halibut bottom trawl permits for both the LE and OA trawl sectors effectively represented all vessels targeting California halibut. Thus, landed California halibut weights for both the LE and OA sectors were compiled from "non-mid-water" trawl fish tickets (see Figure 1) for those vessels that had a state-issued California halibut bottom trawl permit in 2008-2010.

Bycatch estimates were computed for each sector and year based on the following equation:

$$\hat{D}_s = \frac{\sum_t d_t}{\sum_t r_t} \times F_s$$

where:

      s: season
      t: observed tows
      d: observed bycatch (number) of green sturgeon
      r: observed retained weight (mt) of California halibut
      F: weight (mt) of retained California halibut recorded on all fish tickets in season s
      D_s: bycatch estimate for season s

Fleet-level bycatch estimates of green sturgeon for each California halibut fishery component (LE and OA) are presented in Table 2.

LE groundfish trawl tows can be differentiated from California halibut tows during observed trips by the observer. However, fish tickets are reported at the trip level, and landings cannot be differentiated between tows. This inability to distinguish between catch from LE trawl tows and California halibut tows was not anticipated to be a major source of bias in our analysis, as the primary species retained on observed California halibut tows were non-groundfish (NWFSC 2011b). However, because some flatfish species were retained on these tows, it is possible that bycatch estimates in California for the LE groundfish bottom trawl sector could have been positively biased due to slightly larger expansion factors (caused by the inclusion of landed flatfish that were in fact caught on California halibut tows). Examination of the species composition on fish tickets in the areas where California halibut is typically landed suggests that the impact of other landed species on bycatch estimates is minor.

Pink Shrimp Trawl Fishery

Fleet-wide eulachon bycatch estimates in the Washington, Oregon and California pink shrimp trawl fisheries were derived from WCGOP observer data and fish ticket landings data (Figure 1). Annual pink shrimp fisheries occur from April to October. WCGOP coverage of the Washington pink shrimp fleet began in 2010 and is utilized for the first time in this report. For analysis purposes, only trips by shrimp vessels landing in a

particular state are considered part of that state's pink shrimp fishery. This definition is consistent with state management.

Bycatch ratios for these fisheries were calculated by dividing the observed bycatch of eulachon (number of fish) by the observed retained weight (mt) of pink shrimp (Table 4). The fleet landed weight of pink shrimp was then used as a multiplier to expand observed eulachon bycatch ratios to the fleet. The equation for the expansion of bycatch ratios in the pink shrimp fishery is identical to that presented for the California halibut fishery, but where r represents the retained weight of pink shrimp and F represents the weight of retained pink shrimp recorded on fish tickets.

Table 4 presents observed eulachon bycatch, bycatch ratios, fleet pink shrimp landings, and fleet eulachon bycatch estimates in the pink shrimp trawl fishery.

Results

Green Sturgeon

A summary of green sturgeon bycatch in all U.S. West Coast groundfish fisheries observed by the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP) from 2002-2010 is provided in Table 5. Green sturgeon bycatch was estimated for all fisheries monitored by the WCGOP in which green sturgeon were observed. Estimates were not provided for the OA sector of the California halibut fishery during 2002 and 2006 because this sector was not observed during those years. As such, the overall green sturgeon bycatch estimate in 2002 and 2006 (Table 5) should be interpreted as the lowest possible estimate of bycatch in those years.

The largest amounts of green sturgeon bycatch were estimated in the limited entry (LE) sector of the California halibut fishery. Fishing in this sector primarily takes place in depths of less than 30 fathoms in fishing grounds adjacent to San Francisco Bay, California. The largest estimate of green sturgeon bycatch in the LE sector of the California halibut fishery occurred in 2006, when 786 individuals were estimated to have been caught by the entire sector (Table 5). In that year, the largest number of green sturgeon (108 individuals) were observed on LE vessels conducting California halibut tows during the winter season (Table 2).

Overall, estimated green sturgeon bycatch from 2003 through 2006 was higher, in contrast with bycatch estimates from 2007 through 2010 with the exception of 2009. Green sturgeon bycatch in 2009 was estimated at 333 individuals, which is similar to 2003 and 2004 estimates (Table 5). A dramatic reduction in total California halibut landings in the LE sector of the fishery occurred in 2007 relative to prior years (Table 2). LE California halibut landings remained at a low level with only a slight increase in 2009 and 2010 relative to 2007. OA sector landings were also lower in 2007 than in the two years prior, but have increased since then. The highest OA sector landings during this time series were reported in 2009 (85.4 mt) (Table 2).

Green sturgeon bycatch in the at-sea hake fishery was very low, as the A-SHOP only recorded a total of 3 green sturgeon from 2002-2010 (Table 5).

While we provide estimates of green sturgeon bycatch in groundfish fisheries on the U.S. west coast, we have not applied rates of discard survivorship to estimate mortality resulting from green sturgeon bycatch.

Although studies examining release mortality of sturgeon have been conducted, all of these have studied sturgeon in the freshwater environment, using drift gill nets and hook and line gears (NMFS 2005, Robichaud et al 2006). Overall, release mortalities have been found to be very low, falling between 2.8% and 5.2%. Since this report covers green sturgeon encountered by trawl gears in the marine environment, results from the existing mortality studies are not applicable.

Green sturgeon critical habitat is designated from 0 to 60 fathoms (74 FR 52300). The deepest observed tow that encountered a green sturgeon was at 65 fathoms (Figure 2a) and was the only encounter deeper than 60 fathoms. The depth distribution of all observed green sturgeon catch between 2002 and 2010 indicates that 60% of fish were encountered in the depth range of 5-9 fathoms, and 75% were from 5-18 fathoms (Figure 2b). The depth distribution of all observed tows encountering green sturgeon bycatch was similar, with 60% of tows in the depth range of 5-15 fathoms and 75% from 5-20 fathoms.

Since 2007, the WCGOP has collected lengths, general condition, photographs, and tissue samples from all green sturgeon observed. All but one green sturgeon observed by the WCGOP have been fish that are not obviously dead, and thus observers have largely been unable to determine sexes or collect fin ray samples. Information regarding biological sampling procedures for green sturgeon is available in the WCGOP observer training manual (http://www.nwfsc.noaa.gov/research/divisions/fram/observer/ observer_manuals.cfm). The length frequency distribution of green sturgeon bycatch from 2007 through December 2010 is presented in Figure 4. Based on the age-fork length relationship presented by ODFW (2005), all but one green sturgeon observed and measured as bycatch between 2007 and 2010 appeared to be less than 20 years of age (< 145 cm fork length). Green sturgeon age at first maturity in the Klamath River is approximately 14 years for males and 16-20 years for females, which corresponds to 139 cm and 152-162 cm fork length, respectively (Van Eenennaam et al. 2006). Extensive life history information about green sturgeon is available in Beamesderfer et al. (2007).

A mapped representation of the spatial distribution of green sturgeon bycatch encounters in the limited entry trawl, limited entry California halibut and open access California halibut trawl sectors from 2002-2010 is provided in Figure 5. All observations were mapped as lines between the start and end coordinates of trawl tows. These data were the basis for a density calculation (parameters: radius 3 sq km, output cell size 500 m x 500 m). The density results were classified into 4 categories (zero values excluded) basically representing a scale from low, moderate, to high bycatch encounters of green sturgeon. Data within cells with less than 3 vessels were removed to ensure confidentiality. The spatial distribution of green sturgeon encounters relative to overall observations in these sectors indicate the highest likelihood of encounter is in shallow depths surrounding the Columbia River plume at the Washington and Oregon border and off of San Francisco Bay, California. Genetic analyses of green sturgeon in west coast rivers have determined that 97% of genetically analyzed green sturgeon samples collected in the Sacramento river belong to the southern DPS, and that the green sturgeon population found in the Columbia river is "composed almost exclusively" of green sturgeon from the southern DPS (Israel et al. 2009). The majority of bottom trawl fishing grounds do not encounter green sturgeon bycatch.

