2018 Leatherback sea turtle estimated bycatch reporting requirements as set out in the NMFS Biological Opinion for the continuing authorization of the Pacific Coast groundfish fisheries

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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

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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 non-discretionary 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 eulachon, green sturgeon, humpback whales, Steller sea lions, leatherback turtles, and were likely to destroy or adversely modify critical habitat of green sturgeon. 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 2011) 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-and-line, and fish pots/traps.

Under the FMP, the groundfish fishery consists of four management groups: limited entry, open access, recreational, and tribal fisheries. The Limited Entry (LE) fishery 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) fishery 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 fishery includes recreational anglers who target or incidentally catch groundfish species. Recreational fishery is not included in this report. The Tribal fishery includes native tribal commercial fishers in Washington State that have treaty rights to fish groundfish. Tribal fishery also is 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 multiple sectors. This report includes data from the following sectors.

Limited Entry (LE) sectors

- Individual fishing quota (a.k.a., catch shares) fishery (known as LE bottom trawl and at-sea hake from 2002 to 2010): this sector is subdivided into the following components due to differences in gear type and target species:
    - Bottom trawl: Bottom trawl nets are used to catch a variety of non-hake groundfish species. Catch is delivered to shore-based processors.
    - Midwater non-hake trawl/Midwater Rockfish: Midwater trawl nets are used to target mid-water non-hake species, mainly mid-water rockfish such as yellowtail and widow rockfish. Catch is delivered to shore-based processors.
    - Pot/traps: Pot/traps are used to target groundfish species, primarily sablefish. Catch is delivered to shore-based processors.
    - Hook-and-line: Longlines are primarily used to target groundfish species, mainly sablefish. Catch is delivered to shore-based processors.
    - Electronic Monitoring (EM) Exempted Fishing Permit (EFP): Some IFQ vessels fishing with bottom trawl, midwater trawl, or pots participate in the IFQ EM EFP. EM systems use video recordings to estimate weights of certain IFQ species that are allowed to be discarded at sea. Targets are similar to those targets described above for similar gear types.
    - Vessels fishing using pot or bottom trawl gear followed guidelines for optimized retention and could discard only certain allowed species; on those vessels, observer coverage was targeted at a random sample of 30% of trips to result in 25 to 30% of landings.
    - California halibut trawl: Bottom trawl nets are used to target California halibut by fishers holding a California state halibut permit and an LE federal trawl groundfish permit. Catch is delivered to shore-based processors.

  - Shoreside hake/Midwater hake: Midwater trawl nets are used to target Pacific hake. Catch is delivered to shore-based processors.
  - At-sea motherships and catcher-processors: Midwater trawl nets are used to catch Pacific hake. Catcher vessels deliver unsorted catch to a mothership. The catch is sorted and processed aboard the mothership. Catcher-processors catch and process fish at-sea and may receive unsorted catch from catcher vessels to process. This component also includes the at-sea processing component of the tribal sector. The tribal sector must operate within defined boundaries in waters off northwest Washington State.
- LE fixed gear (non-nearshore): This component is subdivided into two sub-components due to differences in permitting and management:
  - LE sablefish endorsed season: Longlines and pots are used to target sablefish. Catch is generally delivered to shore-based processors.
  - LE sablefish non-endorsed: Longlines and pots are used to target groundfish, primarily sablefish and thornyheads. Catch is delivered to shore-based processors or sold live dockside.

Open Access (OA) federal sector

- OA fixed gear (non-nearshore): Fixed gear, including longlines, pots, fishing poles, stick gear, etc. is used to target non-nearshore groundfish. Catch is delivered to shore-based processors.

Open Access (OA) state sectors

- OA pink shrimp trawl: Trawl nets are used to target pink shrimp. Catch is delivered to shore-based processors.
- OA California halibut trawl: Trawl nets are used to target California halibut by fishers holding a California state halibut permit. Catch is delivered to shore-based processors.

- Nearshore fixed gear: a variety of fixed gear, including longlines, pots, fishing poles, stick gear, etc. are used to target nearshore rockfish and other nearshore species managed by state permits in Oregon and California. Catch is delivered to shore-based processors or sold live at the dock.
- California ridgeback prawn trawl: Trawl nets are used to target prawn in California waters. Observers were first deployed in this fishery in 2017.
- **Pacific halibut hook-and-line derby:** Longline and hook-and-line vessels target Pacific halibut during single day openers as determined by the International Pacific Halibut Commission (IPHC). Observers were first deployed in this fishery in 2017.

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).

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 3 to 200 miles 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 (up to 3 miles 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, at-sea mothership catcher-vessels fishing for Pacific hake, LE and OA fixed gear, and state-permitted nearshore fixed gear sectors. The WCGOP also observes several state-managed fisheries that incidentally catch groundfish, including the California halibut trawl and pink shrimp trawl fisheries. The A-SHOP observes the IFQ fishery that targets Pacific hake at-sea including: catcher-processor, mothership, and tribal vessels.

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 point posteriorly. The carapace and plastron are barrel-shaped and streamlined.

In the Pacific Ocean, genetic studies have identified three distinct populations (referred to also as genetic stocks or Management Units; see Wallace et al., 2010) of leatherback turtles: (1) Mexico and Costa Rica, which are genetically homogenous but distinct from the western populations; (2) Papua Barat in Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu, which comprise a metapopulation representing a single genetic stock; and (3) Malaysia. The genetically distinct Malaysia nesting population is functionally extinct (Chan & Liew, 1996, Dutton et al., 1999).

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 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. 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. Nesting, however, is confined to tropical and subtropical latitudes (reviewed in Eckert et al., 2012). In the Pacific Ocean, nesting aggregations occur primarily in Mexico, Costa Rica, Indonesia, the Solomon Islands, and Papua New Guinea.

