2009 Annual Report

Seabird Interactions and Mitigation Efforts in the Hawaii Longline Fisheries

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Cover photo:

Juvenile short-tailed albatrosses (*Phoebastria albatrus*) and decoys, Mukojima, Japan, by Greg Balogh, U.S. Fish and Wildlife Service.

Annual Report on Seabird Interactions and Mitigation Efforts in the Hawaii Longline Fisheries for 2009

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Acronyms

BiOp	Biological Opinion
BFAL	Black-footed Albatross
CFR	Code of Federal Regulations
C.I.	Confidence Interval
CPUE	Catch Per Unit Effort
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
FR	Federal Register
FMP	Fishery Management Plan
MHI	Main Hawaiian Islands
LAAL	Laysan Albatross
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWHI	Northwestern Hawaiian Islands
PIFSC	Pacific Islands Fisheries Science Center, NMFS
PIRO	Pacific Islands Regional Office, NMFS
SFD	Sustainable Fisheries Division, NMFS
STAL	Short-tailed Albatross
USFWS	U.S. Fish and Wildlife Service
WPFMC	Western Pacific Fishery Management Council

Preface

The "Annual Report on Seabird Interactions and Mitigation Efforts in the Hawaii Longline Fisheries for 2009" is the most recent in a series of National Marine Fisheries Service (NMFS) Pacific Islands Regional Office (PIRO) reports that describes sightings of short-tailed albatrosses and any interaction, i.e., hooking or entanglement in fishing gear, with the Hawaii-based pelagic longline fisheries. The report also contains observed and estimated total numbers of interactions with Laysan and black-footed albatrosses and other seabird species, and notes the levels of observer coverage on Hawaii longline vessels. There is an assessment on the effectiveness of required seabird interaction deterrents, a summary of the results of protected species workshops, and other information relative to NMFS"s mission to protect seabirds.

Dr. Marti McCracken of the NMFS Pacific Islands Fisheries Science Center (PIFSC) provided the 2009 interaction estimates for protected species incidentally caught in the Hawaii deep-set longline fishery. M. Kimberly Lowe and David Hamm, PIFSC, provided plots of fishing effort distribution. Frederick Dowdell provided data on 2009 fishing and observer effort levels. Lesley Jantz, PIRO Observer Program provided spatial distribution interaction and sighting plots and general data requests. Eric Forney and Jeremy Willson, PIRO Observer Program, were essential in gathering observer program data for the report. Dr. Beth Flint and Dr. Greg Balogh, U.S. Fish and Wildlife Service (USFWS) provided information on the current status of albatross populations.

This annual report was prepared by Lewis Van Fossen, seabird and annual report coordinator, and Sustainable Fisheries Division staff. Dr. Eric Gilman, affiliate faculty Hawaii Pacific University, reviewed the draft report and provided invaluable comments.

1. Introduction

National Oceanic and Atmospheric Administration‟s (NOAA‟s) NMFS PIRO is responsible for managing, protecting, and conserving living marine resources in Federal waters of the U.S. western Pacific.[1] PIRO accomplishes this mission 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 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 and recommending to the Secretary of Commerce domestic fishery policies and management plans for the region. PIRO, PIFSC, WPFMC, and USFWS work cooperatively to prevent and mitigate the bycatch of protected resources, including seabirds, by U.S. domestic fisheries managed under fishery management plans.[2] Seabird interaction mitigation measures, authorized under the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), are found in regulations implementing the Western Pacific Pelagic Ecosystem Plan developed by WPFMC and approved by the Secretary of Commerce.

To assess possible impacts of the Hawaii pelagic longline fisheries on the endangered short-tailed albatross (*Phoebastria albatrus*) population NMFS consulted with USFWS under Section 7 of the Endangered Species Act (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 only 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 short-tailed albatross (*Phoebastria albatrus*)" (FWS 1-2-1999-F-02.2: USFWS 2004). Prior to its suspension, the Hawaii shallow-set 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 2004-2009, no short-tailed albatross interactions were observed or reported in the shallow-set longline fishery. This fishery operates under the requirement to have 100% observer coverage.[3] The deep-set fishery operates under annual observer coverage of at least 20%.

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

[2] In 2009, five western Pacific fishery management plans were converted to five fishery ecosystem plans as developed by the WPFMC and approved by the Secretary of Commerce: The plans are placed-based: Hawaii Islands Archipelago FEP, Pacific Remote Island Areas FEP, American Samoa Archipelago FEP, Mariana Islands Archipelago FEP, and Pacific Pelagics FEP

[3] The Hawaii shallow-set longline fishery reopened with a final rule on April 2, 2004 (69 FR 17329).

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 short-tailed albatross (STAL) is anticipated per year for the shallow-set fishery under the 2004 BiOp (USFWS 2004) and 15 over a 7-year period for the deep-set fishery (USFWS 2002).

The three BiOps (USFWS 2000, 2002, 2004) required NMFS to report annually any observed interactions and sightings of short-tailed albatrosses with the Hawaii longline fisheries, and any observed and estimated total number of interactions with Laysan (*P. immutabilis*) and black-footed (*P. nigripes*) albatross by set type.[4] This report addresses the reporting requirements contained in those BiOps.

On June 12, 2001, NMFS issued an emergency rule that closed the shallow-set fishery and implemented the Terms and Conditions of the November 28, 2000, Short-tailed Albatross BiOp issued by USFWS (66 FR 31563). After the shallow-set fishery closure, some traditional swordfish vessels switched to targeting tunas or left Hawaii for other fisheries. Even with the reopening of the shallow-set fishery in 2004, the number of hooks deployed per year in the deep-set fishery continued to increase until 2009 (Fig. 8). About twice as many hooks were deployed per year in the deep-set fishery from 2005 through 2009 as were in 2000. Conversely, the number of hooks deployed in the shallow-set fishery from 2005 through 2009 was about half of the number deployed in 2000.

In April 2004, the shallow-set fishery was reopened under a suite of new management measures that required new gear configurations, and specialized turtle dehooking equipment and handling procedures were put in place to reduce incidental captures of sea turtles and increase their post-hooking survival (69 FR 17329, May 19, 2004). In 2009, these requirements were modified by eliminating the 2,120 sets per year effort limit and the certificate program that administered the set limit, and raising the interaction limit for loggerhead sea turtles from 17 to 46 per year.

Sea turtle mitigation requirements for the shallow-set fishery (50 CFR 665 Subpart F) include:

- 18/0 or larger circle hooks with no more than a 10° offset;
- Mackerel-type bait (no squid);
- Sea turtle handling measures, including dehooking equipment;
- Annual attendance at mandatory Protected Species Workshops for vessel operators and owners; and
- Interaction limits for loggerhead sea turtles (n=46) and leatherback sea turtles (n=16).

Additionally, NMFS places observers on 100% of shallow-set vessels.

[4] NMFS described deep-set (tuna) and/or shallow-set (swordfish) type.

2. Description and Status: Short-tailed Albatross

The short-tailed albatross is the largest of the northern hemisphere albatross species (body lengths of 33-37" as compared with 31-32" for Laysan and 27-29" for black-footed albatrosses, USFWS 2005). They are long-lived and reach breeding age around six years old (USFWS 2004). Their plumage varies in color as they mature. Shortly after fledging (leaving the nest), STALs develop a distinctive large pink bill with a gray tip and thin black line at its base which they have for the rest of their lives. The feet are pinkish. When STALs are one year old, their plumage may resemble a black-footed albatross (BFAL), but may be distinguished from BFALs primarily by their pink bills (the BFAL has a black beak). As the STAL matures, its stomach and back become white in color. It is the only albatross in the North Pacific with a white back. The color on the upper surface of the wings is variable, being proximally white and distally brown. A fully mature STAL has a golden-colored head.

STALs once ranged throughout most of the North Pacific and Bering Sea, with known nesting colonies on western Pacific islands near Japan and Taiwan (Hasegawa 1979). During the early 20th century, the species was nearly extirpated due to overharvest for feathers and oil. Between 1880 and 1903, 5 million STALs were harvested on Torishima alone (USFWS 2004). The population began to recover during the 1950s, likely due to habitat protection, and is growing annually (Fig. 1). Today, the only known 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) (USFWS 2004). It is estimated that 80-85% of the known breeding STAL use a single colony at Tsudame-zaki, on Torishima, an active volcanic island (Suryan et al. 2007). In 2008, the worldwide STAL population estimate was 2,771 individuals (G. Balogh, USFWS, pers. comm. July 2008), with 446 eggs observed laid on Torishima Island during the 2008-2009 breeding season (G. Balogh, USFWS, pers. comm. March 2009).

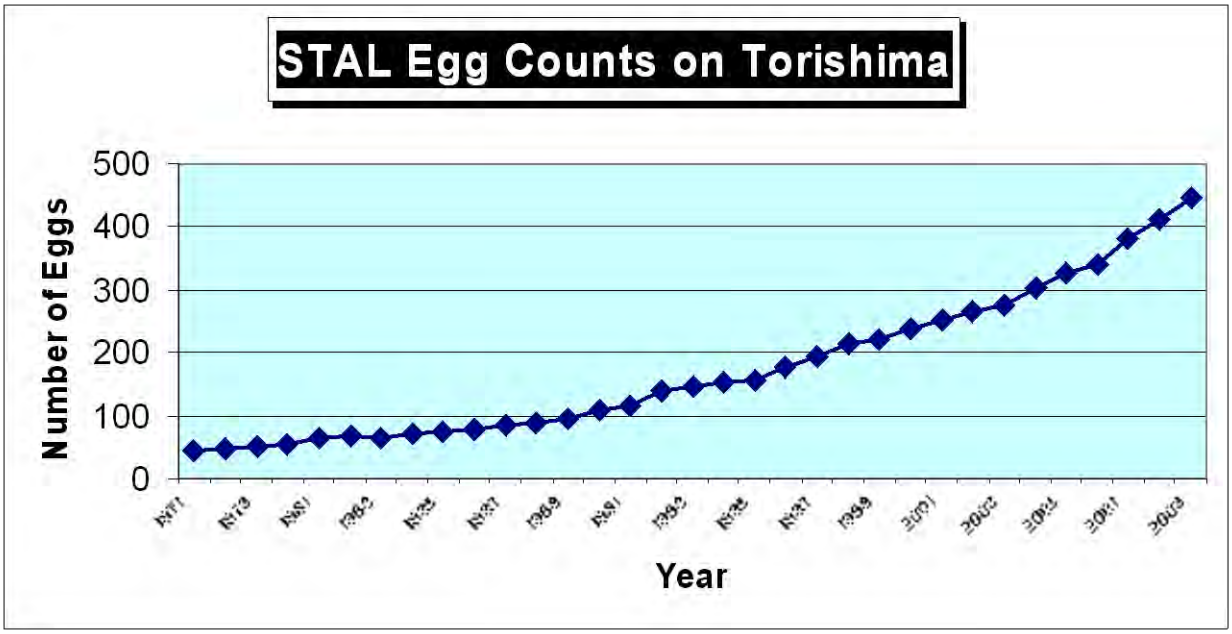

Figure 1. Short-tailed albatross egg counts on Torishima Island, Japan, 1976-2009.
(Sources: pers. comms. Sievert, Univ. of Massachusetts, April 2007; Hasegawa, Toho Univ., Japan, Jan. 2006, Jan. 2007, Dec. 2007; Jacobs, USFWS, Mar. 2009; and Balogh, USFWS, March 2010)

It is estimated that 80-90% of all STALs breed on Torishima which is potentially subject to severe volcanism. A single eruption during the breeding season could severely set back the recovery of the species. In order to establish a colony at a safer site and promote the expansion of the species within its former range, Japanese wildlife managers began translocating chicks from Torishima to Mukojima Island which is non-volcanic (USFWS 2008). Ten chicks from Torishima were transferred and successfully fledged during the 2008-2009 breeding season (C. Kim, NMFS contractor, pers. comm. Feb. 2008, Suryan 2008). The project continued in 2009 and another 15 chicks had fledged by June 2010 (G. Balogh, pers. comm., June 2010). Mukojima is 200 miles south of Torishima in the Bonin Archipelago (USFWS 2008).

3. Description and Status of Other Albatross Species

There have been no observed gear interactions between short-tailed albatross and Hawaii pelagic longline vessels, and interactions are thought to be very rare. However, NMFS observers have documented STALs foraging on spent bait and offal around Hawaii longline vessels (NMFS unpub.). Surrogate species are used to predict expected interaction rates. Black-footed albatross 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.

Laysan Albatross

The Laysan albatross (LAAL) is one of the most abundant albatrosses in the world (BirdLife International 2004). They are characterized by a white head, neck and under parts. There is dark plumage surrounding the eyes. The back and dorsal side of the wings are dark brown. Ventrally, the wings are variably white and brown differing between individuals. The tail is dark brown.

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 monitor LAAL populations. The worldwide breeding population of LAAL is estimated at 590,000 pairs in 2005 (Naughton et al. 2007) and 99% of the world‟s LAAL breed in the Northwestern Hawaiian Islands (NWHI). Other breeding sites are in Japan and Mexico.

Black-footed Albatross

BFALs have black legs and black bills with a prominent ring of white plumage at the base of the bill. Overall, the plumage is dark brownish-gray. Birds older than two years have white plumage surrounding the vent. The world breeding population of BFAL was estimated to be 61,700 pairs in 2005 (Naughton et al. 2007) and according to USFWS, approximately 97% of BFALs breed in the NWHI (72 FR 57278). A smaller population of approximately 2,000 breeding pairs nests in the Bonin Islands south of Japan. Walsh and Edwards (2005) have demonstrated that the Japanese sub-population is reproductively isolated from NWHI BFALs.

Population Status of Proxy Species

Direct counts of populations cannot be made because not all birds (e.g., juveniles and some adults) return to the breeding colonies every year. Instead, the numbers of breeding pairs, or numbers of active nests, are used to assess the health of albatross populations. Environmental factors such as foraging success may influence how many albatrosses return to a colony to breed. Therefore, foraging success should not be considered to assess short-term changes in population. However, this measurement can be used to assess long-term trends in populations. Figures 2 and 3 illustrate trends in breeding pair numbers at Midway Atoll, Laysan Island, and French Frigate Shoals from 1998-2009.