Pacific eulachon

A summary of eulachon bycatch in all U.S. west coast fisheries observed by the WCGOP and the A-SHOP from 2002-2010 is provided in Table 6. Eulachon bycatch was estimated for all fisheries observed by the

WCGOP in which eulachon were reported. Estimates were not provided for the pink shrimp trawl fisheries in 2002, 2003, and 2006 because these fisheries were not observed during these years.

Eulachon appears to be encountered in the at-sea hake fishery as bycatch in the catcher-processor sector of the fishery more than other sectors (Table 6). The highest eulachon bycatch in this mid-water trawl fishery was in the summer of 2006 with 145 individuals caught. In contrast, no eulachon were observed as bycatch in the bottom trawl fishery during 2006. The estimates of overall eulachon bycatch in 2002, 2003, and 2006 (Table 6) should be interpreted as the lowest possible estimates because pink shrimp fisheries were not observed in those years, and they traditionally contribute the largest proportion to eulachon bycatch estimates.

The depth distribution of all observed tows encountering eulachon bycatch from 2002-2010, inclusive, indicates that 86% of tows that encountered eulachon, as well as 86% of the eulachon encountered, were in the depth range of 60-90 fathoms. The shallowest observed tow that encountered eulachon was at 19.5 fathoms and the deepest observed tow was at 118.5 fathoms (Figure 3). Collection of eulachon length data will begin in 2012.

The largest amounts of eulachon bycatch were estimated in the Oregon pink shrimp trawl fishery. The largest number of eulachon observed on the Oregon fleet was in 2010 (88,373 individuals) and the smallest number of eulachon observed was in 2004 (11,291 individuals). The largest estimate of the Oregon fleet eulachon bycatch in this fishery occurred in 2009, when 845,081 individuals were estimated to have been caught (Table 4). Eulachon bycatch estimates from 2010 were also high (741, 203 individuals). In 2009, 4 of the 5 tows with the largest eulachon bycatch occurred during one observed fishing trip.

In 2010, fleet-wide pink shrimp landings in the California pink shrimp fishery were much lower than in the Oregon fishery (Table 4), and eulachon bycatch estimates were consequently also lower in California than in Oregon despite a higher bycatch ratio.

WCGOP observers were placed on Washington pink shrimp vessels beginning in 2010. Fleet-wide pink shrimp landings in the Washington pink shrimp fishery were much lower than in the Oregon fishery but higher than in the California fishery (Table 4). However, the eulachon bycatch estimate in Washington was lower than both the Oregon and California pink shrimp fisheries in 2010.

The largest estimate of coast-wide eulachon bycatch in the pink shrimp fishery occurred in 2010, when 1,075,081 individuals were estimated to have been caught (Table 4).

A mapped representation of the spatial distribution of eulachon bycatch encounters in the state pink shrimp trawl fisheries from 2002-2010 is provided in Figure 6. All observations were mapped as lines between the start and end coordinates of trawl tows. These data were the basis for a density calculation (parameters: radius 4 sq km, output cell size 300 m x 300 m). The density results were classified into 4 categories (zero values excluded) representing a scale from low, moderate, to high bycatch encounters of eulachon. Data within cells with less than 3 vessels were removed to ensure confidentiality. The spatial distribution of eulachon encounters relative to overall observation of the fishery indicates a high likelihood that eulachon may be encountered in the majority of pink shrimp fishing grounds.

Point estimates of bycatch fluctuate due to a number of non-biological factors, including annual variation in observer coverage rates, fishing behavior, and various physical characteristics. Currently, it is not possible to fully quantify uncertainty for bycatch estimates presented in this report, as measures of the variability associated with all data sources are not available. Estimates of observer data uncertainty are presented in this report in the form of confidence intervals around bycatch estimates.

Acknowledgements

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Figures

Figure 1. Fish ticket and logbook data processing for division into groundfish fishery sectors after retrieval of a full calendar year data set from the Pacific Fisheries Information Network (PacFIN) database. Grey highlight indicates sectors for which federal observer data are available.

