Annual Report on Seabird Interactions and Mitigation Efforts in the Hawaii Longline Fishery for 2006

ADMINISTRATIVE REPORT

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Cover photo: Short-tailed albatrosses (*Phoebastria albatrus*), Torishima Island, Japan. Photo courtesy U.S. Fish and Wildlife Service.

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List of Acronyms

BiOp	Biological Opinion
BFAL	Black-footed Albatross
CI	Confidence Interval
CMC	Center for Marine Conservation
CPUE	Catch Per Unit Effort
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
FR	Federal Register
FMP	Fishery Management Plan
HLA	Hawaii Longline Association
LAAL	Laysan Albatross
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWHI	Northwestern Hawaiian Islands
OLE	Office for Law Enforcement
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
PMUS	Pelagic Management Unit Species
PRIA	Pacific Remote Islands Area
SFD	Sustainable Fisheries Division
STAL	Short-tailed Albatross
USFWS	U.S. Fish and Wildlife Service
WPFMC	Western Pacific Fishery Management Council

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1.0 Introduction

In the western Pacific, the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), through its Pacific Islands Regional Office (PIRO), is responsible for managing, protecting, and conserving living marine fishery resources in Federal waters of the U.S. Pacific islands areas.[1] PIRO accomplishes this aim through the implementation of regulations and policies designed to sustain healthy marine resources, prevent overfishing, rehabilitate depleted stocks, and promote the recovery of protected species. The NMFS Pacific Islands Fisheries Science Center (PIFSC) conducts fisheries research and provides scientific information and expertise on Pacific insular and pelagic marine resources and protected species. The Western Pacific Fishery Management Council (WPFMC) is responsible for developing domestic fishery policies and management plans for the region. The PIRO, PIFSC, WPFMC, and the U.S. Fish and Wildlife Service (USFWS) work cooperatively to prevent and mitigate the bycatch of protected resources, including seabirds, by U.S. domestic fisheries governed under fishery management plans.[2]

Seabird mitigation measures, authorized under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), are prescribed in fishery management plans governing fisheries operating in the U.S. Exclusive Economic Zone (EEZ) and international waters of the western Pacific region. To assess possible impacts of the Hawaii pelagic longline fishery on the endangered short-tailed albatross (*Phoebastria albatrus*) population NMFS consulted with USFWS under Section 7 of the ESA. A "Biological Opinion on the effects of the Hawaiian Longline Fishery on the short-tailed albatross" (BiOp) was issued by USFWS on November 28, 2000 [FWS 1-2-1999-F-02; USFWS 2000], and subsequently revised November 18, 2002 [FWS 1-2-1999-F-02R; USFWS 2002]. The 2002 revision examined the effects of the deep-set fishery on the short-tailed albatross after a suspension of the shallow-set fishery was ordered by the U.S. Court in *Center for Marine Conservation (CMC)* v. *NMFS* on April 1, 2001. USFWS issued a supplement to the BiOp in October 2004 entitled "Biological Opinion on the Effects of the reopened shallow-set sector of the Hawaii Longline Fishery on the STAL" [FWS 1-2-1999-F-02.2: USFWS 2004]. Prior to its suspension, the shallow-set sector of the Hawaii longline fishery accounted for the majority of seabird mortalities, so the October 2004 BiOp evaluated only the effects of the April 2004 reopening of the shallow-set longline fishery on the short-tailed albatross. From 2004-2006, no short-tailed albatross interactions were reported in

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[1] American Samoa, Guam, Hawaii, Northern Mariana Islands, and the U.S. Pacific remote islands areas (PRIA), consisting of Howland Island, Baker Island, Jarvis Island, Johnston Atoll, Midway Atoll, Kingman Reef, Palmyra Atoll, and Wake Island.

[2] Fishery management plans, if approved by the Secretary of Commerce, are implemented by regulations by NMFS at 50 CFR 665. Five fishery management plans governing western Pacific fisheries including pelagics, bottomfish/seamount groundfish, crustaceans, precious corals, and coral reef ecosystems.

the Hawaii shallow-set longline fishery which is required to have 100% observer coverage.[3] The BiOp issued on November 18, 2002, on the deep-set sector remains in effect.

The three BiOps (USFWS 2000, 2002, 2004) require NMFS to report annually any observed interaction of short-tailed albatross with the Hawaii longline fishery, and any observed and estimated total number of interactions with Laysan (*P. immutabilis*) and black-footed (*P. nigripes*) albatross by set type.[4] Because observed interactions between short-tailed albatrosses and Hawaii pelagic longline vessels are non-existent and are thought to be very rare, surrogate species must be used. Black-footed and Laysan albatrosses are used as surrogate species to assess the effects of fishery interactions and the efficacy of mitigation measures on the short-tailed albatross population due to their relatedness, similar habitats, and likely similar foraging strategies. In addition, NMFS must report on the status of observer coverage, provide assessments of the effectiveness of required seabird deterrents including review of the observer data from vessels choosing to side-set, and summarize the results of the Federally-mandated Protected Species Workshops. This report includes the reporting requirements for the Hawaii longline fishery operating during 2006.

2.0 Description and Status: Short-tailed Albatross

The short-tailed albatross (STAL) is the largest of the northern hemisphere albatross species. They are long-lived and slow to mature. They have distinctive pink bills, and the plumage varies in color at different stages of its life. When the STAL is one year old, the bird looks similar to a BFAL, except for the STAL's bill and flesh colored legs and feet. As the STAL gets older, its head, neck, stomach and back become lighter in color. A fully mature STAL has a golden head, a bright pink bill, and a characteristic thin black line around the base of its bill. STALs once ranged throughout most of the North Pacific Ocean and Bering Sea, with known nesting colonies on numerous western Pacific islands in Japan and Taiwan (Hasegawa 1979). During the early 20th century, the species declined in numbers to near extinction, primarily from direct harvest at breeding colonies in Japan. The species began to recover during the 1950s and currently, due to habitat management and habitat protection, the population is growing exponentially at about 7.3% annually (Fig. 1). Today, the only known currently-active breeding colonies of STALs are on Torishima south of Honshu Island, Japan, (30° 29' N 140° 18' E) and Minami-kojima in the Senkaku Islands just north of Taiwan (25° 43' N 123° 33' E). It is estimated that 80-85% of the known breeding STAL use a single colony at Tsudame-zaki, on Torishima, an active volcanic island. The current worldwide STAL population is estimated to be approximately 2,000 individuals, with 341 nesting pairs observed on Torishima Island during the 2006-2007 breeding season (Hasagawa 2007).

[3] The shallow-set sector of the Hawaii longline fishery reopened with a final rule on April 2, 2004 (69 FR 17329).
[4] NMFS described tuna (deep-set) and/or swordfish (shallow-set) type.

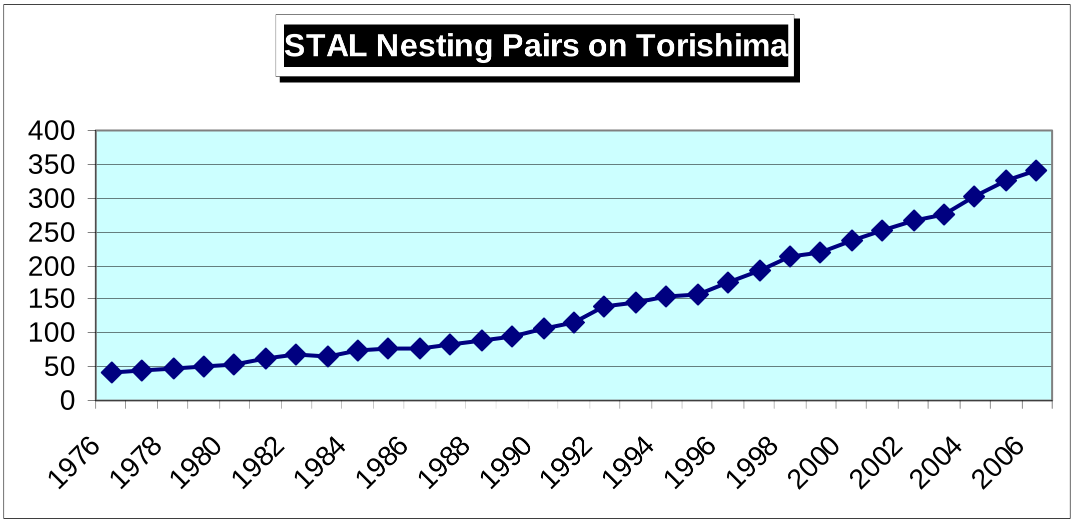

Figure 1. Estimated pairs of short-tailed albatross on Torishima Island, Japan, 1976-2006. (Sources: Sievert 2007, Hasegawa 2006, 2007)

3.0 Description and Status of Proxy Species: Laysan and Black-footed Albatrosses

The Laysan albatross (LAAL) is the most abundant albatross in the world. They are characterized by a white head, neck and under parts. Their upper wings and back are black to dark gray and they have flesh-colored legs, feet, and bill. They also have dark plumage highlighting their eyes. In the U.S.A., the LAAL is designated by the USFWS as a “bird of conservation concern” (USFWS 2002), meaning that it is a high priority species that without additional conservation actions are likely to become candidates for listing under the U.S. Endangered Species Act (ESA).

