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Observed and Estimated Bycatch of Short-tailed Albatross in U.S. West Coast Groundfish Fisheries 2014-2015

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Contents

Executive Summary

In accordance with the National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) on Continuing Operation of the Pacific Coast Groundfish Fishery, this document reports observed bycatch and estimates fleet-wide take of U.S. Endangered Species Act (ESA)-listed short-tailed albatross (*Phoebastria albatrus*) in all sectors of the west coast groundfish fishery for the latest biennium (2014–2015).

Short-tailed albatrosses are large, pelagic seabirds of the Order Procellariiformes with long narrow wings adapted for soaring just above the water surface. The largest of the three species of North Pacific albatrosses, they are continental shelf-edge specialists. Individuals breed at 5-6 years of age, laying a single egg, and chicks are fed by adults by surface feeding on squid, shrimp, fish, and fish eggs.

Bycatch of short-tailed albatrosses in commercial fisheries continues to be a major conservation concern. Since 1983, 19 short-tailed albatross takes have been documented throughout the North Pacific. On April 11, 2011, a single short-tailed albatross mortality was documented off the Oregon coast in a West Coast Groundfish Fishery, namely the limited-entry sablefish longline fishery.

Following this mortality in one of the Pacific Coast Groundfish Fisheries, the Pacific Fisheries Management Council adopted recommendations for seabird bycatch mitigation, requiring streamer lines be deployed during setting operations on commercial fixed gear vessels 55’ (17 m) or greater in length. Outreach efforts have increased seabird bycatch awareness as well as voluntary use of seabird deterrents throughout the U.S. portion of the range of this species.

No short-tailed albatross takes were documented in the West Coast groundfish fisheries in 2014-2015. We modeled bycatch rate as constant and inferred annual expected mortality, given specified levels of observed effort, and fleet-wide bycatch was estimated using annual observer coverage. Fleet-wide estimates of mean bycatch ranged from 0.22 to 0.60 STAL/year using observed sets as the effort metric, from 0.20 to 0.38 STAL/year using observed retained catch as the effort metric, and from 0.20 to 0.58 STAL/year using observed hooks as the effort metric. For these same effort metrics, the upper confidence limit ranged from 0.81 to 2.27 STAL/year (observed sets), from 0.74 to 1.42 STAL/year (observed retained catch), and from 0.71 to 2.03 STAL/year (observed hooks).

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Introduction and Background

In accordance with the National Marine Fisheries Service (NMFS) Biological Opinion (BiOp) Regarding the Effects of the Continued Operation of the Pacific Coast Groundfish Fishery as governed by Pacific Coast Groundfish Fishery Management Plan and implementing regulations at 50 CFR Part 660 (USFWS 2012, p. 37), this document provides an analysis of observed takes and fleet-wide bycatch estimates of U.S. Endangered Species Act-listed short-tailed albatross (*Phoebastria albatrus*) in U.S. west coast groundfish fisheries.

Historically, the short-tailed albatross was probably the most abundant albatross in the North Pacific, with potential breeding sites also in the North Atlantic (Olson and Hearty 2003). Starting before and after the turn of the 20th century, millions of these birds were hunted for feathers, oil, and fertilizer (USFWS 2008). By 1949, no birds were observed breeding and the species was thought to be extinct. The species began to recover during the 1950s, and currently occurs throughout the North Pacific Ocean.

The short-tailed albatross was federally listed as endangered throughout its range, including the United States, on July 31, 2000 (65 FR 147:46643-46654, USFWS 2000). Under the Endangered Species Act, the Short-tailed Albatross Recovery Plan was finalized in September 2008 (USFWS 2008). There have been two 5-year reviews (USFWS 2009, 2014).

Short-tailed albatross Life History

The short-tailed albatross is a colonial, annual breeding species, with each breeding cycle lasting about 8 months. On the main breeding colony on Torishima Island, Japan, birds begin to arrive in early October. A single egg is laid in late October to late November, and incubation lasts 64 to 65 days. Hatching occurs in late December through January (Hasegawa and Degange 1982), and chicks begin to fledge in late May into June (Austin 1949). First breeding attempts sometimes occur when birds are five years old, but more commonly when birds are aged six (USFWS 2008).

Today, breeding colonies exist on two small islands in the western Pacific, with 80-85% of the breeding population on Torishima Island, which is an active volcano. The other breeding colony in the Senkaku Islands is in disputed ownership among China, Japan and Taiwan, making access impossible since 2002.

In 2008, in the hope of re-establishing an inactive colony**,** 10 chicks were translocated to a former colony site on Mukojima, a non-volcanic island, south of Torishima in the Ogasawara (Bonin) Islands. All chicks in this group survived to fledging, and from 2009 through 2012, 15 chicks per year have been moved to Mukojima and reared to fledging (Deguchi et al. 2014). One pair nested on Mukojima in 2012 and 2013, but did not successfully hatch an egg. In May 2014, a nearly fledged chick was discovered at nearby Nakodo-jima (also in the Ogasawara Islands; USFWS 2014). In February 2015, a short-tailed albatross pair was documented on the island; both members of the pair were born on Torishima, and the female was one of the chicks translocated to Mukojima in 2009. No chick was found with the pair in 2015, but DNA test results now indicate that this pair almost certainly produced the chick discovered at the breeding site in 2014 (Japan Ministry of Environment press release, 26 March, 2015).

In 2011 and again in 2012, a short-tailed albatross pair hatched and successfully reared a chick on Midway Atoll, in the northwest Hawaiian Islands. The hatching in 2011 marked the first confirmed hatching of a short-tailed albatross outside of the islands surrounding Japan in recorded history. Prior to that, observations of eggs and reports from the 1930s suggested that short-tailed albatross may have nested on Midway Atoll in the past. A female-female pair of short-tailed albatross has been suspected at Kure Atoll in the Northwestern Hawaiian Islands, but neither observed egg at this nest has produced chicks, possibly because the eggs are infertile (USFWS 2014).

