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Leatherback Sea Turtle Bycatch in U.S. West Coast Groundfish Fisheries 2002-2019

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Figure Captions

Figure 1: The number of stranded leatherback turtles along the West Coast of the US in the stranding database that were not released alive (assumed dead) and were reported as human interaction or unknown (n = 130). Data were available up to 2020. Note the time axis (years) is not continuous. Years without stranding records were omitted from the plot to make it concise.

Figure 2: Stranding locations of leatherback turtles (not released alive) along the West Coast of the US with reported or approximated latitude/longitude data (n = 123; 7 strandings from AK were omitted). The two polygons outlined in black denote Pacific leatherback critical habitat, which was designated on January 26, 2012 (77 FR 4170).

Figure 3: The Open Access (OA) Pot fishery proportion of landings that were observed (observed landings [mt]/total landings [mt], top panel) and fleet-wide landed catch (metric tons, bottom panel) by year.

Figure 4: Probability of exceeding the number of entanglements of leatherback turtles in OA fixed gear fishery estimated using a statistical model with fixed bycatch rate (solid line) and another model including uncertainty in the bycatch rate (dashed line). The dotted grey vertical line represents the maximum allowable entanglements across 5 years (1.9) under the 2012 Biological Opinion for leatherback sea turtles in the U.S. West Coast groundfish fisheries.

Table Captions

Table 1: Observed number of vessels, trips, sets, pots and leatherback sea turtles (LBT takes), observed landed catch (mt = metric tons), total fleet-wide landings (mt = metric tons) and the proportion of landings that were observed (a.k.a., observation rate or coverage rate = observed catch/fleet-wide landings), for the Open Access (OA) pot fishery, 2003-2019.

Table 2: The observed number of leatherback turtle (LBT) entanglements, the observed groundfish landings, the bycatch ratio, and the total (fleet-wide) groundfish landings from OA fixed gear vessels fishing pot gear during the last two 5-year periods. Landings and LBT values are summed across years within each 5-year period; bycatch ratio is calculated as the number of LBT / observed landings for each 5-year period. The 2005-2009 values were used in the probability models. The estimated number of individuals caught by the fleet is the rounded estimated mean from the model that uses uncertainty in the rate parameter (see Table 3).

Table 3: Summary statistics of the number of entanglements based on 100,000 random draws from the fixed bycatch rate model (no uncertainty) and the model with uncertainty in bycatch rate. The models were only run for the 2005-2009 period which includes the single leatherback sea turtle take (2008). See text for model descriptions.

Table 4: Observed number of vessels, trips, sets, pots, observed landed catch (mt = metric tons), total fleet-wide landings (mt = metric tons) and the proportion of landings that were observed (a.k.a., observation rate or coverage rate = observed catch/fleet-wide landings), for the Limited Entry (LE) pot fishery, 2002-2019.

Table 5: Number of vessels, trips, sampled sets, unsampled sets, sampled landed catch (mt = metric tons), unsampled catch (metric tons) and the proportion of fleet-wide sets and fleet-wide catch that was sampled, for the Catch Shares pot fishery, 2011-2019. This fleet carries an observer on 100% of trips.

Table 6: Observed number of vessels, trips, sets, and catch (mt = metric tons), total fleet-wide landings (mt = metric tons) and the proportion of landings that were observed (a.k.a., scientific observation rate or scientific coverage rate = observed catch/fleet-wide landings), for the Electronic Monitoring (EM) Catch Shares pot fishery, 2015-2019. This fleet carries electronic monitoring equipment on 100% of trips for the purposes of catch accounting. Human observation for scientific purpose (e.g., protected species, biological samples) occurs on a randomly sampled subset of the fleet.

List of acronyms and abbreviations

A-SHOP: At-Sea Hake Observer Program

BiOp: Biological Opinion

CCL: Curved Carapace Length

CI: Confidence Interval

EEZ: Exclusive Economic Zone

ESA: Endangered Species Act

FMP: Fishery Management Plan

FR: Federal Register

IFQ: Individual Fishing Quota

ITS: Incidental Take Statement

LE: Limited Entry

mt: metric ton

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration

NOI: Northern Oscillation Index

NWFSC: Northwest Fisheries Science Center

OA: Open Access

PacFIN: Pacific Fisheries Information Network

PFMC: Pacific Fishery Management Council

RPM: Reasonable and Prudent Measure

US: United States

USFWS: United States Fish and Wildlife Service

WCGOP: West Coast Groundfish Observer Program

Introduction

ESA Section 7(a)(2) consultation and the Biological Opinion (BiOp) process

Section 7(a)(2) of the Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. § 1531, et seq.), and implementing regulations at 50 Code of Federal Regulations (CFR) Part 400 requires Federal agencies to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or result in adverse modification of their critical habitat.

Section 7(a)(2) requires Federal agencies to engage in consultations with either or both National Marine Fisheries Service (NMFS) and the US Fish and Wildlife Service (USFWS) when a federal agency determines that a proposed action may affect a listed species or designated critical habitat. Under Section 7(b)(3) of the ESA, if the activity "adversely affects" ESA-listed species, the agencies undergo formal consultation, which requires a Biological Opinion (BiOp). If incidental take is expected, section 7(b)(4) requires the consulting agency to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) to minimize such impacts and recommendations for further conservation measures.

The 2012 BiOp by NMFS determined that the components of the groundfish fishery were likely to adversely affect leatherback sea turtles. With respect to leatherback turtles interacting with US West Coast groundfish fisheries, the BiOp identified a set of non-discretionary terms and conditions as necessary to implement the RPMs identified in the BiOp. These terms and conditions relate to two main areas: a) management planning and take reporting; and b) take monitoring. The BiOp identified the take limit of leatherback turtles to be 0.38 turtles/year over a 5-year average not exceeding 1 turtle/yr.

Specific Terms and Conditions with respect to leatherback sea turtles that we will address in this report include:

- Preparation of biennial fleet-wide take estimates
- Updating reporting of take considered in the BiOp
- Identifying minimum coverage levels and monitoring goals for those fisheries with anticipated observable take

U.S. West Coast Groundfish Fishery

The U.S. West Coast groundfish fishery is a multi-species fishery that utilizes a variety of gear types. The fishery harvests species designated in the Pacific Coast Groundfish Fishery Management Plan (Groundfish FMP; PFMC 2020) and is managed by the Pacific Fishery Management Council (PFMC). Over 90 species are listed in the Groundfish FMP, including a variety of rockfish, flatfish, roundfish, skates, and sharks. These species are found in both federal (> 5.6 km from the coastline) and state waters (0-5.6 km from the coastline).