Fish Ticket Processing

Logbook Processing
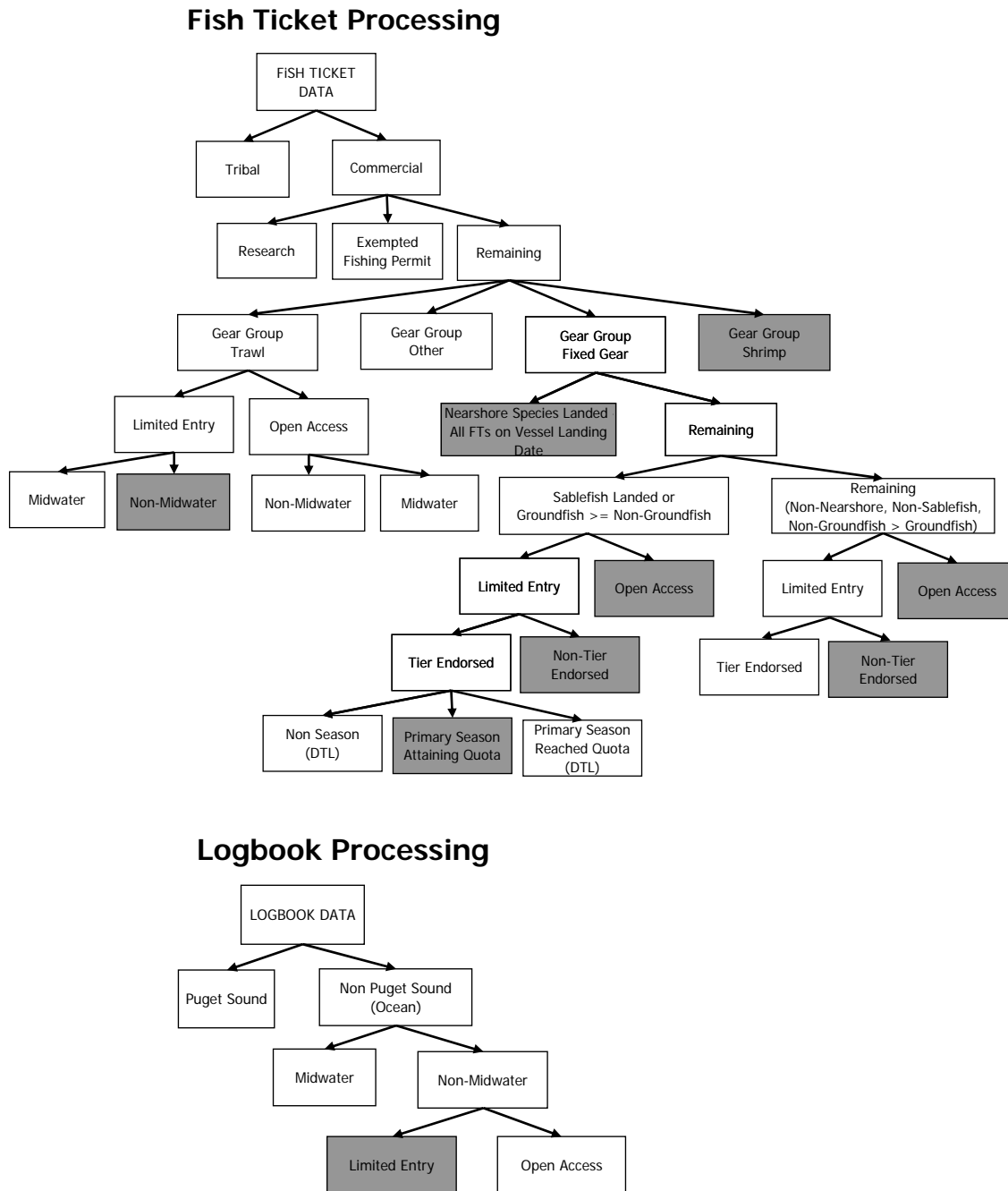
Figure 2. Depth distribution (every 5 fathoms) of A.) tows encountering green sturgeon bycatch and B.) the number of individual green sturgeon observed by the West Coast Groundfish Observer Program from 2002 through 2010 among all fishery sectors.
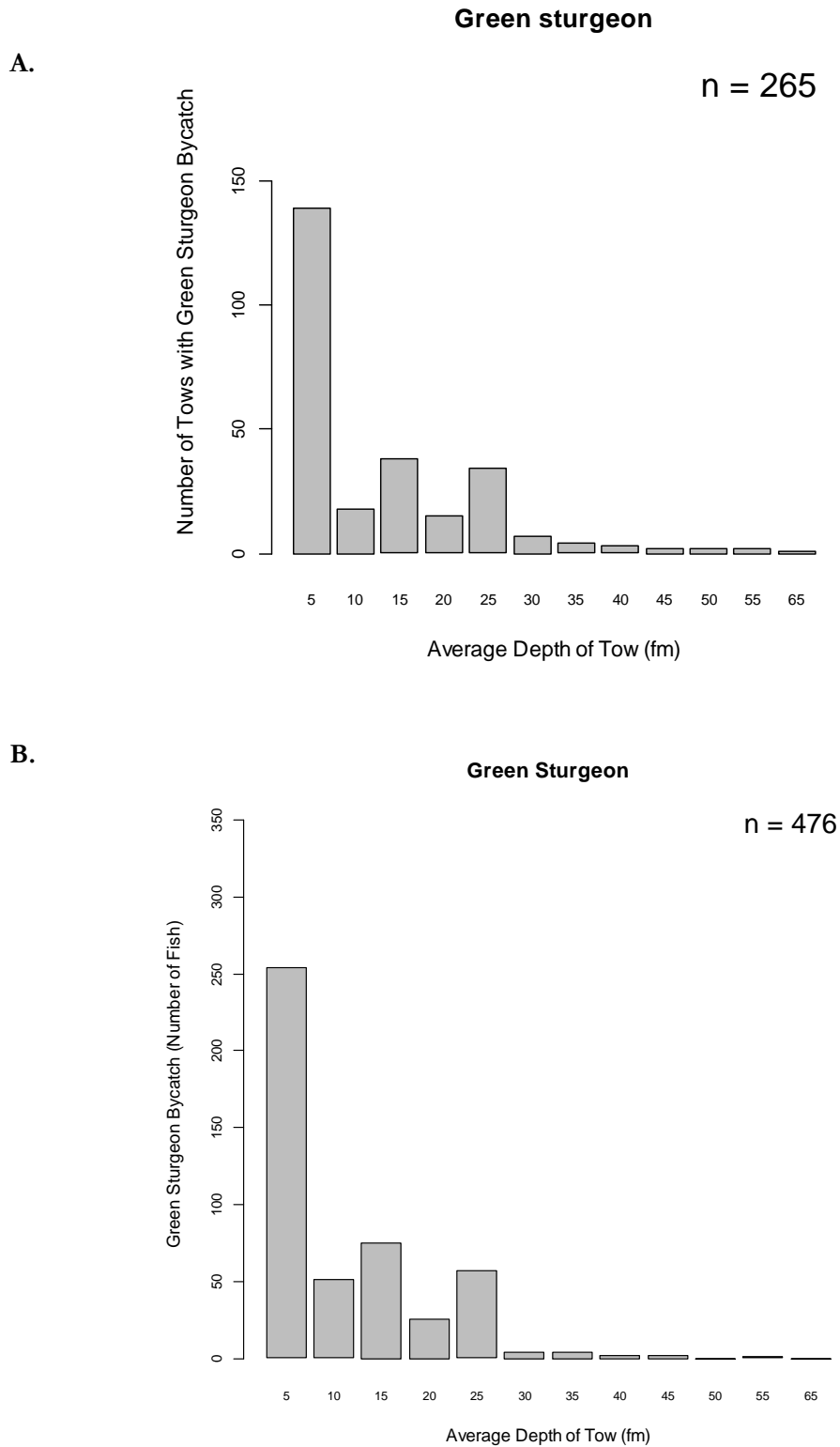
Figure 3. Depth distribution (every 5 fathoms) of A.) tows encountering eulachon