Short-tailed albatross bycatch

Bycatch of short-tailed albatrosses in commercial fisheries continues to be a major conservation concern, especially for younger age classes (ca. 2/3 of the 19 reported fishing mortalities were < 4 years old; Table 1). The most recent 5-year review (USFWS 2014) reported five short-tailed albatross mortalities observed during commercial fishing activities from 2009-2013, three off Alaska, one off Oregon, and one off Japan. Since that report, three more short-tailed albatross mortalities have been reported from observed Alaskan fisheries (NOAA Information Bulletins 49 and 52; 2014; NOAA Information Bulletin 31; 2015). There were no mortalities documented in Alaskan fisheries in 2015.

For U.S. fisheries, those mortalities from 2010-2013 reported in the most recent 5-year review were the first observed mortalities of short-tailed albatrosses since 1998. During that 12-year period, however, there were three reported mortalities in Russian fisheries (2002, 2003, 2006). On April 11, 2011, a short-tailed albatross was killed by a Pacific Coast Groundfish Fishery vessel's longline fishing gear. Specifically, it was killed by a fixed demersal long-line vessel from the limited entry sablefish fishery approximately 65 kilometers off the Oregon coast.

Following the mortality of a short-tailed albatross off the U.S. west coast in 2011, the Pacific Fisheries Management Council (PFMC), which provides oversight to fisheries management in the Pacific, adopted recommendations for seabird bycatch mitigation in November 2013. The mitigation required that streamer lines be deployed during setting operations on commercial fixed gear vessels ≥55 feet (17 meters) in length, with a safety exception in the event of rough weather (PFMC 2013). In 2015, the use of streamer lines on vessels ≥55 feet long became mandatory (80 FR 71975; NMFS 2015), with tribal vessels using streamer lines voluntarily. Smaller vessels are also not required to use seabird bycatch avoidance measures under the current council action; consequently, voluntary adoption of streamer lines is important to address albatross conservation across the sablefish longline fleet. Research has been conducted to develop seabird bycatch options in the west coast sablefish fishery for vessels less than 55 feet in length and to confirm the effectiveness of the regulations for vessels ≥55 feet using particular gear configurations (Gladics et al. in prep.). Additionally, efforts are continuing to increase seabird bycatch awareness as well as the use of seabird deterrents throughout the range of this species.

Table 1. Reported short-tailed albatross mortalities associated with North Pacific, Russian, Japanese, and West Coast fishing activities since 1983.

Date	Fishery	Observer program	In sample*	Bird age	Location	Source
7/15/1983	Net	No	n/a	4 months	Bering Sea	USFWS (2008)
10/1/1987	Halibut	No	n/a	6 months	Gulf of Alaska	USFWS (2008)
8/28/1995	IFQ sablefish	Yes	No	1 year	Aleutian Islands	USFWS (2008)
10/8/1995	IFQ sablefish	Yes	No	3 years	Bering Sea	USFWS (2008)
9/27/1996	Hook-and-line	Yes	Yes	5 years	Bering Sea	USFWS (2008)
4/23/1998	Russian salmon drift net	n/a	n/a	< 1 year	Bering Sea, Russia	USFWS (2008)
9/21/1998	Pacific cod hook-and-line	Yes	Yes	8 years	Bering Sea	USFWS (2008)
9/28/1998	Pacific cod hook-and-line	Yes	Yes	Sub-adult	Bering Sea	USFWS (2008)
7/11/2002	Russian **	n/a	n/a	3 months	Sea of Okhotsk, Russia	Yamashina Institute of Ornithology (YIO; 2011)
8/29/2003	Russian demersal longline	n/a	n/a	3 years	Bering Sea, Russia	YIO (2011)
8/31/2006	Russian **	n/a	n/a	1 year	Kuril Islands, Russia	YIO (2011)
8/27/2010	Cod freezer longline	Yes	Yes	7 years	Bering Sea/ Aleutian Islands	NOAA (2010)
9/14/2010	Cod freezer longline	Yes	Yes	3 years	Bering Sea/ Aleutian Islands	NOAA (2010)
4/11/2011	Sablefish demersal longline	Yes	Yes	1 year	Pacific Ocean/Oregon	USFWS (2012)
10/25/2011	Cod freezer longline	Yes	Yes	1 year	Bering Sea	NOAA (2011)
5/24/2013	Seabird bycatch mitigation research - longline	No	n/a	1 year	Pacific Ocean, Japan	YIO, pers. comm.
9/7/2014	Pacific cod hook-and-line	Yes	No	5 years	Bering Sea/ Aleutian Islands	NOAA Information Bulletin 49 (2014)
9/7/2014	Pacific cod hook-and-line	Yes	Yes	Sub-adult	Bering Sea/ Aleutian Islands	NOAA Information Bulletin 52 (2014)
12/16/2014	Pacific cod hook-and-line	No***	No	< 1 year	Bering Sea/ Aleutian Islands	NOAA Information Bulletin 31 (2015)

* "In sample" refers to whether specimen was in catch sample analyzed by a fisheries observer
** Specifics regarding the type fishery are unknown
*** Review of on-board video documented the bird

U.S. West Coast Groundfish Fisheries

The west coast groundfish fishery (WCGF) 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 (PFMC 2011) and is managed by the Pacific Fishery Management Council. 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 off-shore) and state waters (0-5.6 km). Groundfish are both targeted and caught incidentally by trawl nets, hook-&-line gear, and fish pots.

Under the FMP, the groundfish fishery consists of four management components:

The Limited Entry (LE) component encompasses all commercial fishers who hold a federal limited entry permit. The total number of limited entry permits available is restricted. Vessels with an LE permit are allocated a larger portion of the total allowable catch for commercially desirable species than vessels without an LE permit.

The Open Access (OA) component 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.

The Recreational component includes recreational anglers who target or incidentally catch groundfish species. Recreational fisheries are not covered by this report.