Groundfish are both targeted and caught incidentally by trawl nets, hook-&-line gears, and fish pots.

Under the FMP, the groundfish fishery consists of four management groups: limited entry, open access, recreational, and tribal. The Limited Entry (LE) encompasses all commercial fishers who hold a federal limited entry permit. The total number of limited entry permits is restricted. Vessels with an LE permit are allocated a larger portion of the total allowable catch for commercially desirable species, such as sablefish, than vessels without an LE permit. The Open Access (OA) encompasses commercial fishers who do not hold a federal LE permit. Some states require fishers to carry a state-issued permit for certain OA sectors (i.e., a subgroup of a fishery characterized by gear type, target species, and regulation). The recreational management group includes recreational anglers who target or incidentally catch groundfish species. Recreational fisheries are not covered by this report. The tribal management group includes native tribal commercial fishers in Washington State that have treaty rights to fish groundfish. Tribal fisheries also are not included in this report, with the exception of the observed tribal at-sea Pacific hake sector.

These four groups can be further subdivided into sectors based on gear type and target species. This report focuses on the OA Pot fishery, the only fishery to have an interaction with a leatherback sea turtle. The OA Pot fishery target non-nearshore groundfish with pot and trap gear and deliver catch to shore-based processors. Basic observation statistics for other pot fisheries observed by the NWFSC Observer Program are presented for comparison purposes.

Northwest Fisheries Science Center (NWFSC) Groundfish Observer Program

The NWFSC Groundfish Observer Program observes commercial sectors that target or take groundfish as bycatch. The observer program has two units: the West Coast Groundfish Observer Program (WCGOP) and the At-Sea Hake Observer Program (A-SHOP). For an overview of all fisheries covered by the NWFSC Observer Program, please see the fishery descriptions on the NWFSC website.

The WCGOP was established in May 2001 by NOAA Fisheries (a.k.a., National Marine Fisheries Service, NMFS) in accordance with the Groundfish FMP (50 CFR Part 660, 50 FR 20609). This regulation requires all vessels that catch groundfish in the US Exclusive Economic Zone (EEZ) from 5.6 to 370.4 kilometers from shore carry an observer when notified to do so by NMFS or its designated agent. Subsequent state rule-making has extended NMFS' ability to require vessels fishing in the state territorial zone (0-5.6 km from shore) to carry observers.

The NWFSC Groundfish Observer Program's goal is to improve estimates of total catch and discard by observing groundfish fisheries along the U.S. West Coast. The WCGOP and A-SHOP observe distinct sectors of the groundfish fishery. The WCGOP observes multiple sectors of the groundfish fisheries, including Individual Fishing Quota (IFQ) shore-side delivery of groundfish and Pacific hake, as well as, LE and OA fixed gear fisheries. Vessels in the IFQ fishery, a.k.a., Catch Share (CS), are required to carry an observer on 100% of their trips unless they also carry electronic monitoring equipment (EM). CS EM vessels are 100% monitored for catch accounting; however human observers for scientific observation (e.g., protect resources, biological sampling) are only deployed on a subset of randomly selected trips.

Leatherback turtles in the US West Coast EEZ

The leatherback turtle (*Dermochelys coriacea*) is the sole remaining member of the taxonomic family Dermochelyidae. All other extant sea turtles belong to the family Cheloniidae. Leatherbacks are the largest marine turtle, with a curved carapace length (CCL) of adults often exceeding 150 cm and front flippers that can span 270 cm (NMFS and USFWS, 1998). The leatherback's slightly flexible, rubber-like carapace is distinguishable from other sea turtles that have carapaces with bony plates covered with horny scutes. In adults, the carapace consists mainly of tough, oil-saturated connective tissue raised into seven prominent ridges and tapered to a blunt posterior point. The carapace and plastron are barrel-shaped and streamlined.

In the Pacific Ocean, two populations exhibit genetic discontinuity and marked separation: West Pacific and East Pacific (NMFS and USFWS, 2020). The East Pacific population nests primarily at beaches in Mexico and Costa Rica, with a single nesting season during boreal winter. The West Pacific metapopulation nests at beaches in Papua Barat (Indonesia), Papua New Guinea, Solomon Islands, and Vanuatu and exhibits a bimodal nesting pattern, with nesting peaks during the boreal winter (December-February) and boreal summer (May-July).

Adult and sub-adult leatherbacks display several unique physiological and behavioral traits that enable this species to inhabit cold water, unlike other sea turtle species. These include a countercurrent circulatory system (Greer et al., 1973), a thick layer of insulating fat (Goff & Lien, 1988, Davenport et al., 1990), large body size that promotes thermal inertia limiting heat loss (i.e., gigantothermy; Paladino et al., 1990), and the ability to elevate body temperature through increased metabolic activity (Southwood et al., 2005, Bostrom & Jones, 2007, Bostrom et al., 2010). These adaptations also enable adult and sub-adult leatherbacks to have a larger geographic range than other sea turtle species. Leatherback turtles have the most extensive range of any living reptile and have been reported circumglobally. Adult and sub-adult leatherback turtles can forage in the cold temperate regions of the oceans and have been reported at latitudes as high as 71°N and 47°S. Distribution of the younger age class, juvenile leatherbacks (<100 cm curved carapace length), is limited to warmer tropical and sub-tropical waters and nesting is confined to tropical and subtropical latitudes (reviewed in Eckert et al., 2012).

Migratory routes of leatherback turtles have been documented by recent satellite telemetry studies. Adult leatherbacks undergo transoceanic migrations between nesting beaches and foraging areas within both the Atlantic and Pacific Ocean basins, migrating up to 10,000 km in a year (Ferraroli et al., 2004, Hays et al., 2004, James et al., 2005, Eckert, 2006, Eckert et al., 2006, Benson et al., 2007a, Benson et al., 2011). Leatherback turtles nesting in Central America and Mexico migrate thousands of kilometers into tropical and temperate waters of the eastern and central South Pacific (Eckert and Sarti, 1997, Shillinger et al., 2008). West

Pacific females that nest during the boreal summer make long-distance migrations into the Sulawesi and Sulu and South China Seas, the North Pacific Transition Zone and Sea of Japan, and the eastern North Pacific. In contrast, West Pacific leatherbacks that nest during the boreal winter migrate southward to foraging grounds in the western South Pacific Ocean and Tasman Sea, or nearby Indonesian seas including the Ceram, Molucca, and Banda seas (Benson et al., 2007a; Benson et al., 2011).