Because variables such as population structure, mortality, and individual breeding frequency are not fully understood, a total world population estimate cannot be determined for LAAL. Instead, an estimate of total numbers of nesting pairs has been used to track LAAL populations. Conveniently, 99% of the world’s LAAL breed in the Northwestern Hawaiian Islands (NWHI). Other breeding sites are in Japan and Mexico. The estimated world number of nesting pairs for the 2006-07 breeding season was 590,722 (Flint 2007). The largest breeding colony is at Midway Atoll, where the 2006-07 (December-January) count was 398,529 breeding pairs.

The black-footed albatross (BFAL) is slightly larger than the Laysan and prefers to nest in more open areas. The BFAL has black feet, legs, and bills. The plumage is brown and there is a white ring around the base of the bill. Birds older than two years have white on their tail feathers. In the U.S.A., the BFAL is designated by the USFWS as a “bird of conservation concern” (USFWS 2002). Approximately, 97% of BFALs breed in the NWHI. A smaller population of approximately 2000 breeding pairs nests on small islands south of Japan. Walsh and Edwards (2005) have demonstrated that the Japanese sub-population is reproductively isolated from

NWHI BFALs. Due to this reproductive isolation, they suggest designating the Japanese sub-population as a separate species. An estimated 62,437 breeding pairs were found on the NWHI in the hatch year 2006-07 count (Flint 2007).

4.0 The Hawaii Pelagic Longline Fishery in 2006

The Hawaii longline fishery has historically had the greatest number of seabird interactions of any commercial fishery managed under the Fishery Management Plan for Pelagic Fisheries of the Western Pacific region (FMP) (NMFS 2001a). The Hawaii longline fishery is comprised of a deep-setting component, targeting tuna, and a shallow-setting component, targeting swordfish. In April 2001, the shallow-setting component of the fishery was restricted by U.S. Court orders intended to protect threatened and endangered sea turtles taken incidentally in the fishery (66 FR 31562, June 12, 2001). In April 2004 (69 FR 17329), the shallow-setting component of the Hawaii longline fishery was reopened under a suite of management measures that required new gear configurations and specialized turtle dehooking equipment, in order to prevent the incidental capture of and increase the post-hooking survival of sea turtles.

Key requirements for the shallow-set fishery (69 FR 17354, April 2, 2004) include:

- 100% observer coverage
- 2,120 shallow set certificates issued per year
- 18/0 circle hooks with 10 degree offset
- Mackerel-type bait
- Sea turtle handling measures including dehooking equipment; and
- Annual attendance at mandatory Protected Species Workshops for vessel operators and owners

The Hawaii longline fishery operating in 2006 consisted of both deep-set and shallow-set components (see Appendix 1). There were 127 active Hawaii longline vessels that made 1,437 trips (Table 1). The trips targeted tunas (bigeye, albacore, and yellowfin tuna) and swordfish. A total of 1,380 tuna trips and 57 swordfish trips were made[5]. Of the total number of trips in 2006, 583 trips were made above 23° N. latitude (PIFSC, unpubl.). Table 2 shows the catch per unit effort (CPUE) values attained by the Hawaii longline fishery in 2006. Out of a total of 35,192,344 hooks fished, the deep-set fishery deployed a reported 34,486,898 hooks in 16,397 sets and the shallow-set fishery deployed a reported 705,446 hooks on 850 sets.

[5] The shallow-set fishery was closed on March 20, 2006 after reaching the interaction limit for loggerhead sea turtles (17) on March 17, 2006. There is an interaction limit in this fishery of 16 leatherback turtles that has never been reached.

Table 1. Hawaii Longline Fishery effort data, 1999–2006
(number of vessels departing in calendar year 2006)
(Source: PIFSC)

Year	Vessels	Trips	Sets	Hooks	Light Sticks
1999	122	1,165	12,805	19,145,304	818,149
2000	125	1,135	12,930	20,282,826	715,975
2001	101	1,075	12,169	22,327,897	26,519
2002	102	1,193	14,225	27,018,673	1,569
2003	110	1,215	14,560	29,297,813	0
2004	125	1,338	15,976	31,967,874	36,625
2005	124	1,533	18,083	34,895,229	750,417
2006	127	1437	17,247	35,192,344	408,183

Table 2. Hawaii Longline Fishery catch per unit effort
(number of fish caught per 1,000 hooks), 1999–2006.
(Source: PIFSC)

Year	No. Tuna	No. Sharks	No. Billfish	No. Other PMUS*
1999	9.21	4.59	3.9	4.8
2000	8.18	3.91	2.88	4.8
2001	8.64	2.1	1.61	4.21
2002	7.48	1.87	0.98	4.27
2003	6.33	2.32	1.77	4.58
2004	6.42	2.34	1.24	5.49
2005	5.32	2.15	1.69	5.06
2006	4.92	1.94	1.58	4.24

* Other Pelagic Management Unit Species (PMUS): mahimahi, moonfish, oilfish, pomfret, and wahoo.

5.0 Seabird Deterrence Measures

A variety of seabird deterrence methods have been tested and found to reduce interaction rates and/or mortality of seabirds with longline fisheries (e.g., Brothers 1995; Brothers et al. 1999; McNamara et al. 1999; Gilman et al., 2003, 2005, and 2007). When employed effectively, seabird avoidance measures have the potential to nearly eliminate seabird interactions. To resolve the problem of seabird mortality in these fisheries, there is a need to identify deterrent methods that not only have the capacity to minimize seabird interactions, but are also practical and convenient to use by fishermen (Gilman et al. 2005).

Since June 2001, the Hawaii longline fishery has been required to use seabird deterrence measures. An emergency rule published on June 12, 2001 (66 FR 31563), closed the swordfish fishery and implemented the terms and conditions of the BiOp issued by the USFWS on November 28, 2000 (USFWS 2000). These measures included a suite of mitigation techniques to be used north of 23° N. latitude: thawed blue-dyed bait, strategic offal discards, a line-setting machine, and 45 g weights attached to the hook end of each branchline. On May 14, 2002, a final rule (67 FR 34408) was published in order to codify the terms and conditions contained in the 2000 BiOp. The suite of seabird mitigation techniques was defined as follows: when making deep sets north of 23° N., vessels must employ a line-setting machine with at least 45 g weights attached within 1 m of each hook, use thawed blue-dyed bait and strategic offal discards during the setting and hauling of longline gear. These measures were further altered by a final rule on December 19, 2005 (70 FR 75075), to satisfy the terms and conditions of the 2004 BiOp. These measures, which were recommended by WPFMC, became effective on January 18, 2006, include the following:

When fishing north of 23° N. latitude, all deep-setting Hawaii longline vessels must either:

- Side-set (including using 45 g weighted swivel within 1 m of the hook, and a bird curtain)

or

- Use thawed, blue-dyed bait;
- Discard offal strategically, only when seabirds are present;
- Use at least 45 g weights within 1 m of each hook;
- Use a line shooter or basket gear;
- Handle all seabirds in a manner that maximizes the probability of their long-term survival;
- Notify NMFS immediately if a STAL is hooked or entangled; and
- Retain all dead STAL and submit the carcass upon return to port.

All shallow-setting Hawaii longline vessels, wherever they fish, must either:

- Side-set (including using 45 g weighted swivel within 1 m of the hook, and a bird curtain)

or

- Night set
- Use thawed, blue-dyed bait;
- Discard offal strategically, only when seabirds are present;
- Handle all seabirds in a manner that maximizes the probability of their long-term survival;
- Notify NMFS immediately if a STAL is hooked or entangled; and
- Retain all dead STAL and submit the carcass upon return to port.

Fishermen are educated on these regulations during mandatory annual Protected Species Workshops, and observers are educated on these regulations during their mandatory training. Vessel operators, crew, enforcement officials, and observers all receive the same current seabird mitigation information summarized in Table 3.

Table 3. Summary of seabird regulations for the Hawaii longline fleet, effective as of January 18, 2006.

(Source: NMFS PIRO)

Effective Date: January 18, 2006 **X = Required Measure**		**Side-Setting**			**Stern-Setting**	
	Shallow Set	Deep Set >23°N	Deep Set <23°N	Shallow Set	Deep Set >23°N	Deep Set <23°N
45 g weights	**X**	**X**			**X**	
Weights within 1m of the hook	**X**	**X**			**X**	
Blue-dyed bait (thawed)				**X**	**X**	
2 (1 lb) containers of blue dye				**X**	**X**	
Set from port or starboard side	**X**	**X**				
Setting station at least 1 m forward of stern corner	**X**	**X**				
Line shooter at least 1 m forward of stern corner (if used)	**X**	**X**				
Deploy gear so that hooks do not resurface	**X**	**X**				
Bird curtain	**X**	**X**				
Use line shooter					**X**	
Retain fish parts and spent bait (hooks removed)				**X**	**X**	
Retain and prepare swordfish head and liver				**X**	**X**	
Begin set 1 hr after sunset/complete before dawn				**X**		

Follow seabird handling procedures	**X**	**X**	**X**	**X**	**X**	**X**

The following seabird deterrent methods are explained in more detail:

- strategic offal discarding;
- thawed blue-dyed bait;
- weighted branch lines;
- night setting; and
- side-setting.