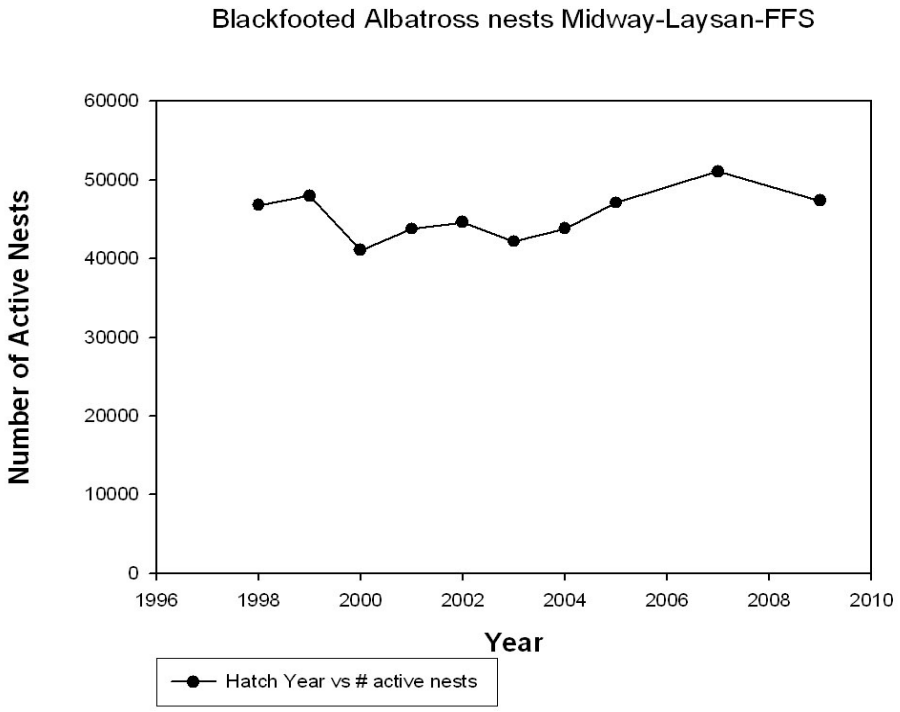

Figure 2. Number of black-footed albatross breeding pairs in three areas in the Northwestern Hawaiian Islands 1998-2009.
(Source: Flint 2009)

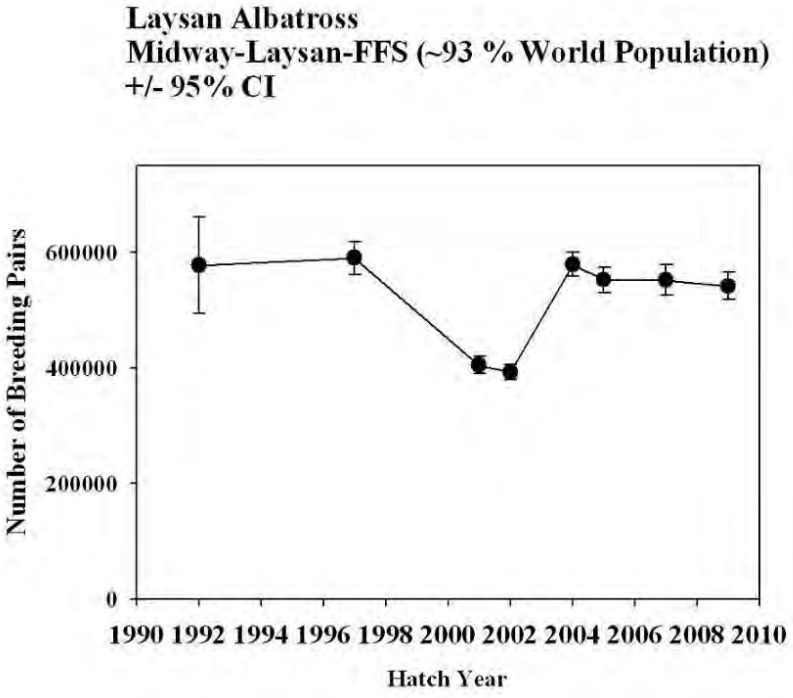

Figure 3. Number of Laysan albatross breeding pairs at three islands in the Northwestern Hawaiian Islands.
(Source: Flint 2009)

4. Description of the Hawaii Pelagic Longline Fisheries

Background

Historically, the Hawaii-based longline fishery has had the most seabird interactions when compared to other U.S. managed fisheries in the tropical Pacific (NMFS 2001). The fishery began around 1917 employing techniques brought to Hawaii by Japanese immigrants. Early Hawaii-based longliners used tarred, braided rope and flagged marker buoys. A relatively small number of vessels continued targeting tuna using this gear through the late 1980s. The fleet expanded from 37 vessels in 1987 to 138 vessels in 1991 with the influx of longline vessels targeting swordfish using monofilament mainlines and radio buoys from the East Coast and Gulf of Mexico (NMFS 2007).

Managers officially began considering the deep- and shallow-set components as distinct fisheries in December 2008 (73 FR 73032) based on the deep-set regulatory definition. Specifically, a deep-set must have: all float lines on the vessel at least 20 m in length, 15 or more branch lines between any two floats, no light sticks may be used, and a maximum of 10 swordfish may be retained or landed by the vessel. If any one of these criteria is not met, the vessel is considered to be shallow-setting. There are additional differences. The deep-set fishery generally targets bigeye tuna (*Thunnus obesus*), and the shallow-set fishery targets swordfish (*Xiphias gladius*). In addition to tunas and swordfish, a variety of other pelagic fish species are caught in both fisheries. Some of these species are kept and considered catch, while others are discarded and considered bycatch[5]. The general characteristics of the two gear types are provided in Table 1 and Figure 4, illustrating the differences and similarities between them.

Table 1. Characteristics of the Hawaii shallow-set (swordfish-targeting) and deep-set (tuna-targeting) longline fisheries.

Characteristics	Shallow-set	Deep-set
Set depth	~ 25-75 m	~ 40-350 m
Hook type	18/0 circle hook (≤10° offset)	3.6-3.8 mm tuna hooks or 14/0-16/0 circle hooks
Bait	fusiform fish (mackerel)	saury, sardines
Light sticks used?	Yes	No, not permitted
Set deployment/retrieval	Night/Morning	Morning/Night
No. hooks between floats	~ 4	~ 27
Approx. no. hooks per set	850	2,000 to 3,000

[5] For the purpose of this report, "bycatch" is defined as discards plus unseen mortality due to fishing operations. This includes incidental interactions with seabirds.

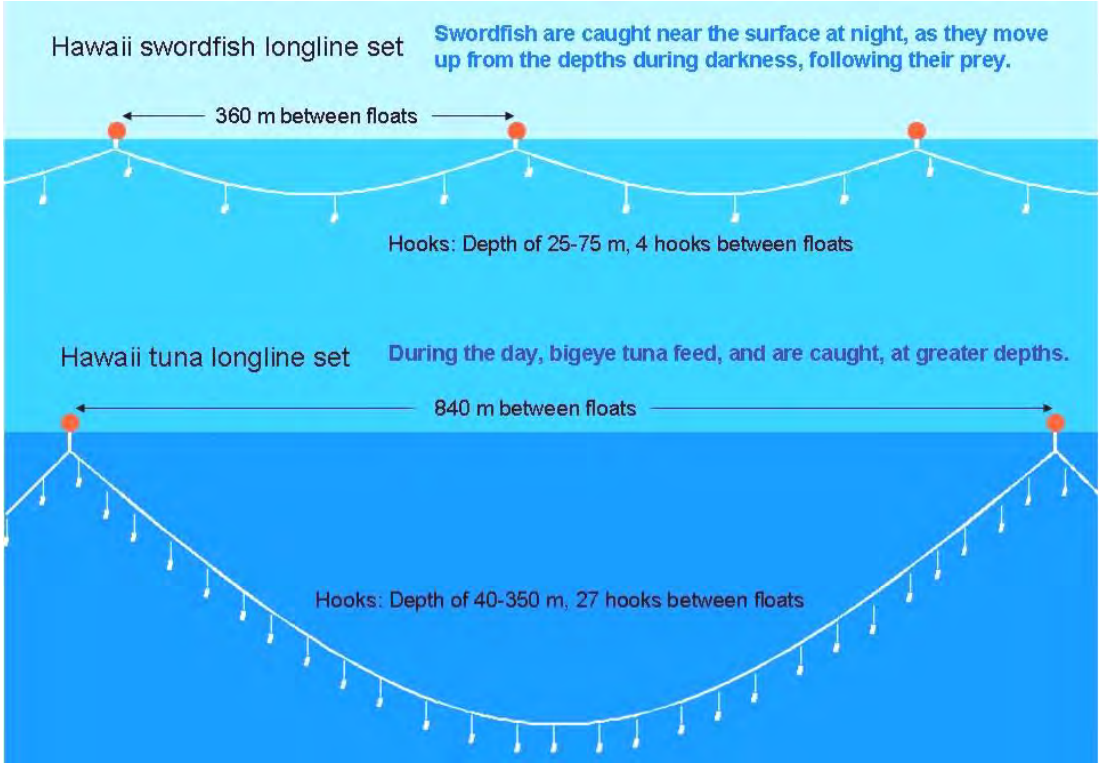

Figure 4. Generalized depiction of shallow-set (swordfish) and deep-set (tuna) gear types. (Source: PIFSC)

Matsumoto et al. (2007) demonstrated through archival tagging studies that bigeye tuna tend to congregate at depths reached by the lower half of mainline in the deep-set fishery. This is consistent with earlier findings for bigeye in the pelagic zone (Musyl et al. 2003). As seen in Figure 4, deep-set gear is intended to reach depths where bigeye tuna concentrations are highest. The deep-set configuration is achieved by use of a line shooter. The line shooter deploys the line faster than the vessel is moving forward, thus forming deep sags in the line. In contrast, shallow-set gear is usually deployed by simply allowing the mainline to spool off of the mainline reel as the vessel is underway; no line shooter is used. Also, shallow-setting deploys fewer hooks between floats. This results in the line being set relatively shallow in the water column where swordfish tend to congregate at night.

Spatial distribution of shallow-set fishery effort 2004-2009

Since the shallow-set fishery was reopened in April 2004, almost all fishing effort has occurred to the north of Hawaii in the same areas fished prior the 2001 closure (Fig. 5).[6]

[6] It should be noted that all figures contained in this report conform to NMFS data confidentiality guidelines as required by the Magnuson-Stevens Fishery Management and Conservation Act as reauthorized.

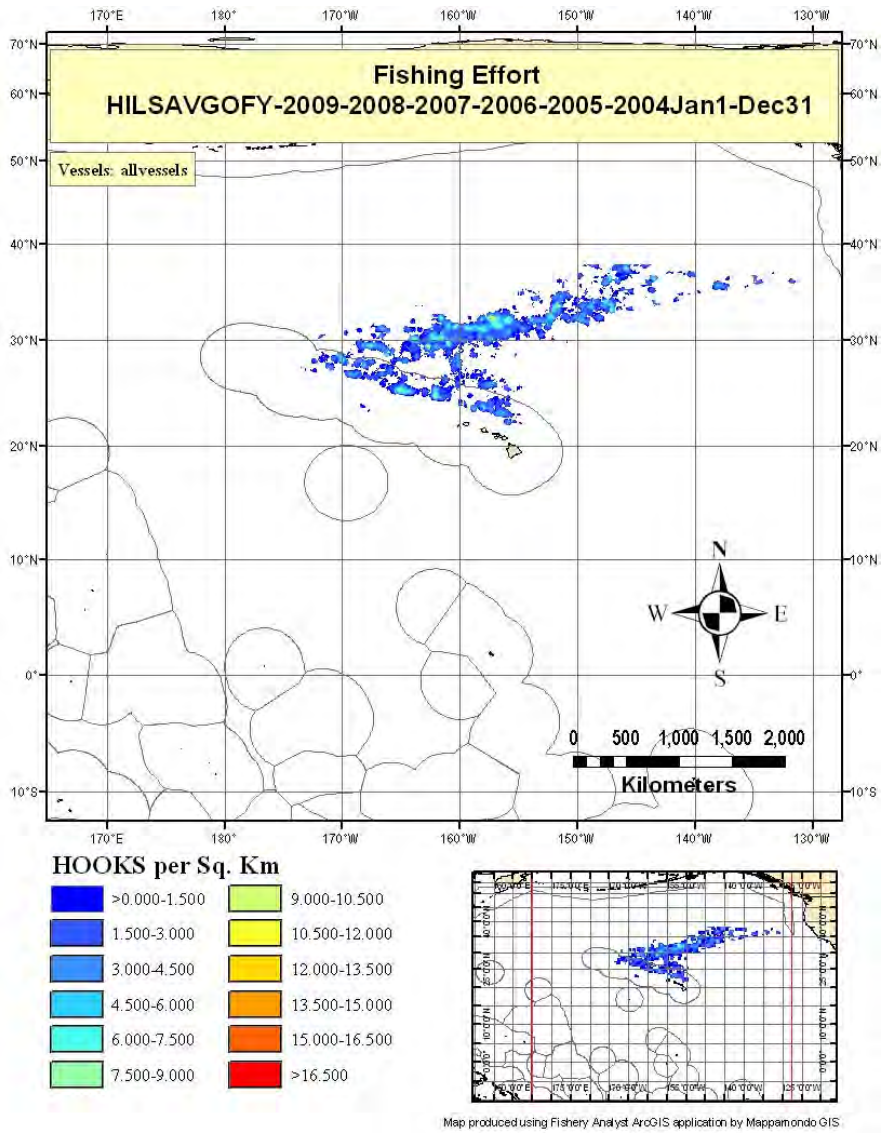

Figure 5. Spatial distribution of shallow-set fishing effort, 2004-2009.
(Source: M. Kimberly Lowe, PIFSC)

Spatial distribution of deep-set fishing effort 1994-2009

The deep-set fishery targeting tunas has changed over the last 15 years both in terms of the amount of fishing effort and spatial distribution. Figures 6-8 show the changes in distribution during three stages of the deep-set fishery. Figure 6 shows the deep-set effort prior to the curtailment and eventual closure of the shallow-set fishery in 2000 and 2001. During this time period the majority of deep-set fishing activity took place to the south of Hawaii. Some deep-set activity did occur to the north of Hawaii during this time, especially during the summer months (June-September) (Polovina et al. 2009).

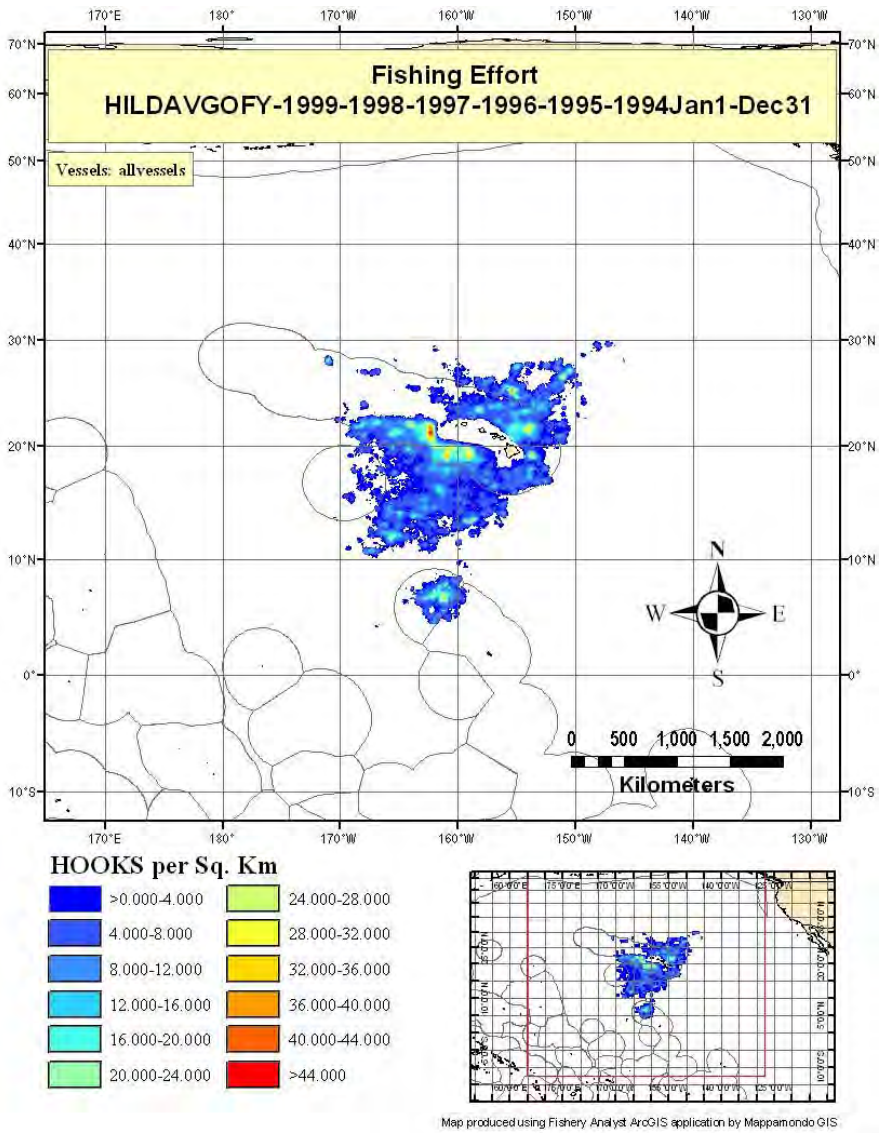

Figure 6. Spatial distribution of deep-set fishing effort, 1994-1999.
(Source: M. Kimberly Lowe, PIFSC)

Figure 7 shows how fishing effort distribution changed after the shallow-set fishery was completely closed in 2001. Deep-set fishing effort to the south continued, but what is striking is the expansion of the fishery to the north. Also, as Table 2 illustrates, the deep-set fishery started rapidly expanding until the number of hooks set had more than doubled compared to 2000. As previously stated, the increased spatial extent of the fishery and numbers of hooks set coincides with the closure of the shallow-set fishery and is likely due to displaced shallow-set vessels participating in the deep-set fishery.