Leatherback turtles mainly eat gelatinous organisms, particularly of the class Scyphozoa, but other taxa including crustaceans, vertebrates, and plants are ingested (reviewed by Eckert et al. 2012, Dodge et al., 2011, Jones and Seminoff 2013). Because leatherbacks must consume large amounts of food to meet their energetic demands (Heaslip et al., 2012, Jones et al., 2012), it is important that they have access to areas of high productivity. Leatherback turtles tagged after nesting in July at Jamursba-Medi, Indonesia, arrived in waters off the US West Coast during July- August (Benson et al., 2007a, 2011) coinciding with the development of seasonal aggregations of jellyfish (Shenker, 1985, Larson, 1990, Suchman & Brodeur, 2005, Suchman et al., 2008). Other studies similarly have documented leatherback sightings along the Pacific coast of North America during the summer and autumn months, when large aggregations of jellyfish form (Starbird et al., 1993, Bowlby et al., 1994, Benson et al., 2007b). Leatherbacks primarily forage on cnidarians (jellyfish and siphonophores) and, to a lesser extent, tunicates (pyrosomes and salps; NMFS and USFWS, 2013). Turtle-borne video cameras, direct observations, and stable isotope studies have revealed that leatherbacks primarily consume Pacific sea nettles (*Chrysaora fuscescens*) at central California neritic foraging grounds (Benson et al. 2007b, Hetherington et al. 2019). Throughout the multiple foraging grounds utilized by western Pacific leatherbacks, various oceanic features such as water temperature, down-welling, Ekman upwelling, sea surface height, chlorophyll-a concentration, and mesoscale eddies affect the behavior of leatherbacks (Bailey et al., 2012, Benson et al. 2011).

Genetic evidence (Dutton et al. 1999, Dutton et al. 2000) and telemetry data from both nesting beaches and foraging areas (Benson et al. 2011) indicate that leatherback turtles found along the US West Coast are part of the West Pacific population. Combined stable isotopes and telemetry studies estimated that 38-57% of boreal summer nesting females at the largest remaining nesting beach complex in Indonesia travel across the Pacific to forage off the US West Coast (Seminoff et al., 2012; Benson et al. 2020). The nesting population at this beach complex has been declining at approximately 6% per annum (Tapilatu et al., 2013, Martin et al., 2020, NMFS and USFWS, 2020). The foraging population that occurs seasonally off the coast of California has been monitored using aerial surveys since 1990, and a recent assessment indicated that the foraging population has declined at 5.6% per annum, corresponding to an overall decline of 80%, since 1990 (Benson et al. 2020). The annual abundance of leatherback turtles in the California foraging area is also affected by oceanographic events, as illustrated by a positive linear relationship between the Northern Oscillation Index (NOI) and the estimated leatherback abundance (Benson et al., 2007b; Benson et al., 2020). Further, the arrival and departure of leatherbacks from the California Current Ecosystem can be predicted using upwelling indices at various latitudes with time lags, indicating effects of physical oceanography on leatherback turtles' presence in a foraging area, presumably because of oceanographic effects on leatherback prey (Eguchi et al. 2016). However, because the vast majority of survey effort has been focused over the continental shelf and up to 32 km from the coast, little information is available on the distribution and abundance of leatherback turtles in offshore waters. Foraging habitat of leatherback turtles off California primarily includes shallow nearshore waters, but offshore areas may also be used as foraging areas in some years if nearshore conditions are not favorable (Eguchi et al. 2016). Off Oregon and Washington, leatherbacks are known to forage in shallow nearshore and deeper offshore waters (Bowlby 1994, Benson et al. 2011, NMFS 2012). Critical habitat for leatherback turtles along the U.S. West Coast was designated in 2012 (77 FR 4169, 26 January 2012).

Methods

Data

Fisheries

Data sources for this analysis include onboard observer data (from WCGOP), and landing receipt data (referred to as fish tickets, obtained from the Pacific Fisheries Information Network; PacFIN). Observer data are the sole source for discard estimation in the U.S. West Coast groundfish fisheries. A list of fisheries, coverage priorities and data collection methods employed by WCGOP in each observed fishery included in this report can be found in the WCGOP manual (NWFSC 2020).

The sampling protocol employed by the WCGOP is primarily focused on the discarded portion of catch. To ensure that the recorded weights for the landed portion of the observed catch are accurate, haul-level retained catch weights recorded by observers are adjusted based on trip-level landing receipts (a.k.a., fish tickets). Fish tickets are issued to fish-buyers by a state agency and must be returned to that state agency for processing. When a vessel delivers fish to a port, fish tickets are completed by fish-buyers and represent either a single or multiple species. Fish ticket and species-composition data are submitted by state agencies to the PacFIN regional database (for details, see Appendix B in Somers et al., 2020b). Annual fish ticket landings data were retrieved from the Pacific Fisheries Information Network (PacFIN) database (April 2020) and subsequently divided into various sectors of the groundfish fishery (for details, see Appendix B in Somers et al., 2020b). For data processing purposes, species and species groups were defined based on management (for details, see Appendix B in Somers et al., 2020b). A complete listing of groundfish species is defined in the Pacific Coast Groundfish Fishery Management Plan (PFMC 2020).

Leatherback turtles

For leatherback turtles, we provide observed bycatch, sightings of leatherback turtles by observers aboard groundfish fishing vessels, and records of strandings. In the available datasets (2002-2019), one leatherback turtle has been reported entangled and killed in a groundfish fishing gear, whereas four leatherback turtles have been sighted by observers while aboard groundfish fishing vessels. The death occurred in 2008 (OA pot fishery), whereas the sightings occurred in 2005 (LE sablefish hook and line fishery), 2007 (LE bottom trawl fishery), 2011 (catch shares pot fishery) and 2014 (OA fixed gear fishery). In this report, we use the single lethal bycatch observation to determine the fleet-wide bycatch estimate of leatherback turtles for the OA pot fishery. All other fishery sectors and gears mentioned in this report and observed by the NWFSC Observer Program have never had an observed bycatch incident with a leatherback sea turtle, although opportunistic reports of entanglements by the public are reported to the NMFS Stranding Network.

Stranding data and at-sea reports of dead or entangled leatherbacks (henceforth 'stranding records') were obtained from the Marine Turtle Stranding Network database housed at the NMFS West Coast Regional Office, Long Beach, CA, and Seattle, WA. Stranding records are based on opportunistic discoveries of turtles; therefore, there is a greater probability of reports when and where there are greater concentrations of people along the coastline or engaged in marine activities. In addition, turtles may have drifted considerably post mortem, before subsequent reporting to the stranding networks. Consequently, the time-series of the number of stranded turtles and spatial distribution alone cannot be directly used to infer the change in strandings over time and space.