Strategic Offal Discarding

Strategic offal discarding involves throwing overboard fish offal (i.e., fish, fish parts, and spent bait) while setting and hauling gear, on the opposite side of the vessel from where the longline gear is being set or hauled. Swordfish heads must be removed and cut in half vertically (between the eyes) before discarding. Livers must also be removed and discarded. In the past, only swordfish were dressed at sea (heads and guts were removed before the carcasses were packed on ice in the vessel's hold). Recently, however, tuna are being dressed at sea, as well. Thus, a supply of offal can be routinely generated for the next set on both swordfish- and tuna-targeting vessels. Gilman (2004), in his analysis of Hawaii longline observer data, found that only 18% of tuna-targeting sets employed strategic offal discards. This percentage increased in 2005 to approximately 50%[6], partially due to more vessels gutting their tunas. Vessels that do not dress their tuna at sea must retain spent bait and non-saleable bycatch (such as snake mackerel and lancetfish) during the haul to use for the next set when strategic offal discards are required.

Strategic offal discards have been known to be effective in reducing interactions with seabirds. Tests by McNamara et al. (1999) showed that strategic offal discards reduced gear contacts with seabirds in the Hawaii longline shallow-set fishery by 51% and seabird interactions by 88%. However, over time, this practice is believed to attract birds to the vicinity of the vessel, increasing bird abundance, searching intensity, and interaction (Brothers et al. 1999). In the long term, strategic offal discarding may reinforce the association that birds make with specific longline vessels being a source of food. Brothers (1996) hypothesizes that seabirds learn to recognize by smell specific vessels that provide a source of food, implying that vessels that consistently discard offal and fish bycatch will attract more seabirds resulting in higher interaction rates than vessels that do not discard offal and fish waste. Nevertheless, vessels that practice strategic offal discards have shown lower bird interaction rates than those that do not employ strategic offal discarding at all.

[6] This percentage is an estimated value, as observer data was recorded differently beginning in June of 2005 when the regulation for "strategic offal discards" changed to be recorded only when seabirds are present (T. Swenarton, NMFS PIRO, pers. comm., April 4, 2006).

Strategic offal discarding is a cost-effective mitigation technique with an initial maximum investment of $150, especially for swordfish-targeting vessels that routinely generate large quantities of offal. However, this requirement is difficult to monitor for compliance, especially on non-observed vessels. Regulations promulgated on December 19, 2005 (70 FR 75075), modified the requirement to use strategic offal discards only when seabirds are present, so the requirement should be less of a burden on fishermen.

Thawed Blue-dyed Bait

Dying bait to a specific blue color is an attempt to reduce a seabird's ability to see the bait by reducing the bait's contrast with the sea surface. The bait is thawed in order to increase sink rates. In a study by Gilman et al. (2003), blue-dyed bait showed to be 63% effective at avoiding seabird interactions in the deep-set fishery as a stand-alone seabird avoidance technique.

Blue dye is taken up less readily by fish baits such as sardines and sanma, than by squid bait, and fishermen report difficulty in achieving the desired intensity of the blue color specified by NMFS due to the shedding of baitfish scales.   Squid bait is no longer being used in the Hawaii longline fishery because of the number of turtle interactions while using squid bait. Blue-dyed bait usually results in less bait retention because thawed bait falls off the hook faster than partially frozen bait. Thawed blue-dyed bait also results in slower hook setting rates because of the time spent thawing and dying the bait blue during the setting of longline gear. This technique is often inconvenient for crew because the dye can be messy, dyeing the hands and clothes of the crew and the deck of the vessel, and is therefore not used consistently from vessel to vessel.

Dying bait is a relatively inexpensive measure costing each vessel approximately $1,400 annually. However, compliance with this method is difficult to monitor. Gilman et al. (2007) found that blue-dyed bait produced a higher seabird interaction rate than side-setting or an underwater setting chute, when used with either tuna or swordfish gear. Most of the practicality, convenience, and enforceability problems could be addressed if pre-blue-dyed bait were commercially available. Thawed blue-dyed bait is part of the suite of measures currently required for vessels that do not side-set in the Hawaii longline fleet.

Weighted Branch Lines

Weights at the hook end of branch lines are intended to quickly sink baited hooks, before foraging seabirds can take the baits and subsequently become hooked or entangled in longline gear. Hawaii longline vessels use 45 g, 60 g, and/or 80 g weights within 1 m of the hook to quickly sink their branchlines to desired target depths. A recent study comparing the effective sink rates of 45 g (1.2 m/s) and 60 g (1.3 m/s) weighted branch lines concluded the difference in sink rates to be negligible (Brothers, Gilman 2005). Thus, 45 g weights are the current minimum weight requirement for deep-setting vessels fishing north of 23° N. latitude and for side-setting vessels, wherever they fish.

This deterrence method has an associated cost of approximately $5,700 (start-up) and $2,400 (annual maintenance) for deep-setting and/or side-setting vessels. Compliance with this method is easy to enforce dockside, because the gear is prepared before vessels leave port.

Night Setting

Night setting involves beginning fishing operations (the set) no earlier than one hour after local sunset, and completing the set no later than sunrise, using only the minimum vessel lights necessary to conform with navigation rules and best safety practices. The concept is that seabirds cannot see the baited hooks in the dark, and, therefore, do not dive for the bait, thus avoiding interactions with longline gear. The effectiveness of this measure is influenced by the moon phase and cloud cover, vessel lighting, and light sticks. Night setting appears to be very effective as a mitigation measure. In the past, vessels were able to set before sunset and there were correspondingly high sea bird interaction rates. The current 100% observer coverage in the shallow-set fishery ensures that this measure is adhered to and interaction rates have remained low in the shallow-set fishery.

Night setting is required only for shallow-setting (swordfish-targeting) vessels. If night setting is executed following the regulations, it proves to be a very effective method of avoiding seabird interactions. A study by McNamara et al. (1999) shows night setting to be 73% effective at avoiding seabird interactions, whereas a study by Boggs (2001) shows night setting to be 98% effective. Vessels use light sticks on each branchline in order to entice nocturnally foraging swordfish and, most likely, prey items close to the baited branch lines.

Side-setting

Side-setting involves deploying the gear from the side of the vessel, as opposed to the conventional approach of setting from the stern. The effect is that baited hooks are set closer to the side of the vessel's hull where seabirds are unable or unwilling to pursue the hooks. Ideally, when side-setting with proper line weighting, by the time the stern passes the point where the hook entered the water, the hook has sunk below the maximum diving depth of the birds. A bird curtain (a bird-scaring device) deployed in combination with this technique reduces the ability of seabirds to establish a flight path along the side of the vessel, thus increasing the effectiveness of this method to avoid capturing seabirds.

The current regulations, effective on January 18, 2006 (70 FR 75075), require vessels choosing to side-set to employ the following measures:

1) Deploy the mainline as far forward on the vessel as practicable, and at least 1 m forward from the stern of the vessel;
2) Set the mainline and branch lines from the port or starboard side of the vessel;
3) If the mainline shooter is used, it must be mounted as far forward on the vessel as practicable, and at least 1 m forward from the stern corner of the vessel;
4) Branch lines must have weights with a minimum weight of 45 g;
5) One weight must be connected to each branch line within 1 m of each hook;

6) When seabirds are present, the longline gear must be deployed so that baited hooks remain submerged and do not rise to the sea surface; and
7) A bird curtain must be deployed, that consists of the following three components:
    a) a pole that is fixed to the side of the vessel aft of the line shooter and that is at least 3 m long;
    b) at least three main streamers that are attached at regular intervals to the upper 2 m of the pole and each of which has a minimum diameter of 20 mm; and
    c) branch streamers attached to each main streamer at the end opposite from the pole, each of which is long enough to drag on the sea surface in the absence of wind, and each of which has a minimum diameter of 10 mm.

Side-setting has been demonstrated to have the greatest promise of any single seabird mitigation method tried to date in reducing albatross mortality in the Hawaii longline fishery. In deep-set and shallow-set trials conducted by Gilman et al. (2007), side-setting was shown to produce the lowest seabird interaction rates when compared to setting with two lengths of an underwater setting chute (a device that sets hooks underwater), or setting with blue-dyed bait. In 2005, observers did not record any seabird interactions on vessels employing side-setting. Out of 124 active Hawaii longline vessels, 44 had converted their vessels to side-setting by December 2005. In 2006, 35 vessels side setting in Hawaii pelagic longline fisheries. One of these vessels is participating in the shallow-set fishery. Some vessels that were outfitted for side-setting never used the measure and some vessels actually reverted to stern-setting (Brothers et al 2007).An effective seabird avoidance measure with the ability to provide large operational benefits for many vessels, side-setting is anticipated to become the preferred technique for tuna-targeting vessels in upcoming years.