The Tribal component includes native tribal commercial fishers in Washington State that have treaty rights to fish groundfish. Tribal fisheries are not included in this report, with the exception of the observed tribal at-sea Pacific hake (*Merluccius productus*) (also known as whiting) sector.

These four components are further subdivided into sectors based on gear type, target species, permits and other regulatory factors. This report includes data from the following sectors:

Limited Entry (LE) sectors
Beginning in 2011, an Individual Fishing Quota (IFQ) program for the LE bottom trawl fleet and the at-sea Pacific hake fleet was implemented, under the West Coast Groundfish Trawl Catch Share Program.

- IFQ fishery (formerly LE bottom trawl and at-sea Pacific hake, 2002-2010): This sector is subdivided into components due to differences in gear type and target strategy:
  - Bottom trawl: Bottom trawl nets target a variety of non-hake groundfish species. Catch is delivered to shore-based processors. Some bottom trawl vessels began carrying electronic monitoring (EM) equipment in 2015 for the purposes of compliance with catch quotas under the IFQ program.
  - Midwater non-hake trawl/Midwater Rockfish: Midwater trawl nets target midwater non-hake species, mainly mid-water rockfish such as yellowtail and widow rockfishes. Catch is delivered to shore-based processors. Some midwater trawl vessels began carrying electronic monitoring (EM) equipment in 2015 for the purposes of compliance with catch quotas under the IFQ program.
  - Pot: Pot gear targets groundfish species, primarily sablefish (*Anoplopoma fimbria*). Catch is delivered to shore-based processors. Some pot vessels began carrying electronic monitoring (EM) equipment in 2015 for the purposes of compliance with catch quotas under the IFQ program.
  - Hook-and-line: Longline gear targets groundfish species, mainly sablefish. Catch is delivered to shore-based processors.

- LE California halibut (*Paralichthys californicus*) trawl: Bottom trawl nets targets California halibut by fishers holding both a state California halibut permit and an LE federal trawl groundfish permit. Catch is delivered to shore-based processors.
- Shoreside Pacific hake trawl/Midwater hake: Midwater trawl nets target Pacific hake. Catch is delivered to shore-based processors.
- At-sea motherships and catcher-processors: Midwater trawl nets target Pacific hake. Catcher vessels deliver unsorted catch to a mothership. The catch is sorted and processed aboard the mothership. Catcher-processors catch and process at-sea. 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. Tribal catch can be delivered to a contracted mothership by catcher vessels for processing or be caught and processed by a contracted catcher-processor.

- LE fixed gear (non-nearshore): This sector is subdivided into two components due to differences in permitting and management:
  - LE sablefish endorsed season: Longlines and pots target sablefish. Catch is generally delivered to shore-based processors.
  - LE sablefish non-endorsed: Longlines and pots targets groundfish, primarily sablefish and thornyheads. Catch is delivered to shore-based processors or sold live at the dock.

Open Access (OA) Federal sectors

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

Open Access (OA) state sectors

- OA ocean shrimp (*Pandalus jordani*) trawl: Trawl nets target ocean shrimp. Catch is delivered to shore-based processors.
- OA California halibut trawl: Trawl nets target California halibut by fishers holding a state California halibut permit. Catch is delivered to shore-based processors.
- Nearshore fixed gear: A variety of gear, including longlines, pots, fishing poles, stick gear, etc. targets nearshore rockfish and other nearshore species managed by state permits in Oregon and California. Catch is delivered to shore-based processors or sold live.

NWFSC Groundfish Observer Program

The NWFSC Groundfish Observer Program's goal is to improve estimates of total catch and discard by observing commercial sectors of groundfish fisheries along the U.S. west coast 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 Program was established in May 2001 by NOAA Fisheries (a.k.a., National Marine Fishery Service, NMFS) in accordance with the Pacific Coast Groundfish Fishery Management Plan (50 CFR Part 660) (50 FR 20609). This regulation requires all vessels that catch groundfish in the US EEZ from 3-200 miles offshore carry an observer when notified to do so by NMFS or its designated agent. Subsequent state rule-making has extended NMFS's ability to require vessels fishing in the 0-3 mile state territorial zone to carry observers.

The WCGOP and A-SHOP observe distinct sectors of the groundfish fishery. The WCGOP observes the following sectors: IFQ shore-based delivery of groundfish and 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 ocean shrimp trawl fisheries. The A-SHOP observes the IFQ fishery that delivers Pacific hake at-sea including: catcher-processor, mothership, and tribal vessels. Details on how fisheries observers operate in both the IFQ (Catch Share) and Non-IFQ sectors can be found at: http://www.nwfsc.noaa.gov/research/divisions/fram/observation/index.cfm.

Albatross Bycatch in West Coast Groundfish Fisheries

The primary objective of this report is to provide estimates of bycatch of the ESA-listed short-tailed albatross in observed U.S. West Coast federally permitted groundfish fisheries since the last report in 2015, which covered the years 2010-2013. Previous reports (Jannot et al. 2011 and reports on the NWFSC Protected Species Reports webpage http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_products/protected_species.cfm) have provided data on estimated bycatch of seabirds including short-tailed albatross in U.S. west coast commercial fisheries, which were derived from the WCGOP and A-SHOP data.

Groundfish Fishery Sectors with Short-tailed albatross Bycatch

The only known short-tailed albatross take in a Pacific Coast Groundfish Fishery was reported in the limited entry sablefish longline fishery off the Oregon coast in 2011.

Amount and Extent of Short-tailed Albatross Take

The previous Biological Opinion (BiOp) Regarding the Effects of the Continued Operation of the Pacific Coast Groundfish Fishery (PCGF) (USFWS 2012) stated that:

> "The extent of take of short-tailed albatross will be assessed by documented takes and by assessing effects to a surrogate species (black-footed albatross). The extent of take of the short-tailed albatross documented by either approach is expected to be within the limits defined in the effects analysis in this biological opinion (i.e., a yearly average take of one short-tailed albatross). As actual levels of take are expected to vary from year to year, the average take average should not exceed two over a two-year period. A floating two year period beginning at the time this BO is signed [12 Nov 2012] will be used to quantify the two-year actual take average."