bycatch and B.) the number of individual eulachon observed by the West Coast Groundfish Observer Program from 2002 through 2010 among all fishery sectors.
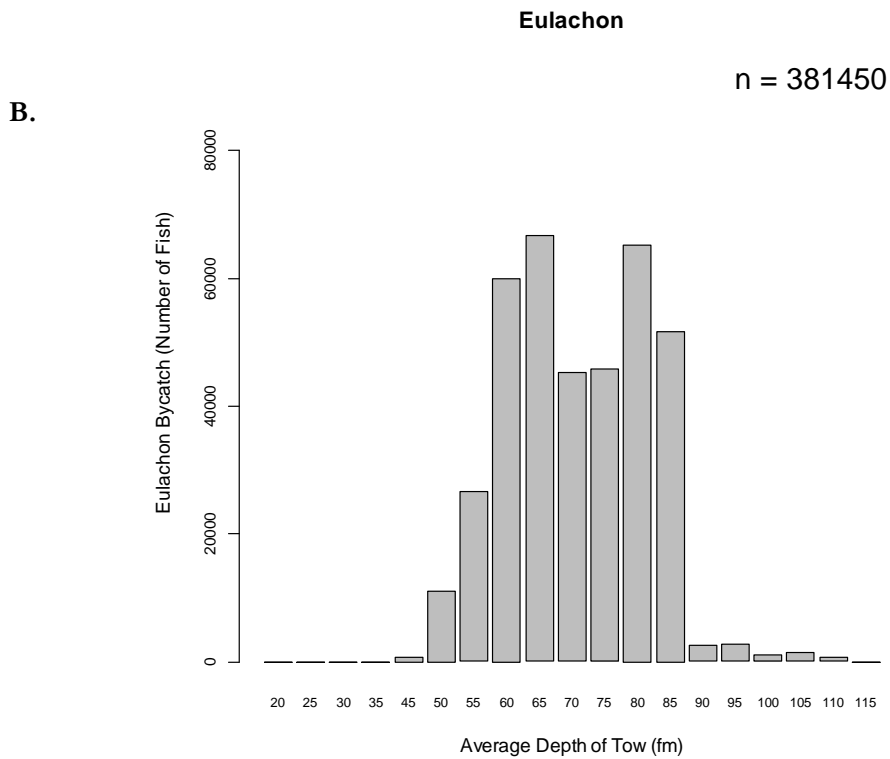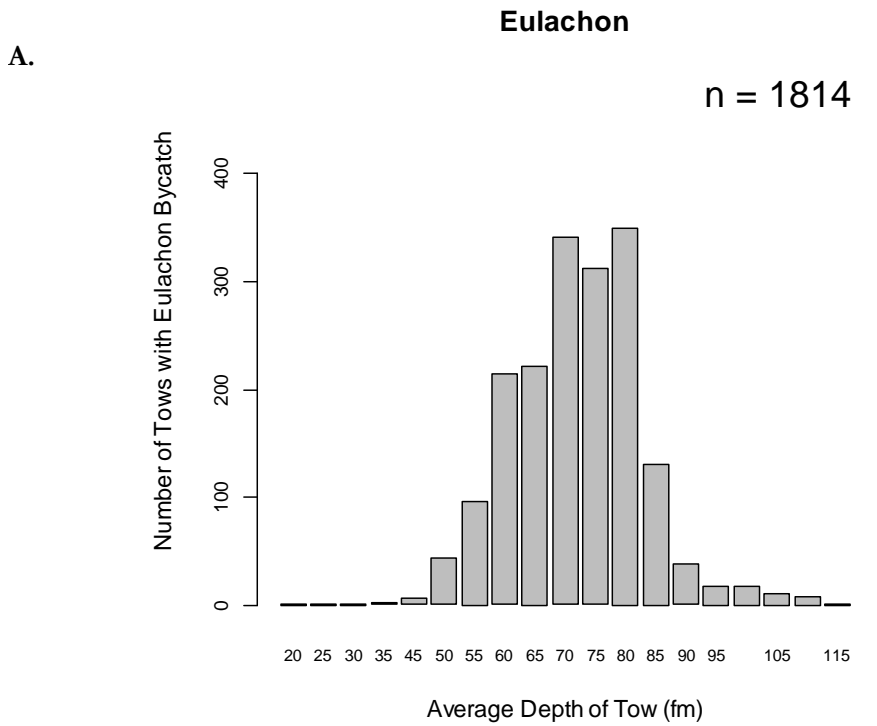
Figure 4. Length frequency distribution (every 2 cm) of discarded green sturgeon observed in the WCGOP observed sectors from 2007 through December 2010.
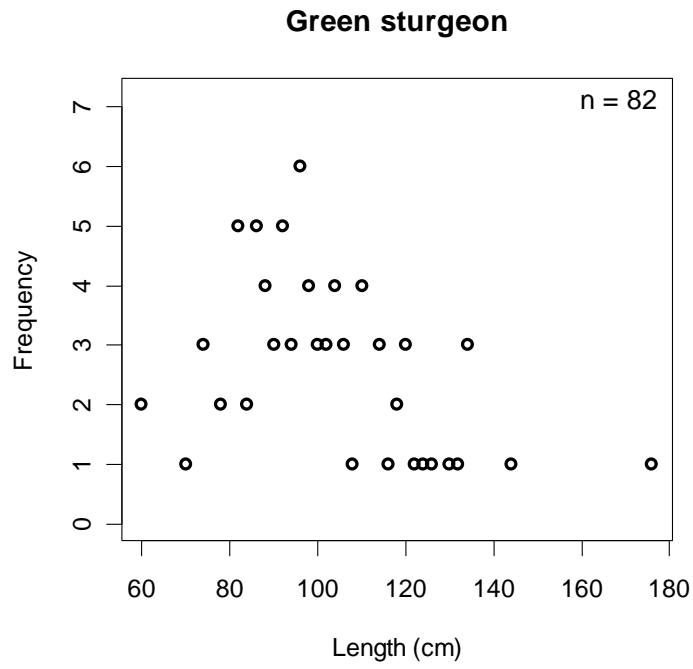
Green sturgeon