However, swordfish vessels are unlikely to switch to side-setting due the unwillingness of swordfish fishermen to place weights within one meter of the hook. Therefore, these vessels even if they set their gear from the side would not conform to the *definition* of side-setting under current regulations. While weights (≥45 g) are normally placed on branchlines, they are usually situated far from the hook in the middle of the branchline. Safety considerations are usually cited by fishermen as the reason for placing weights in the middle of branchlines. However, there is no evidence that weights in the middle of branchlines are less dangerous than weights placed within one meter of the hook. More research should be done to investigate how weight placement on branchlines affects safety.

Side-setting minimizes bait theft by preventing seabirds from having access to baited hooks. The use of a bird curtain scares birds away from the zone adjacent to the side of the vessel where baits are deployed. By the time baited hooks reach the stern of the vessel, they have sunk beyond the reach of most seabirds – and certainly most all albatrosses – by placing weights (≥45 g) within 1 m of the hooks. It also increases fishing efficiency by eliminating the need to transport gear from the stern of the vessel to amidships between setting and hauling operations.

Side-setting does require an initial investment of about $1,500 to reconfigure the vessel's deck design, and to construct a bird curtain (pers. comm. Sean Martin 2007). A side-setting technical assistance project, however, begun in 2005, provides assistance for vessels to convert their deck designs to side-set, including reimbursing fishermen for relocating their setting machines (up to $1000) and installing a bird curtain (up to $200). In 2005, the project, funded by PIFSC and the Hawaii Longline Association (HLA), converted 28 vessels to side-setting. In 2006, PIRO had funds to assist in the conversion of three more vessels. These conversions were completed by September 2006. Monitoring the requirement to side-set is relatively easy to enforce, as the orientation of the gear on deck can be monitored through dockside inspection, and vessel operations can be readily observed at sea.

6.0 Historic Seabird Interactions and Deterrence Effectiveness

Since 2001, the estimated number of seabirds incidentally taken in the Hawaii pelagic longline fisheries has dramatically decreased (Fig. 2). Below is a brief history of the efforts to reduce incidental seabird takes in these fisheries.

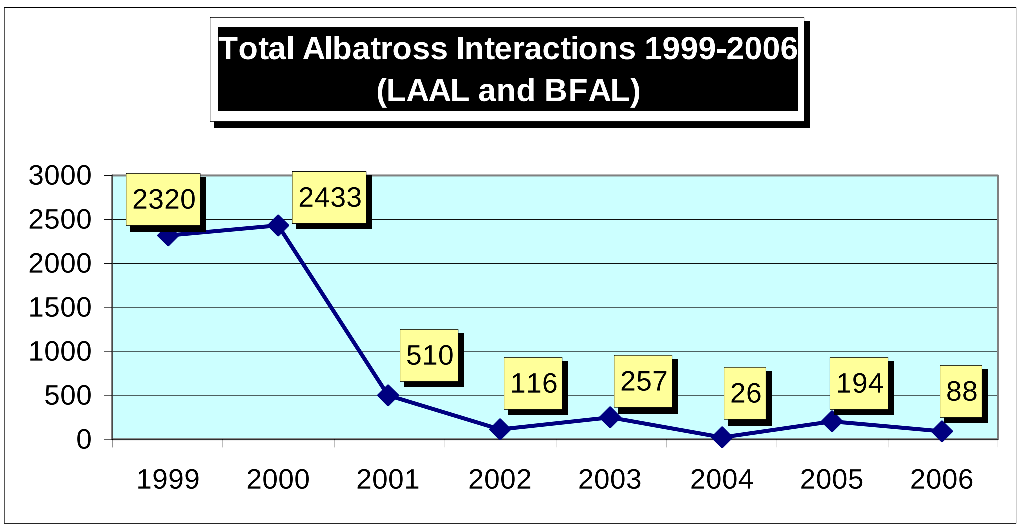

Fig. 2 Total Estimated Albatrosses Incidentally Taken by Hawaii Longline Vessels 1999-2006
(Source NMFS PIRO)

In 1999, an estimated 2,320 seabirds were caught in the combined deep-set and shallow-set components of the Hawaii longline fishery. In 2000, an estimated 2,433 seabirds were captured. In 2001, there were an estimated 510 seabirds incidentally taken in Hawaii longline fisheries. This drop from the previous year was largely due the curtailment and eventual closure of the swordfish fishery beginning in April 2001. These management actions decreased fishing effort on the swordfish fishing grounds when albatrosses forage in these same areas during the breeding season (late winter through early spring) (Eric Gilman, pers. comm. 2005). The swordfish fishery remained closed throughout 2002 and 2003. During this period, an estimated 373 seabirds (116 in 2002 and 257 in 2003) were incidentally caught by the deep-set fishery. In April 2004, the swordfish fishery re-opened under a management program with an annual limit on shallow-sets allowed north of the Equator (69 FR 17330). During 2004, 26 albatrosses were estimated to be captured in the combined shallow-set and deep-set components of the Hawaii longline fishery. The low numbers can be attributed to a combination of a decrease in fishing effort with the closure of the swordfish fishery and the effectiveness of seabird deterrence measures. In 2005, with the same seabird deterrents in place and fishing effort very similar to that in past years, 194 seabirds were estimated to be captured in the combined shallow-set and deep-set components of the fishery. However, the swordfish fishery, opened the entire year, likely had an effect on seabird interaction estimates (i.e., 100 more swordfish trips were conducted in 2005 than in 2004). While the shallow-set fishery was curtailed in 2006 because it reached the loggerhead sea turtle interaction limit, both the total numbers of birds taken (as would be expected) and the seabird interaction rate (0.015 seabirds per 1000 hooks) remained low compared to 2001 and earlier.

Another contributing factor to the decrease in seabird interaction estimates over the years is the implementation of seabird deterrence measures. In June 2001, a suite of seabird measures became mandatory in the Hawaii longline fishery with the implementation of an emergency rule (66 FR 31561). The final rule for this suite of seabird deterrence techniques was published in May 2002 (67 FR 34408). Since then, the numbers of seabirds incidentally taken in the Hawaii longline fishery have remained low. New seabird measures effective as of January 18, 2006 (70 FR 75075), are projected to result in continued low numbers of seabird interactions. The efficacy of these measures relative to no treatments is difficult to quantify. Fishery data, when properly monitored, can help gauge the effectiveness of mitigation measures relative to historical baselines. However, due to confounding variables such as location, date, and fishing techniques, results can be misleading if relationships between these variables cannot be clarified. There have been no studies evaluating current seabird mitigation measures with a true control using fusiform fish baits which are required under current sea turtle mitigation rules (50 FR 665.32). What can be said is that experiments using shallow-set vessels, showed that side-setting reduced seabird interactions by 87.5% over simply dying fish baits blue (0.01 seabirds per 1000 hooks versus 0.08 seabirds per 1,000 hooks). In deep-set experiments, there was a 100% improvement using side-setting compared to blue-dyed fish baits (0.03 seabirds per 1,000 hooks versus 0.00 seabirds per 1,000 hooks) (Gilman et. al. 2005).

Gilman (2006) attempted to use observer data to determine the effectiveness of three treatments: 1) side setting with plain baits; 2) stern setting with plain baits; and 3) stern setting with blue-dyed baits using observer data from the deep-set fishery. The results were inconclusive owing to the small number of albatross interactions (n=6). Because albatross interactions in the deep-set fishery are such rare events the sample size of 323 sets was not adequate to provide great enough detection to make any solid conclusions. In 2007, the PIRO is planning a more comprehensive approach to analyzing observer data for seabird interactions that includes the use of scan counts to filter out only those sets where seabirds were present.

An important factor in assessing seabird mitigation measures is understanding the extent to which localized seabird abundance around vessels influences interaction rates and changes both temporally and spatially. The NMFS observer program records relative seabird abundance during fishing operations. Including relative seabird abundance into analyses will improve the understanding of the relative success of seabird mitigation measures and enable more precise interaction rates. For instance, it is possible that observed reductions in seabird interaction rates result from fewer albatrosses in the vicinity of observed fishing vessels. However, Clemens (2005) found that there were no discernable spatial differences in fishing effort since the reopening of the swordfish fishery in 2004 compared to historic fishing effort for either the deep-set fishery or the shallow-set fishery (Figs. 2 and 4). Therefore, if albatross abundances in the vicinity of Hawaii longline vessels have also not changed, then differences in seabird interaction rates must be a result of something besides differences in spatial-temporal patterns of fishing effort and seabird abundance proximal to fishing operations. NMFS's efforts to gather ship-board estimates of relative seabird abundance should continue. These observations will likely prove valuable when combined with on-going tracking studies of all three species of North Pacific albatrosses. Even with no changes in temporal-spatial effort over time and seabird abundance, it is difficult to gauge the effectiveness of mitigation measures in Hawaii longline fisheries - especially, in the shallow-set fishery. In addition to seabird mitigation measures, the shallow-set fishery is required to employ sea turtle mitigation measures including large circle hooks (minimum size 18/0) and a ban on squid bait (50 CFR 665.32). It is highly possible that sea turtle mitigation measures may also have the ancillary effect of reducing seabird takes. The March 20, 2006 shallow-set fishery closure (71 FR 14416) triggered by sea turtle interactions definitely reduced fishing effort in areas frequented by foraging albatrosses and likely reduced the number seabirds that could have potentially been taken incidentally to fishing operations.