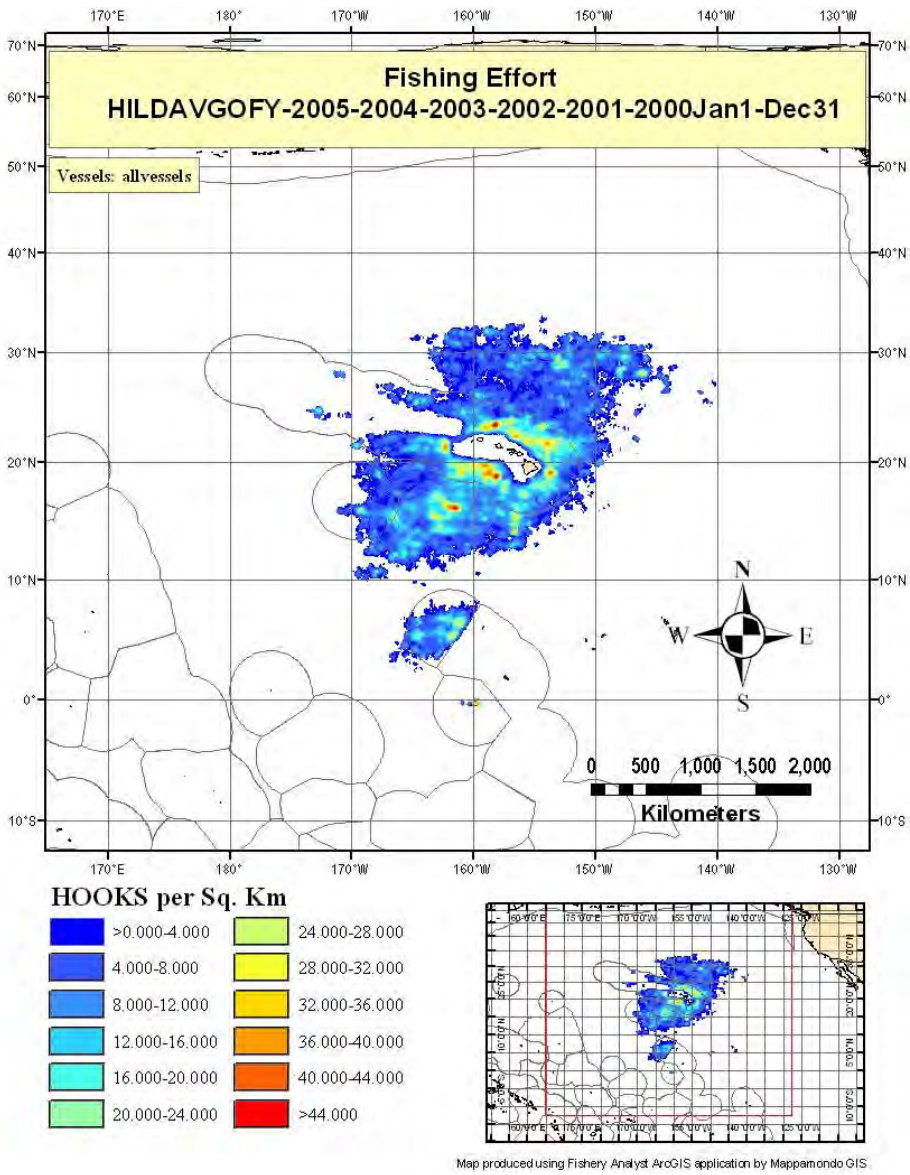

Figure 7. Spatial distribution of deep-set fishing effort, 2000-2005.
(Source: M. Kimberly Lowe, PIFSC)

In 2004, a limited shallow-set fishery was authorized and some vessels returned to the shallow-set fishery, if only in limited capacity, as described in the Introduction. In 2006, the fishery was closed in late March after reaching the loggerhead sea turtle interaction limit of 17. Because of the limited nature of the shallow-set fishery, most longline vessels continued to participate in the deep-set fishery as well. As a consequence, the deep-set fishery continued to expand geographically from 2006-2009 (Figure 8).

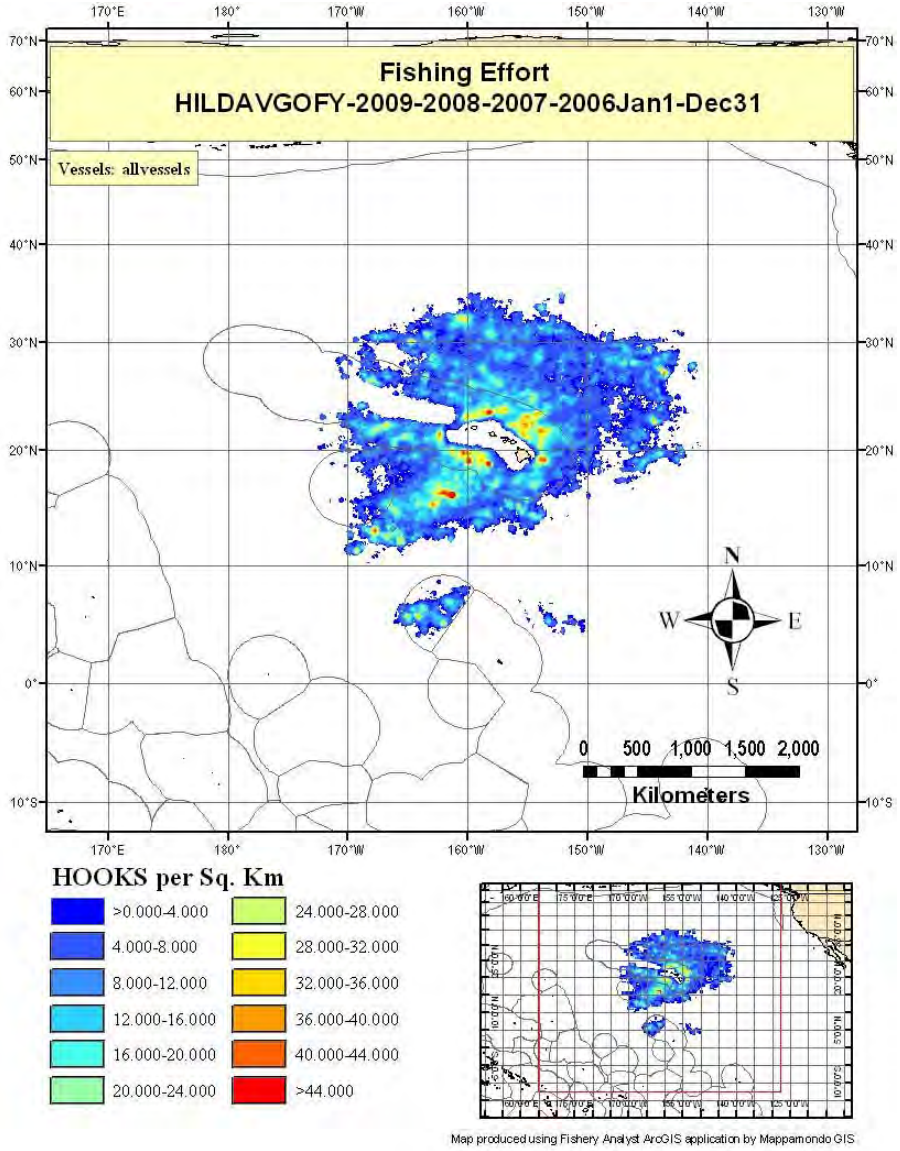

Figure 8. Spatial distribution of deep-set fishing effort, 2006-2009.
(Source: M. Kimberly Lowe, PIFSC)

Twenty-three degrees North latitude is the trigger line for deep-set fishing vessels to begin employing seabird mitigation measures and seems like a logical dividing line to assess geographical effort changes in the deep-set fishery. Figures 9 and 10 show the increases in recent deep-set fishing effort above 23° N. Figure 9 also demonstrates the number of sets fished above 23° N has increased with the geographic expansion of the fishery to the north shown in Figure 8.

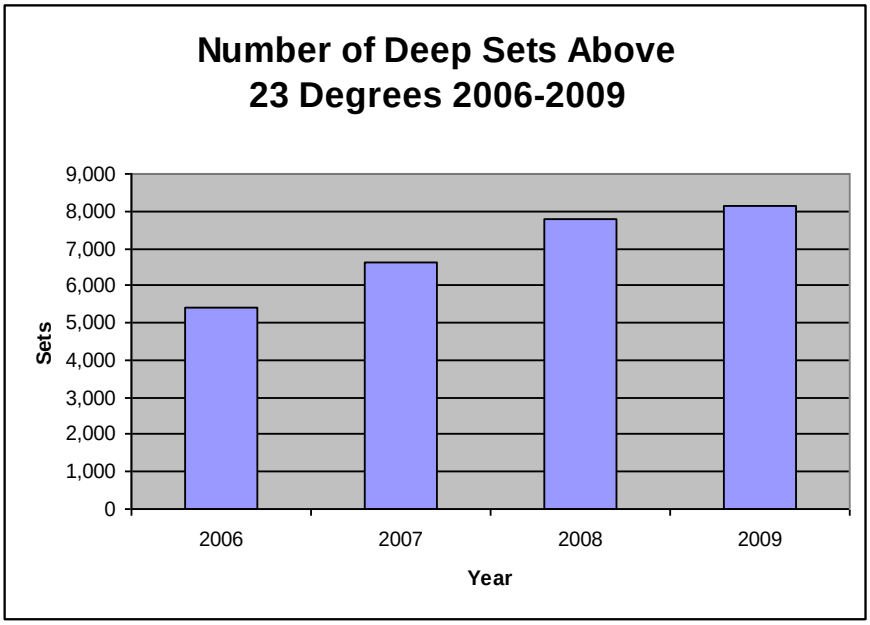

Figure 9. Number of deep sets fished above 23° N from 2006-2009.
(Source: PIFSC)

Additionally, the proportion of deep-set fishing effort above 23° N steadily increased from 2006 through 2009 (Fig. 10). The deep-set fishery has expanded to the north in recent years. This is a different situation from the one depicted in Figure 6, showing the deep-set effort from 1994-1999, when a smaller portion of the fishery took place to the north of the main Hawaiian Islands (MHI).

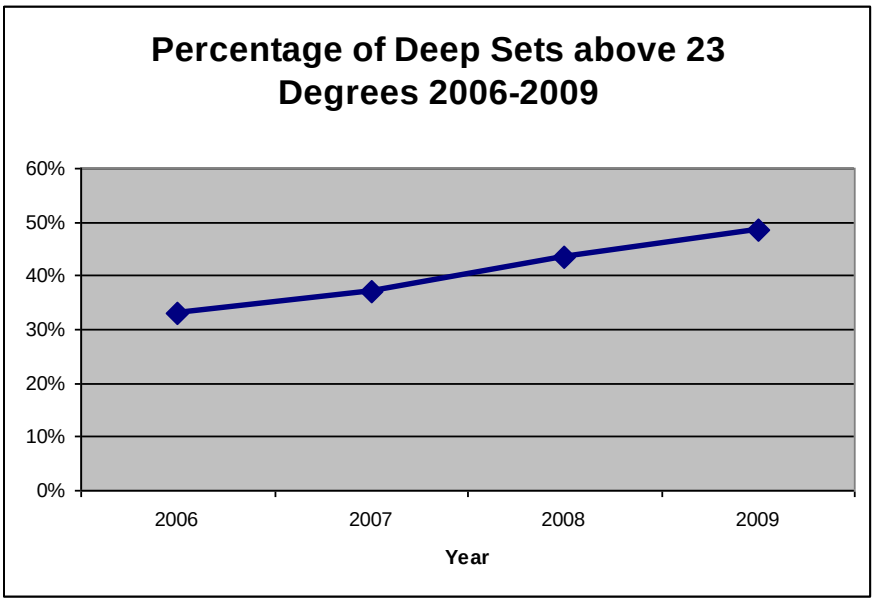

Figure 10. Percentage of deep-set effort above 23° N, 2006-2009.
(Source: NMFS)

The implication of the fishery shifting to the north for seabirds, especially albatrosses, is that there is a stronger overlap between foraging areas and flyway corridors and the deep-set fishing grounds than in the past. The temporal and spatial distributions of incidental interactions with seabirds in 2009 will be described later in this report.

Historic fishing effort 2000-2009

Effort, as measured by number of vessels or number of trips, has been relatively stable from 2000 to 2009 for the combined fisheries (both shallow- and deep-sets) (Table 2). 2009 marks the first year since 2000 that fewer trips were taken and hooks were set in the Hawaii deep-set longline fishery compared to the previous year. Effort in the smaller shallow-set fishery increased in terms of number trips and hooks deployed in 2009. Even at its highest effort, the shallow-set fishery has always deployed far fewer hooks per year than the deep-set fishery (Table 2).

Table 2. Hawaii longline fisheries effort data, 2000–2009.
(Sources: NMFS 2008, PIFSC, WPFMC)

Year	# Vessels	# Trips	# Sets	# Hooks (Total)	# Hooks (Deep-set)	# Hooks[7] (Shallow-set)
2000	125	1,135	12,930	20,282,826	17,192,826	3,090,000
2001	101	1,075	12,169	22,327,897	21,837,897	490,000
2002	102	1,193	14,225	27,018,673	27,018,673	0
2003	110	1,215	14,560	29,297,813	29,297,813	0
2004	125	1,338	15,976	31,967,874	31,891,124	76,750
2005	124	1,533	18,083	34,895,229	33,566,423	1,328,806
2006	127	1,437	17,247	35,192,344	34,486,898	705,446
2007	129	1,515	19,379	40,197,926	38,825,977	1,371,949
2008	129	1,470	19,468	41,564,853	40,078,613	1,486,240
2009	127	1,364	18,562	39,473,259	37,751,913	1,721,346

[7] Hooks deployed in the shallow-set fishery for 2000 and 2001 include hooks reported deployed for swordfish and mixed species targeted trips. Mixed targeted trips were generally reported for smaller shallow-set vessels that would often target swordfish at the beginning of fishing trips and target tuna or marlins towards the end. Source: WPFMC.

Summary of 2009 Fisheries Effort

In 2009, 127 Hawaii longline vessels made 1,364 trips (Table 2). The trips targeted tunas (bigeye, albacore, yellowfin) and swordfish. A total of 1,252 tuna trips and 112 swordfish trips were made. There were 9,841 sets made at or above 23° N latitude. Of these, 8,138 were deep-sets and 1,703 were shallow-sets (PIFSC, unpub.). Of 39,473,259 total hooks fished, the deep-set fishery deployed a reported 37,751,913 hooks in 16,800 sets and the shallow-set fishery deployed a reported 1,721,346 hooks in 1,762 sets (PIFSC, unpub.).

5. Seabird Mitigation Measures

Background

The emergency rule (66 FR 31563, June 12, 2001) that closed the shallow-set fishery also implemented non-discretionary reasonable and prudent measures of the BiOp issued by the USFWS on November 28, 2000 (USFWS 2000). A final rule (67 FR 34408, May 14, 2002) subsequently implemented the requirements contained in the emergency rule. The required seabird mitigation techniques applied when making deep-sets north of 23° N and required fishermen to employ a line-setting machine with at least 45 g weights attached within 1 m of each hook. They must have also used thawed blue-dyed bait and strategic offal discards during the setting and hauling of longline gear. These measures were revised (70 FR 75075, December 19, 2005) to satisfy the terms and conditions of the 2004 BiOp. The seabird mitigation requirements for Hawaii-based longline fishermen are listed in Table 3.

Description of Mitigation Measures

Vessel operators have the option of either side-setting (as defined under the regulations) or using an alternate suite of mitigation methods. A variety of seabird deterrence methods for longline fisheries have been tested and found to reduce interaction rates and mortality of seabirds (e.g., Brothers 1995; Brothers et al. 1999; Gilman et al. 2003, 2005, and 2007; McNamara et al. 1999). When employed effectively, seabird interaction 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).

The following seabird deterrent methods are explained in more detail:

- Side-setting;
- Strategic offal discarding;
- Thawed blue-dyed bait;
- Weighted branch lines; and
- Night setting.