The quality of stranding records has improved over time, with more complete information available for recent records than for older records. To facilitate regional summaries and plotting of stranding records, missing geolocation information (latitude/longitude) within the database has been approximated based on location descriptions. Not all stranded turtles were dead, and some stranded leatherback turtles were revived and released back to the sea. For the summaries in this report, we have included all dead or not reported as released alive and therefore presumed dead stranded leatherback turtles. Only those strandings which were reported as human interaction or where human interactions could not be ruled out are reported here.

Bycatch Estimation

For some fisheries, there is 100% observer coverage or EM required on every trip. In these cases, we assume a complete census of sea turtles because sea turtle mortality is one of the highest priorities of observers, and crew are required to show all sea turtles to the cameras on EM vessels. For fisheries where there is less than 100% monitoring, we use a model based approach employing Bayesian methods.

Fisheries with less than 100% Observer Coverage

Fisheries observers monitor and record catch data on commercial fishing vessels by following protocols in the WCGOP manual (NWFSC 2020). Observer sampling focuses on discarded catch and supplements existing fish ticket landing receipt data to inform weights of retained catch. Observers generally sample 100% of tows or sets made during a trip. Because sea turtles are high priority for observers and because of their large size, we consider sea turtles to be a census sample of the catch.

Bycatch for the sampled portion of each fleet must be expanded to the unsampled portion of the fleet in fisheries where there is less than 100% observer monitoring. Ratio estimators have been widely used in discard estimation (Stratoudakis et al., 1999; Borges et al., 2005; Walmsley et al., 2007). This method relies heavily on the assumption that bycatch is proportional to some metric or proxy of fishing effort, such as fishery landings (Rochet and Trenkel, 2005). Rochet and Trenkel (2005) note that this assumption is often not supported by data and that in some cases, bycatch might vary nonlinearly or even be unrelated to the ratio denominator. Sea turtles are encountered so rarely by these fisheries that it is difficult to assess whether the number of bycatch events is indeed linked to levels of fishing effort. Furthermore, bycatch estimates produced using ratio estimators have been shown to be biased, particularly when observer coverage is low (Carretta and Moore 2014, Martin et al. 2015). To overcome the limitations of ratio estimators for estimating seabird bycatch, we applied a modeling approach.

Statistical Models

We applied two statistical models to characterize uncertainty in the leatherback turtle bycatch in the OA pot fishery. Because only one turtle was encountered as bycatch in this fishery, we were restricted to using simple statistical models while estimating variances of total bycatch. The first approach we used was the Poisson process model, where the total number of entanglements or bycatch events were assumed to follow a Poisson distribution:

$$n_{bycatch} \sim Poisson(\lambda_1 \cdot E_y)$$

In this approach, the Poisson rate or intensity parameter (λ_1, where $0 \leq \lambda_1 \leq 1$) was fixed at the annual bycatch point estimate (e.g., 1 bycatch event out of 1000 sets would lead to λ_1 = 0.001), and the effort for a particular year (E_y) was used to estimate the total bycatch. A caveat of this first approach was that by fixing λ_1, we were ignoring the uncertainty in the bycatch rate, making the 95% confidence intervals (CIs) overly narrow. For example, two fishery sectors might have the same bycatch point estimate, but if one sector fished with 10x as much effort, that second estimate would be more precise. To incorporate this uncertainty due to variable sample sizes, our second approach was to treat the rate parameter as a random variable (λ_2, where $0 \leq \lambda_2 \leq 1$). We did not use a common approach to model uncertainty in the proportion p of a Binomial distribution using the Normal approximation:

$$p \sim Normal\left(\hat{p}, \sqrt{\frac{\hat{p} \cdot (1-\hat{p})}{n}}\right)$$

where p is the estimated proportion and n is the sample size, because the 95% CIs can include negative values due to the small estimated proportion. To keep p positive, we instead simulated the number of bycatch events that would have occurred given a certain level of effort, and divided that result by effort. Using our previous numbers as an example:

$$\lambda_2 \sim Binomial(p = 0.001, E = 1000)/1000$$

Both approaches require at least one bycatch event. For each model, we generated 100,000 random draws from the distributions of potential bycatch and calculated summary statistics (mean, median, and variance) as well as measures of uncertainty (95% CIs).

Groundfish landings from OA fixed gear vessels fishing with pots were summarized in 5-year averages for three periods: 2005-2009, 2010-2014, and 2015-2019. Statistical models could only be applied to the 2005-2009 period because the only leatherback turtle take occurred in 2008. The model with uncertainty in the rate parameter was used as the estimate for the 2005-2009 period.

Statistical Software

The statistical software R (R Core Team, 2020) was used to produce the analyses, tables, figures in this report. Specifically, we relied heavily on the R packages:

- ggplot2 (Wickham, 2016) for plotting figures,
- knitr (Xie, 2020) for tables and dynamic reporting, and
- tidyverse (Wickham et al. 2019) & dplyr (Wickham et al. 2020) for data wrangling.

Results & Discussion

Strandings

From 1963 to 2020, there have been 130 reported leatherback sea turtle strandings along the US West Coast, including AK (n=7), WA (n=9), OR (n=1), and CA (n=113) (Hodge & Wing, 2000, R. LeRoux et al. in prep, NMFS/SWFSC unpublished data). The number of annual strandings, as defined above, fluctuated from 1 to 12 during years when at least one stranding was reported (Figure 1). Seven of the strandings indicated evidence of fishery interactions (1992, 1993, 1998, 2003, 2008, 2015, and 2019), with two in southern California, four in central California, and one in Oregon. No strandings have been reported in AK since 1993 (Figure 1). The reported or approximated stranding locations of leatherback turtles along the US West Coast were concentrated along central and southern California, including the Channel Islands (Figure 2).

Bycatch Estimates

No leatherback sea turtles were observed as bycatch in the most recent 5-year period (2015-2019). The single take observed in 2008 in the OA Pot fishery and reported in previous iterations of this report, remains the only observed take of leatherback sea turtles in fisheries observed by the NWFSC.

Comparison of estimates from the two models for the period that includes the single leatherback take (2008) are presented in Figure 4 and Table 3.

Minimum Observer Coverage

Fishing effort and observer coverage for the OA Pot fishery can be found in Figure 3 and Table 1. Other sectors that fish pot gear include the LE Sablefish Pot fishery, Catch Share

Pot fishery, and Electronic Monitoring Catch Share Pot fishery. Effort and observer coverage for these other sectors are provided in Tables 4, 5, and 6, respectively.