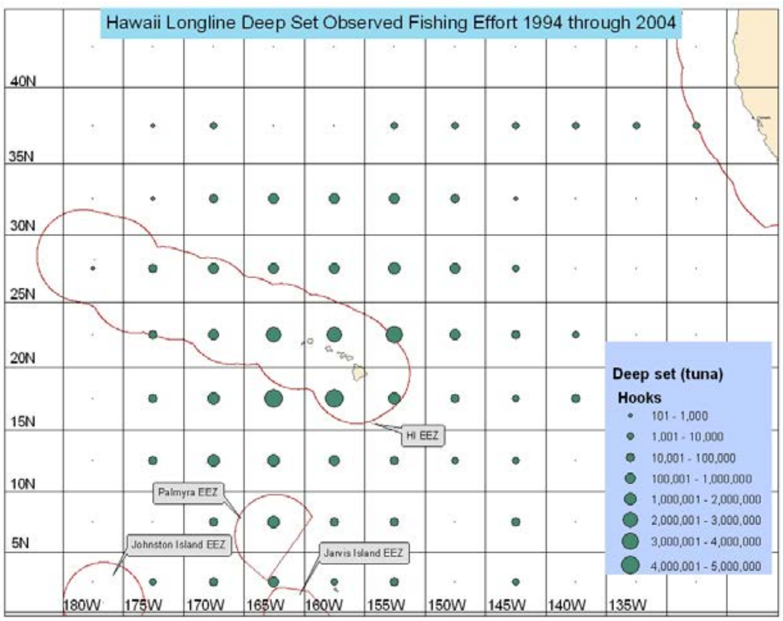

Figure 3. Observed fishing effort in the deep-set fishery, 1994-2005.
(Source: NMFS PIRO)

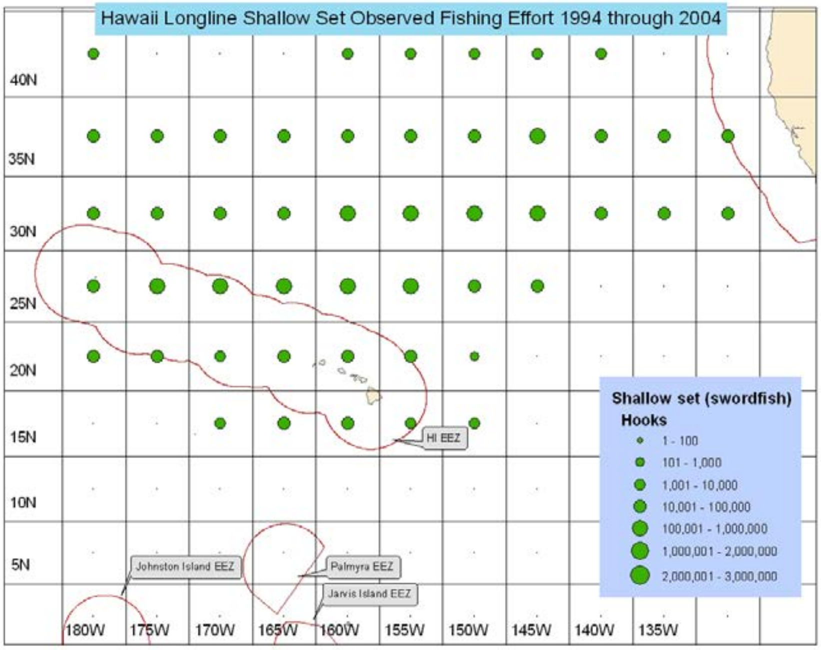

Figure 4. Observed fishing effort in the shallow-set fishery, 1994-2005.
(Source: NMFS PIRO)

7.0 Observer Coverage in 1994-2006

The two major sources of information regarding albatross interactions with the Hawaii longline fishery are mandatory logbooks and observer data collection programs, both administered by NMFS. The longline logbook program requires longline vessel operators to complete and submit to NMFS a daily log sheet containing detailed catch and effort information about each set, including interactions with protected species (50 CFR 665.14).

NMFS observers have been deployed aboard Hawaii longline vessels since 1994, primarily to document protected species interactions, collect fishery-related information, and perform other biological work as requested by PIRO. The terms and conditions of the 2004 Pelagics BiOp (NMFS 2004) require 100% observer coverage on shallow-setting vessels, whereas the 2005 BiOp on the deep-set fishery (NMFS 2005a) directs NMFS to maintain an annual level of at least 20% observer coverage on deep-setting vessels.

Until 2001, the NMFS Hawaii Longline Observer Program Field Manual (Manual) specifically instructed observers not to record seabird sightings unless birds interacted with the fishing gear (NMFS 1999). In the June 2001 revised Manual, observers were instructed to record sightings of STALs only, and fishing interactions with all seabird species (NMFS 2001b). From October 2002 to November 2004, observers on vessels operating north of 23° N. latitude were required to identify, record behaviors toward fishing gear, and any interactions with all seabird species during the setting and hauling of longline gear. In November 2004, observers were redirected to focus their seabird observations only to STAL, LAAL, and BFALs north of 23° N. latitude to comply with the USFWS 2004 BiOp. Observers are now instructed to record details and take photographs when STALs are sighted (USFWS 2004). Observers are also now asked to observe the first hour of setting operations for any seabirds by conducting 5-minute scan counts at the beginning of the hour and after the first half hour. During scan counts, observers are required to survey the area around the vessel in a 360 degree radius out to 200 m. During the retrieval of longline gear, observers are directed to conduct scan counts for any seabirds every two hours, at the beginning of each hour. Sightings and interactions with STAL, LAAL, and BFALs are to be recorded during the setting and hauling of longline gear (PIRO Circular Update 55B, November 2, 2004). Scan counts provide a way to estimate the relative abundance of seabirds which can be compared over the years.

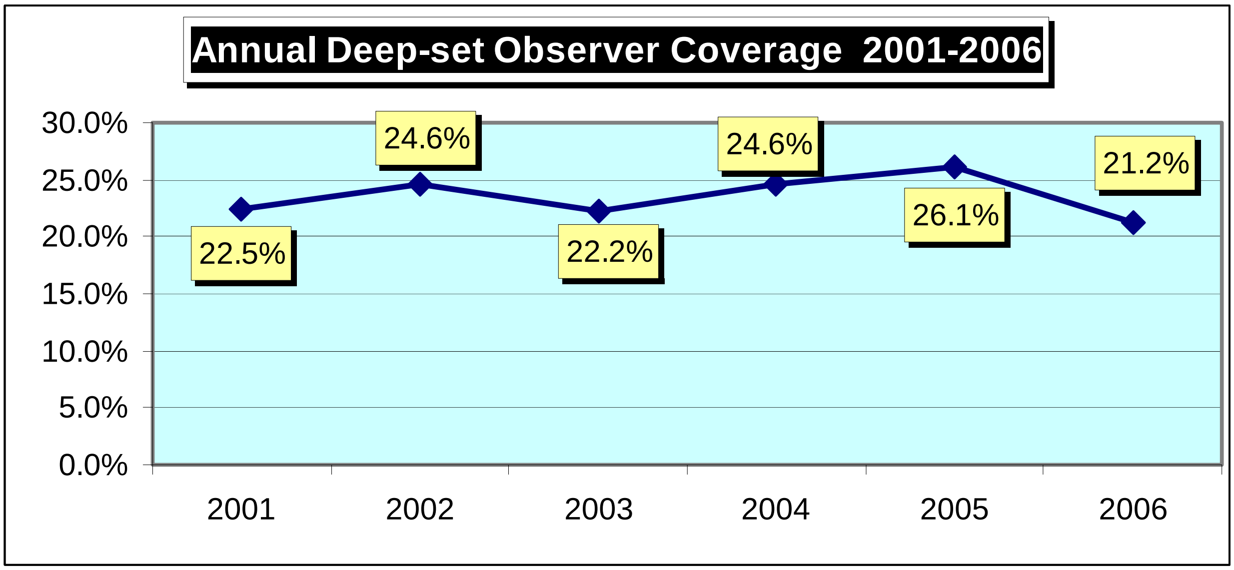

Figure 5. Observer coverage on deep-setting vessels, 2000-2006.
(Source: NMFS PIRO)

The observer program exceeded the required 5% coverage for deep-setting vessels operating north of 23° N. latitude. In 2006, NMFS maintained a 17.7% annual observer coverage rate on deep sets vessels fishing above 23° N. latitude observing 958 out of 5404 sets (Fig. 6). All shallow-sets above 23° N. latitude were observed in 2006.