Migratory routes of leatherback turtles have been studied in recent years via satellite telemetry. These studies documented transoceanic migrations of adult leatherback turtles between nesting beaches and foraging areas in the Atlantic and Pacific Ocean basins, where they may migrate more than 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 South Pacific (Eckert and Sarti, 1997, Shillinger et al., 2008). Females from the western Pacific make long-distance migrations into the central and eastern North Pacific, westward to the Sulawasi and Sulu and South China Seas, northward to the North Pacific Transition Zone and the Sea of Japan, and south to the western South Pacific Ocean and Tasman Sea (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 California and Oregon during July- August of the following year (Benson et al., 2007a, 2011) coinciding with the development of seasonal aggregations of jellyfish

(Shenker, 1985, Larson, 1990, Suchman et al., 2008, Suchman & Brodeur, 2005). 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 (pyrosomas and salps; NMFS and USFWS, 2013). Within these ecosystems, various oceanic features such as water temperature, down-welling, Ekman upwelling, sea surface height, chlorophyll-a concentration, and mesoscale eddies influence the behavior of leatherbacks (Bailey et al., 2012, Benson et al. 2011, Eguchi et al. 2016).

Genetic evidence presented by Dutton et al. (2000) and telemetry data from both nesting beaches and foraging areas (Benson et al. 2011) indicated that leatherback turtles found along the west coast of the US are actually part of a distinct population originating in the western Pacific. These turtles nest on beaches in Indonesia whose population size has been declining at approximately 6% per annum (Tapilatu et al., 2013). A recent study using stable isotopes indicated that up to two thirds of boreal summer nesting females in Indonesia travel across the Pacific to reach the US west coast (Seminoff et al., 2012). Annual abundance of leatherback turtles in the California Current Ecosystem is affected by local oceanographic events. A positive linear relationship between the Northern Oscillation Index (NOI) and the estimated abundance in a foraging area has been reported (Benson et al., 2007b). Further, a recent study found that 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 through affecting abundance of their diet (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 along the west coast of the US appears to exist in shallow nearshore waters when the environmental condition is favorable but it is possible that the offshore areas may be used as their foraging areas in some years (Eguchi et al. 2016).

On January 26, 2012, NMFS designated critical habitat for leatherback turtles within the Pacific Ocean. This designation includes approximately 16,200 square miles (43,798 square kilometers) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour. In addition, approximately 25,004 square miles (64,760 square kilometers) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000-m depth contour was designated. The primary constituent elements essential to the conservation of leatherback turtles include prey, primarily scyphomedusae, of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of the species.

BiOp Terms and conditions

Data

Fisheries

Data sources for this analysis include onboard observer data (from the WCGOP and A-SHOP), and landing receipt data (referred to as fish tickets, obtained from the Pacific Fisheries Information Network; PacFIN). Observer and electronic monitoring 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 can be found in the IFQ and Non-IFQ WCGOP manuals (NWFSC 2013b). A-SHOP program information and documentation on data collection methods can be found in the A-SHOP observer manual (NWFSC 2013b).

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 single or multiple species. Fish ticket and species-composition data are submitted by state agencies to the PacFIN regional database. This process is described in further detail on the WCGOP Data Processing webpage (NWFSC 2013a). Annual fish ticket landings data were retrieved from the PacFIN database and subsequently divided into various sectors of the groundfish fishery as indicated in further detail online (NWFSC 2013c). For data processing purposes, species and species groups were defined based on management (NWFSC 2013c). A complete listing of groundfish species is defined in the Pacific Coast Groundfish Fishery Management Plan (PFMC 2011). Fishing effort and observer coverages for OA fixed gear, LE Sablefish, LE bottom trawl, and catch share are provided in Tables 1, 2, 3, and 4, respectively.

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 (2002-2017), one leatherback turtle has been reported entangled and killed in a groundfish fishing gear, whereas five leatherback turtles have been sighted. The death occurred in 2008 (OA pot fishery), whereas the sightings occurred in 2005 (LE sablefish endorsed hook and line fishery), 2007 (LE bottom trawl fishery), 2008 (OA fixed gear), 2011 (catch shares pot fishery), and 2014 (OA fixed gear, hook and line fishery). In this report, we use the single lethal bycatch datum 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.

Stranding data 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 discoveries of turtles; therefore, there is a greater probability of encountering turtles ashore when and where there are higher concentrations of people along the coastline. In addition, turtles may have drifted considerably following deaths and subsequent report 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.

From 1963 to 2017, there have been 135 reported leatherback sea turtle strandings along the west coast of the US, including AK, WA, OR, and CA (Hodge & Wing, 2000, R. LeRoux et al. in prep). The quality of data has improved over time, where complete information is available for more recent records than old records. Not all stranded turtles were dead and some stranded leatherback turtles were revived and released back to the sea (n = 7). The number of annual strandings, as defined above, fluctuated from 0 to 12 (Figure 1). Twelve indicated evidence of fishery interactions, where 11 were found in central and southern California and one in Oregon. The majority were in the state of California (118) and no strandings in AK have been reported since 1993 (Figure 1). The annual numbers of stranded leatherback turtles without evidence of human interaction were greatest in the early 1990s and declined thereafter. The stranding locations of leatherback turtles along the west coast of the US were concentrated along central and southern California, including the Channel Islands (Figure 2).

Bycatch Estimation

Statistical Model

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, $n_{bycatch} \sim Poisson(\lambda_1 \cdot N_y)$. 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 (N_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, $p \sim Normal(\hat{p}, \sqrt{\frac{\hat{p}(1-\hat{p})}{n}})$, where $\hat{p}$ 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 this parameter (*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, $\lambda_2 \sim Binomial(p = 0.001, N = 1000)/1000$. 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 running averages for two periods; 2008-2012 and 2013-2017 (Table 5). Therefore, we present the annual average and five-year total landings. The observed annual average groundfish landings for the first period was 11.59 mt, whereas the fleet-wide total landing over the 5-yr period was 1313.31 mt. For the second period, they were 14.54 mt (annual average) and 871.52 mt (5-yr sum of fleet-wide landing).