Figure 5. Spatial distribution of green sturgeon bycatch encounters in the limited entry trawl, limited entry CA halibut and open access CA halibut sectors from 2002-2010. All observations in the fishery were mapped as lines between the start and end coordinates of trawl tows. The data were the basis for a density calculation (parameters: radius 3 sq km, output cell size 500 m x 500 m). The density results were classified into 4 categories (zero values excluded) representing a scale from low, moderate, to high bycatch encounters of green sturgeon. Data representing less than 3 vessels have been removed to preserve confidentiality.
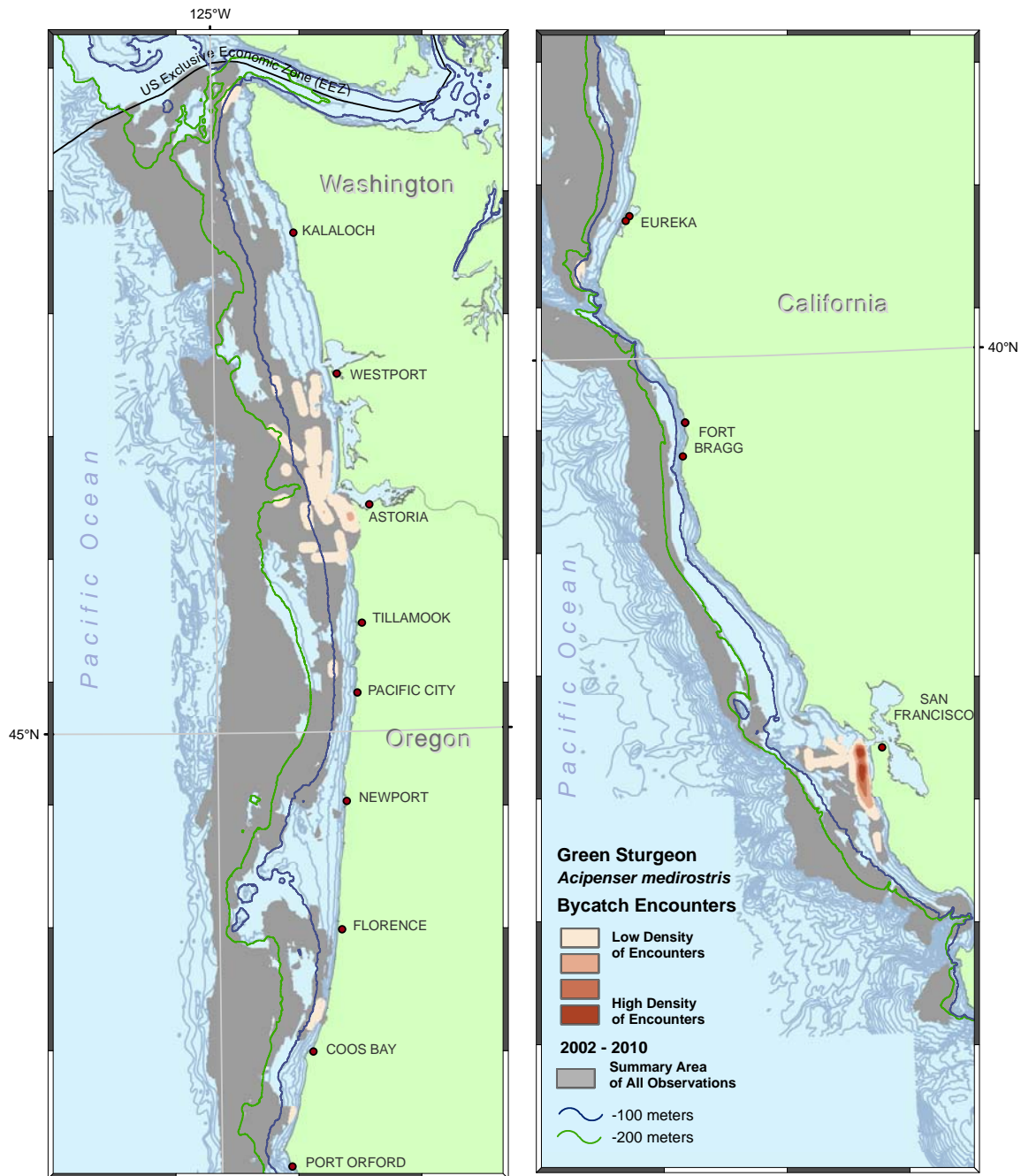
Figure 6. Spatial distribution of eulachon bycatch encounters in the state pink shrimp trawl fisheries from 2002-2010. All observations in the fishery were mapped as lines between the start and end coordinates of trawl tows. The data were the basis for a density calculation (parameters: radius 4 sq km, output cell size 300 m x 300 m). The density results were classified into 4 categories (zero values excluded) representing a scale from low, moderate, to high bycatch encounters of eulachon. Data representing less than 3 vessels have been removed to preserve confidentiality.
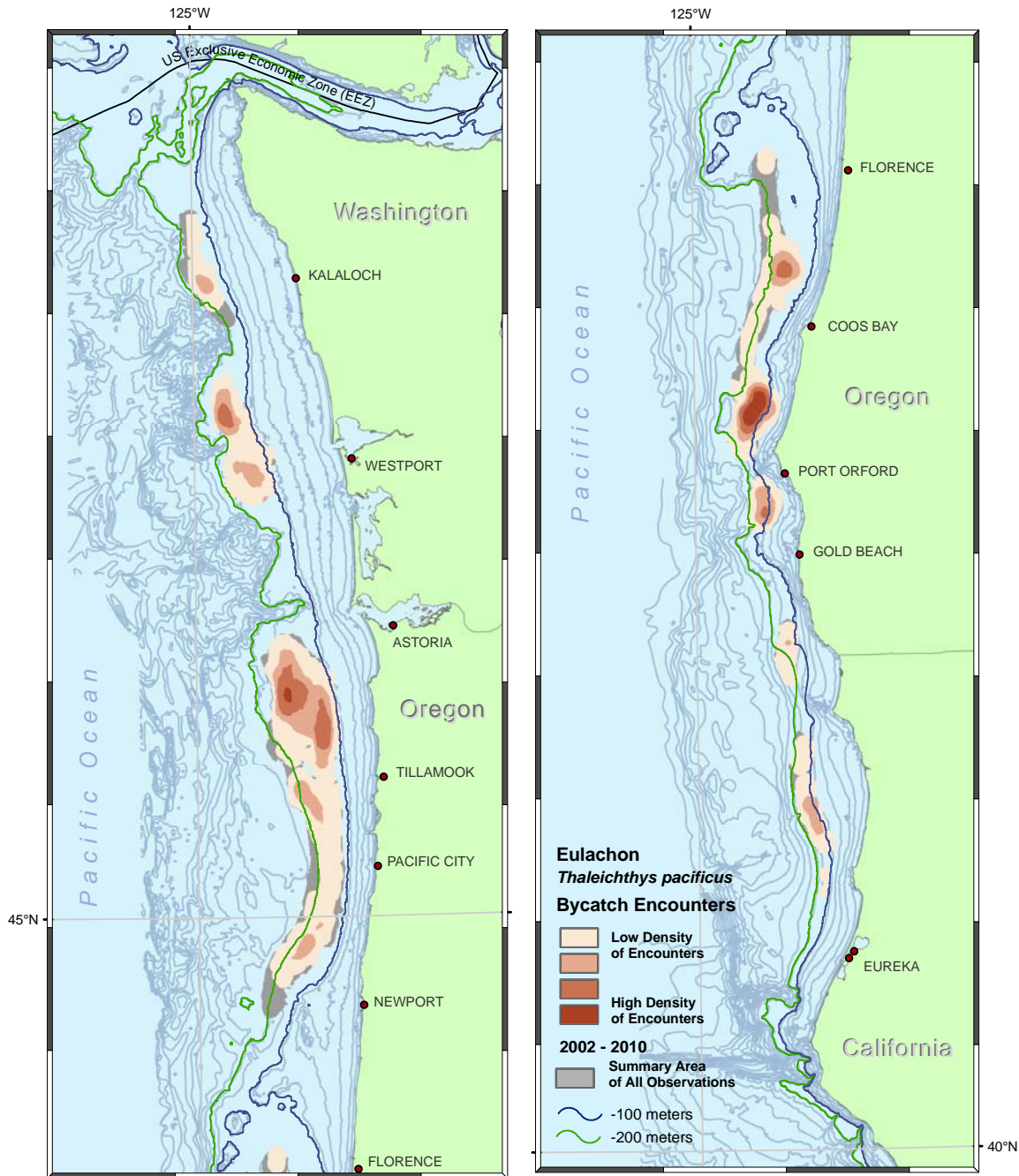
Tables