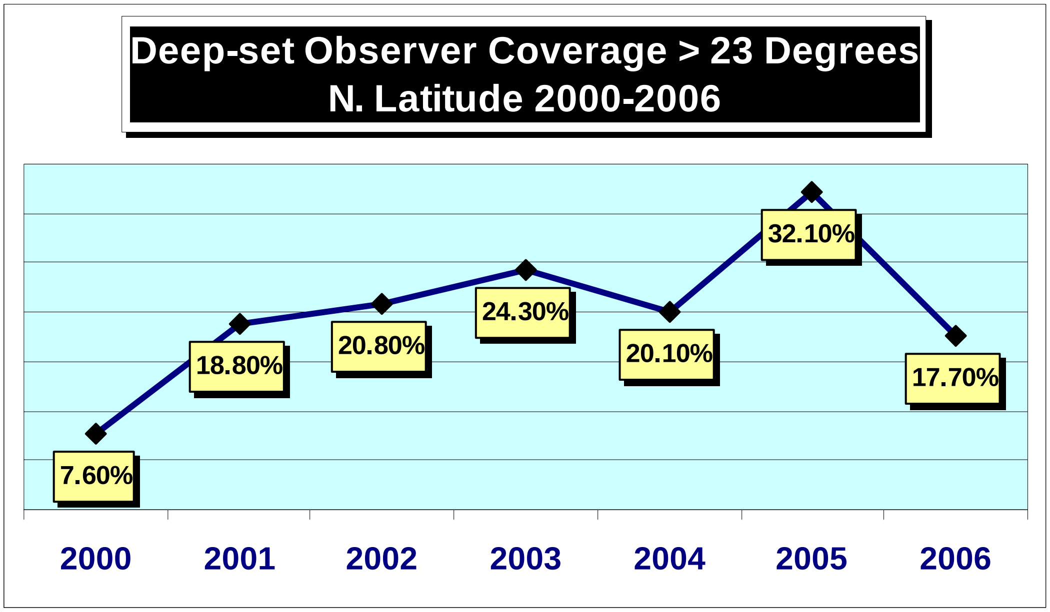

Figure 6. Observer coverage on deep-setting vessels north of 23° N latitude, 2000-2006. (Source: NMFS PIRO)

8.0 Seabird Interactions in 2006

For the purposes of this report, *interaction* means that the seabird was incidentally taken by becoming hooked or entangled with the fishing gear. Seabird strikes with vessels are not recorded as incidental takes by NMFS observers. Incidental takes of seabirds are usually recorded during the haulback of longline gear, but on rare occasions they may be recorded by observers during the setting of gear. Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species without special exemption. Take is defined as to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct." An incidental take of one STAL is allowed per year for the shallow-set fishery under the 2004 BiOp (USFWS 2004).

Observed Interactions

There were no sightings, nor were there any observed interactions of STALs in either the deep-set or shallow-set components of the Hawaii longline fishery during 2006. However, the deep-set fishery interacted with 17 BFAL, 1 LAAL, 3 Sooty Shearwaters (*Puffinous griseus*), and two unidentified shearwaters (*Puffinus* spp.) with a 21.2 % observer coverage rate (0.003 seabirds per 1,000 hooks). The shallow-set fishery interacted with 3 BFAL and 8 LAAL with a 100% observer coverage rate (0.015 seabirds per 1,000 hooks). It should be noted that the shallow-set fishery was closed for the 2006 season on March 20, 2006, after reaching the allowed sea turtle interaction limit of 17 loggerhead sea turtles (*Caretta caretta*).

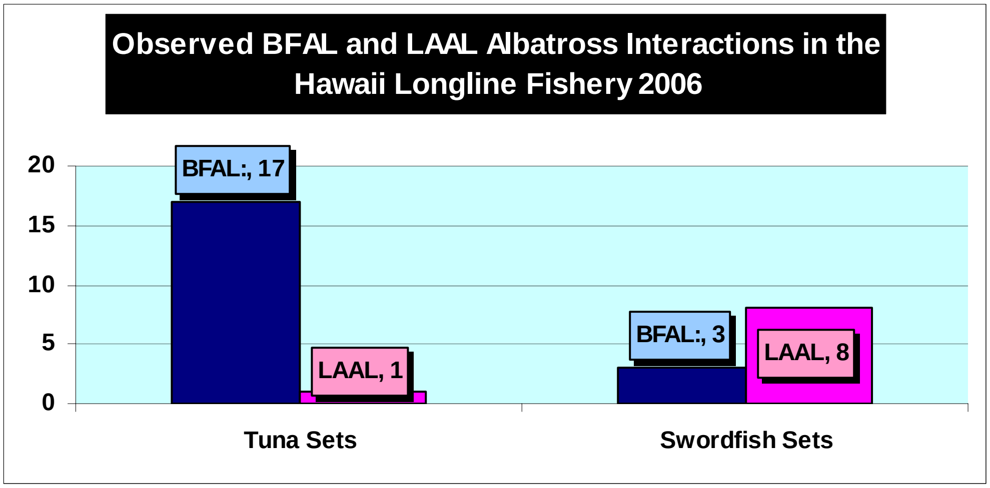

Figure 7. Total observed black-footed and Laysan albatross interactions in the Hawaii pelagic longline fishery, 2006.
(Source: NMFS/PIRO)

Estimated Interactions

Interaction estimates are calculated for the deep-set fishery in which ≥20% observer coverage is maintained annually (NMFS 2005a). In the shallow-set fishery, 100% observer coverage is required; therefore, all *observed* interactions are assumed to equal *total* interactions.

Because of fluctuations in the fleet's activity levels and observer availability, coverage levels vary throughout the year. These fluctuations make it impractical to sample trips so that each trip has an equal chance of being sampled (*simple random sample*). Furthermore, it is inappropriate to estimate the total number of incidental interactions by simple raising the average observed catch rate by the total amount of effort as this estimator assumes a simple random sample.

The Horvitz-Thompson estimator employed by McCracken (2006) for the deep-set fishery is an unbiased estimator based on the sampling design. The sampling design uses a systematic sample as the primary sample and a daily random sample as a secondary sample. The systematic component uses a random number generator to select trips based on the order in which they are called in. This systematic schedule is usually designed to provide a 15% sampling rate. The daily sample selects trips randomly from vessel notifications at the end of a business day when observers are available. This hybrid approach to sampling is necessary to address the needs of fishing vessels to be able to fish, the ability of the NMFS Observer Program to place observers on vessels as observer availability varies, and the need to maintain a minimum 20% annual observer coverage rate for deep-set vessels. For instance, right after an observer training class there may be more than an adequate number of observers available to cover 20% of deep-set trips. Sampling can easily follow the systematic schedule. Often during these periods the coverage rate is above 20% and vessels have a greater chance of being sampled. Conversely, if there are other demands on observers, like when trying to cover 100% of shallow-set trips, NMFS cannot simply prevent deep-set vessels from fishing. This leads to periods of low observer coverage and lower probabilities that a particular vessel will be sampled. The Horvitz-Thompson estimator used by McCracken accounts for the interplay between observer availability and fleet activity which, in turn, influences the *probability* of whether a trip is sampled, or not. This estimator takes all the above variables into account.

While point estimates derived through the Horvitz-Thompson estimator are considered reliable, periods of low observer coverage (i.e., small sample size) lead to wider confidence intervals. Because seabird interactions are relatively rare events, confidence intervals were computed using accepted methods for estimating confidence intervals for rare events (Poissant variants). Confidence intervals for the yearly total were not computed because it is unreasonable to assume the interaction rates are constant throughout the year (McCracken 2006).

Table 4. Interaction estimates with incidentally caught albatrosses and corresponding 95% confidence intervals (C.I.) for the Hawaii deep-set longline fishery in 2006.
Source: PIFSC, unpublished data.

	Quarter 1	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Annual Total**
Species	Point Estimate, C.I.	Point Estimate, C.I.	Point Estimate, C.I.	Point Estimate, C.I.	
Black-footed Albatross	28, [5,112]	21, [8,39]	8, [2,26]	13, [2,34]	70
Laysan Albatross	0, [0,43]	0, [0,11]	7,[1,24]	0, [0,16]	7

In 2006, the Hawaii deep-set longline fishery was estimated to have incidentally interacted with 70 BFAL and 7 LAAL. The 2006 estimated interaction rates for the deep-set fishery by species are 0.002 BFAL per 1000 hooks and 0.0002 LAAL per 1000 hooks. The overall deep-set fishery interaction rate was 0.002 albatrosses per 1000 hooks.

In 2006, there were an estimated 73 total interactions with BFAL and 15 interactions with LAAL (88 total). Fleet-wide seabird interactions for both components of the Hawaii longline fishery (estimated deep-set and observed shallow-set) during years 1999 through 2006 are depicted in Figure 8, taking into account that the shallow-set fishery closed in April 2001, and re-opened in April 2004.