A new Biological Opinion will propose new take limits based on analyses presented here.

Methods

Data Sources

Data for this analysis is from the West Coast Groundfish Observer Program, specifically the Limited Entry sablefish longline fishery sector, the source of the only short-tailed albatross take.

Observer Program Data

A list of fisheries, coverage priorities and data collection methods employed by WCGOP in each observed fishery can be found in the Catch Shares (IFQ) and Non-Catch Shares (Non-IFQ) WCGOP manuals (NWFSC 2015a, b). The sampling protocol of the WCGOP is focused on the discarded portion of catch. To ensure recorded weights for the retained portion of the observed catch are accurate, haul-level retained catch weights recorded by observers are adjusted based on trip-level fish ticket records. This process is described in detail on the WCGOP Data Processing webpage (http://www.nwfsc.noaa.gov/research/divisions/fram/observation/data_processing.cfm). Data processing was applied prior to analyses presented in this report. For a list of groundfish species defined in the Pacific Coast Groundfish Fishery Management Plan see PFMC (2011).

Fish Ticket Data

For bycatch estimation, the landed amount of a particular fish species or species group is used as one measure of fishing effort. Thus, the retained landing information from fish tickets is crucial for fleet-wide total bycatch estimation for sectors of the U.S. west coast commercial groundfish fishery. Fish ticket landing receipts are completed by fish-buyers in each port for each delivery of fish by a vessel. Fish tickets are trip-aggregated sales receipts for market categories that may represent single or multiple species. Fish tickets are issued to fish-buyers by a state agency and must be returned to the agency for processing. Fish tickets are designed by the individual states (Washington, Oregon, and California) with slightly different formats by state. In addition, each state conducts species-composition sampling at the ports for numerous market categories that are reported on fish tickets. Fish ticket and species-composition data are submitted by state agencies to the PacFIN regional database. Annual fish ticket landings data for 2014-2015, with state species composition sampling applied, were retrieved from the PacFIN database in 2016 and subsequently divided into various sectors of the groundfish fishery. Observer and fish ticket data processing steps are described in detail on the WCGOP website under Data Processing Appendix (http://www.nwfsc.noaa.gov/research/divisions/fram/observer/data_processing.cfm/). Data processing steps specific to this report are described in the bycatch estimation methods below.

Documenting Short-tailed Albatross Bycatch

Designation of 'take' interactions

WCGOP and A-SHOP observers record a variety of fishery interactions with seabirds. A standard system for recording interactions is used by both observer programs and includes a variety of interaction categories: killed by gear, killed by propeller, previously dead, lethal removal (trailing gear), lethal removal (not trailing gear), entangled in gear (trailing gear), entangled in gear (not trailing gear), feeding on catch, deterrence used, boarded vessel, sighting only, other, and unknown. Take designations for species listed under the ESA as threatened or endangered differ from those for species that are not ESA-listed. Section 3 of the ESA specifies the term 'take' to mean 'harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct' (16 USC 1532). Any interaction encompassing the ESA definition with an ESA-listed seabird species (*i.e.*, a short-tailed albatross) was identified as a take. This designation was informed by specific details in observer notes recorded at the time of the interaction. Observers typically detail the nature of injuries and any changes in the

animal's behavior following its release. Birds documented to have exhibited bleeding, broken bones, or lost feathers were identified as takes; birds that did not fly away or return to normal behavior within a few minutes of the interaction were also considered to be takes.

Estimating Short-tailed Albatross Bycatch

For West Coast groundfish fisheries in general, ratio estimators are used to extrapolate seabird bycatch from observed bycatch rates using effort metrics for the fishery (*e.g.*, the ratio of observed retained catch to total retained catch; Jannot et al. 2011). However, using ratio estimators is problematic when bycatch is rare or observer coverage is low (Martin et al. 2015). Initial summaries of seabird bycatch in West Coast groundfish fisheries reported no observed short-tailed albatross takes from 2002-2009 (Jannot et al. 2011). Subsequent reporting in a risk assessment for West Coast groundfish fisheries on ESA-listed species (Ford et al. 2012) included the one documented take from 2011.

Due to the rarity of short-tailed albatross take in West Coast groundfish fisheries, bycatch estimation has relied on other methods. The previous Biological Opinion (USFWS 2012) relied on bycatch estimation reported in Ford et al. (2012), which used black-footed albatross as a surrogate species to estimate short-tailed albatross bycatch in West Coast groundfish fisheries. This proxy method had been used in the Hawaiian pelagic longline fisheries (see USFWS 2004, NMFS 2011). This methodology was also used to estimate short-tailed albatross bycatch in West Coast groundfish fisheries for the previous report to the PFMC ESA Workgroup (Good et al. 2015).

However, multiple questions were raised concerning the proxy estimation of short-tailed albatross bycatch; these are outlined in the recent risk assessment for NMFS' Biological Assessment (NMFS 2016). In summary, assumptions and limitations of the proxy calculations rendered them problematic for use in assessing short-tailed albatross bycatch in West Coast groundfish fisheries. The methods:

- assumed risk to black-footed and short-tailed albatross from West Coast groundfish fisheries was equal, so that estimated bycatch of STAL was simply a product of the global ratio of to STAL to BFAL;
- calculated proportional BFAL mortality based on global population estimates of black-footed albatross, accurate estimates of which are notoriously difficult to obtain;
- assumed the "at-risk area" parameter was a reflection of the species' global geographic ranges, which were, for the purposes of West Coast groundfish fisheries, completely overlapping;
- likely overestimated albatross bycatch by incorporating speculative drop-off rates (from pelagic longline fisheries) into bycatch calculations.

For these reasons, alternative approaches for estimating short-tailed albatross bycatch in West Coast groundfish fisheries were sought.