Biennial fleet-wide take estimates

We estimated the total bycatch in the most recent two 5-year periods (2008-2012, 2013-2017,Table 5). No leatherback sea turtles were observed as bycatch in the most recent 5-year period (2013-2017) and thus, all U.S. west coast groundfish fisheries are below the BiOp take limit of 0.38 leatherbacks per year for the most recent 5-year period. Since 2003, there has only been one observed leatherback sea turtle caught in U.S. west coast groundfish fishing gear, which occurred in 2008 in the OA fixed gear fishery on a vessel fishing pot gear. The bycatch rate during the 2008-2012 period was 0.017. Given the observer coverage rate of approximately 3%, this produces an estimate of 23 individuals caught by the OA pot fleet during the 2008-12 period (Table 5). It is important to note that extrapolating the bycatch rate computed from only 3% observer coverage to the entire fleet results in large uncertainty.

Estimation of the fleet-wide bycatch is challenging because only one leatherback turtle has been observed taken in the U.S. west coast groundfish fisheries and observer coverage has been low in the OA fixed gear sector (<10%; Table 1). Therefore, to determine the risk of leatherback turtle entanglement in the OA fixed gear fishery, we provide probabilistic estimates of the number of entanglements for the period 2008-2012 (Figure 3) based on the two versions of the Poisson statistical model described above. We also provide summary statistics for each of the model outputs (Table 6). We could only apply these models for the period 2008-2012 because that was the only period in which a leatherback sea turtle was entangled in gear in a U.S. west coast groundfish fishery. Extrapolating these models beyond the 2008-2012 period or to other gear types or fishery sectors would not be appropriate.

For the 2008-2012 period, the model with a fixed bycatch rate (solid line, Figure 3) indicated that the probability of exceeding 1.9 leatherback entanglements in this 5-year period (grey dotted vertical line intersects with solid black line Figure 3) was >90%. Exceeding 1.9 leatherbacks is equivalent to exceeding an average of 0.38 leatherbacks per year for a 5-year period. If we model the bycatch rate with uncertainty, the probability of exceeding 1.9 entanglements drops to approximately 60% (grey dotted vertical line intersects with dashed black line, Figure 3). The probability of more than 1.9 entanglements decreased more rapidly when uncertainty was included in the model, compared to the model without uncertainty. The large variation in entanglement represented in both models (Figure 3 & Table 6) was a result of only a single bycatch incident in all U.S. west coast groundfish fisheries in the 15 years of observation (2003-2017).

Minimum Observer Coverage

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 14 years of observation. 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), resource availability, logistics, safety and fishing effort. The WCGOP plans to maintain historic coverage rates (3-6%) in the OA fixed gear fishery where the single leatherback interaction occurred (Table 1). Target coverage rates for other sectors are as follows: Catch Shares sectors 100%; Catch Shares EM vessels 16-36%; LE sablefish 25-30%; LE Daily Trip Limits 10%; OA ocean shrimp trawl 15%; state nearshore fisheries 7-10%; and California halibut fishery 3-5%; California ridgeback prawn fishery 11%; Pacific halibut derby fishery 7%. Historic coverage rates by year can be found on the NWFSC Observer Program webpage (Somers & Jannot 2014). The WCGOP will assess the feasibility of a formal investigation of observer coverage for leatherback sea turtle interactions as new data are collected.

Leatherback-specific terms and conditions

The NWFSC Groundfish Observer program maintains a database of both sea turtle interactions with fishing vessels and sightings of sea turtles by at-sea observers. The few records of sightings by the observers indicate that leatherback turtles occur in the fishing grounds. It is also possible that the observed bycatch was an extreme rare event because of the gear configurations and behavior of leatherback turtles where the fishery and turtles co-occur. These possibilities cannot be ruled out without collecting more data through increased observer coverage of all sectors or obtaining more information from fishers.

Because only one leatherback turtle has been observed to be killed by this fishery between 2003 and 2017, 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). Consequently, every turtle counts for sustaining and hopefully recovering 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 following protocols set by NMFS (e.g., NMFS 2008). Resuscitation procedures include the following steps: retain on a fishing vessel up to 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 for a period of 4 up to 24 hours. 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 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. Further, 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 in the classroom.

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 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. Only one bycatch event was recorded in one fishery over the last 15-year period. Because of the low observer coverage of the fishery, however, conclusive statements about leatherback turtle bycatch in the groundfish fishery in general cannot be made without more data on fishery (bycatch or no bycatch) and on overlap between the fishery and leatherback turtles. The large uncertainty resulted from the extrapolation of observed bycatch rate to the entire fleet of the OA fixed-gear fishery. 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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References

Bailey, H.B., Benson, S.R., Shillinger, G.L., Bograd, S.J., Dutton, P.H., Eckert, S.A., Morreale, S.J., Paladino, F. V, Eguchi, T., Foley, D.G., Block, B.A., Piedra, R., Hitipeuw, C., Tapilatu, R.F. & Spotila, J.R. (2012) Identification of distinct movement patterns in Pacific leatherback turtle populations influenced by ocean conditions. *Ecological Applications* 22: 735–747.

Benson, S.R., Dutton, P.H., Hitipeuw, C., Samber, B.P., Bakarbessy, J. & Parker, D.M. (2007a) Post-Nesting Migrations of Leatherback Turtles (*Dermochelys coriacea*) from Jamursba-Medi, Bird's Head Peninsula, Indonesia. *Chelonian Conservation and Biology* 6: 150–154.

Benson, S.R., Forney, K.A., Harvey, J.T., Carretta, J. V & Dutton, P.H. (2007b) Abundance, distribution, and habitat of leatherback turtles (*Dermochelys coriacea*) off California, 1990−2003. *Fishery Bulletin* 105: 337–347.

Benson, S.R., Eguchi, T., Foley, D.G., Forney, K.A., Bailey, H., Hitipeuw, C., Samber, B.P., Tapilatu, R.F., Rei, V., Ramohia, P., Pita, J. & Dutton, P.H. (2011) Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. *Ecosphere* 2: Article 84.

Bostrom, B.L. & Jones, D.R. (2007) Exercise warms adult leatherback turtles. *Comparative biochemistry and physiology. Part A, Molecular & integrative physiology* 147: 323–331.

Bostrom, B.L., Jones, T.T., Hastings, M. & Jones, D.R. (2010) Behaviour and physiology: the thermal strategy of leatherback turtles. *PloS one* 5: e13925.