It is interesting to note that BFALs are incidentally taken at a rate that is disproportionate to their population (recall that the BFAL nesting pair population is about one tenth that of LAALs). This trend seems to be consistent over the years (Fig. 8). Fernandez et. al. (2001) note that this species is commonly seen following ships, and the results of a satellite telemetry study by Hyrenbach et. al. (2002) suggests that BFALs may selectively forage during the breeding season in the same areas that are fished by Hawaii-based longline vessels. Both studies show that during the early breeding period (January and February) both species may make short foraging trips to areas that are often fished by Hawaii-based longline vessels close to the NWHI. The Hyrenbach study also demonstrates a preference by LAALs for boreal and sub-arctic waters away from pelagic longline fishing grounds later in the breeding season (March and April). The differences in behavior and preferred foraging areas during the breeding season between the two species may have some influence on why BFALs are caught in disproportionate numbers relative to their population. Research into the feeding behaviors, monitoring of albatross abundance and interactions on fishing grounds, and telemetry studies should continue in order to help clarify why BFALs are taken more often in pelagic longline fishing operations relative to their population size.

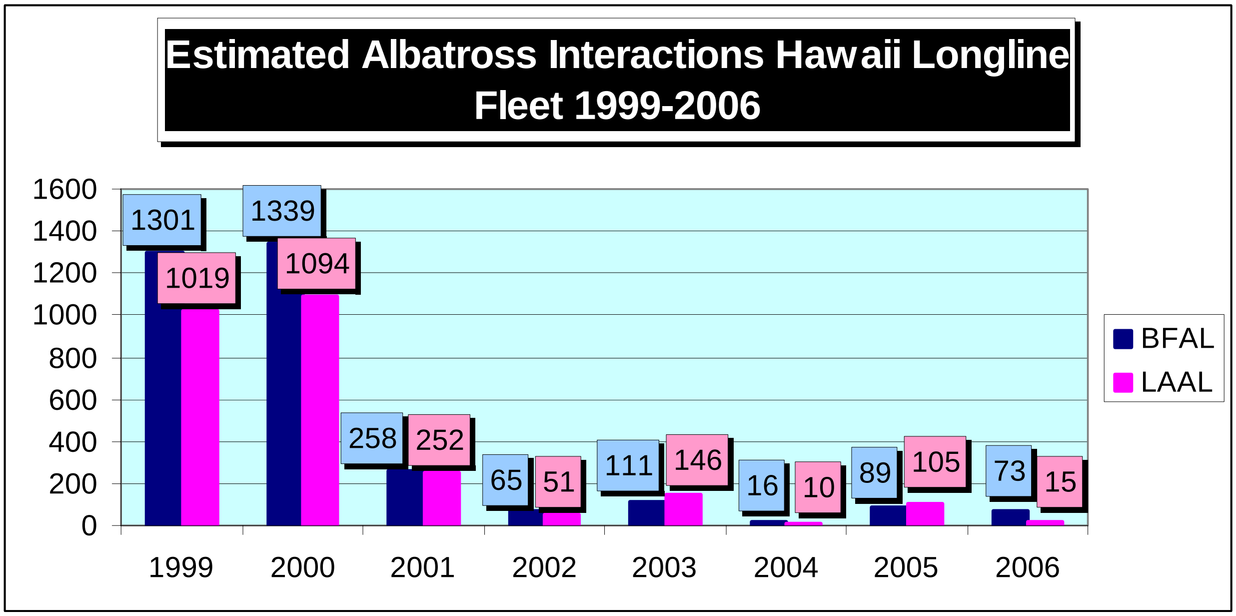

Figure 8. Estimated fleet-wide incidental interactions of black-footed and Laysan albatrosses in the Hawaii longline fishery during, 1999-2006. (Source: NMFS PIRO)

9.0 Protected Species Workshops in 2006

The Protected Species Workshops have been conducted by PIRO, Sustainable Fisheries Division (PIRO SFD) annually since 2000. Workshops are mandatory for all longline vessel operators and owners with a Hawaii or American Samoa longline limited entry permit, and recommended for all vessel operators with a general longline permit. Participants receive a certification card upon completion of the workshop, and the card must be carried on board the vessel during fishing operations. PIRO SFD collaborates with other agencies, including USFWS, PIFSC, and NMFS Office for Law Enforcement (OLE), and other PIRO divisions involved with the Hawaii longline fishery, including the Observer Program and the Protected Resources Division. This collaborative effort between the agencies has led to informative and successful Protected Species Workshops.

The workshops present information on seabird, sea turtle, and marine mammal identification and life history, mitigation techniques, current regulations, and any updates on current research pertinent to the fishery. Participants receive workbooks containing current regulations, copies of presentations, and information placards. Written materials and video presentations are provided in English, Vietnamese, and Korean, which are the predominant languages of captains of Hawaii longline vessels. In recent years, crews have been imported from outside of the U.S. to work on Hawaii longline vessels. Crews have been recruited from various parts of Micronesia, the Philippines, and Indonesia. Most Micronesians speak English and no translation of outreach materials is necessary. The majority of materials have been translated into Tagalog to accommodate crews from the Philippines. The introduction of Indonesian workers is fairly recent, and outreach materials have not yet been prepared for this group. Additionally, all outreach materials have been translated into Samoan for use in the American Samoa-based longline fishery.

In 2006, NMFS presented the Protected Species Workshops to 308 longline vessel operators and owners in Hawaii and American Samoa (Fig. 9).

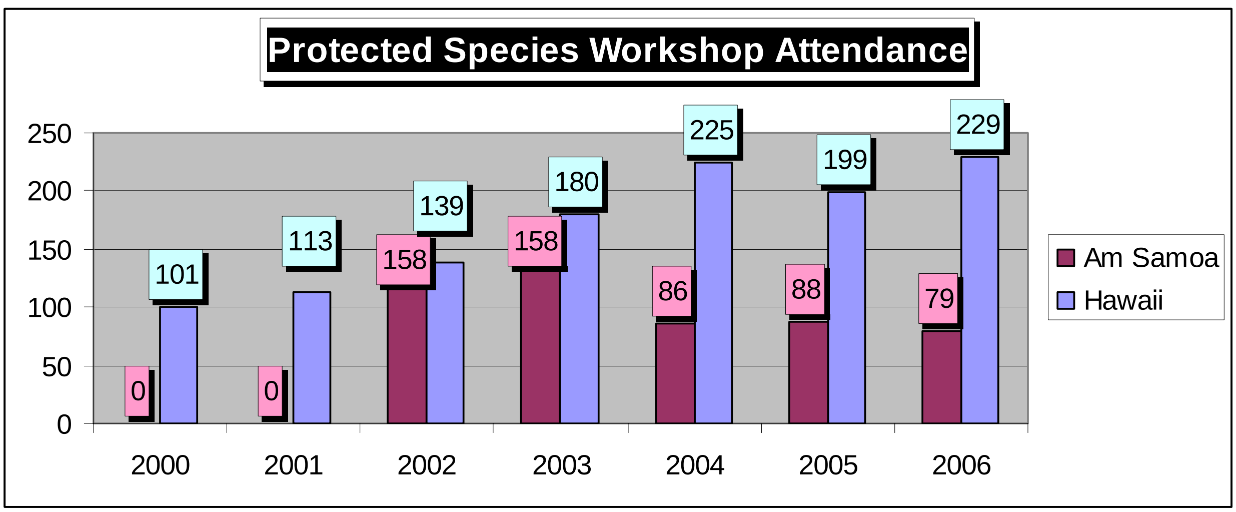

Figure 9. Protected Species Workshop certifications for Hawaii-based and American Samoa longline fishermen, 2000-2006.
(Source: NMFS/PIRO)

NMFS is in the process of developing a web-based interactive version of the Protected Species Workshops to teach fishermen and the public about protected species including seabirds, sea turtles, and marine mammals that occur in the Pacific Islands Region. This on-line course will cover identification and basic biology of the above species, handling procedures, and regulations designed to mitigate the frequency and severity of protected species interactions. It is intended for vessel owners learning from a distance and captains who are comfortable with computer learning and willing to come to the PIRO offices or suitable dock-side kiosks. Classroom style workshops will still be held throughout the year with decreasing frequency as appropriate.

10.0 Summary

In 2006, total observer coverage averaged 26.3% (21.2% for deep-setting vessels and 100% for shallow-setting vessels; 4544 of 17,247 total sets) based on trips arriving in 2006. Additionally, NMFS observers monitored 28.7% of all longline sets above 23° N. latitude and 17.7% of deep-sets above 23° N. latitude that were hauled in 2006 (NMFS unpubl. 2007).

Out of a total of 35,192,344 hooks fished, the deep-set fishery deployed a reported 34,486,898 hooks in 16,397 sets, and the shallow-set fishery deployed a reported 705,446 hooks in 850 sets.

No interaction was observed or reported with a STAL in the Hawaii longline fishery, either by deep-setting or shallow-setting vessels. However, in 2006, the shallow-set fishery was observed to interact with three BFALs and eight LAALs giving an interaction rate of 0.015 seabirds per 1000 hooks. It should be noted that the shallow-set fishery was short-lived in 2006 closing on March 20, 2006. In the deep-set fishery, it was estimated that there were 70 BFAL and seven LAAL interactions in 2006. Additionally, there were three sooty shearwaters and two unidentified shearwaters observed incidentally taken in the deep-set fishery. Overall, the deep-set fishery had an interaction rate of 0.002 albatrosses per 1000 hooks. Since no interaction estimates were produced for the shearwater interactions, an interaction rate for these species and an overall *seabird* interaction rate cannot be computed for the deep-set fishery. Since 2004, the estimated number albatrosses taken incidentally to fishing operations by Hawaii pelagic longline fisheries has been reduced by 92-99% compared to the level seen in 2000.