Estimating short-tailed albatross bycatch in the sablefish longline fishery using a Bayesian modeling approach

We explored alternative approaches to bycatch estimation of short tailed albatross by applying statistical models to characterize uncertainty in short-tailed albatross bycatch in the Limited Entry sablefish longline fishery. Because only one bird was encountered as bycatch from 2002-2015, we used simple Bayesian models while estimating variances of total bycatch. These methods have been used with other rare bycatch species, including cetaceans, delphinids, pinnipeds, sea turtles, and sharks (Martin et al. 2015). To do this, we modeled bycatch rate as constant and inferred annual expected mortality, given a specified level of effort. Fleet-wide bycatch of short-tailed albatross from the sablefish longline fleet was estimated using data on observer coverage obtained from the NWFSC West Coast Groundfish Observer Program (summarized in Table 2).

Table 2. Fishing effort, observer coverage, and short-tailed albatross observed takes in the LE sablefish fishery 2002–2014 (data from the West Coast Groundfish Observer Program).

Year	Vessels (#)	Trips (#)	Sets (#)	Hooks (#)	Observed Retained Catch (mt)	Fleet-wide Landed Catch (mt)	Observer coverage (%)	Observed STAL takes (#)
2002	25	68	395	788,213	190.79	788.54	24	0
2003	15	48	364	743,653	222.85	1,028.82	22	0
2004	17	45	333	499,617	179.08	1,305.94	14	0
2005	26	101	681	1,462,757	481.45	1,293.13	37	0
2006	19	68	480	957,892	295.9	1,377.29	21	0
2007	22	75	524	1,045,050	298.49	1,080.66	28	0
2008	18	77	543	1,252,301	330.03	1,094.65	30	0
2009	8	45	290	658,110	97.81	1,447.12	7	0
2010	21	143	788	1,884,106	343.10	1,304.16	26	0
2011	23	98	675	1,410,945	240.74	1,153.42	21	1
2012	17	88	535	1,586,259	227.19	1,075.01	21	0
2013	18	58	353	1,047,526	166.42	750.43	22	0
2014	17	85	496	1,203,871	203.03	746.08	27	0
2015	26	97	632	1,536,820	391.96	911.88	43	0

The general modeling approach was to use a simple Poisson process model, where the total number of bycatch events were assumed to follow a Poisson distribution,

$$\boldsymbol{n_{take,y} \sim Poisson\left(\lambda_y = \theta \cdot E_y\right)},$$

where $\boldsymbol{E_y}$ represents the effort in year y, $\boldsymbol{\theta}$ is an estimated bycatch rate, $\boldsymbol{\lambda_y}$ represents the mean expected bycatch, and $\boldsymbol{n_{take,y}}$ represents the number of observed bycatch events (or take events) in year $\boldsymbol{y}$. The estimated bycatch rate $\boldsymbol{\theta}$ is assumed constant through time, but the quantity $\boldsymbol{\theta \cdot E_y}$ includes uncertainty (as $\boldsymbol{\theta}$ is estimated). Thus, a time series of the mean bycatch can be

generated for a given species, with a given metric of effort. All uncertainty in the time series originates from fluctuating levels of effort through time (percent observer coverage only affects the expansion). We used a Bayesian model (Martin et al. 2015) to generate mean and 95% CIs of the parameter $\boldsymbol{\theta}$, as well as for $\boldsymbol{\theta} \cdot \boldsymbol{E_y}$.

Because observer coverage is less than 100%, and variable through time, we also need to expand the estimated bycatch, $\boldsymbol{\theta} \cdot \boldsymbol{E_y}$, to the fleet-wide level. One approach for expansion would be to divide $\boldsymbol{\theta} \cdot \boldsymbol{E_y}$ by the percent observer coverage; however, this ignores uncertainty in the expansion. We accounted for uncertainty in the expansion by treating the observer coverage and estimated bycatch ($\boldsymbol{\theta} \cdot \boldsymbol{E_y}$) as known ('p', 'x', respectively) and sampling from the distribution of total bycatch (N) in proportion to the Binomial density function. This process was repeated for each Markov Chain Monte Carlo (MCMC) draw, to propagate uncertainty in the estimates through the uncertainty in the expansion.

Results

Documented Short-tailed Albatross Bycatch

For the years 2014-2015, no short-tailed albatross takes were documented in the West Coast groundfish fisheries. The lone documented short-tailed albatross take from 2010-2013 was observed in the Limited Entry sablefish fishery in April 2011 (Ford et al. 2012). There were no recorded takes documented by West Coast groundfish fisheries observer programs from 2002-2009 (Jannot et al. 2011).

Estimated Short-tailed Albatross Bycatch

We fit models using three different measures of effort. First, we fit a model that used the number of observed sets as the measure of effort (Martin et al 2015). This resulted in estimates of mean expected bycatch (lambda) over time (Fig. 1).

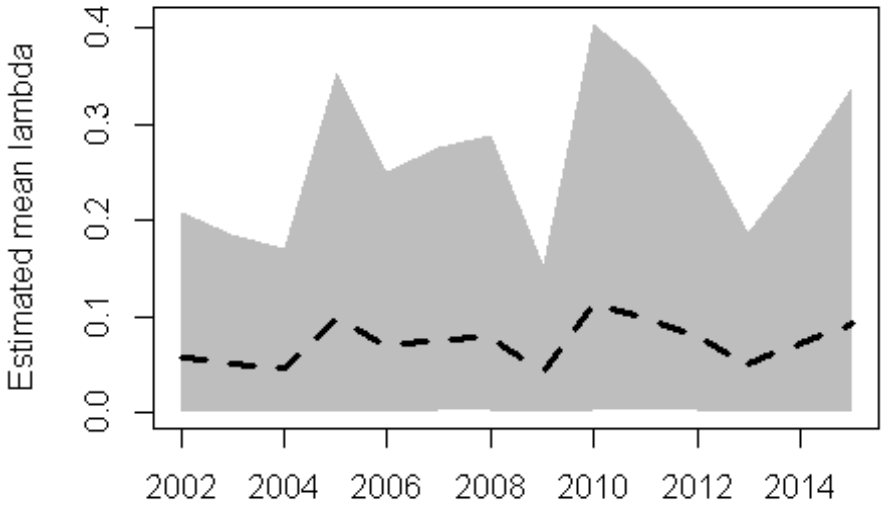

Figure 1. Mean expected bycatch of short-tailed albatross (effort = observed sets) estimated for 2002 - 2015. Dashed line is mean; gray area represents 95% confidence limits.