Reasonable and prudent non-discretionary measures for the ESA Section7(a)(2) 2012 BiOp includes "…identify[ing] goals for minimum [observer] coverage levels to achieve fleet-wide take estimates for leatherback sea turtles…and a plan for implementation." (p. 124). Unfortunately, the BiOp provides no guidance on the metrics needed to identify minimum goals for appropriate observer coverage. Interactions between leatherback sea turtles and U.S. West Coast groundfish vessels are extremely rare. To date only one leatherback sea turtle has been observed interacting with a groundfish vessel in the 16 years of observation of the OA Pot fishery. The lack of data makes any formal investigation into necessary observer coverage rates very challenging. The WCGOP stated target coverage rate (i.e., pre-observation) for the OA fixed gear fishery is to observe 5% of the groundfish landings (excluding Pacific hake). Realized coverage rates (i.e., post-observation) vary around the target coverage rate for a variety of reasons including (but not limited to), vessel activity, observer availability, logistics, safety and fishing effort. The WCGOP plans to maintain historic coverage rates (3-12%) in the OA fixed gear fishery where the single leatherback interaction occurred. Target coverage rates for other sectors are as follows: Catch Shares sectors 100%; LE sablefish 25-50%; CS EM 25-40%. Historic coverage rates by year and fishery sector can be found in Somers et al. (2020a).

Leatherback-specific terms and conditions

The NWFSC Groundfish Observer program maintains data of both observed sea turtle interactions with fishing vessels and sightings of sea turtles by at-sea observers on US West Coast groundfish vessels. The few records of sightings by the observers indicate that leatherback turtles occur in the fishing grounds. Additionally, tracking data indicate that three post-nesting leatherbacks with satellite-linked transmitters swam from beaches in Papua Barat, Indonesia to forage in Pacific Northwest waters, including the fishing grounds, during August-September of 2004, 2006, and 2008. The fact that the NWFSC Observer Program has only witnessed a total of five turtles, including one mortality, over an 18 year period suggests that sea turtle mortalities are extremely rare. In addition the behavior of leatherback turtles around pot gear buoys may have contributed to the 2008 mortality. Increasing observer coverage and obtaining data directly from fishers could shed light on the risks of pot gear to sea turtles.

Because only one leatherback turtle has been observed to be killed by this fishery between 2002 and 2019, it is possible that the likelihood of the fishery affecting the leatherback turtle population is low. However, the population of leatherback turtles that are interacting with this fishery is declining rapidly (Tapilatu et al., 2013, Benson et al. 2020). Curtis et al. (2015) estimated the local biological limit reference point (LRP) for the U.S. West Coast EEZ with one management objective to allow no more than 7.7 leatherback mortalities over five years (or an average of 1.54/year) if further declines are to be prevented. Consequently, leatherback sea turtle bycatch should be minimized to the greatest extent possible to sustain and eventually recover the population. Therefore, for rare but not negligible instances of interactions, some measures are necessary to reduce deaths of bycaught turtles.

The BiOp requires NMFS to provide information and training to observers regarding regulations requiring fishermen to properly handle, release, and resuscitate sea turtles, per 50 CFR 223.206(d)(1), and demonstrate these methods during observer training. In addition, the BiOp requires NMFS to educate observers on handling methods that will reduce sea turtle injury or mortality. The NWFSC Observer Program currently provides this information and training to all its observers. Observers are instructed on the safe handling, release, and resuscitation of sea turtles using model sea turtles in the classroom and a photo slide presentation following protocols set by NMFS (NMFS 2008, NWFSC 2020). Resuscitation procedures include the following steps: retain the sea turtle on a fishing vessel for a minimum period of 4 hours but not longer than 24 hours, place turtle on plastron, elevate hindquarters using a cushion, tire etc. (minimum 15 - 30 degrees) to permit the lungs to drain off water. Observers should rock sea turtle left to right raising edge of carapace 8 cm each time; keep turtle in the shade, at a temperature similar to the water temperature, and moist by covering with a wet towel and periodically spraying it with water in a freshly cleaned enclosed area; periodically test turtle for positive response to resuscitation by gently touching the corner of the eye or eyelid and pinching the tail near the vent to monitor consciousness. Sea turtles may take some time to revive. Turtles that are successfully resuscitated benefit from being held on deck as long as possible (up to 24 hours) to fully recover from the stress of accidental forced submergence. Observers are trained, and vessel crew are required, to release sea turtles from the stern or side of the vessel (or the trawl ramp if available) while the vessel's engines are in neutral position with all fishing gear out of the water.

NMFS shall provide information on sea turtle biology during groundfish observer training. Observers are instructed on the identifying characteristics of sea turtles using a dichotomous key. Each dichotomy is explained and shown using model sea turtles and photos in the classroom. Observers are instructed to take photos of the sea turtle from all angles to confirm identification if they encounter a sea turtle. When possible observers are instructed to collect biological data from the turtle, including carapace length and width, weight, tail length for sex determination, condition of specimen is noted, and, if a tag is present, the tag is photographed and documented.

Conservation Recommendations

The BiOp requires NMFS to assess the feasibility of collecting data to determine bycatch of jellyfish in the groundfish trawl fisheries. Identifying jellyfish to the species level in groundfish trawl fisheries is not feasible.

The large trawl nets used in these fisheries result in jellyfish that are not whole specimens. The U.S. West Coast bottom trawl survey run by the NWFSC has had little success identifying jellyfish. Jellyfish captured in trawl nets in both the survey and on commercial trawlers are most often recorded as jellyfish unidentified. Incorporating a protocol for identifying jellyfish to species would result in most jellyfish being recorded as unidentified due to poor condition, and any resulting data would be of low quality and value.

Concluding statement

Leatherback turtle entanglements in the groundfish fishery appear to be rare events. Because of the low observer coverage of the fishery, however, conclusive statements about leatherback turtle bycatch cannot be made without more data on overlap between the fishery and leatherback turtles. The large uncertainty in our bycatch estimate resulted from the extrapolation of observed bycatch rate to the entire fleet. If the bycatch rate was derived from a larger proportion of the total fleet, uncertainty around the estimate would have been smaller.