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12.0 Acknowledgements

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13.0 Appendices

Appendix 1: Characteristics of the swordfish fishery versus the tuna fishery.

Table 5. Characteristics of the shallow-set (swordfish-targeting) and deep-set (tuna-targeting) components of the Hawaii longline fishery.

Characteristics	Swordfish-targeting	Tuna-targeting
Set depth	Shallow (~ 40 m)	Deep (~100-300 m)
Hook type	18/0 Circle hook with a 10° offset	Tuna "J" hook (3.6 or 3.8 mm)
Bait	Mackerel type (e.g. saury)	Saury
Lightsticks used?	Yes	No
Set deployment/retrieval	Night/Morning	Morning/Night
No. hooks between floats	4 - 6	15 - 30
Approx. no. hooks per set	800	2,000 to 3,000

Appendix 2: Interactions estimates with incidentally caught sea turtles, seabirds, and marine mammals in the Hawaii longline deep-set fishery.

Estimation of Incidental Interactions with Sea Turtles, Seabirds, and Marine Mammals in the 2006 Hawaii Longline Deep Set Fishery[7]

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Pacific Islands Fisheries Science Center
National Marine Fisheries Service

This report provides estimates of the number of incidental interactions with protected species by the Hawaii longline deep set fishery in the year 2006 (Table 1). Within this report, an incidental interaction means an event during a longline fishing operation in which a protected animal is hooked or entangled by the fishing gear. An incidental interaction estimate refers to the estimated total number of incidental interactions for all longline deep set fishing trips landing in the specified time period. A longline deep set fishing trip is defined as any commercial fishing trip by a vessel with a Hawaii longline permit that departs or returns at a Hawaii port, excluding those trips using a certificate for swordfishing.

The interaction estimates are based on a random sample of longline trips on which scientific observers are deployed. In 2006, observed trips were selected using two sampling schemes to accommodate fluctuating coverage levels and utilize observers efficiently. Coverage levels vary throughout the year because of fluctuation in the fleet's activity level, demands of 100% coverage in the Hawaii longline shallow set fishery, and an influx of observers after completion of NMFS observer training. Because observers are not paid while waiting to be deployed, they must be assigned with minimal delay when available. The alternative of paying them while they are waiting to be deployed would increase the cost of the observer program. The two sampling schemes attempt to reach a balance between obtaining a probability sample and being cost effective. A probability sample implies that all trips have a probability of being sampled and the sampling probabilities are known. These sampling probabilities form the basis of design-based estimators. An unbiased design-based estimator has the merit that it is unbiased regardless of the characteristics of the population being surveyed.

The primary scheme was a systematic sample. Before departing on a fishing trip, longline vessels were required to call the NOAA Fisheries Pacific Islands Regional Office (PIRO) observer program contractor at least 72 hours prior to their intended departure date. To enable sample selection, the PIRO contractor numbered calls sequentially in the order in which they were received. Herein, this assigned number is referred to as the call number. Prior to the beginning of a quarter, a systematic sample of call numbers was drawn by PIFSC and supplied to the contractor. The trips associated with these selected call numbers were designated to be sampled. Although every reasonable effort was made to sample selected trips, there were some selected trips that departed without an observer. In this situation, the PIRO contractor recorded

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that the trip was not sampled along with a short explanation of why it was not sampled. If a trip was selected but did not leave within a reasonable amount of time, usually the observer was reassigned to a different trip. When the selected vessel was ready to depart an observer was assigned to it.

The systematic sample requires having an observer available to be deployed whenever a selected trip is ready to depart. To achieve this requirement under full targeted coverage throughout the year requires increasing the current number of observers on contract and paying them when they are not deployed. These requirements cannot be met under the current level of funding; therefore, the quarterly sample selected under the systematic design was slightly smaller than the targeted coverage, typically 5% less. The additional trips needed to reach the full targeted level were then selected using a secondary sampling scheme. This secondary scheme was used when all trips selected by the systematic sample were already covered and an observer was ready to be deployed. In this instance, a trip was randomly selected with equal probability from the calls received that day that had not already been selected. If more than one observer needed to be assigned, the appropriate number of trips was sampled with equal probability from this pool of call-ins. The coverage obtained by this secondary sampling scheme was flexible and dependent on the need to deploy observers. The additional samples drawn under the secondary sampling scheme depart from traditional probability samples because the days when additional samples were drawn were not randomly selected but determined by the need to deploy observers.

Because the systematic sample was selected quarterly, point estimates of incidental interactions were computed on a quarterly basis and then summed to estimate the year's total interactions for non-experimental trips (see below). All observed incidental interactions on a trip were assigned to the quarter when the vessel returned to port after completing the trip. Some quarterly estimates of interactions therefore involve interactions that occurred during an earlier quarter. Accordingly, these estimates are not the best source of information on seasonality of interactions.

The contractor's sampling records were used to approximate sampling probabilities. The sampling probabilities during the periods when additional (secondary) samples were drawn were computed by enumerating the number of call-ins during consecutive periods of comparable coverage. It was then assumed that the additional trips were selected with equal probability from those trips that had not been selected as part of the systematic sample. When coverage was below that of the anticipated systematic sample, the sampling probabilities were computed by enumerating all call-ins during this period and assuming that the trips sampled were selected with equal probability. Because the coverage level changed with the fluctuations in observer availability and fishing activity, trips were not selected with equal probability. Therefore, the Horvitz-Thompson estimator was used to estimate total interactions, as it takes into account unequal sampling probabilities. The incidental interaction records used to compute the Horvitz-Thompson estimator were those available in the Longline Observer Database System on 23 March 2007.

Confidence intervals for the quarterly incidental interactions were estimated using the approximated sampling probabilities and assuming that the number of incidental interactions per trip for a given species was an independent Poisson variate with a constant mean value. The assumption that the average rate of incidental interactions was constant throughout a quarter is questionable but necessary to compute confidence intervals. Confidence intervals for the yearly total were not computed, as it seems unreasonable to assume that incidental interaction rates were constant throughout the entire year.

During the third and fourth quarter of year 2005 and the first quarter of year 2006, several vessels participated in an experiment that involved alternating, within a set, between circle hooks and the hook style the vessel normally used. Additionally, in the third and fourth quarters of 2006, one vessel made seven trips as part of an experiment to test a deep setting fishing method. All trips involved in these experiments had an observer or scientist onboard. Since the protocol for these experiments fell under the current legal practices for this fishery, these trips were considered to be part of the Hawaii longline deep set longline fishery activity and the data were included in the estimation of interactions. Because the experimental trips had 100% coverage they were not part of the random sampling scheme. To estimate the total incidental interactions for all deep set longline fishing activity, the numbers of interactions observed on the experimental trips were added to the estimated numbers of interactions on trips subject to the random sampling scheme; i.e., all trips not participating in the experiments.

Additional estimates of marine mammal interactions required for stock assessment and management will be provided later in a separate report.

Table 1. Point estimates of the number of incidental interactions by species and corresponding 95% confidence intervals (C.I.) for the Hawaii deep set longline fishery in 2006. All protected species with an observed interaction are listed as well as species that most commonly interact with the fishery.

	Quarter								Annual Total
	1		2		3		4		
	Number of Incidental Interactions								
Species	**Point Estimate**	**C.I.**	**Point Estimate**	**C.I.**	**Point Estimate**	**C.I.**	**Point Estimate**	**C.I.**	**Point Estimate**
Turtles									
Loggerhead	0	[0,43]	0	[0,11]	0	[0,15]	0	[0,16]	0
Leatherback	0	[0,43]	2	[1,13]	7	[1,24]	0	[0,16]	9
Olive Ridley	6	[1,51]	18	[4,36]	30	[6,58]	0	[0,16]	54
Green	0	[0,43]	2	[1,13]	4	[1,21]	0	[0,16]	6
Albatrosses									
Black-footed	28	[5,112]	21	[8,39]	8	[2,26]	13	[2,34]	70
Laysan	0	[0,43]	0	[0,11]	7	[1,24]	0	[0,16]	7
Dolphins									
Striped	0	[0,43]	0	[0,11]	0	[0,15]	6	[1,25]	6
Bottlenose	1	[1,44]	0	[0,11]	0	[0,15]	0	[0,16]	1
Risso	0	[0,43]	5	[2,18]	0	[0,15]	0	[0,16]	5
Unidentified Dolphin	7	[1,64]	2	[1,13]	0	[0,15]	0	[0,16]	9
Whales									
Pilot	1	[1,44]	5	[1,18]	0	[0,15]	0	[0,16]	6
Humpback	0	[0,43]	0	[0,11]	0	[0,15]	0	[0,16]	0
False Killer	6	[1,51]	2	[1,13]	3	[1,19]	6	[1,25]	17
Beaked	0	[0,43]	0	[0,11]	0	[0,15]	0	[0,16]	0
Unidentified whale	11	[1,90]	0	[0,11]	0	[0,15]	3	[1,20]	14