Bowlby, C.E., Green, G.A. & Bonnell, M.L. (1994) Observations of Leatherback Turtles Offshore of Washington and Oregon. *Northwestern Naturalist* 75: 33–35.

Chan, E.-H. & Liew, H.-C. (1996) Decline of the leatherback population in Terengganu, Malaysia, 1956-1995. *Chelonian Conservation and Biology* 2: 196–203.

Davenport, J., Holland, D.L. & East, J. (1990) Thermal and biochemical characteristics of the lipids of the leatherback turtle Demochelys coriacea: Evidence of endothermy. *Journal of the Marine Biological Association of the UK* 70: 33–41.

Dodge, K.L., Logan, J.M. & Lutcavage, M.E. (2011) Foraging ecology of leatherback sea turtles in the Western North Atlantic determined through multi-tissue stable isotope analyses. *Marine Biology* 158: 2813–2824.

Dutton, P.H., Bowen, B.W., Owens, D.W., Barragan, A.R. & Davis, S.K. (1999) Global phylogeography of the leatherback turtle (Demochelys coriacea). *Journal of Zoology* 248: 397–409.

Dutton, P.H., Frey, A., LeRoux, R., Balazs, G. (2000) Molecular ecology of leatherback turtles in the Pacific. In N. Pilcher, G. Ismail, and U. Sarawak, editors. Sea turtles of the Indo-Pacific: Research management and conservation. ASEAN Academic Press.

Eckert, S.A. and Sauti M., L. (1997) Distant fisheries implicated in the loss of the world's largest leatherback nesting population. Marine Turtle Newsletter 78:2-7.

Eckert, K.L., Wallace, B.P., Frazier, J.G., Eckert, S.A. & Pritchard, P.C.H. (2012) *Synopsis of the biological data on the leatherback sea turtle (Dermochelys coriacea). Biological Technical Publication.* Available at: http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1519.

Eckert, S.A. (2006) High-use oceanic areas for Atlantic leatherback sea turtles (*Dermochelys coriacea*) as identified using satellite telemetered location and dive information. *Marine Biology* 149: 1257–1267.

Eckert, S.A., Bagley, D.A., Kubis, S.A., Ehrhart, L.M., Johnson, C.C., Stewart, K.R. & DeFreese, D. (2006) Internesting and postnesting movements and foraging habitats of leatherback sea turtles (*Dermochelys coriacea*) nesting in Florida. *Chelonian Conservation and Biology* 5: 239–248.

Eguchi, T., Benson, S.R., Foley, D.G., Forney, K.A. 2016. Predicting overlap between drift gillnet fishery and leatherback turtle habitat in the California Current Ecosystem. Fisheries Oceanography 26:17-33.

Federal Register 2012. Final rule to revise the critical habitat designation for the endangered leatherback sea turtle. Available from http://www.nmfs.noaa.gov/pr/pdfs/fr/fr77-4170.pdf

Ferraroli, S., Georges, J.Y., Gaspar, P. & Maho, Y. Le (2004) Where leatherback turtles meet fisheries. *Nature* 429: 521–522.

Goff, G.P. & Lien, J. (1988) Atlantic leatherback turtles, *Dermochelys coriacea*, in cold water off Newfoundland and Labrador. *The Canadian Field-Naturalist* 102: 1–5.

Greer, A.E., Lazell, J.D. & Wright, R.M. (1973) Anatomical evidence for a counter-current heat exchanger in the leatherback turtle (*Dermochelys coriacea*). *Nature* 244: 181–181.

Hays, G.C., Houghton, J.D.R. & Myers, A.E. (2004) Pan-Atlantic leatherback turtle movements. *Nature* 429: 522.

Heaslip, S.G., Iverson, S.J., Bowen, W.D. & James, M.C. (2012) Jellyfish support high energy intake of leatherback sea turtles (*Dermochelys coriacea*): video evidence from animal-borne cameras. *PloS one* 7: e33259.

Hodge, R.P. & Wing, B.L. (2000) Occurrences of marine turtles in Alaska waters: 1960-1998. *Herpetological Review* 31: 148–151.

James, M.C., Eckert, S. a. & Myers, R. a. (2005) Migratory and reproductive movements of male leatherback turtles (*Dermochelys coriacea*). *Marine Biology* 147: 845–853.

Jones, T.T., Bostrom, B.L., Hastings, M.D., Van Houtan, K.S., Pauly, D. & Jones, D.R. (2012) Resource requirements of the Pacific leatherback turtle population. *PloS one* 7: e45447.

Jones, T.T., and J.A. Seminoff. (2013) Feeding Biology: Advances from Field-Based Observations, Physiological Studies, and Molecular Techniques. In: Musick, J., J. Wyneken, and K. Lohman (Eds.), Biology of the Sea Turtles, Volume 3. CRC Press, Boca Raton, FL., pp 211-248.

Larson, R.J. (1990) Scyphomedusae and cubomedusae from the eastern Pacific. *Bulletin of Marine Science* 47: 546–556.

Mast, R.B. and Hutchinson, B.J. (2005) The world's first global glimpse of leatherback nesting beaches. SWOT (The State of the World's Sea Turtles) Report, 1:14-15. Available from http://www.seaturtlestatus.org/report/view

NMFS 2008. Southeast Fisheries Science Center sea turtle research techniques manual. NOAA Technical Memorandum NMFS-SEFSC-579. Available from http://www.sefsc.noaa.gov/turtles/TM_579_SEFSC_STRTM.pdf

NMFS and USFWS 2013. Leatherback sea turtle (*Dermochelys coriacea*) 5-Year Review: Summary and Evaluation. Available from http://www.nmfs.noaa.gov/pr/listing/5yearreview_leatherbackturtle.pdf

NWFSC. 2013a. FOS Observer Program Data Processing. http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_processing.cfm

NWFSC. 2013b. FOS Observer Program Manuals. http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_collection/training.cfm

NWFSC. 2013c. WCGOP Data Processing Appendix. http://www.nwfsc.noaa.gov/research/divisions/fram/observation/xls/DataProcessingAppendix_2012Data_Final.xlsx

NWFSC. 2019 Training manual. West Coast Groundfish Observer Program. NWFSC, 2725 Montlake Blvd. East, Seattle, Washington, 98112.