Table 1. Numbers of green sturgeon observed and bycatch ratios from limited entry bottom trawl vessels from 2002-2010. Bycatch ratios were calculated for each year by state of landing and season, as the observed catch of green sturgeon (in number of fish) divided by the observed weight (in mt) of retained groundfish (except Pacific hake). A fleet-wide bycatch estimate is obtained by multiplying the bycatch ratio by fleet-wide groundfish landings. Winter season is January-April and November-December; summer is May-October. Discard survivorship rates have not been applied to these bycatch estimates. C.I.'s are confidence intervals based on: 1) bycatch ratio standard errors, or 2) 95% quantiles of bootstrapped bycatch ratios, where fewer than three vessels were observed. Italicized bycatch ratios and bycatch estimates result from bootstrapping. Asterisks (*) signify strata with fewer than three observed vessels.

Year	Season	Washington Bycatch (no. of fish)	Observed Groundfish Catch (mt)	Bycatch Ratio	SE of Ratio	Fleet Groundfish Landings	Bycatch Estimate (no. of fish)	95% Confidence interval	Oregon Bycatch (no. of fish)	Observed Groundfish Catch (mt)	Bycatch Ratio	SE of Ratio	Fleet Groundfish Landings	Bycatch Estimate (no. of fish)	95% Confidence interval	California Bycatch (no. of fish)	Observed Groundfish Catch (mt)	Bycatch Ratio	SE of Ratio	Fleet Groundfish Landings	Bycatch Estimate (no. of fish)	95% Confidence interval	Coastwide Bycatch Estimate (no. of fish)	95% Confidence interval
2002	winter	0	303.31	0.00	NA	1332.88	0.00	0.00 / 0.00	1	609.69	0.00	0.00	4288.82	7.03	1.00 / 20.82	0	451.34	0.00	NA	3870.79	0.00	0.00 / 0.00	7	1 / 21
2002	summer	1	155.85	0.01	0.01	3105.37	19.92	1.00 / 58.98	1	537.93	0.00	0.00	3645.44	6.78	1.00 / 20.06	0	525.47	0.00	NA	3987.18	0.00	0.00 / 0.00	27	2 / 79
2003	winter	0	132.67	0.00	NA	1370.98	0.00	0.00 / 0.00	0	898.02	0.00	NA	4667.33	0.00	0.00 / 0.00	0	337.28	0.00	NA	3049.25	0.00	0.00 / 0.00	0	0 / 0
2003	summer	0	59.05	0.00	NA	674.22	0.00	0.00 / 0.00	0	576.14	0.00	NA	4624.93	0.00	0.00 / 0.00	0	582.12	0.00	NA	4217.79	0.00	0.00 / 0.00	0	0 / 0
2004	winter	0	345.45	0.00	NA	895.71	0.00	0.00 / 0.00	0	1,227.06	0.00	NA	4554.95	0.00	0.00 / 0.00	0	732.51	0.00	NA	2251.85	0.00	0.00 / 0.00	0	0 / 0
2004	summer	0	188.51	0.00	NA	958.32	0.00	0.00 / 0.00	2	1,032.69	0.00	0.00	5449.61	10.55	2.00 / 25.18	1	771.99	0.00	0.00	3682.22	4.77	1.00 / 14.12	15	3 / 39
2005	winter	0	174.17	0.00	NA	1004.31	0.00	0.00 / 0.00	0	1,268.84	0.00	NA	4850.76	0.00	0.00 / 0.00	0	503.43	0.00	NA	2531.28	0.00	0.00 / 0.00	0	0 / 0
2005	summer	1	426.55	0.00	0.00	2025.80	4.75	1.00 / 14.06	1	1,272.04	0.00	0.00	5826.62	4.58	1.00 / 13.56	0	596.64	0.00	NA	3128.81	0.00	0.00 / 0.00	9	2 / 28
2006	winter	0	92.16	0.00	NA	525.69	0.00	0.00 / 0.00	1	855.40	0.00	0.00	4346.20	5.08	1.00 / 15.04	0	367.89	0.00	NA	1961.07	0.00	0.00 / 0.00	5	1 / 15
2006	summer	0	304.90	0.00	NA	1323.38	0.00	0.00 / 0.00	0	1,210.62	0.00	NA	6644.09	0.00	0.00 / 0.00	0	607.45	0.00	NA	3076.23	0.00	0.00 / 0.00	0	0 / 0
2007	winter	0	170.95	0.00	NA	723.12	0.00	0.00 / 0.00	0	877.45	0.00	NA	6158.86	0.00	0.00 / 0.00	0	427.82	0.00	NA	2401.86	0.00	0.00 / 0.00	0	0 / 0
2007	summer	0	63.63	0.00	NA	879.67	0.00	0.00 / 0.00	1	1,199.38	0.00	0.00	6598.04	5.50	1.00 / 16.28	0	702.85	0.00	NA	3752.07	0.00	0.00 / 0.00	6	1 / 16
2008	winter	*	*	*0.00*	*NA*	794.01	*0.00*	*0.00 / 0.00*	0	1,401.01	0.00	NA	7999.89	0.00	0.00 / 0.00	0	575.62	0.00	NA	3242.34	0.00	0.00 / 0.00	0	0 / 0
2008	summer	0	324.40	0.00	NA	931.37	0.00	0.00 / 0.00	0	1,922.71	0.00	NA	7867.46	0.00	0.00 / 0.00	0	647.72	0.00	NA	3377.36	0.00	0.00 / 0.00	0	0 / 0
2009	winter	0	366.63	0.00	NA	1415.35	0.00	0.00 / 0.00	3	2,204.74	0.00	0.00	9030.64	12.29	3.00 / 30.24	0	545.35	0.00	NA	2875.26	0.00	0.00 / 0.00	12	3 / 30
2009	summer	0	402.83	0.00	NA	1280.37	0.00	0.00 / 0.00	6	1,895.09	0.00	0.00	7985.58	25.28	5.05 / 45.52	1	630.31	0.00	0.00	3572.25	5.67	1.00 / 16.78	31	6 / 62
2010	winter	0	282.50	0.00	NA	1237.30	0.00	0.00 / 0.00	0	931.46	0.00	NA	7488.44	0.00	0.00 / 0.00	0	203.76	0.00	NA	2176.57	0.00	0.00 / 0.00	0	0 / 0
2010	summer	0	221.87	0.00	NA	891.61	0.00	0.00 / 0.00	2	1,881.10	0.00	0.00	7509.31	7.98	2.00 / 19.05	0	579.62	0.00	NA	3106.97	0.00	0.00 / 0.00	8	2 / 19

Table 2. Numbers of green sturgeon observed and bycatch ratios from limited entry and open access California halibut bottom trawl vessels from 2002-2010. Bycatch ratios were calculated for each year by sector and season, as the observed catch of green sturgeon (in number of fish) divided by the observed weight (in mt) of retained California halibut. A fleet-wide bycatch estimate is obtained by multiplying the bycatch ratio by the fleet-wide California halibut landings. Winter season is January-April and November-December; summer is May-October. Discard survivorship rates have not been applied to these bycatch estimates. C.I.'s are confidence intervals based on: 1) bycatch ratio standard errors, or 2) 95% quantiles of bootstrapped bycatch ratios, where fewer than three vessels were observed. Italicized bycatch ratios and bycatch estimates result from bootstrapping. The open access sector was not observed in 2002 and 2006. Dashes (--) signify years when the sector was not observed. Asterisks (*) signify strata with fewer than three observed vessels.

Year	Season	Limited Entry — Bycatch (no. of fish)	CA Halibut Catch (mt)	Bycatch Ratio	SE of Ratio	Fleet CA Halibut Landings	Bycatch Estimate (no. of fish)	95% Confidence interval	Open Access — Bycatch (no. of fish)	CA Halibut Catch (mt)	Bycatch Ratio	SE of Ratio	Fleet CA Halibut Landings	Bycatch Estimate (no. of fish)	95% Confidence	Coastwide Bycatch Estimate (no. of fish)	95% Confidence interval
2002	winter	1	3.59	0.28	0.28	68.80	19.18	1.00 / 56.78	--	--	--	--	21.56	--	-- / --	19	1 / 57
2002	summer	*	*	*4.52*	*3.74 / 5.35*	36.38	*164.42*	*136.26 / 194.82*	--	--	--	--	14.21	--	-- / --	164	136 / 195
2003	winter	2	12.88	0.16	0.11	61.92	9.61	2.00 / 22.91	*	*	*1.45*	*0.19 / 3.17*	18.50	*26.87*	3.57 / 58.66	36	6 / 82
2003	summer	48	6.22	7.71	2.15	43.62	336.40	152.38 / 520.42	4	1.85	2.16	1.08	7.26	15.71	0.28 / 31.14	352	153 / 552
2004	winter	0	14.69	0.00	NA	79.88	0.00	0.00 / 0.00	2	0.91	2.20	1.55	29.63	65.30	2.00 / 155.55	65	2 / 156
2004	summer	58	16.80	3.45	0.74	56.45	194.91	113.25 / 276.58	*	*	*1.78*	*1.13 / 2.52*	41.26	*73.62*	46.62 / 103.90	269	160 / 380
2005	winter	18	10.73	1.68	0.72	131.43	220.43	36.11 / 404.76	6	2.04	2.94	2.09	24.09	70.82	6.00 / 169.40	291	42 / 574
2005	summer	98	19.78	4.95	0.81	57.44	284.57	193.27 / 375.87	*	*	*1.78*	*1.13 / 2.52*	40.42	*72.13*	45.68 / 101.80	357	239 / 478
2006	winter	108	11.07	9.75	1.77	80.61	786.17	507.28 / 1065.06	--	--	--	--	18.44	--	-- / --	786	507 / 1,065
2006	summer	0	3.21	0.00	NA	38.94	0.00	0.00 / 0.00	--	--	--	--	35.41	--	-- / --	0	0 / 0
2007	winter	6	3.00	2.00	1.14	27.42	54.79	6.00 / 115.91	0	0.78	0.00	NA	8.16	0.00	0.00 / 0.00	55	6 / 116
2007	summer	10	2.42	4.14	1.74	11.77	48.72	8.52 / 88.92	0	1.92	0.00	NA	30.95	0.00	0.00 / 0.00	49	9 / 89
2008	winter	44	9.51	4.58	0.93	35.79	163.79	98.49 / 229.08	0	0.86	0.00	NA	20.13	0.00	0.00 / 0.00	164	98 / 229
2008	summer	1	0.13	7.60	7.60	3.37	25.65	1.00 / 75.93	0	1.77	0.00	NA	30.23	0.00	0.00 / 0.00	26	1 / 76
2009	winter	--	--	*2.54*	*1.91 / 3.22*	40.75	*103.33*	77.98 / 131.26	*	*	*1.45*	*0.19 / 3.17*	39.27	*57.05*	7.58 / 124.52	160	86 / 256
2009	summer	18	2.90	6.21	1.82	7.59	47.14	20.09 / 74.19	*	*	*1.78*	*1.13 / 2.52*	46.11	*82.27*	52.11 / 116.12	129	72 / 190
2010	winter	*	*	*2.54*	*1.91 / 3.22*	33.13	*84.01*	63.41 / 106.72	0	0.69	0.00	NA	26.63	0.00	0.00 / 0.00	84	63 / 107
2010	summer	*	*	*4.52*	*3.74 / 5.35*	21.59	*97.57*	80.86 / 115.62	0	1.66	0.00	NA	40.22	0.00	0.00 / 0.00	98	81 / 116