Table 3. Summary of current seabird regulations for the Hawaii longline fleet, effective as of January 18, 2006.
(Source: PIRO)

X = Required Measure * = Not required, but must be done to be "side-setting"	Side-Setting			Stern-Setting		
	Shallow Set	Deep Set >23° N	Deep Set <23° N	Shallow Set	Deep Set >23° N	Deep Set <23° N
Weights (minimum 45 g) attached within 1 m of the hook	X	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	*			
Use bird curtain	X	X	*			
Use thawed & blue-dyed bait				X	X	
Maintain at least 2 - one lb containers of blue dye on board the vessel at all times				X	X	
Use line shooter					X	
Employ strategic offal discards				X	X	
Begin set 1 hr after local sunset & complete before dawn				X		
Follow all seabird handling procedures	X	X	X	X	X	X

Side-setting

Side-setting involves deploying the gear from the side of the vessel, as compared to the conventional approach of setting from the stern (Fig. 11). Crew set baited hooks forward and close to the side of the vessel‟s hull where seabirds are unable or unwilling to pursue them. With proper branch line weighting, by the time the vessel stern passes the location where baited hooks have been set, the baited hooks will have sink to a depth where a North Pacific albatross species

cannot reach them (Brothers and Gilman, 2005, 2006, 2007; Gilman et al., 2007). Additionally, deploying a bird curtain inhibits the ability of seabirds to land along the side of the vessel where baits are accessible. An ancillary benefit of this technique is reduced bait loss for fishermen.

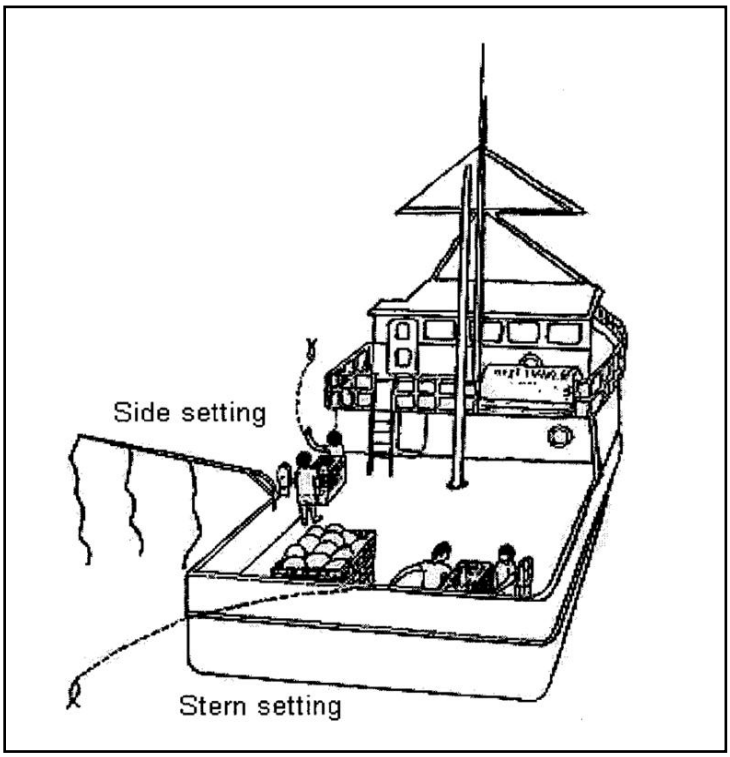

Figure 11. Depictions of side-setting and stern setting.
(Source: Gilman et al. 2003)

Side-setting requirements are as follows:

- Deploy the mainline as far forward on the vessel as practicable, including mounting line shooters (if used) at least 1 m forward from the stern corner of the vessel;
- Set the mainline and branch lines from the port or starboard side of the vessel;
- Attach weights (45 g minimum) to branch line within one meter of the hook;
- 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
- A bird curtain must be deployed aft of where the gear is being set that consists of the following three components (See example in Fig. 12):
    - A pole that is fixed to the side of the vessel aft of the line shooter and that is at least 3 m long;
    - 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
    - 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.

If all of the above conditions are not met by a vessel, it is not considered to be side-setting by NMFS.

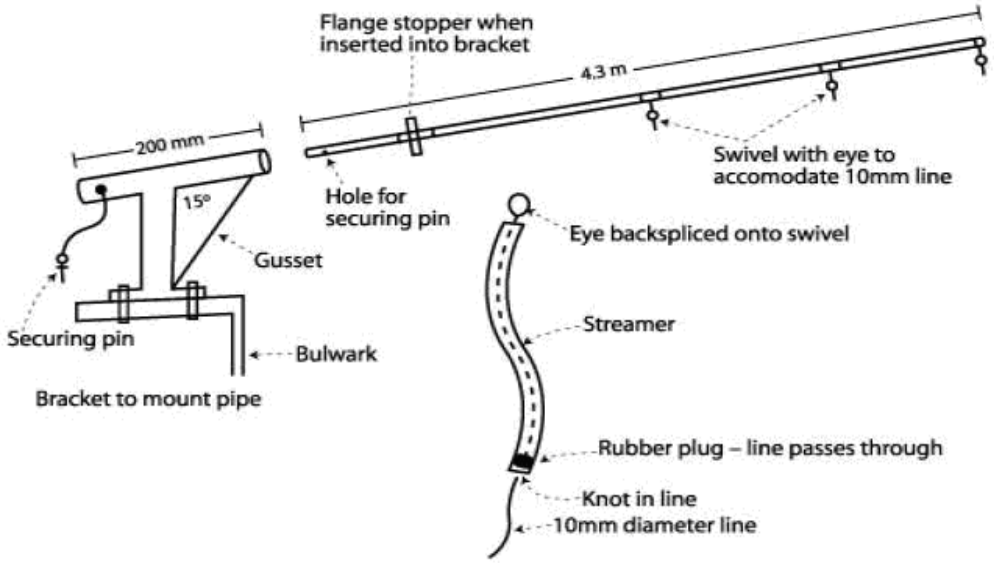

Figure 12. Bird curtain example design.
(Source: Modified from Gilman et al. 2003)

A growing number of effective seabird bycatch avoidance methods have been identified over the past two decades. These include measures to: (i) avoid peak periods of seabird foraging via night setting; (ii) reduce seabirds‟ detection of baited books through dyeing bait blue, shielding deck lights, employing underwater setting devices, retaining offal and other discards, and using artificial bait; (iii) limit bird access to baited hooks through underwater setting devices, side setting, increased weighting near hooks, thawed bait, bait casting machine, and avoiding setting terminal tackle and mainlines into propeller turbulence; and (iv) deterring birds from taking baited hooks through the use of bird scaring „tori‟ lines, towed buoys and other objects, water cannons, and acoustic deterrents (Brothers et al. 1999, FAO, 1999a; Gilman et al. 2003, 2005, 2007, 2008). Table 4 provides a review of research on gear technology approaches (involving changes in fishing gear and fishing methods) to seabird bycatch in the Hawaii pelagic longline fisheries. For example, side setting in combination with 45 g weights, increased line weighting from 45 g to 60 g, and thawed and blue-dyed bait in combination with 45 g weights, were inferred to each have reduced seabird catch rates by greater than 67% in the Hawaii longline tuna fishery, based on a comparison of observations of commercial fishing operations before vs. after regulations were in effect, employing a model that accounted for temporal and spatial effects of fishing effort on seabird catch rates (Gilman et al., 2005, 2007, 2008). Similarly, experiments have found the single factor effect of employing blue-dyed fish bait reduced seabird captures by 63-95%, side setting eliminated seabird captures, an underwater setting chute reduced seabird captures by 38-100%, and night setting reduced seabird captures by 97-98% (McNamara et al., 1999; Boggs, 2003; Gilman et al., 2003, 2007).

Table 4. Findings from gear technology seabird bycatch research in the Hawaii pelagic longline fisheries (updated from Gilman et al. 2005). Interaction rates are expressed normalized for seabird abundance (expressed as contacts or captures per 1,000 hooks per bird) and without normalizing for bird abundance (expressed in parentheses as contacts or captures per 1,000 hooks). Percent reductions are based on the normalized rates unless noted otherwise.

Study[a]	Treatment	Contact rate	Contact reduction	Capture rate	Capture reduction
McNamara et al. (1999) Hawaii longline swordfish gear	Control[a]	32.8 (265.7)[b]		2.23 (18.0)	
	Blue-dyed bait	7.6 (61.6)	77%	0.12 (17.5)	95%
	Towed buoy	16.1 (130.4)	51%	0.26 (6.8)	88%
	Offal discards	15.7 (124.7)	53%	0.32 (2.3)	86%
	Streamer line	15.7 (127.2)	52%	0.47 (6.6)	79%
	Night setting			(0.60)[d]	97%[d]
Boggs (2001) Hawaii longline swordfish gear	Control[a]	7.60 (313.5)[b,d]			
	Blue-dyed bait	0.43 (20.5)[d]	94%		
	Streamer line	1.82 (93.4)[d]	76%		
	Additional 60g weight at bait	0.61 (25.0)[d]	92%		
Gilman et al. (2003) Hawaii longline tuna gear	Control[a]	0.61 (75.93)		0.06 (4.24)	
	Underwater setting chute 9 m	0.03 (1.85)	95%	0.00 (0.00)	100%
Boggs (2003) Hawaii longline swordfish gear	Control[a]	0.78 (27.1)		0.058 (2.0)	
	Night setting	0.053 (4,8)	93%	0.0013 (0.11)	98%
	Night setting & blue-dyed bait	0.01 (0.98)	99%	0.00 (0.00)	100%
Gilman et al. (2007), Hawaii longline	Underwater setting chute 9 m	0.30 (5.0)		0.03 (0.6)	
	Blue-dyed	2.37 (64.9)		0.08 (1.8)	

Study[a]	Treatment	Contact rate	Contact reduction	Capture rate	Capture reduction
swordfish gear	bait				
	Side-setting	0.08 (1.9)		0.01 (0.2)	
Gilman et al. (2007), Hawaii longline tuna gear	Underwater setting chute 9 m	0.28 (10.3)	82%[e]	0.05 (1.7)	38%[f]
	Underwater setting chute 6.5 m	0.20 (5.6)	87%[e]	0.01 (0.5)	88%[f]
	Blue-dyed bait	0.61 (23.8)	60%[e]	0.03 (1.2)	63%[f]
	Side-setting	0.01 (0.1)	99%[e]	0.00 (0.0)	100%[f]

[a] Control treatments in McNamara et al. (1999), Boggs (2001), Gilman et al. (2003a), and Boggs (2003) entailed conventional fishing operations with no seabird avoidance methods.

[b] The different contact rates observed by Boggs (2001) and McNamara et al. (1999) may be explained by the use of different definitions of what constituted a seabird contact. McNamara et al. (1999) counted the total number of times a seabird came into contact with gear near the hook, even if the same bird contacted the gear multiple times, while Boggs (2001) defined a contact where only one contact per bait was recorded as a contact regardless of whether a single bird contacted a bait multiple times.

[c] This rate is not normalized for albatross abundance. McNamara et al. (1999) could not estimate seabird abundance during night setting. McNamara et al."s (1999) control capture rate when not normalized for albatross abundance was 18.0 captures per 1,000 hooks. Night setting reduced this control capture rate by 97%.

[d] Contact rates are averages of rates reported by Boggs (2001) for Laysan and black-footed albatrosses.

[e] Percent reductions use the control treatment contact and capture rates of Gilman et al. (2003).

Furthermore, Gilman et al. (2008) analyzed observer program data for the Hawaii longline deep set fishery to assess the performance of seabird bycatch mitigation measures. A Poisson generalized additive regression modeling approach was used to evaluate the change in seabird bycatch rates from the pre- to post-regulations period, and to evaluate the efficacy of alternative combinations of seabird bycatch reduction methods employed during the post-regulations period. Informative covariates of temporal and geo-referenced spatial effects of fishing effort and sampling variation commonly found with count data were included in the model to provide a better inference of the effect of the employment of required changes in fishing gear and methods. There was a significant 67% (95% CI: 62-72) reduction in the seabird bycatch rate following the introduction of regulations for the deep-set fishery. The pre- and post-regulations nominal seabird bycatch rates were 0.080 (95% CI: 0.066-0.097) and 0.021 (95% CI: 0.018-0.025) seabirds per 1,000 hooks, respectively, a significant 74 percent reduction in the pre-regulations period seabird catch rate. Post-regulations, sets employing four different combinations of seabird avoidance methods all resulted in significant reductions to the pre-regulation seabird catch rate:

- Side-setting with 45 g weights located within 1 m of the hook resulted in a seabird catch rate 40 percent (95% CI: 28 – 58) lower than the pre-regulations seabird catch rate;
- No seabirds were caught in sets employing the combination of side-setting with 60 g weights located within 1 m of the hook (100% reduction);
- Stern setting with 45 g weights located within 1 m of the hook resulted in a seabird catch rate 60 percent (95% CI: 44 – 82) lower; and
- Stern setting with 60 g weights located within 1 m of the hook 41 percent (95% CI: 27 – 62) lower than the pre-regulations seabird catch rate.

For this study on the deep-set fishery, there was no significant difference in seabird catch rates between the three categories of sets where birds were caught (Gilman et al., 2008). Using heavier branch line weights and treated bait (thawed and dyed blue) both significantly reduced seabird catch rates. Based on a Poisson generalized additive model (GAM) fit to two categories of sets made during the post-regulations period of those made from the side vs. the stern of the vessel, conditioned on the factors of time of starting setting, season, location at the start of sets, branch line weighting, and whether or not bait was thawed and dyed blue, there was no significant difference in seabird bycatch rates between side vs. stern setting at the 95% confidence level ($P = 0.14$), but there was a significant difference at the 85% level ($P<0.15$) (Gilman et al., 2008). Side-setting resulted in seabird catch rate 21 percent (95% CI: -8 - 42) lower than stern setting (Gilman et al., 2008). There was a significant difference in seabird catch rates between sets made during the post-regulations period with 45 g weights located within 1 m of the hook vs. sets with 60 g weights within 1 m of the hook, when employing a Poisson GAM model fit to sets employing 45 g vs. 60 g weights, conditioned on the factors of time of starting setting, season, location of the start of sets, side vs. stern setting, and whether or not bait was thawed and dyed blue ($P < 0.01$). Sets with 60 g weights resulted in a seabird catch rate 63 percent (95% CI: 45-88) lower than sets with 45 g weights (Gilman et al., 2008). Similar modeling has not been conducted for the shallow-set fishery, due to inadequate sample sizes for all but one combination of seabird mitigation measures employed by this sector of the fleet.

In 2005, observers did not observe any seabird interactions on vessels employing side-setting. Out of 124 active Hawaii longline vessels, 44 converted their vessels to side-setting by December 2005. In 2006, 35 vessels were configured to employ side-setting. In 2008, the trend of other vessels opting not to side-set continued. A partial survey of longline vessels found that some of the remaining deep-set side-setting vessels were planning on reconfiguring to stern setting vessels. No shallow-setting vessels were found to be using the side-setting technique in 2008. Some vessels that were outfitted for side-setting never used it and some vessels have reverted to stern setting (Brothers and Gilman 2007).

Currently, of a total of 118 deep-setting vessels that had an observer onboard in 2009, for the most current trip, 87 stern set, 31 side set. All shallow-set vessels stern set in 2009. Anecdotal information suggests that fishermen were concerned that setting the gear off of the side of the vessel might lead to fishing gear getting tangled in the propeller, but whether or not this has been widely realized is unknown. Some fishermen have reported no problems with propeller-fouling from side-setting and prefer this method over stern-setting. Another reason cited for not utilizing side-setting, or reconverting back to stern-setting was that after stern crew shelters had been

erected, vessel owners wanted to utilize the shelters after the expense and for crew safety. Again, because of its effectiveness and the high likelihood of compliance, even in the absence of observers, it is the seabird mitigation technique preferred by NMFS for deep-set vessels.

Vessel operators targeting swordfish are unlikely to switch to side-setting due to their unwillingness 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 shallow-set branch lines, they are usually situated far from the hook near the middle of the branch line. Fishermen usually cite safety considerations as the reason for placing weights near the middle of branch lines rather than closer to the hook.