Paladino, F. V, O'connor, M.P. & Spotila, J.R. (1990) Metabolism of leatherback turtles, gigantothermy, and thermoregulation of dinosaurs. *Nature* 344: 858–860.

PFMC. 2011. Pacific Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. http://www.pcouncil.org/wp-content/uploads/GF_FMP_FINAL_Dec2011.pdf

Seminoff, J.A., Benson, S.R., Arthur, K.E., Eguchi, T., Dutton, P.H., Tapilatu, R.F. & Popp, B.N. (2012) Stable isotope tracking of endangered sea turtles: validation with satellite telemetry and δ15N analysis of amino acids. *PLoS ONE* 7: e37403.

Shenker, J.M. (1985) Carbon content of the neritic scyphomedusa *Chrysaora fuscescens*. *Journal of Plankton Research* 7: 169–173.

Shillinger, G.L., Palacios, D.M., Bailey, H., Bograd, S.J., Swithenbank, A.M., Gaspar, P., Wallace, B.P., Spotila, J.R., Paladino, F. V, Piedra, R., Eckert, S.A. & Block, B.A. (2008) Persistent leatherback turtle migrations present opportunities for conservation. *PLoS biology* 6: e171.

Somers, K.A., J.E. Jannot, K. Richerson, V. Tuttle, & J. McVeigh. 2018. FOS coverage rates, 2002-2017. Last updated: July 2018. NOAA Fisheries, NWFSC Observer Program, 2725 Montlake Blvd E., Seattle, WA 98112. http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_products/sector_products.cfm#ob

Southwood, A.L., Andrews, R.D., Paladino, F. V & Jones, D.R. (2005) Effects of diving and swimming behavior on body temperatures of pacific leatherback turtles in tropical seas. *Physiological and biochemical zoology* 78: 285–297.

Starbird, C.H., Baldridge, A. & Harvey, J.T. (1993) Seasonal occurrence of leatherback sea turtles (*Dermochlys coriacea*) in the Monterey Bay region, with notes on other sea turtles, 1986-1991. *California Fish and Game* 79: 54–62.

Suchman, C., Daly, E., Keister, J., Peterson, W. & Brodeur, R. (2008) Feeding patterns and predation potential of scyphomedusae in a highly productive upwelling region. *Marine Ecology Progress Series* 358: 161–172.

Suchman, C.L. & Brodeur, R.D. (2005) Abundance and distribution of large medusae in surface waters of the northern California Current. *Deep Sea Research Part II: Topical Studies in Oceanography* 52: 51–72.

Tapilatu, R.F., Dutton, P.H., Tiwari, M., Wibbels, T., Ferdinandus, H. V, Iwanggin, W.G. & Nugroho, B.H. (2013) Long-term decline of the western Pacific leatherback , *Dermochelys coriacea*: a globally important sea turtle population. *Ecosphere* 4: 1–15.

Wallace, B.P., DiMatteo, A.D., Hurley, B.J., Finkbeiner, E.M., Bolten, A.B., Chaloupka, M.Y., Hutchinson, B.J., Abreu-Grobois, F.A., Amorocho, D., Bjorndal, K.A., Bourjea, J., Bowen, B.W., Dueñas, R.B., Casale, P., Choudhury, B.C., Costa, A., Dutton, P.H., Fallabrino, A., Girard, A., Girondot, M., Godfrey, M.H., Hamann, M., López-Mendilaharsu, M., Marcovaldi, M.A., Mortimer, J.A., Musick, J.A., Nel, R., Pilcher, N.J., Seminoff, J.A., Troëng, S., Witherington, B. & Mast, R.B. (2010) Regional management units for marine turtles: a novel framework for prioritizing conservation and research across multiple scales. *PloS one* 5: e15465.

Tables and Figures

Table 1. Fishing effort and observer coverage in the OA fixed gear from 2003 to 2017. Leatherback turtle entanglement occurred in 2008 using pot gear. Dark and light gray are used to indicate the two 5-yr periods that were used to compute moving averages in Table 5.

Year	Gear	# vessels	# trips	# hauls	# fixed gear units	Observed Retained (mt)	Landed (mt)	Coverage (%)
2003	Hook and Line	13	41	49	86518	16.54	544.89	3.0
2004	Hook and Line	14	42	52	85895	16.21	473.79	3.4
2005	Hook and Line	10	34	37	58384	9.78	623.95	1.6
2006	Hook and Line	7	10	11	29296	4.50	485.93	0.9
2007	Hook and Line	25	51	67	55215	10.40	263.41	3.9
2008	Hook and Line	33	58	68	73885	16.15	401.17	4.0
2009	Hook and Line	34	69	104	119849	21.81	646.27	3.4
2010	Hook and Line	37	70	105	160570	23.05	756.51	3.0
2011	Hook and Line	40	69	101	162419	20.13	434.34	4.6
2012	Hook and Line	24	34	53	82597	11.48	323.09	3.6
2013	Hook and Line	14	23	30	51870	4.71	193.43	2.4
2014	Hook and Line	21	28	39	71459	11.78	219.47	5.4
2015	Hook and Line	20	38	54	124895	17.47	363.90	4.8
2016	Hook and Line	31	57	79	111092	15.65	291.37	5.4
2017	Hook and Line	43	62	80	95811	14.92	348.03	4.3
2003	Pot	7	16	50	345	2.94	190.30	1.5
2004	Pot	17	96	185	1950	16.99	186.03	9.1
2005	Pot	14	43	50	835	10.67	379.29	2.8
2006	Pot	15	38	39	666	7.90	442.93	1.8
2007	Pot	21	46	75	624	8.75	257.86	3.4
2008	Pot	20	55	75	833	10.43	240.83	4.3
2009	Pot	18	30	45	540	8.82	372.58	2.4

2010	Pot	26	40	71	648	10.66	318.29	3.3
2011	Pot	29	61	85	831	18.94	255.80	7.4
2012	Pot	19	35	70	610	9.13	125.82	7.3
2013	Pot	17	25	48	590	6.30	72.18	8.7
2014	Pot	21	41	63	686	11.66	147.70	7.9
2015	Pot	17	49	64	604	14.60	234.25	6.2
2016	Pot	27	55	73	687	15.27	206.76	7.4
2017	Pot	44	87	127	1249	24.89	210.64	11.8

Table 2. Fishing effort and observer coverage in LE sablefish fishery from 2003 to 2017.