Table 3. Numbers of eulachon observed and bycatch ratios from limited entry bottom trawl vessels from 2002-2010. Bycatch ratios were calculated for each year by state of landing and season, as the observed catch of eulachon (in number of fish) divided by the observed weight (in mt) of retained groundfish (except Pacific hake). A fleet-wide bycatch estimate is obtained by multiplying the bycatch ratio by fleet-wide groundfish landings. Winter season is January-April and November-December; summer is May-October. Discard survivorship rates have not been applied to these bycatch estimates. C.I.'s are confidence intervals based on: 1) bycatch ratio standard errors, or 2) 95% quantiles of bootstrapped bycatch ratios, where fewer than three vessels were observed. Italicized bycatch ratios and bycatch estimates result from bootstrapping. Asterisks (*) signify strata with fewer than three observed vessels.

Year	Season	WA Bycatch (no. of fish)	WA Groundfish Catch (mt)	WA Bycatch Ratio	WA SE of Ratio	WA Fleet Groundfish Landings	WA Bycatch Estimate (no. of fish)	WA 95% Confidence interval	OR Bycatch (no. of fish)	OR Groundfish Catch (mt)	OR Bycatch Ratio	OR SE of Ratio	OR Fleet Groundfish Landings	OR Bycatch Estimate (no. of fish)	OR 95% Confidence interval	CA Bycatch (no. of fish)	CA Groundfish Catch (mt)	CA Bycatch Ratio	CA SE of Ratio	CA Fleet Groundfish Landings	CA Bycatch Estimate (no. of fish)	CA 95% Confidence interval	Coastwide Bycatch Estimate (no. of fish)	Coastwide 95% Confidence interval
2002	winter	0	303.31	0.00	NA	1332.88	0.00	0.00 / 0.00	79	609.69	0.13	0.10	4288.82	552.98	78.61 / 1362.43	0	451.34	0.00	NA	3870.79	0.00	0.00 / 0.00	553	79 / 1,362
2002	summer	0	155.85	0.00	NA	3105.37	0.00	0.00 / 0.00	40	537.93	0.07	0.03	3645.44	267.88	68.04 / 467.73	0	525.47	0.00	NA	3987.18	0.00	0.00 / 0.00	268	68 / 468
2003	winter	0	132.67	0.00	NA	1370.98	0.00	0.00 / 0.00	10	898.02	0.01	0.01	4667.33	51.97	10.00 / 135.97	0	337.28	0.00	NA	3049.25	0.00	0.00 / 0.00	52	10 / 136
2003	summer	0	59.05	0.00	NA	674.22	0.00	0.00 / 0.00	0	576.14	0.00	NA	4624.93	0.00	0.00 / 0.00	0	582.12	0.00	NA	4217.79	0.00	0.00 / 0.00	0	0 / 0
2004	winter	0	345.45	0.00	NA	895.71	0.00	0.00 / 0.00	0	1,227.06	0.00	NA	4554.95	0.00	0.00 / 0.00	0	732.51	0.00	NA	2251.85	0.00	0.00 / 0.00	0	0 / 0
2004	summer	0	188.51	0.00	NA	958.32	0.00	0.00 / 0.00	0	1,032.69	0.00	NA	5449.61	0.00	0.00 / 0.00	1	771.99	0.00	0.00	3682.22	4.77	1.00 / 14.12	5	1 / 14
2005	winter	0	174.17	0.00	NA	1004.31	0.00	0.00 / 0.00	0	1,268.84	0.00	NA	4850.76	0.00	0.00 / 0.00	0	503.43	0.00	NA	2531.28	0.00	0.00 / 0.00	0	0 / 0
2005	summer	0	426.55	0.00	NA	2025.80	0.00	0.00 / 0.00	0	1,272.04	0.00	NA	5826.62	0.00	0.00 / 0.00	0	596.64	0.00	NA	3128.81	0.00	0.00 / 0.00	0	0 / 0
2006	winter	0	92.16	0.00	NA	525.69	0.00	0.00 / 0.00	0	855.40	0.00	NA	4346.20	0.00	0.00 / 0.00	0	367.89	0.00	NA	1961.07	0.00	0.00 / 0.00	0	0 / 0
2006	summer	0	304.90	0.00	NA	1323.38	0.00	0.00 / 0.00	0	1,210.62	0.00	NA	6644.09	0.00	0.00 / 0.00	0	607.45	0.00	NA	3076.23	0.00	0.00 / 0.00	0	0 / 0
2007	winter	0	170.95	0.00	NA	723.12	0.00	0.00 / 0.00	0	877.45	0.00	NA	6158.86	0.00	0.00 / 0.00	0	427.82	0.00	NA	2401.86	0.00	0.00 / 0.00	0	0 / 0
2007	summer	0	63.63	0.00	NA	879.67	0.00	0.00 / 0.00	13	1,199.38	0.01	0.01	6598.04	72.45	13.17 / 167.49	0	702.85	0.00	NA	3752.07	0.00	0.00 / 0.00	72	13 / 167
2008	winter	*	*	*0.00*	*NA*	794.01	*0.00*	*0.00 / 0.00*	0	1,401.01	0.00	NA	7999.89	0.00	0.00 / 0.00	0	575.62	0.00	NA	3242.34	0.00	0.00 / 0.00	0	0 / 0
2008	summer	0	324.40	0.00	NA	931.37	0.00	0.00 / 0.00	0	1,922.71	0.00	NA	7867.46	0.00	0.00 / 0.00	0	647.72	0.00	NA	3377.36	0.00	0.00 / 0.00	0	0 / 0
2009	winter	0	366.63	0.00	NA	1415.35	0.00	0.00 / 0.00	0	2,204.74	0.00	NA	9030.64	0.00	0.00 / 0.00	0	545.35	0.00	NA	2875.26	0.00	0.00 / 0.00	0	0 / 0
2009	summer	0	402.83	0.00	NA	1280.37	0.00	0.00 / 0.00	16	1,895.09	0.01	0.01	7985.58	67.42	16.00 / 184.22	0	630.31	0.00	NA	3572.25	0.00	0.00 / 0.00	67	16 / 184
2010	winter	0	282.50	0.00	NA	1237.30	0.00	0.00 / 0.00	0	931.46	0.00	NA	7488.44	0.00	0.00 / 0.00	0	203.76	0.00	NA	2176.57	0.00	0.00 / 0.00	0	0 / 0
2010	summer	0	221.87	0.00	NA	891.61	0.00	0.00 / 0.00	0	1,881.10	0.00	NA	7509.31	0.00	0.00 / 0.00	4	579.62	0.01	0.00	3106.97	21.44	4.00 / 51.15	21	4 / 51

Table 4. Numbers of eulachon observed and bycatch ratios from pink shrimp trawl vessels from 2002-2010. Bycatch ratios were calculated for each year by state of landing, as the observed catch of eulachon (in number of fish) divided by the observed weight (in mt) of retained pink shrimp. A fleet-wide bycatch estimate is obtained by multiplying the bycatch ratio by fleet-wide pink shrimp landings. Discard survivorship rates have not been applied to these bycatch estimates. C.I.'s are confidence intervals based on: 1) bycatch ratio standard errors, or 2) 95% quantiles of bootstrapped bycatch ratios, where fewer than three vessels were observed. Italicized bycatch ratios and bycatch estimates result from bootstrapping. Dashes (--) signify years when the fishery/sector was not observed. Asterisks (*) signify strata with fewer than three observed vessels.