Strategic Offal Discards

Strategically discarding offal is a technique developed by fishermen to mitigate interactions with albatrosses attempting to steal baits from hooks before the branch lines can be retrieved. Fishermen would throw swordfish heads and livers over the side of the vessel to distract albatrosses away from the baited hooks. NMFS observers in the mid-1990s noted that strategically discarding offal seemed to reduce incidental hookings and entanglements of albatrosses. The Hawaii longline seabird regulations require strategic offal discards as a seabird bycatch mitigation measure if a vessel is fishing north of 23° N, not side-setting their gear, and when seabirds are present around the vessel.

There have been mixed evaluations of the effectiveness of strategic offal discharge (Cherel et al. 1996; Brothers 1996; McNamara et al. 1999). The results of research on the short-term effectiveness of strategic offal discharge in a pelagic longline fishery showed reduced seabird interactions with longline gear after offal is thrown overboard (Table 4) (McNamara et al. 1999), and results of a study of the short-term effectiveness of strategic offal discharge in a demersal longline fishery observed reduced seabird capture (Cherel et al. 1996). In the long-term, strategic offal discharge may reinforce the association that birds make with specific longline vessels being a source of food. While discharging offal and fish bycatch during setting can distract birds from baited hooks (Cherel et al. 1996; McNamara et al. 1999), this practice is believed to have the disadvantage of attracting birds to the vessel, increasing bird abundance, searching intensity, and capture (Brothers et al., 1999). For instance, results from Commission for the Conservation of Antarctic Marine Living Resources studies in demersal longline fisheries have shown that vessels consistently discharging offal attract larger numbers of birds to their vessels (CCAMLR, 2002), likely resulting in increased seabird bycatch rates. Brothers (1996) hypothesized that seabirds learn to recognize by smell specific vessels that provide a source of food, implying that vessels that consistently discharge offal and fish bycatch will have higher seabird abundance and capture than vessels that do not discharge offal and fish waste.

There is inconsistency in international measures related to managing discards from longline vessels: Internationally, the Indian Ocean Tuna Commission and Commission for the Conservation of Antarctic Marine Living Resources prohibit the discharge of offal and spent fish during setting and discourage this practice during hauling, while the Western and Central Pacific Fisheries Commission employs a measure similar to the Hawaii regulations.

Even though there are some concerns about potential long-term effects, strategic offal discards have been proven to be effective in reducing interactions with seabirds. Strategic offal discards reduced gear contacts with seabirds in the Hawaii longline shallow-set fishery by 51% and seabird interactions by 88% (McNamara et al. 1999). During setting operations, Hawaii-based longline vessels typically perform strategic offal discard by tossing a handful of bait over the opposite side of the vessel from where hooks are being deployed. During the hauling operations, strategic offal discard is typically performed by retaining used bait in buckets next to where branch lines are being retrieved. As buckets fill up, used bait may be discarded on the opposite side of the vessel, or completely retained for use as bait or offal the next day. After fish are cleaned, the offal is also discarded opposite to where hooks are being retrieved (PIRO Observer Program, pers. comm.). NMFS continues to monitor the effectiveness of strategic offal discards and other mitigation measures.

Strategically discarding offal to reduce seabird interactions requires vessel operators to:

- Retain sufficient quantities of spent bait or fish offal with hooks removed for use as strategic offal discards during fishing operations;
- Prepare any swordfish caught by removing the bill, and cutting them length-wise between the eyes (See Fig. 13);
- Retain swordfish heads and livers; and
- Discharge spent bait or fish parts on the opposite side of the vessel during gear deployment and retrieval, if seabirds are present.

Figure 13. Preparing swordfish head for strategic offal discard.
(Source: PIRO)

Traditionally in the Hawaii-based longline fisheries, only swordfish were gilled and gutted at sea. However, in December 2004, the Food and Drug Administration (FDA) regulations required all fish be gilled and gutted at sea. Results from an analysis of Hawaii longline fisheries observer

data indicate that only 18% of deep-sets employed strategic offal discards (Gilman 2004).[8] This percentage increased to an estimated 50%[9] in 2005, partially due to the new FDA regulations. Since the strategic offal discard requirement was implemented, observed compliance with the regulation has likely exceeded 75% fleet-wide (PIRO Observer Program, pers. comm.).

Thawed Blue-dyed Bait

Dyeing bait to a specific blue color is a means to reduce the visibility of baits by reducing their contrast with the sea surface. The bait is thawed to increase sink rates and to allow a more effective penetration of the blue dye.

Almost all bait used in the Hawaii longline fisheries consists of fusiform fish: mackerel (saba), sardines, and saury (sanma). Using squid for bait is prohibited in the shallow-set fishery to reduce sea turtle interactions. While squid may still be used in the deep-set fishery, the cost is prohibitive. Several concerns have been noted by fishermen regarding the required bait treatments of thawing and dyeing and bait type:

- Blue dye is absorbed less readily by fish than by squid;
- Baits must be thoroughly thawed in order to ensure maximum dye absorption;
- It is difficult to achieve the NMFS-required color intensity due to scale loss by fish baits,
- thawing the bait results in its lower retention because thawed bait falls off the hook more easily than partially frozen bait;
- Thawed blue-dyed bait results in slower hook setting rates because of the time spent thawing and dyeing the bait blue during the setting of longline gear, and
- Dye can be messy, dyeing the hands and clothes of the crew and the deck of the vessel.

While fishermen must comply with blue dyed bait requirements and the benefits have been experimentally proven, they do not favor the technique. Gilman et al. (2007) suggest most of the practicality and convenience problems could be addressed if pre-blue-dyed bait were commercially available.

Weighted Branch Lines

Weights placed close to the hook on branch lines are intended to quickly sink baited hooks, before foraging seabirds can take the baits and then become hooked or entangled in longline gear. Hawaii longline vessels use a range of weight sizes from 45 to 80 grams within 1 m of the hook to quickly sink their branch lines to desired target depths. A recent study comparing the sink rates of terminal tackle between 45 g and 60 g swivels observed there to be a nominal (0.05 - 0.16 sec/m) difference (Brothers and Gilman 2005). 45 g weights are the current minimum weight requirement when line weighing is required.

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[8] Note that when deep-setting south of 23° N, or when north of 23° N and seabirds are not present, strategic offal discards are not required.

[9] This percentage is an estimated value, as observer data was recorded differently beginning in June 2005 when the regulation for recording "strategic offal discards" on the observer"s data forms changed to be recorded only when seabirds are present (NMFS 2006).

Night Setting

The use of night setting as a seabird mitigation measure requires that fishermen set their gear no earlier than one hour after local sunset, and complete the set no later than the following sunrise, using only the minimum number of lights necessary to conform to navigation rules and best safety practices. Night setting is based on the premise that seabirds cannot see baited hooks in the dark and, thus, do not attack them. The effectiveness of this measure may potentially be affected by moon phase and cloud cover, vessel lighting, and the use of light sticks to illuminate baits making them more conspicuous. Night setting has been identified as an effective seabird mitigation measure, reducing seabird interactions by 73% (McNamara et al. 1999) and even by as much as 98% (Boggs 2001). In the past, shallow-set vessels were able to set before sunset, resulting in correspondingly high sea bird interaction rates. Interaction rates have remained lower in the shallow-set fishery with the requirement for night setting.

Because the time at sunset changes with longitude and Hawaii-based longline vessels operate over a wide geographical area, NMFS observers aid fishermen to determine when it is legal for them to begin gear deployment. NMFS observers are trained to use issued Global Positioning System units to determine the exact time of sunset for their vessel‟s longitude. This has proven to be very helpful, especially on cloudy evenings.

Mitigation Research in 2009

In 2009, no seabird mitigation gear research was conducted by NMFS in Hawaii. However, a joint project between PIFSC, PIRO, and WPFMC to evaluate the use of video electronic monitoring (deck cameras) in the Hawaii longline fishery was completed in 2009.

6. Observer Coverage from 1994-2009

Background

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

Table 5 provides a brief history of seabird data collection requirements for the Hawaii Longline Observer Program under program protocols and the terms and conditions of applicable biological opinions.

Table 5. Hawaii longline observer data collection requirements from 1994–2009.

Time Period	Authorities	Observer Data Collection Requirements
1994-2001	Observer Program Protocols (NMFS 1999)	Record all STAL interactions with fishing gear.
2001-2002	November 2000 STAL BiOp (USFWS 2000)	Record all interactions with fishing gear. Record all STAL sightings. Return all dead STAL specimens to port.
2002-2004	November 2001 Revision to November 2000 STAL BiOp (USFWS 2002)	Record all STAL interactions with fishing gear. Record all STAL sightings. Record sightings and behavior of albatrosses during the set and haul of the mainline. Record seabird sightings in the vicinity of the longline gear during setting and haul operations. Return all dead STAL specimens to port.
2004-Present	1) November 2002 Revision to November 2000 STAL BiOp (USFWS 2002) 2) October 2004 STAL BiOp on Shallow-set Fishery (USFWS 2004)	Record all STAL interactions with fishing gear. Record all STAL sightings. Record sightings and behavior of albatrosses during the set and haul of the mainline. Record seabird sightings in the vicinity of the longline gear during setting and haul operations. Conduct two (2) five-minute scan counts for seabird abundance on shallow-sets during the first hour of setting operations as daylight permits and every two hours during haul operations. Return all dead STAL specimens to port.

Observer Coverage in 2009

In 2009, NMFS maintained an observer coverage rate of 21.0% for the deep-set fishery (Fig. 14). Observer coverage north of 23° N was 22.7% in 2009 with 1,847 out of 8,138 sets observed (Fig. 15). All shallow-sets north (and south) of 23° N latitude were observed in 2009.

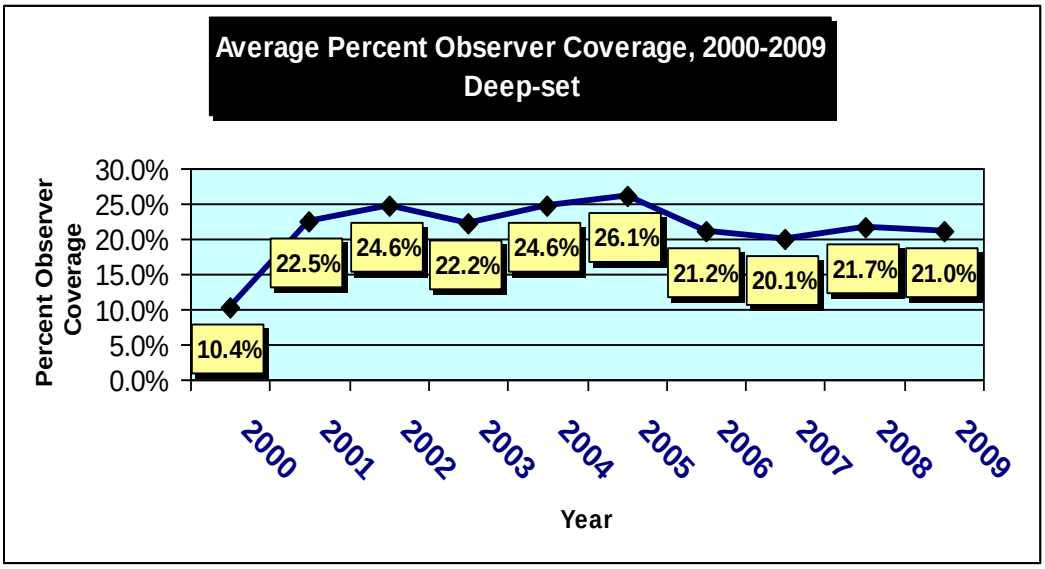

Figure 14. Observer coverage on deep-setting vessels, 2000-2009.
(Source: PIRO)

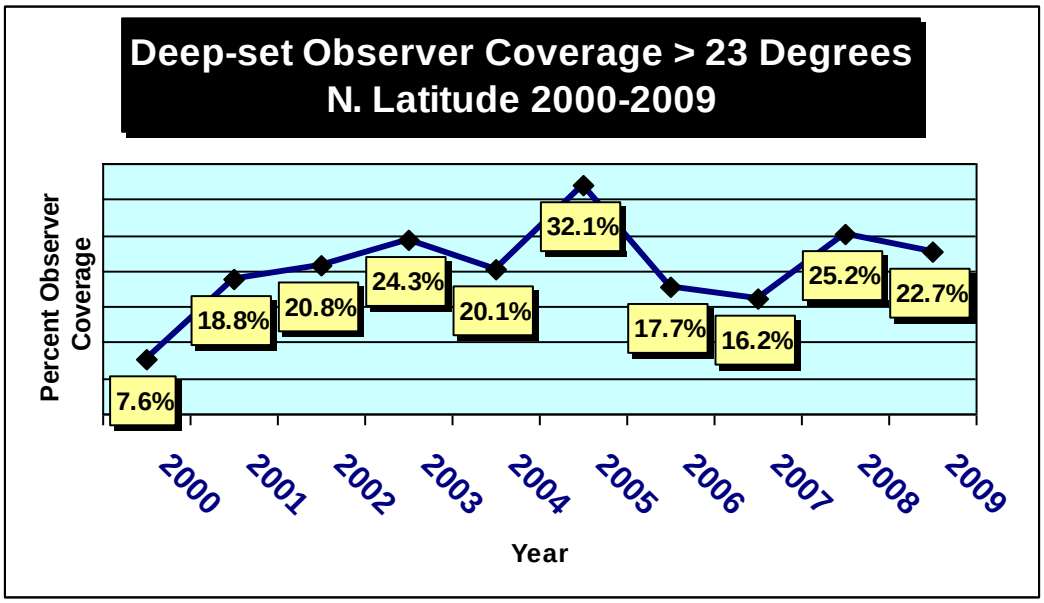

Figure 15. Observer coverage on deep-setting vessels north of 23° N latitude, 2000-2009.
(Source: PIRO)

7. Protected Species Workshops in 2009

The Protected Species Workshops present information on sea turtle, seabirds, and marine mammals. Topics covered include species identification and life history, mitigation techniques, current regulations, and any updates on current research pertinent to the fisheries. Participants receive folders containing current regulation summaries and information placards. Written materials are provided in English, Vietnamese, and Korean, which are the predominant languages of Hawaii longline vessel captains. In recent years, crews have been recruited from various parts of Micronesia, the Philippines, and Indonesia to work on Hawaii longline vessels. Some materials have been translated into Tagalog to accommodate crews from the Philippines. The employment of Indonesian workers is fairly recent, and outreach materials have not yet been translated for this group. Additionally, outreach materials have been translated into Samoan for use in the American Samoa-based longline fishery.

The Protected Species Workshops have been conducted annually by PIRO, Sustainable Fisheries Division (PIRO SFD) since 2000. Workshops are mandatory for all owners and operators of vessels permitted for use with any longline permit issued under 50 CFR 665.801. 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 USFWS, PIFSC, NOAA Office of Law Enforcement, PIRO Observer Program, and Protected Resources Division in the development of content material for the workshops. This collaborative approach has resulted in informative and successful workshops. In 2009, NMFS trained 292 longline vessel operators and owners in Hawaii and American Samoa through the workshops (Fig. 16).