Year	Gear	# vessels	# trips	# hauls	# fixed gear units	Observed Retained (mt)	Landed (mt)	Coverage (%)
2003	Hook and Line	15	48	351	733602	222.85	1051.55	21.2
2004	Hook and Line	17	45	326	492009	180.02	1318.09	13.7
2005	Hook and Line	26	101	678	1456102	481.45	1341.56	35.9
2006	Hook and Line	19	68	471	939951	295.93	1401.23	21.1
2007	Hook and Line	22	75	517	1034046	298.49	1103.93	27.0
2008	Hook and Line	18	77	540	1244141	338.15	1103.35	30.6
2009	Hook and Line	8	45	287	648980	97.81	1441.51	6.8
2010	Hook and Line	21	143	762	1761173	345.77	1304.16	26.5
2011	Hook and Line	23	98	673	1405444	240.74	1153.50	20.9
2012	Hook and Line	17	88	532	1580075	239.32	1079.16	22.2
2013	Hook and Line	18	58	353	1047526	166.42	747.96	22.2
2014	Hook and Line	17	85	495	1200615	203.23	747.12	27.2
2015	Hook and Line	26	97	632	1536820	391.96	939.77	41.7
2016	Hook and Line	21	94	671	1743233	338.12	1031.73	32.8
2017	Hook and Line	25	109	701	2107656	396.86	1060.37	37.4
2003	Pot	6	35	362	9017	148.31	603.97	24.6
2004	Pot	3	13	139	5378	82.68	619.60	13.3
2005	Pot	7	39	492	13822	281.18	615.00	45.7
2006	Pot	7	39	289	10708	200.47	581.80	34.5
2007	Pot	4	30	154	5816	89.97	428.37	21.0
2008	Pot	6	24	329	13638	244.87	432.98	56.6
2009	Pot	3	27	67	3883	66.48	489.07	13.6
2010	Pot	7	43	314	11294	140.39	503.54	27.9
2011	Pot	3	22	227	9029	137.42	371.93	36.9
2012	Pot	5	19	351	14218	101.10	285.98	35.4
2013	Pot	3	14	47	1934	40.52	283.13	14.3
2014	Pot	4	16	195	7561	104.01	338.09	30.8
2015	Pot	9	36	308	11634	223.20	358.21	62.3
2016	Pot	7	55	596	21219	254.27	359.00	70.8
2017	Pot	3	14	186	7852	115.46	375.48	30.8

Table 3. Fishing effort and observer coverage for LE bottom trawl from 2002 to 2010.

Year	# vessels	# trips	# hauls	Tow duration or Soak time (hrs)	Observed Retained (mt)	Landed (mt)	Coverage (%)
2002	132	573	3163	13471.83	2679.97	18005.29	15
2003	125	462	2289	11496.14	2590.36	18388.80	14
2004	103	615	3441	13837.75	4309.78	17673.92	24
2005	105	522	3460	12621.02	4241.57	19286.20	22
2006	87	477	2977	11455.97	3443.33	17794.94	19
2007	88	371	2515	11380.64	3442.33	20442.49	17
2008	100	438	3185	15004.17	4905.22	24188.27	20
2009	101	590	4394	19581.08	6053.39	26055.50	23
2010	83	347	2614	13039.74	4019.52	22320.84	18

Table 4. Fishing effort and observer coverage for catch shares from 2011 to 2017. In Sectors, CS is catch shares and EM are fisheries that are partially monitored for fishing compliance by electronic monitoring systems. In EM fisheries, the coverage is the percentage of observer coverage and exclude electronic monitoring. In gear types (Gear), BT is bottom trawl, MT is midwater trawl, and HL is hook and line.

Year	Sector	Gear	# Vessels	# Trips	# Hauls	# Units	Observed Retained (mt)	Total Landed (mt)	Coverage (%)
2011	CS	BT, MT	72	1134	9195	0	16969.94	16989.16	100
2012	CS	BT	67	1089	8968	0	16949.36	16970.92	100
2013	CS	BT	68	1193	10017	0	18537.64	18512.07	100
2014	CS	BT	64	1033	8322	0	15759.07	15825.47	100
2015	CS	BT	60	904	7480	0	15589.55	15641.96	100
2016	CS	BT	53	802	6623	0	14957.23	14982.93	100
2017	CS	BT	54	839	6398	0	15377.59	15414.12	100
2011	CS	HL	11	94	630	2265264	335.47	364.22	100
2012	CS	HL	8	32	506	1472865	241.27	271.44	100
2013	CS	HL	8	29	215	587238	79.45	81.96	100
2014	CS	HL	8	31	227	601654	88.55	179.47	100
2015	CS	HL	5	16	185	592919	137.84	137.84	100
2016	CS	HL	5	30	351	1110926	192.73	205.39	100
2017	CS	HL	4	13	148	476944	115.94	115.92	100
2011	CS	Pot	17	233	1536	41310	813.82	789.50	100
2012	CS	Pot	19	278	1709	52248	740.69	711.22	100
2013	CS	Pot	10	100	1086	30097	470.84	501.77	100
2014	CS	Pot	14	118	1288	31876	681.15	618.97	100
2015	CS	Pot	8	62	584	18808	405.29	405.29	100
2016	CS	Pot	8	61	584	15785	387.05	394.44	100
2017	CS	Pot	6	44	574	16288	367.35	364.30	100
2015	CS EM	BT	4	9	57	0	134.57	404.20	33
2016	CS EM	BT	7	29	182	0	487.17	1730.93	28
2017	CS EM	BT	8	25	152	0	330.34	2052.25	16
2015	CS EM	Pot	7	18	184	4272	102.37	339.38	30
2016	CS EM	Pot	6	19	249	6275	151.96	470.47	32
2017	CS EM	Pot	7	22	270	7147	184.12	504.53	36

Table 5. 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 2008-2012 values were used in the probability models.