To calculate a fleet-wide estimate of short-tailed albatross bycatch, we then did a binomial expansion of expected bycatch to the fleet level using the number of observed sets as the measure of effort (Fig. 2).

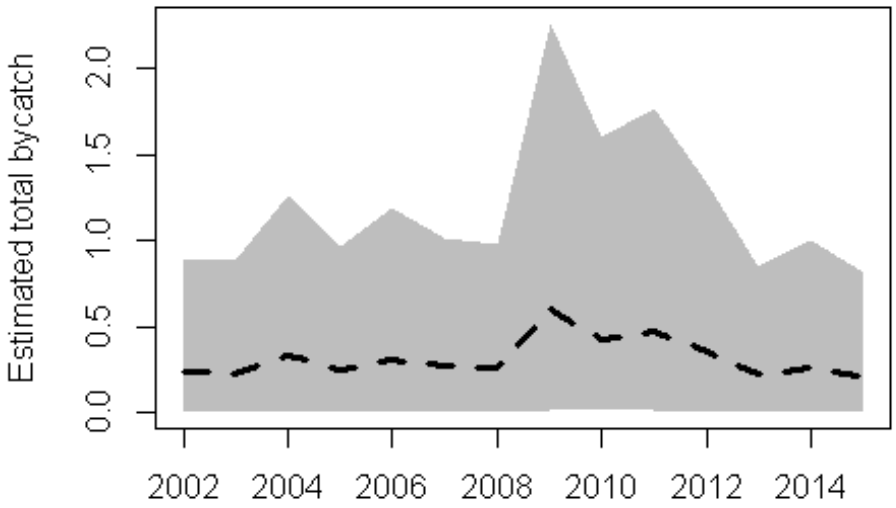

Figure 2. Fleet-wide bycatch of short-tailed albatross (effort = observed sets) estimated for 2002-2015. Dashed line is mean; gray area represents 95% confidence limits.

We fit a second model that used the observed retained catch as the measure of fishing effort. This resulted in estimates of mean expected bycatch (lambda) over time (Fig. 3).

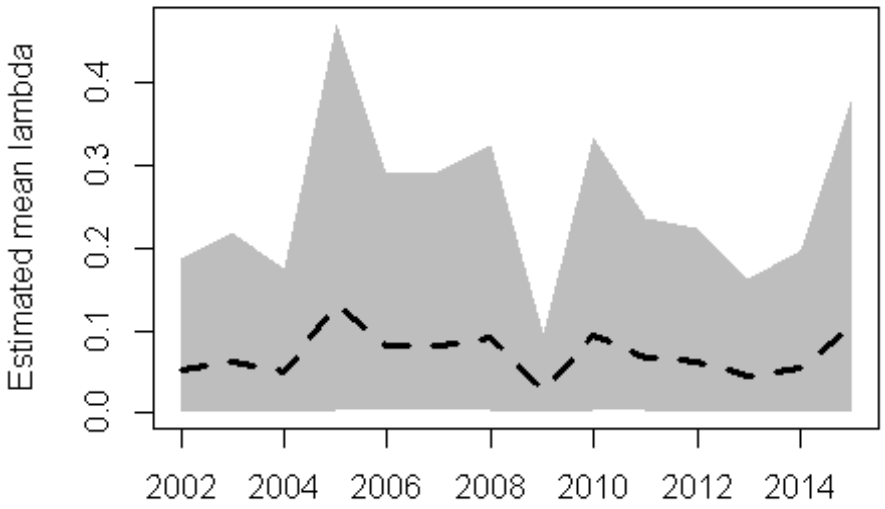

Figure 3. Mean expected bycatch of short-tailed albatross (effort = observed retained catch) estimated for 2002-2015. Dashed line is mean; gray area represents 95% confidence limits.

To calculate a fleet-wide estimate of short-tailed albatross bycatch, we then did a binomial expansion of expected bycatch to the fleet level that used the observed retained catch as the measure of effort (Fig. 4).

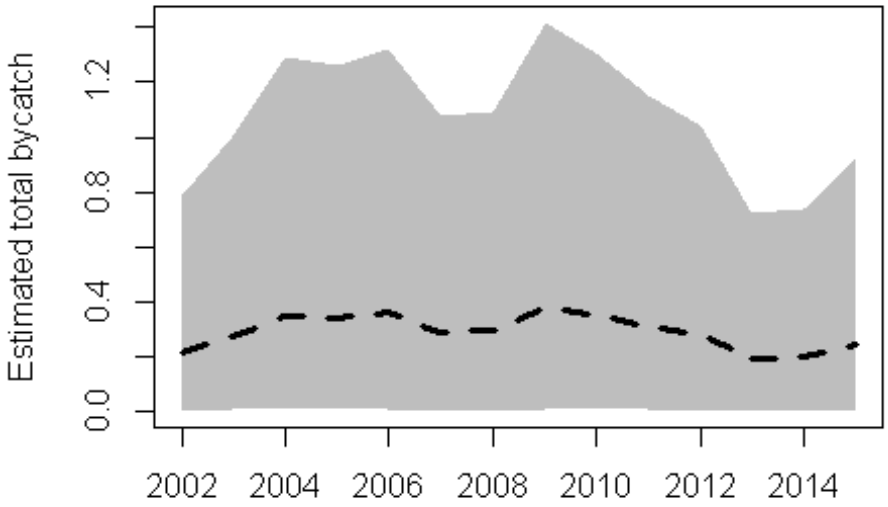

Figure 4. Fleet-wide bycatch of short-tailed albatross (effort = observed retained catch) estimated for 2002-2015. Dashed line is mean; gray area represents 95% confidence limits.