Washington

Year	Observed Bycatch (no. of fish)	Observed Pink Shrimp Catch (mt)	Observed Bycatch Ratio	Observed SE of Ratio	Fleet Pink Shrimp Landings	Bycatch Estimate (no. of fish)	95% Confidence interval
2002	--	--	--	--	4,606.00	--	-- --
2003	--	--	--	--	3,580.61	--	-- --
2004	--	--	--	--	2,440.48	--	-- --
2005	--	--	--	--	2,841.81	--	-- --
2006	--	--	--	--	2,804.43	--	-- --
2007	--	--	--	--	1,517.39	--	-- --
2008	--	--	--	--	2,853.27	--	-- --
2009	--	--	--	--	3,179.98	--	-- --
2010	6,214	399.48	15.56	1.90	4,295.60	66,820.48	50,803 82,838

Oregon

Year	Observed Bycatch (no. of fish)	Observed Pink Shrimp Catch (mt)	Observed Bycatch Ratio	Observed SE of Ratio	Fleet Pink Shrimp Landings	Bycatch Estimate (no. of fish)	95% Confidence interval
2002	--	--	--	--	18,898.25	--	-- --
2003	--	--	--	--	9,327.75	--	-- --
2004	11,291	426.57	26.47	6.14	5,537.01	146,559.94	79,955 213,165
2005	11,669	402.89	28.96	6.96	7,159.42	207,361.80	109,683 305,041
2006	--	--	--	--	5,531.82	--	-- --
2007	14,084	649.98	21.67	7.32	9,128.60	197,807.20	66,925 328,689
2008	22,634	672.49	33.66	5.66	11,575.86	389,603.51	261,194 518,013
2009	63,175	751.20	84.10	23.65	10,048.69	845,081.24	379,221 1,310,942
2010	88,373	1,700.29	51.98	4.44	14,260.61	741,202.87	617,202 865,204

California

Year	Observed Bycatch (no. of fish)	Observed Pink Shrimp Catch (mt)	Observed Bycatch Ratio	Observed SE of Ratio	Fleet Pink Shrimp Landings	Bycatch Estimate (no. of fish)	95% Confidence interval
2002	--	--	--	--	1,870.59	--	-- --
2003	--	--	--	--	978.24	--	-- --
2004	*	*	*71.51*	*35.52 122.93*	996.82	*71,281.23*	*35,403 122,535*
2005	*	*	*71.51*	*35.52 122.93*	860.62	*61,541.53*	*30,566 105,792*
2006	--	--	--	--	63.58	--	-- --
2007	*	*	*71.51*	*35.52 122.93*	289.04	*20,668.99*	*10,266 35,531*
2008	*	*	*71.51*	*35.52 122.93*	945.48	*67,609.80*	*33,580 116,224*
2009	*	*	*71.51*	*35.52 122.93*	1,183.51	*84,631.12*	*42,034 145,484*
2010	40,040	265.53	150.79	55.45	1,771.02	267,057.36	74,589 459,526

Coastwide

Year	Bycatch Estimate (no. of fish)	95% Confidence interval
2002	--	-- --
2003	--	-- --
2004	217,841	115,358 335,700
2005	268,903	140,249 410,833
2006	--	-- --
2007	218,476	77,191 364,220
2008	457,213	294,773 634,237
2009	929,712	421,254 1,456,426
2010	1,075,081	742,594 1,407,567

Table 5. Estimated bycatch of green sturgeon (number of individual fish) in all U.S. west coast fisheries observed by the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP) from 2002-2010. The open access CA halibut sector was not observed in 2002 and 2006. Italicized bycatch estimates result from bootstrapping due to fewer than three observed vessels in those strata. Dashes (--) signify years when the fishery/sector was not observed.

		Green Sturgeon Bycatch Estimates (number of fish)								Total Green Sturgeon	
		WCGOP					A-SHOP				
		LE Trawl			CA Halibut		At-Sea Hake				
					Limited entry	Open Access	Tribal Mothership	Non-Tribal Mothership	Catcher-Processor	Bycatch Estimate	95% Confidence interval
Year	Season	WA	OR	CA							
2002	winter	0	7	0	19	--	0	0	0	217	140
	summer	20	7	0	*164*	--	0	0	0		351
2003	winter	0	0	0	10	*27*	0	0	0	389	158
	summer	0	0	0	336	16	0	0	0		633
2004	winter	0	0	0	0	65	0	0	0	349	165
	summer	0	11	5	195	*74*	0	0	0		575
2005	winter	0	0	0	220	71	0	0	0	658	283
	summer	5	5	0	285	*72*	1	0	0		1,079
2006	winter	0	5	0	786	--	0	0	0	793	508
	summer	0	0	0	0	--	0	2	0		1,080
2007	winter	0	0	0	55	0	0	0	0	109	16
	summer	0	6	0	49	0	0	0	0		221
2008	winter	*0*	0	0	164	0	0	0	0	189	99
	summer	0	0	0	26	0	0	0	0		305
2009	winter	0	12	0	*103*	*57*	0	0	0	333	167
	summer	0	25	6	47	*82*	0	0	0		539
2010	winter	0	0	0	*84*	0	0	0	0	190	146
	summer	0	8	0	*98*	0	0	0	0		241

Table 6. Estimated bycatch of eulachon (number of individual fish) in all U.S. west coast fisheries observed by the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP) from 2002-2010. Pink shrimp fisheries were not observed in 2002, 2003, or 2006. Italicized bycatch estimates result from bootstrapping due to fewer than three observed vessels in those strata. Dashes (--) signify years when the sector was not observed.

		Eulachon Bycatch Estimates (number of fish)									Total Eulachon	
		WCGOP						A-SHOP				
		LE Trawl			Pink Shrimp			At-Sea Hake				
								Tribal Mothership	Non-Tribal Mothership	Catcher-Processor	Bycatch Estimate	95% Confidence interval
Year	Season	WA	OR	CA	WA	OR	CA					
2002	winter	0	553	0	--	--	--	0	0	0	821	147
	summer	0	268	0				0	0	0		1,830
2003	winter	0	52	0	--	--	--	0	0	0	52	10
	summer	0	0	0				0	0	0		136
2004	winter	0	0	0	--	146,560	71,281	0	0	0	217,846	115,359
	summer	0	0	5				0	0	0		335,714
2005	winter	0	0	0	--	207,362	61,542	0	0	0	268,903	140,249
	summer	0	0	0				0	0	0		410,833
2006	winter	0	0	0	--	--	--	0	0	0	145	NA
	summer	0	0	0				0	0	145		NA
2007	winter	0	0	0	--	197,807	20,669	0	0	0	218,559	77,204
	summer	0	72	0				0	4	6		364,387
2008	winter	*0*	0	0	--	389,604	67,610	0	2	37	457,256	294,773
	summer	0	0	0				0	4	0		634,237
2009	winter	0	0	0	--	845,081	84,631	30	0	30	929,848	421,270
	summer	0	67	0				2	6	0		1,456,610
2010	winter	0	0	0	66,820	741,203	267,057	0	0	0	1,075,102	742,598
	summer	0	0	21				0	0	0		1,407,618