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Figures

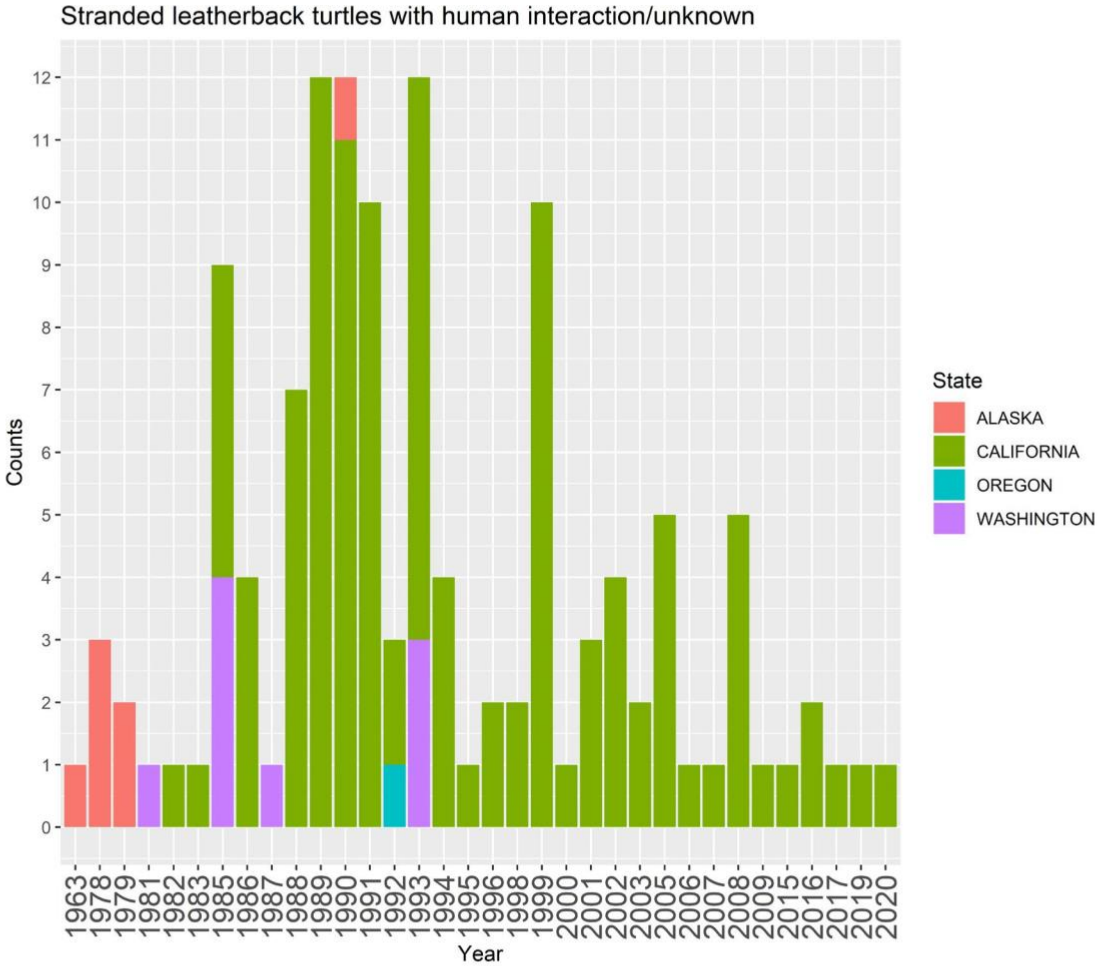

Figure 1: The number of stranded leatherback turtles along the West Coast of the US in the stranding database that were not released alive (assumed dead) and were reported as human interaction or unknown (n = 130). Data were available up to 2020. Note the time axis (years) is not continuous. Years without stranding records were omitted from the plot to make it concise.

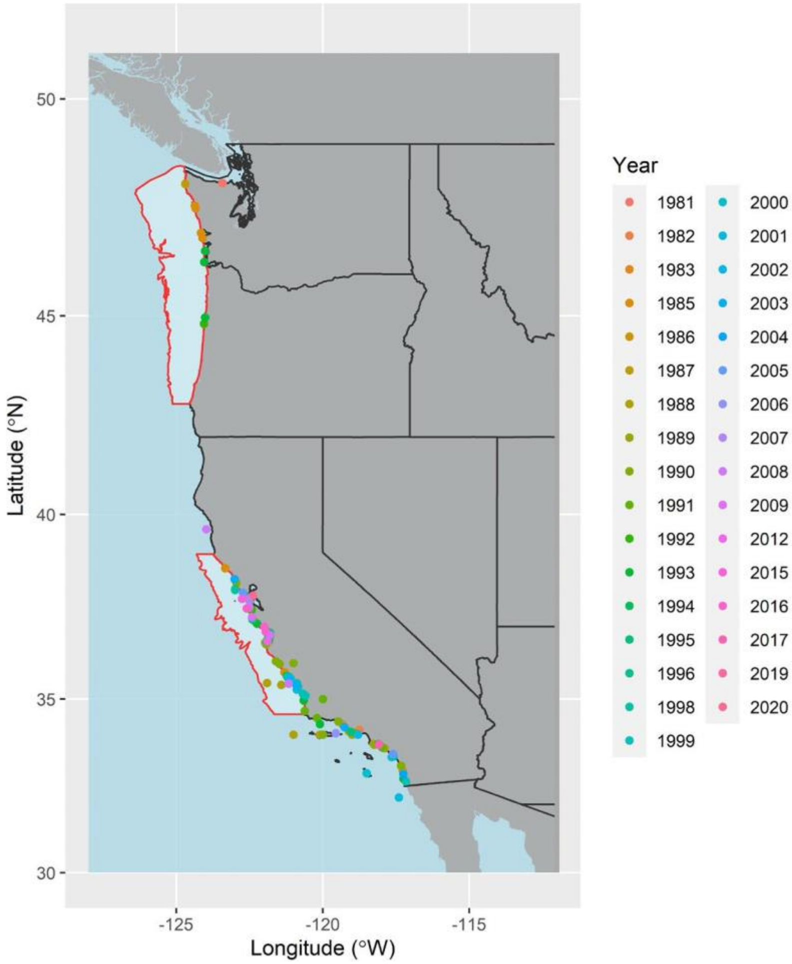

Figure 2: Stranding locations of leatherback turtles (not released alive) along the West Coast of the US with reported or approximated latitude/longitude data (n = 123; 7 strandings from AK were omitted). The two polygons outlined in red denote Pacific leatherback critical habitat, which was designated on January 26, 2012 (77 FR 4170).