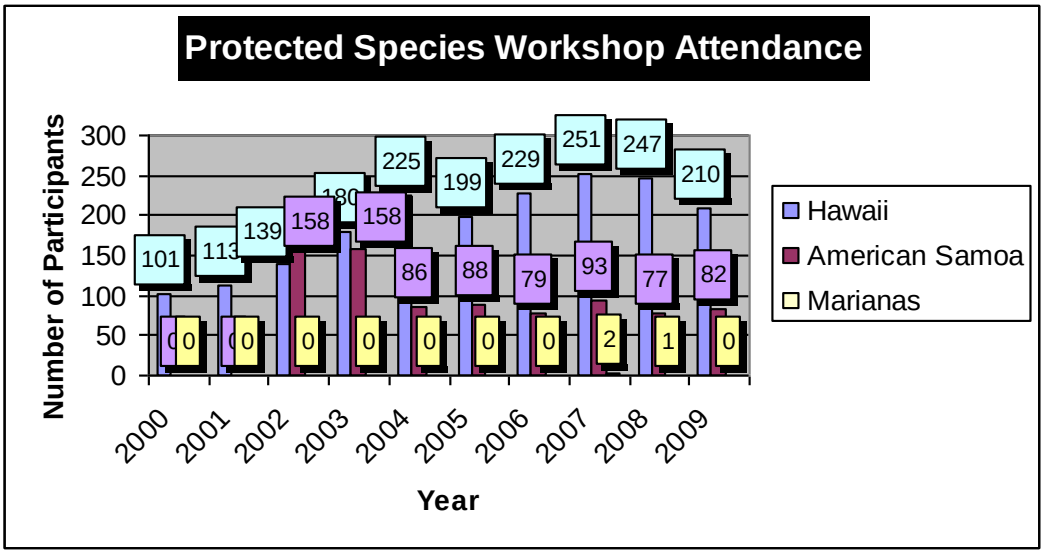

Figure 16. Protected Species Workshop certifications for Hawaii, American Samoa, and Marianas longline fishermen, 2000-2009.
(Source: PIRO)

PIRO SFD made available an online version of the Protected Species Workshop in 2008. In 2009, 80 out of the 292 participants took workshop training online: 79 in Hawaii and 1 in the

Marianas. In addition to the online course, NMFS SFD continues to hold traditional classroom-style workshops.

8. Seabird Interactions

Background

From 1994, the year the Hawaii longline observer program was initiated, through 12 June 2001, the date that the shallow-set fishery was closed, measures to mitigate seabird bycatch were not in effect. During this period, observer coverage was about 4% of both components of the Hawaii longline fleet. An order of magnitude higher level of seabird captures occurred in the shallow-set fishery during this period relative to the post-regulations period. During this pre-regulations period, some vessels would make mixed targeted trips, generally targeting swordfish at the beginning of fishing trips, and targeting tuna or marlins towards the end. Table 6 summarizes observed seabird catch levels and rates for shallow and deep-setting Hawaii longline vessels. For the purpose of this summary, shallow-sets are defined as having less than 15 hooks per basket, while deep-sets contain 15 or more hooks per basket, and the dates of interactions are recorded based on the date and time of the start of the haul. In addition to captures of Laysan and black-footed albatrosses, from 1994-2009 there were observations of captures of 24 shearwaters (assumed to be sooty and/or short-tailed shearwaters), one brown booby, and one red-footed booby (Table 6).

Table 6. Summary of observed seabird catch levels and nominal rates in the Hawaii longline shallow and deep-set fishery based on the beginning of the haul date, 1994-2009. Summary statistics are based on direct observations and not fleet-wide extrapolations. There was 100% observer coverage of shallow-sets starting in 2004. Regulations requiring the employment of seabird bycatch mitigation measures first came into effect on 13 June 2001.

Year	No. Laysan albatross caught	No. black-footed albatross caught	No. shearwaters (not identified to species level) caught	No. other or un-identified bird species caught	Total no. birds observed caught	Total observed effort (no. of hooks)	Nominal seabird catch rate (no. birds per 1,000 hooks)
Shallow sets							
1994	73	126	0	1	200	275,730	0.73
1995	105	104	0	1	210	251,911	0.83
1996	29	56	0	0	85	305,681	0.28
1997	64	105	0	0	169	252,155	0.67
1998	54	45	0	1	100	251,577	0.40
1999	24	47	0	0	71	159,590	0.44
2000	78	146	0	1	225	344,663	0.65
1 Jan - 12 June 2001	20	32	0	0	52	126,038	0.41
13 June - 31 Dec 2001	0	0	0	0	0	12,935	0.00

Year	No. Laysan albatross caught	No. black-footed albatross caught	No. shearwaters (not identified to species level) caught	No. other or un-identified bird species caught	Total no. birds observed caught	Total observed effort (no. of hooks)	Nominal seabird catch rate (no. birds per 1,000 hooks)
2002	0	2	0	0	2	22,627	0.09
2003	0	0	0	0	0	17,965	0.00
2004	1	0	0	0	1	115,718	0.01
2005	62	7	0	0	69	1,358,247	0.05
2006	8	3	0	0	11	676,716	0.02
2007	40	8	0	0	48	1,353,773	0.04
2008	33	6	0	0	39	1,460,042	0.03
2009	81	30	1	0	112	1,694,550	0.07
Deep sets							
1994	0	0	0	0	0	244,292	0
1995	2	1	0	0	3	365,665	0.008
1996	2	3	0	0	5	442,278	0.011
1997	2	2	0	0	4	324,068	0.012
1998	2	1	0	0	3	515,064	0.006
1999	4	4	0	0	8	525,817	0.015
2000	6	10	0	0	16	1,973,389	0.008
1 Jan - 12 June 2001	54	48	0	3	105	2,061,837	0.050
13 June - 31 Dec 2001	2	0	0	0	2	2,920,015	0.001
2002	16	16	0	0	32	6,697,636	0.005
2003	44	24	0	0	68	6,540,606	0.010
2004	2	5	0	2	9	7,937,239	0.001
2005	6	11	0	1	18	9,326,717	0.002
2006	1	17	5	0	23	7,434,798	0.003
2007	7	18	0	0	25	7,751,149	0.003
2008	14	30	14	2	60	8,746,085	0.007
2009	19	23	4	0	46	7,888,838	0.006

The nominal catch rates reported in Table 6 do not account for factors that may have had a significant effect on interactions, including differences in abundance of scavenging seabirds around the vessel, and differences in temporal and spatial distribution of effort between the pre- and post-regulations period, and therefore provide only a rough, first order perspective of differences in seabird catch rates between these two time periods. More sophisticated analysis, as conducted by Gilman et al. (2008) for the Hawaii longline deep-set tuna fishery, have not been conducted for the shallow-set fishery, which would provide an improved understanding of the comparison of bird catch rates between these periods.

In the shallow-set fishery, nominal seabird catch rates during the periods before and after seabird regulations came into effect dropped 93% from 0.57-0.04 birds captured per 1,000 hooks, based

on counts of caught seabirds retrieved during gear hauling. From 2005-2009, the nominal seabird capture rate in the shallow-set fishery ranged from 0.02-0.07 birds per 1,000 hooks, suggesting that seabird regulations are consistently keeping seabird catch rates low relative to before regulations were instituted. Similarly, in the deep-set fishery, nominal seabird catch rates during the periods before and after seabird regulations came into effect dropped 81% from 0.02-0.004 birds captured per 1,000 hooks. From 2005-2009, the nominal seabird capture rate in the deep-set fishery ranged from 0.002-0.007 birds per 1,000 hooks, suggesting that, despite the deep-set fishery having shifted effort northwards in the past few years, which would be expected to result in increased seabird catch rates, as North Pacific albatross abundance is higher at these higher latitudes, seabird regulations are consistently keeping seabird catch rates low relative to before regulations were instituted. These nominal catch rates do not account for factors that may have had a significant effect on interactions, including interannual variability in average albatross abundance around vessels due in part to variability in temporal and spatial distribution of effort, and therefore provide only a rough, first order perspective of differences in seabird catch rates between these two time periods.

In 2000, an estimated 2,433 seabirds were incidentally taken in both fisheries (Fig. 17). In 2001, the number of seabirds incidentally taken dropped to an estimated 510 seabirds in Hawaii longline fisheries. This reduction can be primarily attributed to the closure of the shallow-set fishery in 2001 (due to sea turtle interactions). The swordfish fishery remained completely closed throughout 2002 and 2003. During this period, the deep-set fishery interacted with an estimated 373 seabirds (116 in 2002 and 257 in 2003).

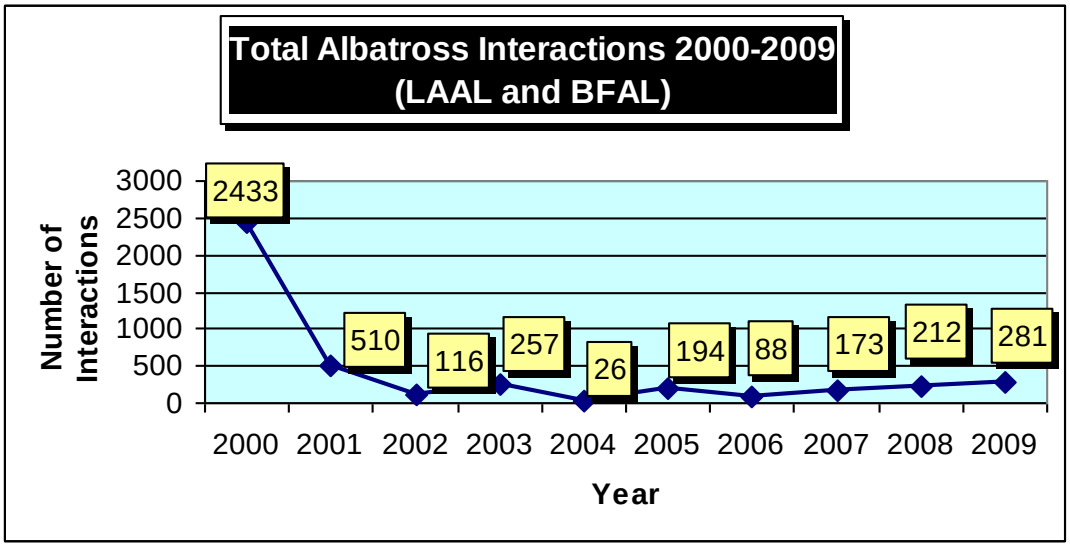

Figure 17. Total estimated fleet-wide albatrosses (LAAL and BFAL) incidentally taken by Hawaii longline vessels, 2000-2009.
(Source: PIRO)

In April 2004, the swordfish fishery re-opened under a new management program that limited effort in the fishery to a maximum of 2,120 sets annually (69 FR 17330). During 2004, 26 albatrosses were estimated to have been incidentally taken in the shallow-set and deep-set

fisheries. It should be noted that the shallow-set fishery was open only from October through December in 2004. In 2005, NMFS estimated that 194 seabirds were interacted with by the combined fisheries. Even with the shallow-set fishery open for the entire year, that fishery did not experience the high interaction rates that occurred in prior years (e.g., 2000). While the shallow-set fishery was closed 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 1,000 hooks) remained low compared to years prior to the 2001 shallow-set closure.

A key factor contributing to the decrease in estimated seabird interactions 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. Since then, the number of seabirds incidentally taken in the Hawaii longline fisheries has continued to remain low under more recent mitigation measures implemented on January 18, 2006 (70 FR 75075).

Spatial and temporal placement of fishing operations and the localized seabird abundance around vessels likely influence interaction rates. The PIRO Observer Program records relative seabird abundance during fishing operations through visual counts. Including relative seabird abundance into analyses will improve the understanding of the relative success of seabird mitigation measures and enable the calculation of more precise interaction rates. These data need to be analyzed especially in light of potential changes in fishing patterns in the deep-set fishery as demonstrated earlier in Section 4 of this report.

Regulations designed to protect sea turtles in the shallow-set fishery have likely provided an ancillary benefit to reduce seabird interactions. For instance, the shallow-set fishery was closed in March 2006 because the interaction limit on loggerhead sea turtles was reached. The closure meant that fewer potential incidental interactions with seabirds occurred that year. With the adoption of increased loggerhead interaction limits, it is unlikely the above benefits to seabirds will continue because it is less likely that sea turtle interaction limits will be reached resulting in a fishery closure.

Observed Interactions and Interaction Rates

There were no observed or reported interactions with STALs in either the deep-set or shallow-set Hawaii longline fisheries during 2009. In 2008, the number of deep-set interactions had increased over previous years. However, the number of observed deep-set albatross interactions decreased slightly from 48 in 2008 to 42 in 2009 (Fig 18). NMFS observers recorded interactions with 23 BFAL and 19 LAAL, and four shearwaters in the deep-set fishery in 2009 with a 21.0% observer coverage rate for sets hauled in 2009. The simple estimated interaction rate in the deep-set fishery for seabirds was 0.005 seabirds per 1,000 hooks and 0.005 birds per 1,000 hooks for albatrosses alone. Interactions with 81 LAAL, 30 BFAL, and one shearwater were observed in the shallow-set fishery in 2009 for an interaction rate of 0.064 seabirds per 1,000 hooks (Fig. 18). This is more than double the rate of 0.029 seabirds per 1,000 hooks seen in 2008 (NMFS 2009). 100% of shallow sets were observed in 2009.

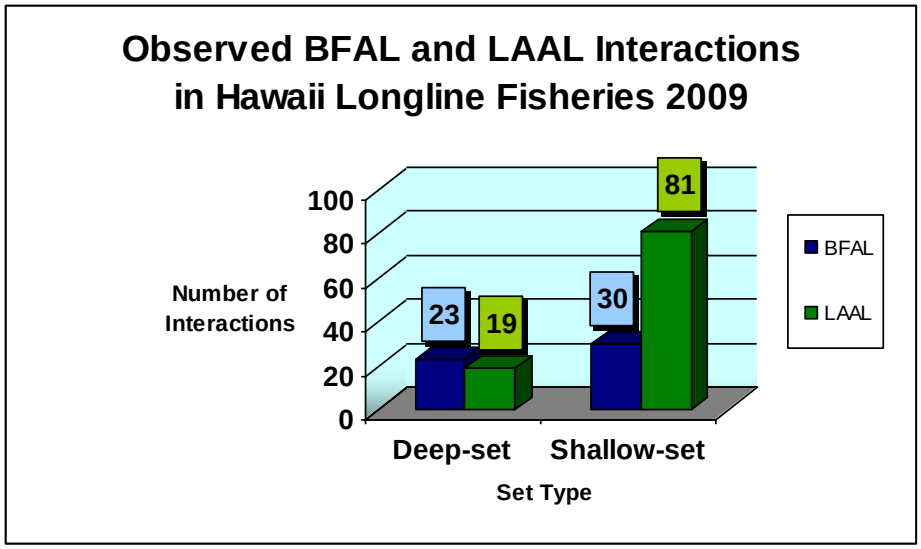

Figure 18. Total observed black-footed and Laysan albatross interactions in the Hawaii pelagic longline fisheries in 2009.
(Source: PIRO)

There were fewer shearwaters incidentally caught in Hawaii longline fisheries in 2009 than in 2008. Historically, shearwaters have not been commonly caught in Hawaii longline fisheries. In 2009, no shearwaters were retained by observers and identification from photos was inconclusive. Seabird experts from USFWS and academic institutions agreed that the birds were most likely sooty shearwaters (*Puffinus griseus*) or short-tailed shearwaters (*Puffinus tenuirostris*). Neither species is listed under the ESA. No other seabird species were reported interacting with Hawaii longline vessels in 2009.

Observed Interaction Statistics

The types of interactions in 2009 occurred in roughly the same proportions in the deep-set and shallow-set fisheries with hookings accounting for the majority of observed interactions. A smaller proportion of albatrosses were entangled. There were five albatrosses observed hooked and entangled in both fisheries (Table 7).

Table 7. Types of interactions between albatrosses and Hawaii longline vessels, 2009.

	Deep-set	Shallow-set	Combined
Hooked	37 (88%)	89 (80%)	126 (82%)
Entangled	2 (5%)	20 (18%)	22 (14%)
Hooked and Entangled	3 (7%)	2 (2%)	5 (3%)

There are large differences between the shallow and deep-set fisheries in terms of the proportion of caught birds that are retrieved alive (Table 8). For example, in 2008, 95% of the deep-set interactions resulted in mortality, while only 38% of the shallow-set interactions resulted in

mortality. While there may be some birds retrieved alive in shallow-sets caught during the set and survived the soak, likely most of these records of live seabird captures represent bird captures occurring during the haul. The lower seabird catch level during hauling in the deep-set fishery might be due to most hauling occurring at night in the deep-set fishery vs. in the shallow-set fishery, where the haul typically starts at dawn when albatrosses are actively foraging. Occasionally observers are able to observe and record bird captures occurring during gear hauling, but observers are not always able to determine when a caught bird was captured. For example, in 2008, observer data identify four records consisting of one BFAL, one LAAL, one red-footed booby, and one unidentified seabird species, caught during gear hauling in deep-sets out of a total of 60 observed bird captures, and nine records of one BFAL and eight LAAL being captured during gear hauling in shallow-sets out of a total of 39 observed bird captures. This represents a minimum estimate of bird capture events during gear hauling. Hence, in 2008, based on direct observations, a minimum of 7% and 21% of total observed bird captures in deep and shallow sets, respectively, were confirmed as having been caught during gear hauling. Seabird bycatch avoidance methods that might be employed by Hawaii longline vessels during hauling include: hauling at night, using weighted branchlines, use of blue-dyed bait, and employment of strategic offal discards.