Five Year Period	Observed LBT (# indiv.) 5 yr. sum	Observed groundfish (mt yr^{-1})	Observed Groundfish (mt) 5 yr. sum	Bycatch Ratio	Fleet-wide Groundfish (mt) 5 yr. sum	Estimated number of individuals caught by the fleet
2003-2007	0	9.45	47.25	0.000	1567.49	0
2008-2012	1	11.59	57.97	0.017	1313.31	23
2013-2017	0	14.54	72.72	0.000	871.52	0

Table 6. 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. See text for model descriptions.

Statistic	Fixed rate	Rate with uncertainty
Minimum	0	0
Mean	4.53	4.53
Median	4	4
Maximum	17	48
Variance	4.54	24.72
Standard Deviation	2.13	4.97

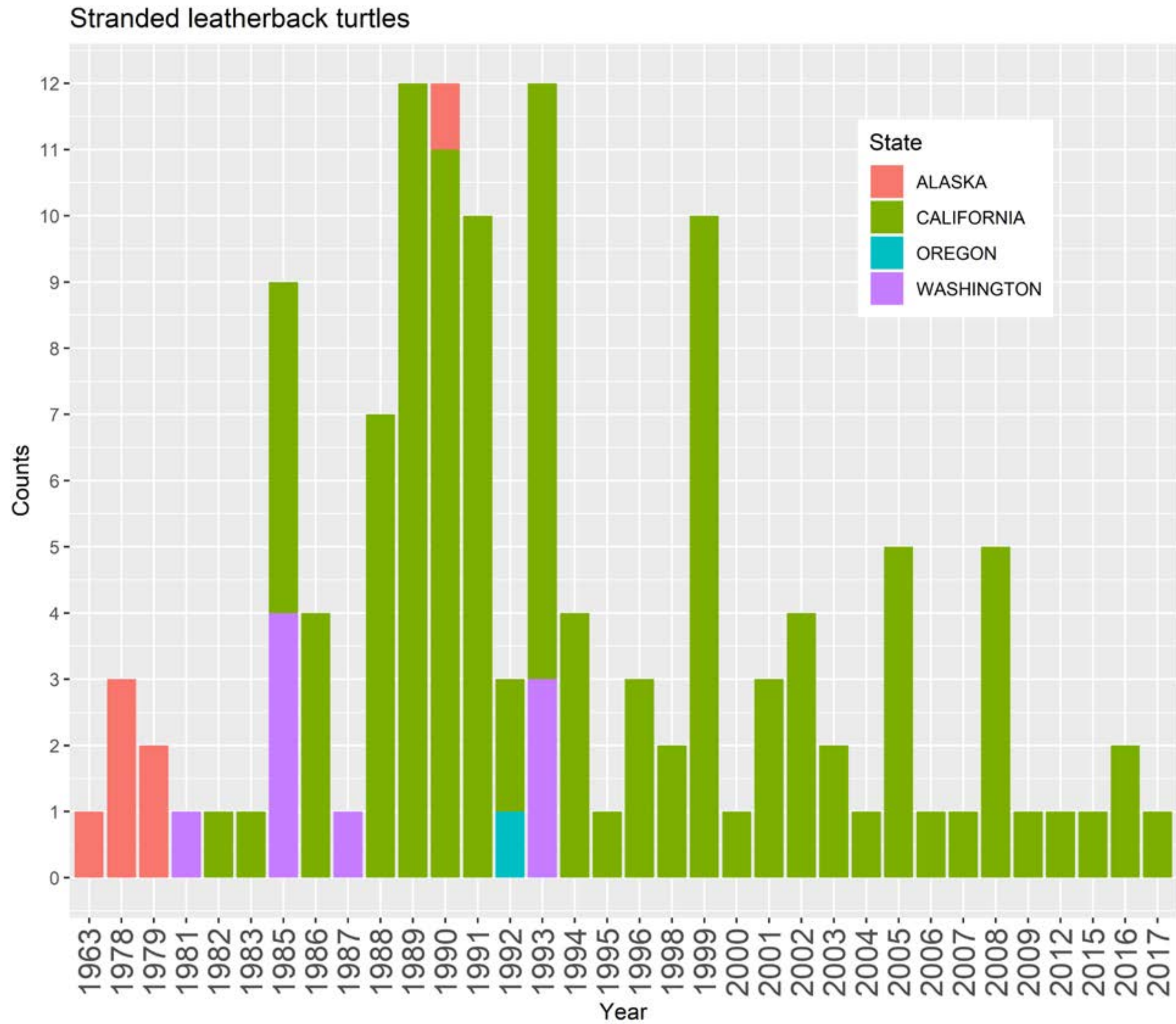

Figure 1. The number of stranded leatherback turtles along the west coast of the US in the stranding database that were not released alive (assumed dead). Data were available up to 2017. Note the time axis (years) is not continuous. Years without stranding records were omitted from the plot to make it concise.