We fit a third model that used the number of observed hooks as the measure of fishing effort. This resulted in estimates of expected bycatch (lambda) over time (Fig. 5).

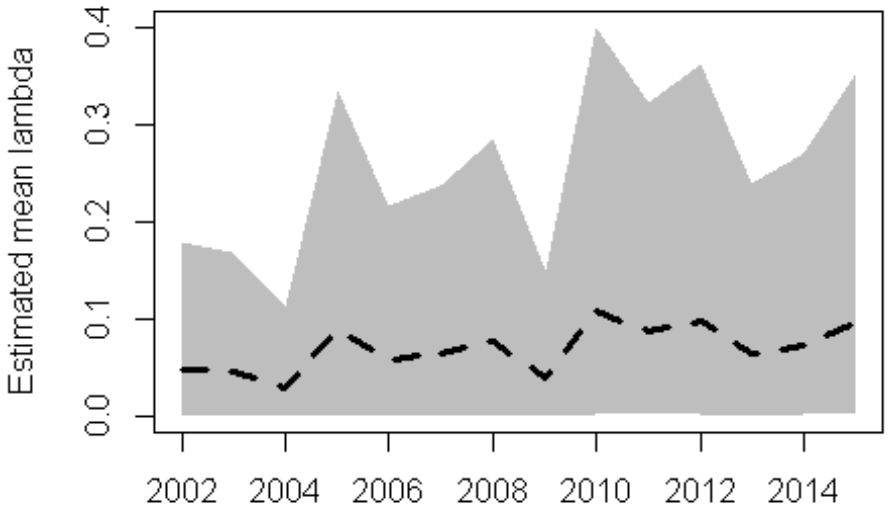

Figure 5. Estimated mean observed bycatch of short-tailed albatross (effort = observed hooks) estimated for 2002-2015. Dashed line is mean; gray area represents 95% confidence limits.

To calculate a fleet-wide estimate of short-tailed albatross bycatch, we then did a binomial expansion of expected bycatch to the fleet level using the number of observed hooks as the measure of effort (Fig. 6).

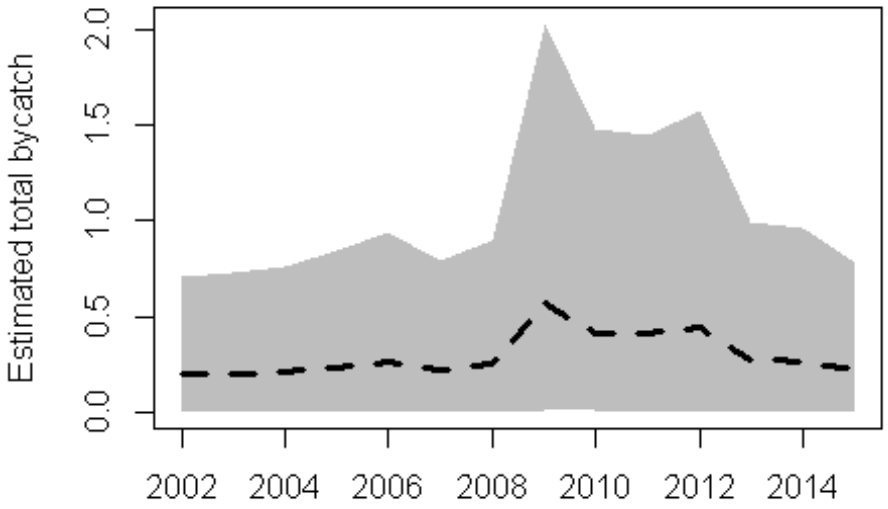

Figure 6. Fleet-wide bycatch of short-tailed albatross (effort = observed hooks) estimated for 2002-2015. Dashed line is mean; gray area represents 95% confidence limits.

The Bayesian modeling analyses show that mean fleet-wide estimates of bycatch were very similar using the three measures of effort; annual mean estimates ranged from 0.22 to 0.60 STAL/year (effort=observed sets), from 0.20 to 0.38 STAL/year (effort=observed retained catch), and from 0.20 to 0.58 STAL/year (effort=observed hooks). The variability of the estimates differed somewhat, with the upper confidence limit ranging from 0.81 to 2.27 STAL/year (effort=observed sets), from 0.74 to 1.42 STAL/year (effort=observed retained catch), and from 0.71 to 2.03 STAL/year (effort=observed hooks). The latter measure of effort (observed hooks) is likely the most relevant to bird risk on the water.

Probability-based methods are particularly useful when bycatch is dominated by zeroes; there is reduced bias from rare events, the methods incorporate uncertainty and are less reliant on assumptions, especially relying on another species as a proxy. The resultant estimates are generally lower than proxy estimates, which were likely inflated due to assumptions of which ratio of short-tailed albatross and black-footed albatross are relevant as well as behavioral differences between the two species. The model-based Bayesian approach also reduces volatility through its formal use of all information contained in the time series, reduces arbitrary decision-making about how many years of data to combine, and it enables probabilistic inference for bycatch and mortality within years, conditional on fishing effort (Martin et al. 2015).