An interaction with a seabird is automatically classified as "Injured", if the animal is not "Dead", and is seldom given an "Alive" release code. "Alive" is a rare release condition, and could only happen if a seabird were to become lightly entangled, not hooked, and freed itself without the aid of the observer (Eric Forney, NMFS, pers. comm. April 2009). No albatrosses in either fishery were observed released alive (Table 8). There is a strong correlation between the release condition and the phase of fishing operations in which seabirds are captured. If seabirds are caught during gear deployment, they are unlikely to survive gear interactions and the gear soak period. In contrast, the majority of seabirds caught during gear retrieval are usually released injured. Based on interpretations of observer data, an attempt can be made to infer whether an albatross was captured during gear deployment and the soak period or gear retrieval.

Table 8. Release condition for albatrosses captured incidentally to fishing operations in the Hawaii longline fisheries, 2009.

	Number (%) captured		
Condition upon gear retrieval	Deep-set	Shallow-set	Combined
Alive	0 (0%)	0 (0%)	0 (0%)
Injured	0 (0%)	87 (78%)	87 (57%)
Dead	42 (100%)	24 (22%)	66 (43%)

In 2009, all albatrosses captured in the deep-set fishery were dead when recovered, including two that were observed captured during the gear retrieval phase of fishing operations (Table 9). Recorded observer comments are consistent with the interpretation that all captures occurred during gear deployment in the deep-set fishery.

In contrast, the majority (78%) of albatrosses captured in the shallow-set fishery were released injured, and were directly observed occurring during the gear retrieval operations (haul). The remaining incidental interactions (22%) in the shallow-set fishery resulted in mortalities. Most interactions that occurred during the haul happened when albatrosses were attempting to steal baits from branch lines that were being retrieved. The rest of the interactions (19%) appear to have occurred during gear deployment. All of the albatrosses in both fisheries that were inferred/hypothesized to have been caught during gear deployment were recovered dead.

Table 9. Probable time of capture for observed albatross interactions in the Hawaii longline fisheries, 2009.

	Number (%) captured		
	Deep-set	Shallow-set	Combined
Set (assumed if bird was retrieved dead and observer didn't observe bird being captured during hauling)	42 (100%)	21 (19%)	63 (41%)
Haul (assumed if bird was retrieved alive and/or if observer observed bird being captured during hauling)	0 (0%)	90 (81%)	90 (59%)

Temporal Distributions of Seabird Interactions in 2009

In the deep-set fishery, all Laysan albatross were caught in the early part of the year in January and February (Fig. 19). Black-footed albatross interactions were observed from January through June: The majority occurring in June (Fig. 19). Figure 19 also shows four shearwaters were incidentally captured in April and May.

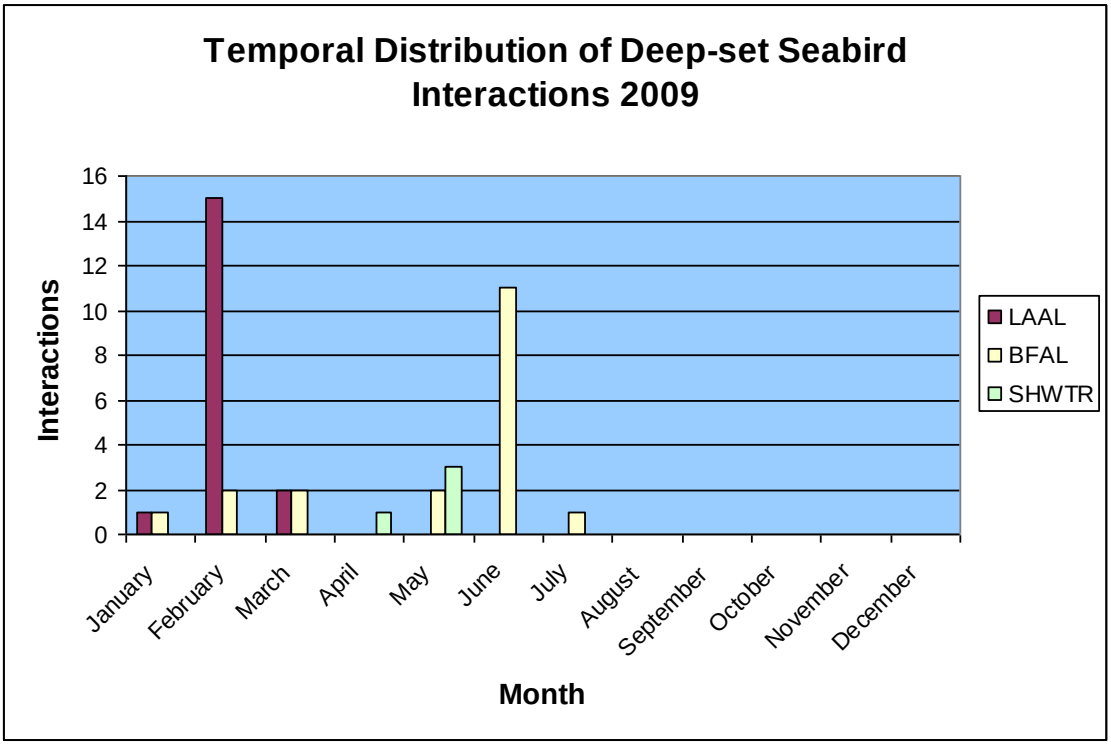

Figure 19. Temporal distribution of observed deep-set seabird interactions in 2009. (Source: PIRO)

Shallow-set interactions with Laysan albatross occurred from January through June with noticeable spikes in February and, especially, April (Fig. 20). Black-footed interactions were distributed from January through December with the majority of interactions between March and May (Fig. 20). Observer accounts indicate that most shallow-set interactions happened because birds attacked baited hooks attached to "lazy lines" trailing behind vessels during gear retrieval. PIRO has contacted industry about the need to reduce these easily preventable interactions. A single shearwater was incidentally captured by the shallow-set fishery in May.

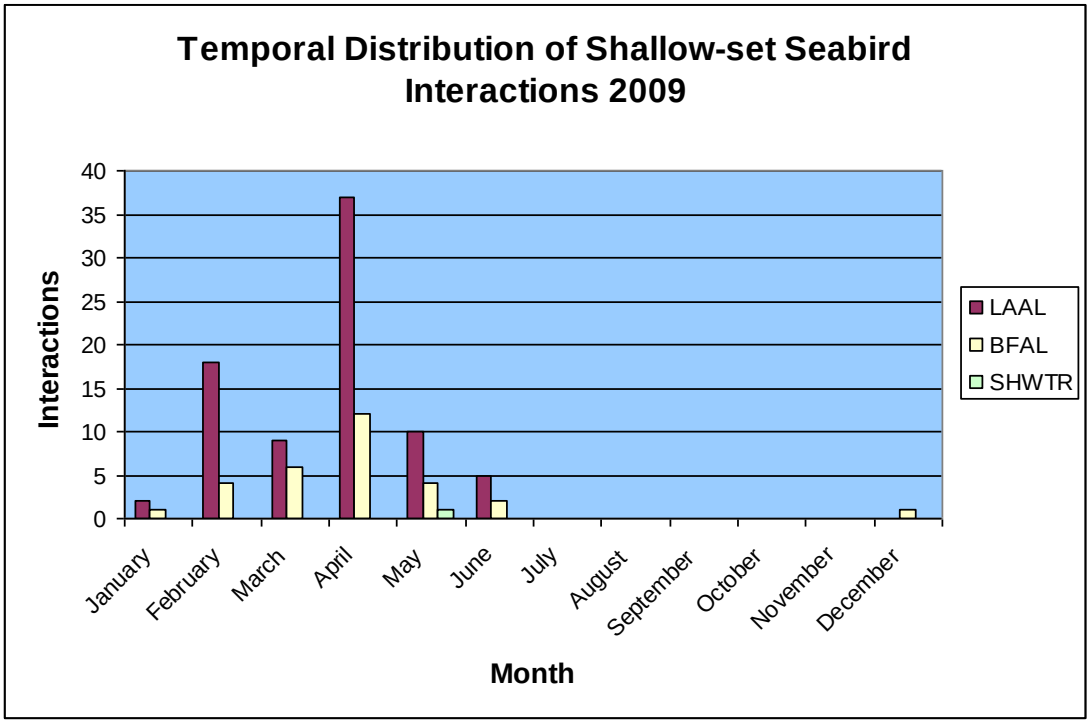

Figure 20. Temporal distribution of shallow-set seabird interactions in 2009.
(Source: PIRO)

Almost all interactions occurred in winter and spring which coincides with the nesting periods of both LAALs and BFALs which are roughly from November through June (Naughton et al. 2008a, Naughton et al. 2008b). The timing of incidental interactions may be important in assessing the impacts that the fisheries have on albatross populations. However, such an assessment is beyond the scope of this report.

Spatial Distributions of Seabird Interactions in 2009

The spatial patterns of longline interactions with seabirds are illustrated in Figures 21 and 22.

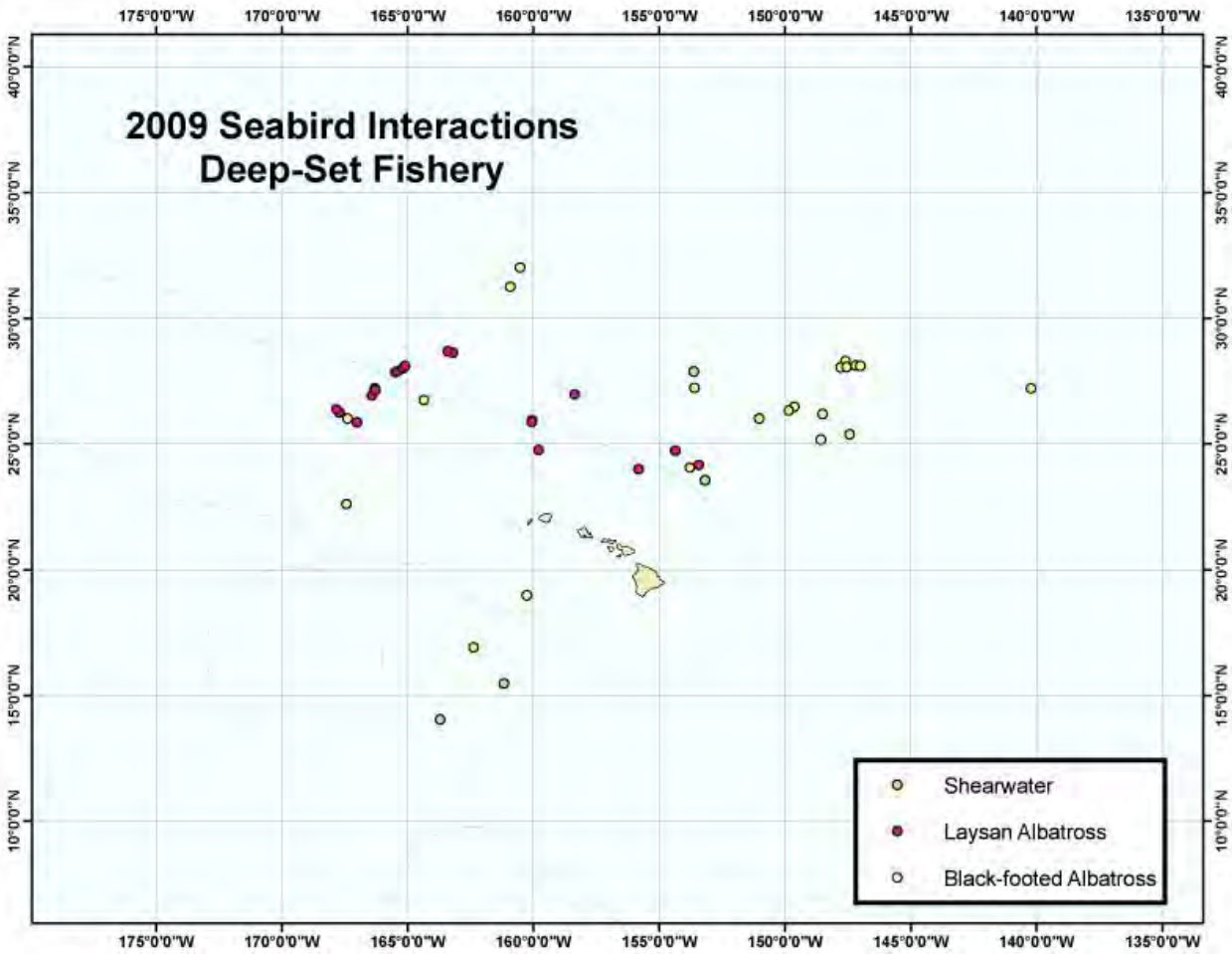

Figure 21. Spatial distribution of observed deep-set seabird interactions in 2009.
(Source: PIRO Observer Program)

By inspection, the majority of seabird interactions in the deep-set fishery (Fig. 21) were north of 23° N. As previously stated, deep-set vessels must deploy seabird mitigation measures above this latitude. Directly to the north of the MHI there was some overlap between areas of interactions with the two albatross species. A few deep-set BFAL interactions occurred to the southwest of the MHI. However, most BFAL interactions were spread across a wide range of longitudes north of Hawaii with a noticeable cluster to the northeast (Fig. 21). This northeast cluster coincides with an area traditionally fished by tuna longliners in the summer months (Polovina et al. 2009). Coincidentally, most deep-set BFAL interactions were in June (Fig. 19). There were no deep-set LAAL interactions south of the MHI. To the north, deep-set LAAL interactions occurred to directly north of the MHI and to the west above the NWHI. Of the four incidentally captured shearwaters by the deep-set fishery, two were caught to the south and two were caught north of the MHI.