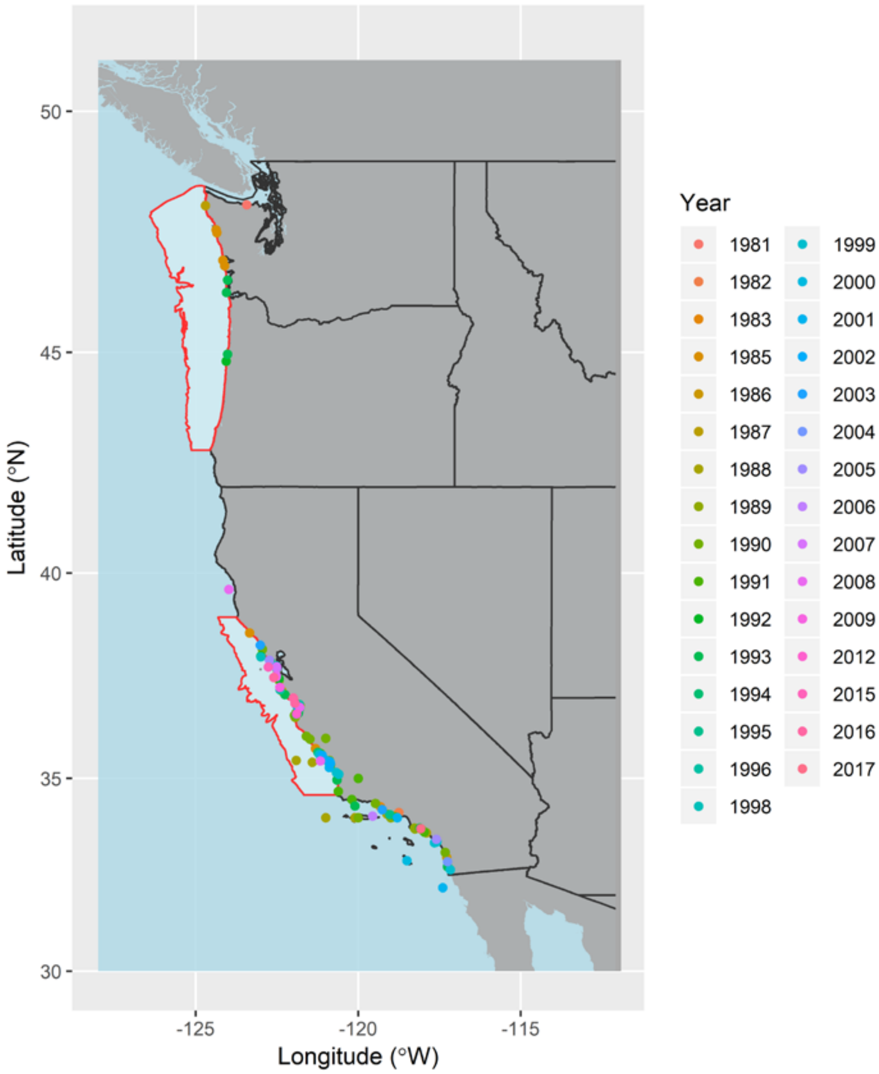

Figure 2. Approximate stranding locations of leatherback turtles along the west coast of the US (those from AK were omitted; n=7) with latitude/longitude data (n = 127). Some strandings are shown on land because of errors in recorded longitude/latitude. The two light-colored polygons with red borders along the coast denote Pacific leatherback critical habitat, which was designated on January 26, 2012 (77 FR 4170).

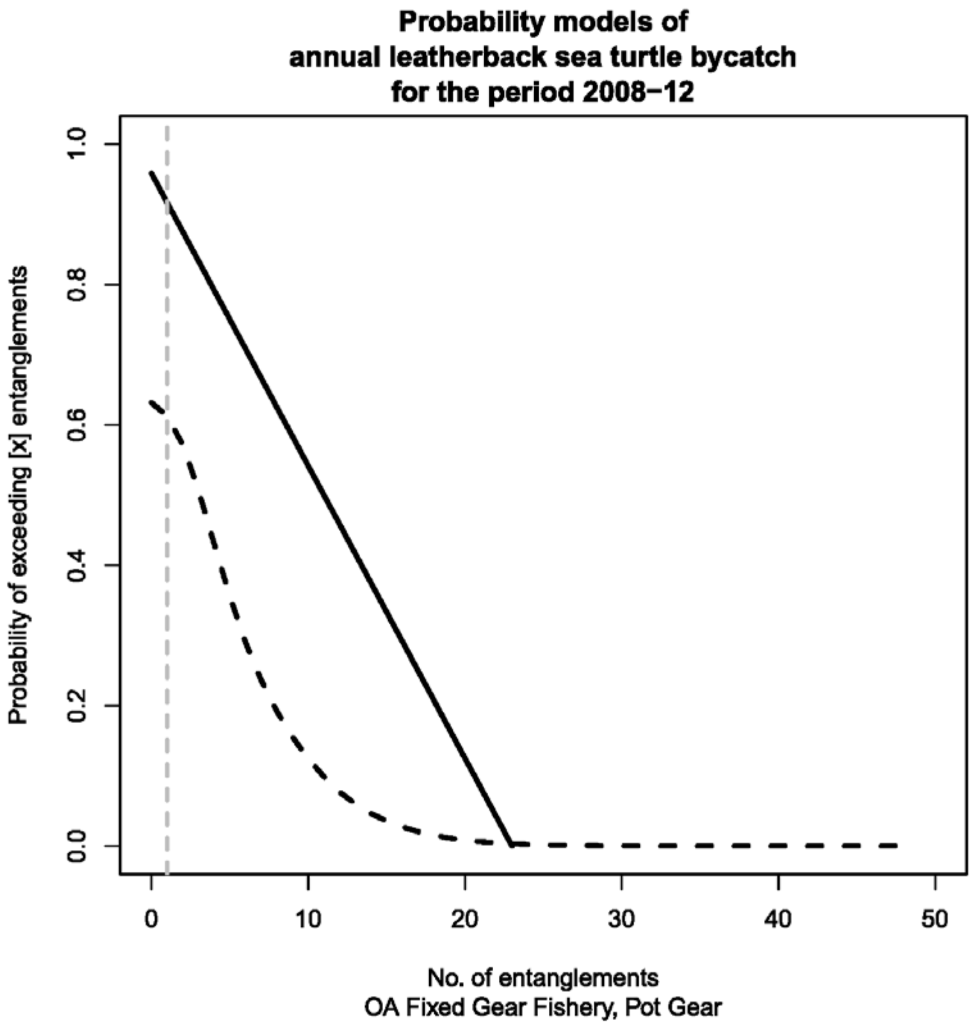

Figure 3. Probability of exceeding the number of entanglements of leatherback turtles in OA fixed gear fishery estimated using a statistical model with fixed bycatch rate (solid line) and another model including uncertainty in the bycatch rate (dashed line). The dotted grey vertical line represents the 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.