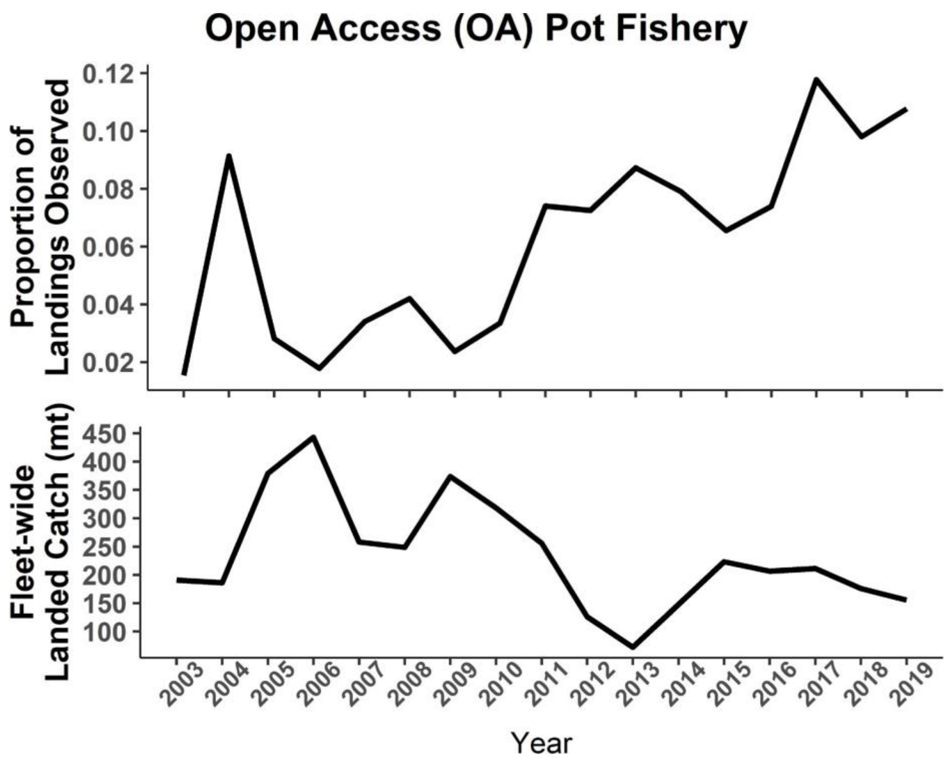

Figure 3: The Open Access (OA) Pot fishery proportion of landings that were observed (observed landings [mt]/total landings [mt], top panel) and fleet-wide landed catch (metric tons, bottom panel) by year.

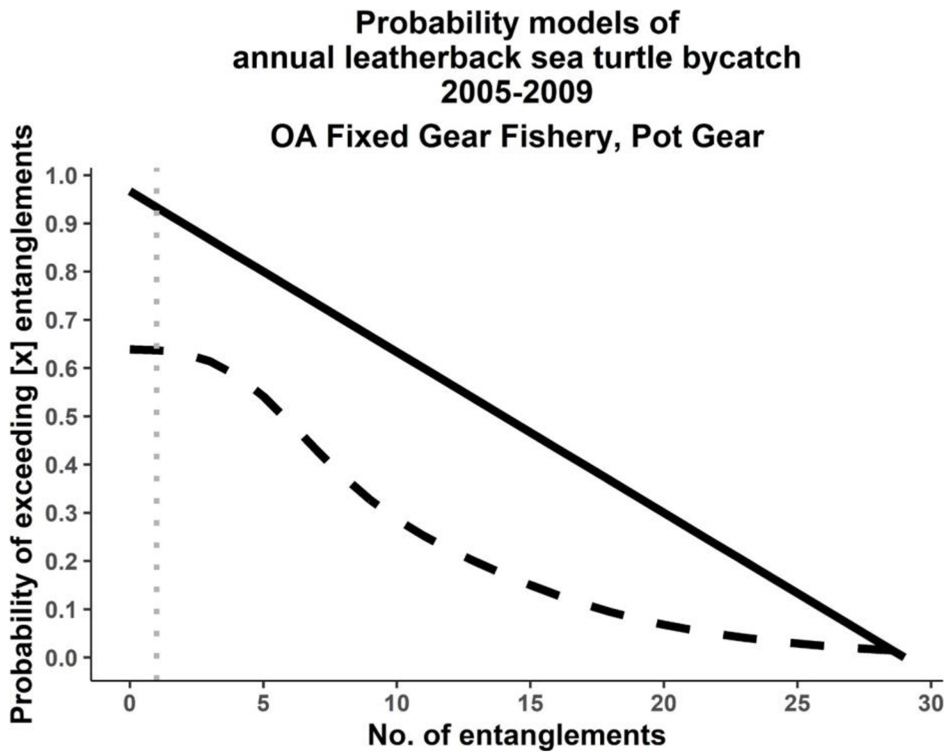

Figure 4: Probability of exceeding the number of entanglements of leatherback turtles in OA fixed gear fishery estimated using a statistical model with fixed bycatch rate (solid line) and another model including uncertainty in the bycatch rate (dashed line). The dotted grey vertical line represents the maximum allowable entanglements across 5 years (1.9) under the 2012 Biological Opinion for leatherback sea turtles in the U.S. West Coast groundfish fisheries.

Tables

			Observed					Fleet-wide		
Year	Sector	Gear	vessels	trips	sets	pots	LBT takes	catch	landings	proportion landed observed
2003	OA Fixed Gear	Pot	7	16	50	345	0	2.94	190.58	0.02
2004	OA Fixed Gear	Pot	17	96	185	1,950	0	16.99	186.03	0.09
2005	OA Fixed Gear	Pot	14	43	50	835	0	10.67	379.29	0.03
2006	OA Fixed Gear	Pot	15	38	39	666	0	7.90	442.93	0.02
2007	OA Fixed Gear	Pot	21	46	75	624	0	8.75	257.86	0.03
2008	OA Fixed Gear	Pot	20	55	75	833	1	10.43	248.39	0.04
2009	OA Fixed Gear	Pot	18	30	45	540	0	8.82	373.51	0.02
2010	OA Fixed Gear	Pot	26	40	71	648	0	10.66	318.28	0.03
2011	OA Fixed Gear	Pot	29	61	85	831	0	18.94	255.79	0.07
2012	OA Fixed Gear	Pot	19	35	70	610	0	9.13	125.94	0.07
2013	OA Fixed Gear	Pot	17	25	48	590	0	6.30	72.18	0.09
2014	OA Fixed Gear	Pot	21	41	63	686	0	11.66	147.70	0.08
2015	OA Fixed Gear	Pot	17	49	64	604	0	14.60	222.94	0.07
2016	OA Fixed Gear	Pot	27	55	73	687	0	15.27	206.50	0.07
2017	OA Fixed Gear	Pot	44	87	126	1,249	0	24.87	211.18	0.12
2018	OA Fixed Gear	Pot	33	58	89	892	0	17.22	175.66	0.10
2019	OA Fixed Gear	Pot	26	46	70	637	0	16.74	155.55	0.11

Table 1: Observed number of vessels, trips, sets, pots and leatherback sea turtles (LBT takes), observed landed catch (mt = metric tons), total fleet-wide landings (mt = metric tons) and the proportion of landings that were observed (a.k.a., observation rate or coverage rate = observed catch/fleet-wide landings), for the Open Access (OA) pot fishery, 2003-2019.