Seabird Avoidance and Mitigation Measures

NMFS has been working with fishermen and Washington Sea Grant to reduce the potential for seabirds to be taken by the fishery. The actual take and the estimates of short-tailed albatross bycatch presented here are based largely on years prior to consistent seabird bycatch mitigation measures, which have been shown to drastically reduce seabird bycatch in Alaskan groundfish

fisheries (Melvin 2000). In this mitigation, streamer lines fly in the air above where baited gear is being deployed and provides a visual stimulus to inhibit seabirds from ingesting baited hooks and drowning. While some longline vessels in the groundfish fishery used streamer lines and other seabird avoidance gear voluntarily, organized efforts promoting the use of streamer lines did not begin until 2009. These efforts are summarized below:

- Pre-2009: some voluntary use of streamer lines and other seabird avoidance gear
- 2009: Washington Sea Grant initiated a NMFS-supported streamer line distribution pilot program with tribal fisheries; West Coast Groundfish Observer Program began documenting use and characteristics of seabird avoidance gear on fixed gear vessels
- 2009-2011: Washington Sea Grant extend free streamer line program to major longline ports in Oregon and Washington (Washington Sea Grant 2011)
- 2013-2016: distribution of free streamer lines and research to refine the design of streamer lines specifically for West Coast groundfish fisheries
- December 2015: use of streamer lines on vessels ≥55 feet long became mandatory (80 FR 71975), and tribal vessels use streamer lines voluntarily. Public outreach materials detailing technical requirements of streamer lines and request for vessels both ≥55 feet and <55 feet to participate in seabird bycatch

Other Short-tailed Albatross Interactions

Interactions and sightings of short-tailed albatross with vessels in some commercial groundfish fishery sectors were recorded during 2014–2015 (Tables 3, 4). These opportunistic data ranged from sightings made during the course of their duties to observations of individuals feeding on catch to takes. None of the interactions apart from the 2011 take resulted in documented short-tailed albatross mortality.

The NWFSC Observer Program conducted a review of sightings to explore the decline in short-tailed albatross sightings in recent years. After combing the data, interviewing former and current observers, and reviewing documentation and protocols for collecting sightings of short-tailed albatross, the program concluded that sightings have been reported accurately in recent years. However, there is no strict protocol or methodology; observers are simply required to record any opportunistic sightings. Thus, sightings data suffer from being "ad hoc" indices. The decreased sightings in 2014-15 likely are due to the ad hoc nature of these data.

Table 3. Short-tailed albatross interactions recorded by observers on U.S. west coast groundfish fishery vessels (2002-15).

Year	Sector	Gear	Killed by gear	Feeding on catch	Other*
2002	Limited Entry Trawl	Bottom Trawl		2	
2009	Limited Entry Trawl	Bottom Trawl		2	
2010	Limited Entry Sablefish	Hook and Line			1
	Limited Entry Trawl	Bottom Trawl		3	
2011	Catch Shares	Bottom Trawl		4	
	Catch Shares	Hook and Line			1
	Limited Entry Sablefish	Hook and Line	1		2
	MS Catcher Vessels	Midwater Trawl		1	

	Shoreside Hake	Midwater Trawl	1	
2012	Catch Shares	Bottom Trawl	3	
	Catch Shares	Pot	2	
	Shoreside Hake	Midwater Trawl	2	
2013	Catch Shares	Bottom Trawl	3	
	Shoreside Hake	Midwater Trawl	1	
2014	Catch Shares	Bottom Trawl	4	
2015	Catch Shares	Bottom Trawl	2	1

*Other includes: feeding on discarded catch, feeding on bait –floating free

Table 4. Short-tailed albatross sightings recorded opportunistically by observers on U.S. west coast groundfish fishery vessels (2002-15).

Year	Sector	Gear	Sighting
2002	Limited Entry Sablefish	Hook and Line	1
	Limited Entry Trawl	Bottom Trawl	12
2003	Limited Entry Sablefish	Hook and Line	1
	Limited Entry Trawl	Bottom Trawl	4
2004	Limited Entry Trawl	Bottom Trawl	3
2005	Limited Entry Sablefish	Hook and Line	3
	Limited Entry Trawl	Bottom Trawl	3
2006	Limited Entry Sablefish	Hook and Line	3
	Limited Entry Trawl	Bottom Trawl	1
2007	Limited Entry Sablefish	Hook and Line	2
	Limited Entry Trawl	Bottom Trawl	1
2008	Limited Entry Sablefish	Hook and Line	1
	Limited Entry Sablefish	Pot	1
2009	Limited Entry Sablefish	Hook and Line	1
	Limited Entry Trawl	Bottom Trawl	17
2010	Limited Entry Sablefish	Hook and Line	4
	Limited Entry Sablefish	Pot	2
	Limited Entry Trawl	Bottom Trawl	6
	OA Fixed Gear	Pot	1
2011	Catch Shares	Bottom Trawl	33
	Catch Shares	Pot	2
	Limited Entry Sablefish	Hook and Line	1
	Limited Entry Sablefish	Pot	2
	MS Catcher Vessels	Midwater Trawl	1
	Shoreside Hake	Midwater Trawl	2
2012	Catch Shares	Bottom Trawl	8
	Catch Shares	Hook and Line	3
	Catch Shares	Pot	2
	Limited Entry Sablefish	Hook and Line	1
	MS Catcher Vessels	Midwater Trawl	1
	Shoreside Hake	Midwater Trawl	1
2013	Catch Shares	Bottom Trawl	13
	Shoreside Hake	Midwater Trawl	1
2014	Catch Shares	Bottom Trawl	1
2015	Catch Shares	Bottom Trawl	1

Additional information relevant to the BiOp/RPMs and Conservation Measures

In the November 21, 2012 Biological Opinion on Continuing Operation of the Pacific Coast Groundfish Fishery, the USFWS outlined Reasonable and Prudent Measures (RPMs) and Conservation Recommendations necessary and appropriate for NMFs to minimize take of short-tailed albatross. NMFS responded to these points in the initial report to the PFMC ESA Workgroup (Good et al. 2015), including:

- NMFS developed streamer line requirements for vessels ≥55 feet
- NMFS facilitated outreach by Washington Sea Grant and Oregon State University
- NMFS convened a Pacific Coast Groundfish and Endangered Species Workgroup
- NMFS reports and retains short-tailed albatross takes, will report on the efficacy of streamer lines, and regularly examines observer protocols
- NMFS produces a biennial bycatch report, make use of other available data on short-tailed albatross, update risk assessments as needed, and consult on unobserved fisheries
- NMFS maintains observer coverage levels

The re-initiation of the Biological Opinion on the continued operation of the Pacific Coast Groundfish Fishery will outline Reasonable and Prudent Measures (RPMs) and Conservation Recommendations to minimize short-tailed albatross take, and NMFS will respond to them.

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