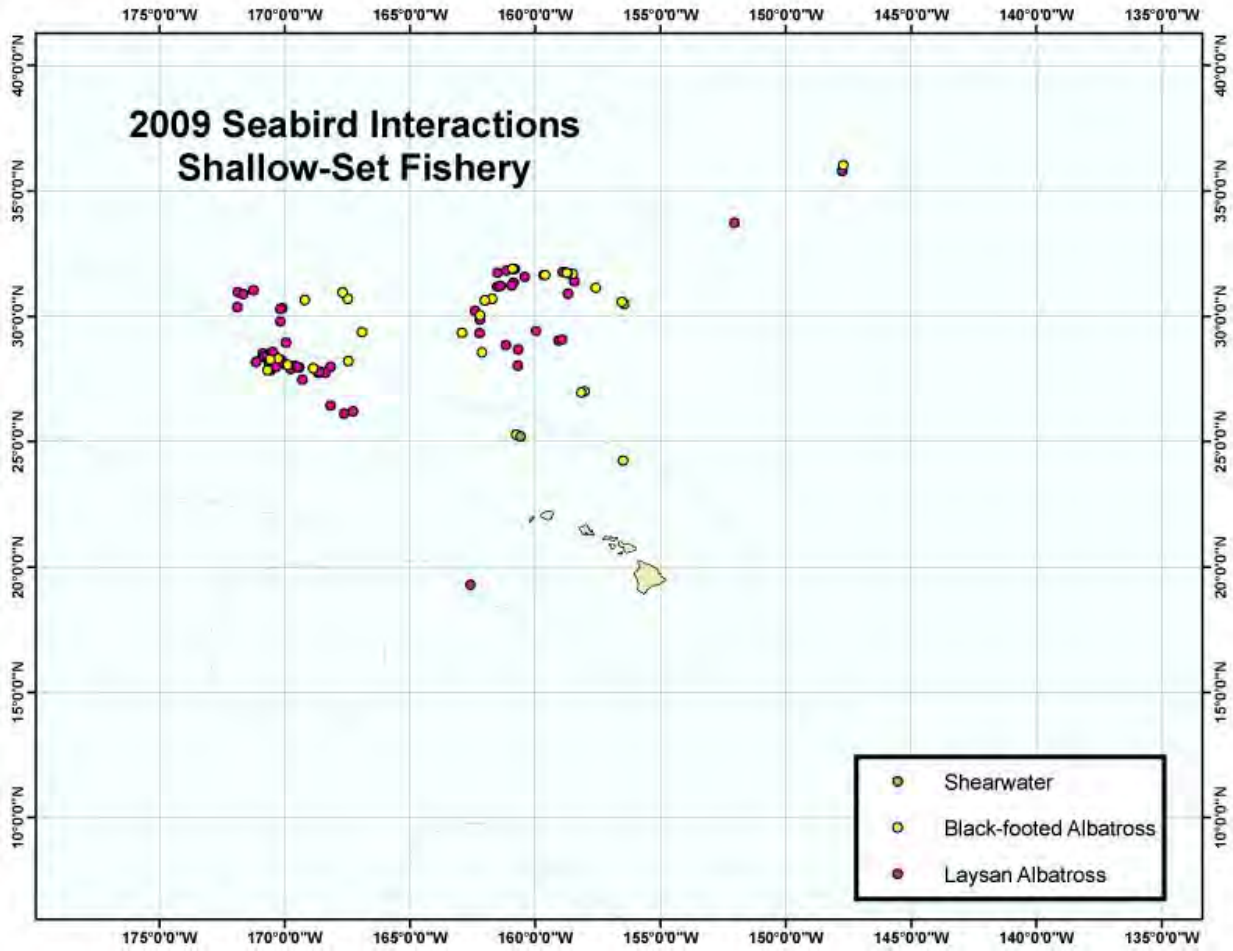

Figure 22. Spatial distribution of shallow-set seabird interactions in 2009.
(Source: PIRO Observer Program)

Only one incidental interaction, a LAAL, was recorded to the south of Hawaii in the shallow-set fishery which probably reflects the fact that most effort takes place to the north of Hawaii. Otherwise, seabird interactions largely took place in two mixed-species clusters: one over a broad area north of Kauai and the other north-northwest of French Frigate Shoals. There were also a few shallow-set interactions northwest of the MHI at about 34°-36° N (Fig. 22).

One shearwater (likely a sooty or short-tailed) was incidentally taken north of Kauai at about 25° N in the shallow-set fishery.

Estimated Interactions

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

Because of fluctuations in the deep-set fleet"s activity 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 selected. Furthermore, it is inappropriate to estimate the total number of incidental interactions by simply raising the average observed catch rate by the total amount of effort as this estimator assumes a simple random sample.

The Horvitz-Thompson estimator methodology used for the deep-set fishery is an unbiased estimator based on the sampling design (McCracken 2010). 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 call in order in which longline vessels notify the PIRO Observer Program of a fishing trip. (See Appendix and 50 CFR 665.803 Notifications for explanations.) 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 availability of observers 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, and 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 may lead to periods of low observer coverage and lower probabilities that a particular vessel will be sampled. The Horvitz-Thompson estimator used by McCracken (2010) accounts for the interplay between observer availability and fleet activity which, in turn, influences the probability of whether a trip is sampled, or not.

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 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 2010).

In 2009, the Hawaii deep-set longline fishery was estimated to have incidentally interacted with 110 BFAL and 60 LAAL. The estimated interaction rates for 2009 in the deep-set fishery by species were 0.003 BFAL per 1,000 hooks and 0.002 LAAL per 1,000 hooks. The overall deep-set fishery interaction rate was 0.005 albatrosses per 1,000 hooks (McCracken 2010).

For both longline fisheries in 2009, there were an estimated 140 interactions with BFAL and 141 interactions with LAAL, totaling 281 for both species. Total estimates for the fisheries were determined by combining the estimated interactions (i.e., point estimates) in the deep-set fishery with the total number of observed shallow-set interactions. Fleet-wide albatross interactions for both fisheries (estimated deep-set plus observed shallow-set) from 2000 through 2009 are depicted in Fig. 25. It should be taken into account that the shallow-set fishery was closed in April 2001, and re-opened in April 2004.

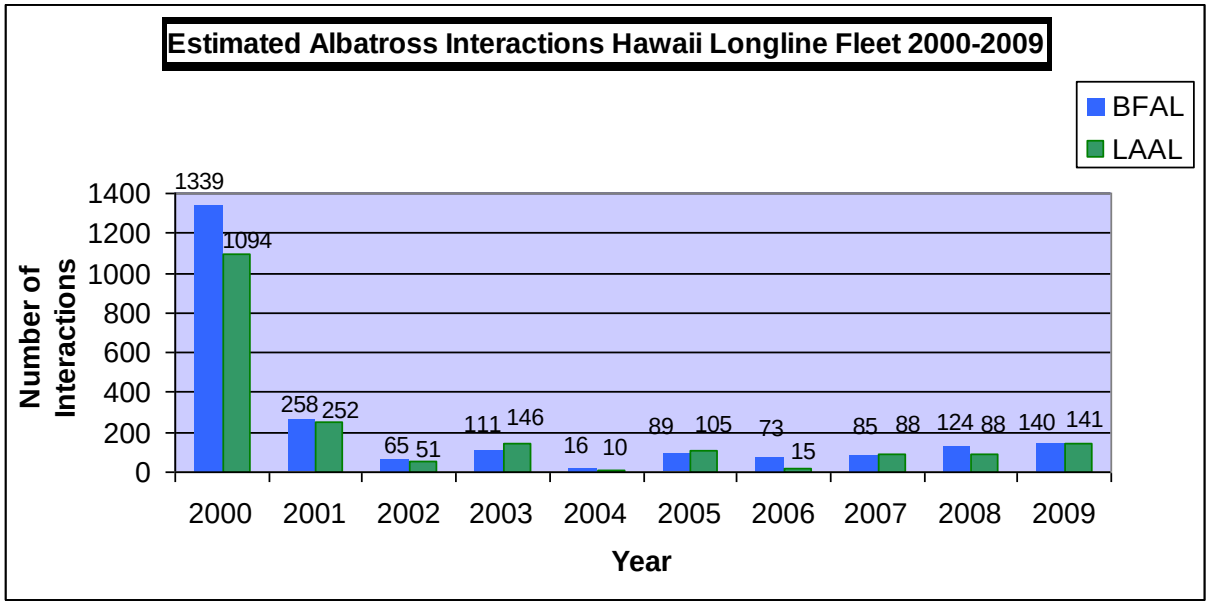

Figure 23. Estimated fleet-wide incidental interactions with black-footed and Laysan albatrosses in the Hawaii longline fisheries during 2000-2009.
(Source: PIRO)

Relatively more BFALs are taken compared to their population size (recall that the BFAL nesting pair population is about one tenth that of LAALs) than are LAALs since they are taken in about even total numbers. This trend seems to be consistent over the years (Fig. 23). Fernandez et al. (2001) note that BFALs are 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 et al. (2002) 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 between the two species may have some influence on why BFALs are caught in disproportionate numbers relative to their population size.

Short-tailed Albatross Sightings in 2009

NMFS observers sighted three short-tailed albatross in 2009 approximately 550 – 1,100 nautical miles north of the Hawaiian Islands. The approximate locations of the sightings are shown in Figure 26, and the details of which were provided to USFWS.

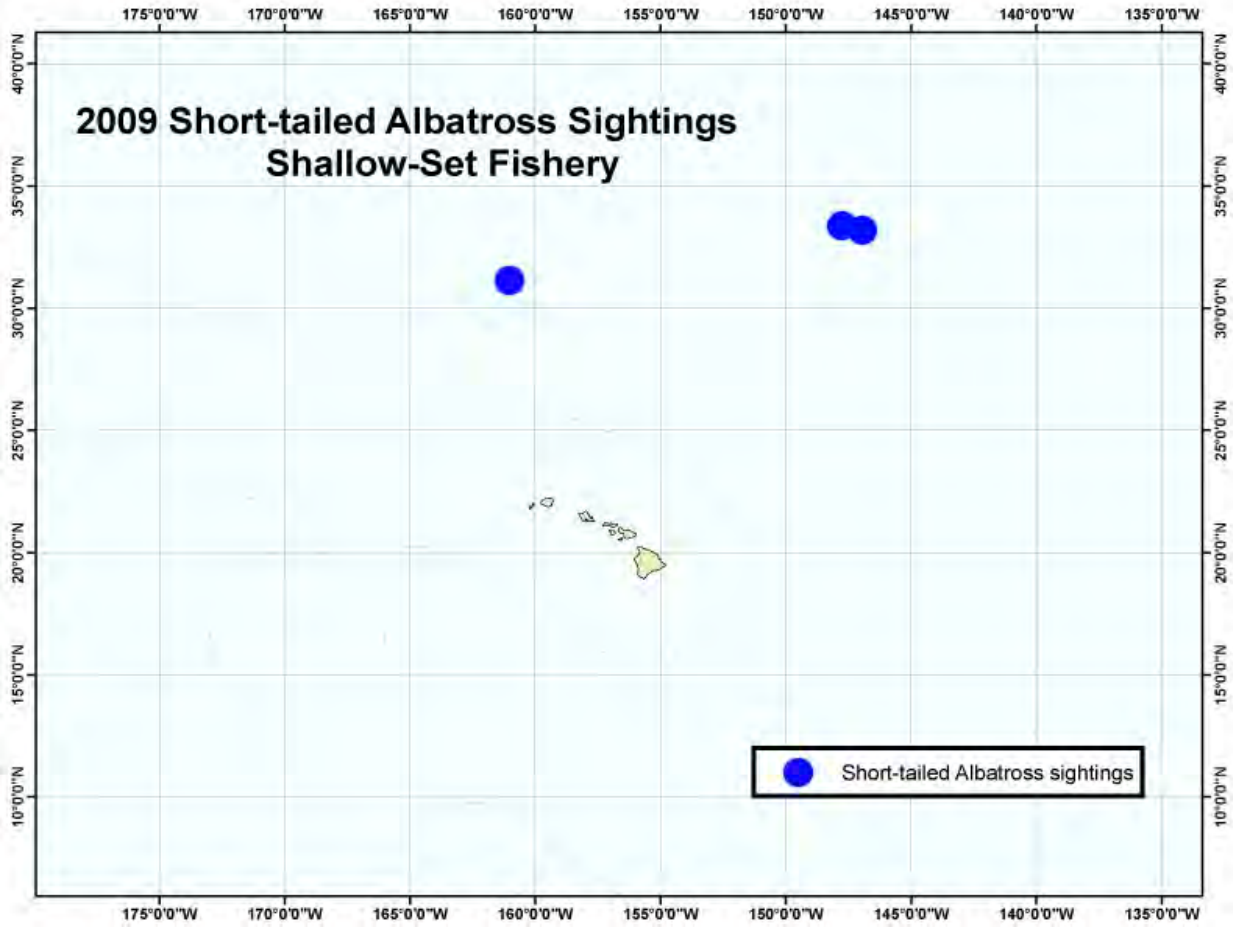

Figure 24. Short-tailed albatross sightings by NMFS observers, 2009.
(Source: PIRO Observer Program)

Observer narratives indicate that all STALs sighted were juvenile birds. Some observers recorded STALs feeding on discarded offal and spent bait in close proximity to longline vessels. No STALs were recorded interacting with fishing gear (NMFS unpub.).

9. Summary

In 2009, observer coverage for the combined Hawaii-based fisheries averaged 28.5% (21.0% for deep-setting vessels and 100% for shallow-setting vessels; 5,294 of 18,562 total sets) based on sets hauled in 2009. Additionally, NMFS observers monitored 37.6% of all longline sets north of 23° N and 25.2% of deep-sets north of 23° N that were hauled in 2009 (NMFS unpub. 2009). Of the 39,473,259 total hooks fished, the deep-set fishery deployed about 37 million hooks in 16,800 sets, and the shallow-set fishery deployed about 1.7 million hooks in 1,762 sets (NMFS 2009).

No gear interaction was observed or reported with a STAL by either deep-setting or shallow-setting Hawaii-based vessels. NMFS observers sighted three STALs during longline fishing operations, but no interactions occurred. The shallow-set fishery was observed to interact with 30 BFALs, 81 LAALs, and 4 shearwaters for an interaction rate of 0.064 seabirds per 1,000 hooks. It was estimated that there were 110 BFAL and 60 LAAL interactions in the deep-set fishery in 2009. Overall, the deep-set fishery had an estimated interaction rate of 0.005 albatrosses per 1,000 hooks. Since 2004, the estimated total number of interactions with albatrosses hooked or entangled incidentally to fishing operations by Hawaii pelagic longline fisheries has been reduced by 92-99% compared to year 2000 estimates. Additionally, there were 5 shearwaters observed captured incidentally to fishing operations in 2009.

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Appendix 1.

Estimation of Incidental Interactions with Sea Turtles and Seabirds in the 2009 Hawaii Longline Deep Set Fishery[1]

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This report provides estimates of the number of incidental interactions with protected species of marine turtles and seabirds by the Hawaii longline deep set fishery in the year 2009 (Table 10). 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 certificates for swordfish fishing.

The interaction estimates are based on a random sample of longline trips on which scientific observers are deployed. In 2009, 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 for swordfish, 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 that the trip was not sampled along with a short explanation of why it was not sampled. If a trip was selected but the vessel did not leave within a reasonable amount of time, usually the observer was reassigned to a different vessel trip. When the selected vessel was ready to depart, a different observer was assigned to it.

1 PIFSC Internal Report IR-10-009, Issued 16 April 2010

The systematic sample requires having an observer available to be deployed whenever a selected trip is ready to depart. Achieving this requirement under full targeted coverage, typically 20% coverage, throughout the year requires having enough observers on contract to accommodate higher levels of fleet activity and paying them when they are not deployed on a vessel. These requirements frequently cannot be met under the current level of funding; therefore, the quarterly sample selected under the systematic design was usually slightly smaller than the targeted coverage, typically 5% less. When this occurred, the additional trips needed to reach the full targeted level were 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. Trips sampled by the systematic and secondary protocol are used to estimate incidental take.

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. 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. Examination of these records revealed periods of time within a quarter when coverage appeared to have been greater or less than the full targeted coverage. Specifically, periods of time for which the number of secondary samples were greater than expected represent higher coverage and those for which the number of secondary samples were fewer than expected represent lower coverage. Before computing the sampling probabilities, periods of comparable coverage were identified. The sampling probabilities were computed by enumerating the number of call-ins during consecutive time periods of comparable coverage and assuming that the secondary samples 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, the observed 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 17 March 2010.

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. A quarter‟s confidence interval does not incorporate information beyond the quarter‟s data. Therefore, for some species the upper bound of the confidence interval may seem high given historical records. For example, there has not been an observed incidental interaction with a short-tailed albatross during the history of the observer program and based on this information it seems highly improbable that the incidental interaction levels would be as high as the upper bounds of the confidence intervals for this species.

Table 10. 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 2009. Point estimates were computed by quarter, using data for vessels returning to port during the quarter, then summed to derive the annual statistics. All protected species of sea turtles and seabirds with an observed interaction are listed as well as species that most commonly interact with the fishery or are of special concern because of their endangered species status.

	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
Sea Turtles									
Loggerhead	0	[0,18]	0	[0,19]	0	[0,11]	0	[0,16]	0
Leatherback	0	[0,18]	0	[0,19]	4	[1,18]	0	[0,16]	4
Olive ridley	0	[0,18]	11	[2,33]	7	[2,39]	0	[0,16]	18
Green	0	[0,18]	0	[0,19]	0	[0,11]	0	[0,16]	0
Seabirds									
Black-footed albatross	19	[5,50]	12	[2,36]	72	[39,105]	7	[1,26]	110
Laysan albatross	60	[24,111]	0	[0,19]	0	[0,11]	0	[0,16]	60
Short-tailed albatross	0	[0,18]	0	[0,19]	0	[0,11]	0	[0,16]	0
Red-footed booby	0	[0,18]	0	[0,19]	0	[0,11]	0	[0,16]	0
Unidentified Shearwater	0	[0,18]	24	[4,52]	0	[0,11]	0	[0,16]	24

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