Five Year Period	Observed LBT (# indv.) 5 yr. sum	Observed Groundfish (mt) 5 yr. sum	Bycatch Ratio	Fleet-wide Groundfish (mt) 5 yr. sum	Estimated number of individuals caught by the fleet
2005-2009	1	46.6	0.02	1,702.0	7
2010-2014	0	56.7	0.00	919.9	0
2015-2019	0	88.7	0.00	971.8	0

Table 2: The observed number of leatherback turtle (LBT) entanglements, the observed groundfish landings, the bycatch ratio, and the total (fleet-wide) groundfish landings from OA fixed gear vessels fishing pot gear during the last three 5-year periods. Landings and LBT values are summed across years within each 5-year period; bycatch ratio is calculated as the number of LBT / observed landings for each 5-year period. The 2005-2009 values were used in the probability models. The estimated number of individuals caught by the fleet is the rounded estimated mean from the model that uses uncertainty in the rate parameter (see Table 3).

Statistic	Fixed rate	Rate with uncertainty
Minimum	0.00	0.00
Mean	7.32	7.38
Median	7.00	6.00
Maximum	22.00	70.00
Variance	7.35	60.28
Standard Deviation	2.71	7.76

Table 3: Summary statistics of the number of entanglements based on 100,000 random draws from the fixed bycatch rate model (no uncertainty) and the model with uncertainty in bycatch rate. The models were only run for the 2005-2009 period which includes the single leatherback sea turtle take (2008). See text for model descriptions.

			Observed				Fleet-wide		
Year	Sector	Gear	vessels	trips	sets	pots	catch (mt)	landings (mt)	proportion landed observed
2002	Limited Entry Sablefish	Pot	6	23	247	5,438	82.47	352.22	0.23
2003	Limited Entry Sablefish	Pot	6	35	362	9,017	148.31	603.97	0.25
2004	Limited Entry Sablefish	Pot	3	13	139	5,378	82.68	619.60	0.13
2005	Limited Entry Sablefish	Pot	7	39	492	13,822	281.18	615.00	0.46
2006	Limited Entry Sablefish	Pot	7	39	289	10,708	200.47	581.80	0.34
2007	Limited Entry Sablefish	Pot	4	30	154	5,816	89.97	428.37	0.21
2008	Limited Entry Sablefish	Pot	6	24	329	13,638	244.87	432.98	0.57
2009	Limited Entry Sablefish	Pot	3	27	67	3,883	66.48	489.07	0.14
2010	Limited Entry Sablefish	Pot	7	43	314	11,294	140.39	503.54	0.28
2011	Limited Entry Sablefish	Pot	3	22	227	9,029	137.42	371.93	0.37
2012	Limited Entry Sablefish	Pot	5	19	351	14,218	101.10	285.98	0.35
2013	Limited Entry Sablefish	Pot	3	14	47	1,934	40.52	283.13	0.14
2014	Limited Entry Sablefish	Pot	4	16	195	7,561	104.01	338.09	0.31
2015	Limited Entry Sablefish	Pot	9	35	299	11,329	218.78	358.21	0.61
2016	Limited Entry Sablefish	Pot	7	55	596	21,219	254.27	359.00	0.71
2017	Limited Entry Sablefish	Pot	3	14	186	7,852	115.46	374.80	0.31
2018	Limited Entry Sablefish	Pot	7	36	523	18,424	292.26	408.53	0.72
2019	Limited Entry Sablefish	Pot	5	24	427	17,518	206.91	410.87	0.50

Table 4: Observed number of vessels, trips, sets, pots, observed landed catch (mt = metric tons), total fleet-wide landings (mt = metric tons) and the proportion of landings that were observed (a.k.a., observation rate or coverage rate = observed catch/fleet-wide landings), for the Limited Entry (LE) pot fishery, 2002-2019.

					Sets		Catch (mt)		Proportion Sampled	
Year	Sector	Gear	vessels	trips	sampled	unsampled	sampled	unsampled	sets	catch
2011	Catch Shares	Pot	17	233	1,536	18	813.81	3.41	0.99	1.00
2012	Catch Shares	Pot	19	278	1,709	0	740.69	0.00	1.00	1.00
2013	Catch Shares	Pot	10	100	1,086	0	470.84	0.00	1.00	1.00
2014	Catch Shares	Pot	14	118	1,288	0	681.15	0.00	1.00	1.00
2015	Catch Shares	Pot	8	62	584	0	405.29	0.00	1.00	1.00
2016	Catch Shares	Pot	8	61	584	0	387.05	0.00	1.00	1.00
2017	Catch Shares	Pot	6	44	574	0	366.01	0.00	1.00	1.00
2018	Catch Shares	Pot	6	24	310	0	292.60	0.00	1.00	1.00
2019	Catch Shares	Pot	6	35	491	14	369.23	6.72	0.97	0.98

Table 5: Number of vessels, trips, sampled sets, unsampled sets, sampled landed catch (mt = metric tons), unsampled catch (metric tons) and the proportion of fleet-wide sets and fleet-wide catch that was sampled, for the Catch Shares pot fishery, 2011-2019. This fleet carries an observer on 100% of trips.

			Observed				Fleet-wide	
Year	Sector	Gear	vessels	trips	sets	catch (mt)	landings (mt)	proportion landed observed
2015	Catch Shares EM	Pot	7	18	184	102.37	339.38	0.30
2016	Catch Shares EM	Pot	6	19	249	151.96	445.51	0.34
2017	Catch Shares EM	Pot	7	22	270	184.12	493.71	0.37
2018	Catch Shares EM	Pot	5	24	321	166.43	414.76	0.40
2019	Catch Shares EM	Pot	6	30	197	127.31	491.12	0.26

Table 6: Observed number of vessels, trips, sets, and catch (mt = metric tons), total fleet-wide landings (mt = metric tons) and the proportion of landings that were observed (a.k.a., scientific observation rate or scientific coverage rate = observed catch/fleet-wide landings), for the Electronic Monitoring (EM) Catch Shares pot fishery, 2015-2019. This fleet carries electronic monitoring equipment on 100% of trips for the purposes of catch accounting. Human observation for scientific purposes (e.g., protected species, biological samples) occurs on a randomly sampled subset of the fleet.