Annual Report on the Hawaii longline fishing experiments to reduce sea turtle bycatch under ESA Section 10 Permit 1303 (November 30, 2002)

Objective of Research

On January 25, 2002, the NOAA Fisheries Office of Protected Resources issued Scientific Research Permit #1303 (the permit), under Section 10 of the ESA, authorizing NOAA Fisheries' Southwest Fisheries Science Center Honolulu Laboratory (HL) to conduct research/experiments to reduce longline fishery bycatch and mortality of sea turtles. The objective of this research is to develop economically viable longline fishing methods to harvest swordfish and tuna while reducing or eliminating the bycatch of sea turtles. The long-term goal of this research is to implement, globally, longline fishing methods that significantly reduce or eliminate the bycatch and mortality of sea turtles. The research covered by the permit was designed to complement similar research being conducted in the Atlantic Ocean, but is distinctly different because longline fishing strategies and tactics differ in the Pacific from those followed in the Atlantic. Research under the permit falls under two categories: 1) Large scale testing of gear modifications known to be economically viable to determine effects on turtle bycatch; and 2) Small scale testing of more substantial gear modifications to determine economic viability.

Litigation against the Permited Experiments

On June 27, 2002, the Ocean Conservancy, Turtle Island Restoration Network, and Center for Biological Diversity filed a complaint with the U.S. District Court for the District of Hawaii against NMFS, DOC, and the Secretary of Commerce challenging: (1) the ESA section 10 permit issued in January 2002 to the Honolulu Laboratory to conduct a longline fishery experiment in the north Pacific; (2) the biological opinion analyzing the experiment; and (3) the adequacy of the NEPA analysis of the experiment. Plaintiffs subsequently asked for declaratory relief and an injunction against the experiments. A hearing was held on October 29-30 before the District Court in Honolulu to consider the arguments raised in the complaint, and the plaintiffs' request for preliminary injunction. On Nov 22, Judge Kay issued his decision not to grant an injuction due to unusual circumstances (i.e. the dire need to conduct the research), but also instructed NMFS to prepare an EIS, to proceed with research at the annual rate of sets per year exactly as originally described for the research (no faster), and to report to the court monthly on the status of the experiments. The plaintiffs will appeal, and have asked for a temporary restraining order until a hearing set January 6 in San Francisco. The complaint itself will not go to court until later in 2003.

The Experiments as Originally Proposed

The fishing experiments were scientifically and statistically designed to test various gear modifications over three years using contracted longline fishing vessels to conduct research longline fishing operations. The primary effort was intended to be a large scale test of several economically viable modifications to fishing gear to determine if these alterations would reduce turtle bycatch. The planned gear modifications were based on 1) analyses of observer records collected during 1994 - 1999, and 2) results from experiments conducted with captive sea turtles.

Statistical analysis of Hawaii longline fishery observer data showed that branch lines attached close to float lines caught the most turtles (Kleiber and Boggs, 2000). Based on this finding, a gear modification experiment was designed to test the technique of attaching branch lines at distances more than 40 fathoms from float lines. This experiment was designed to include blue-dyed squid bait as part of the treatment to be tested against control fishing with normal gear and bait. Strong evidence from studies with captive sea turtles shows that green and loggerhead sea turtles are attracted to natural squid bait, but when they are presented with a choice between blue dyed squid bait and normal squid bait in controlled experiments, the turtles completely ignore the blue bait for up to 8 to 10 days (Swimmer and Brill, 2001, Swimmer et al., 2002).

The statistical design of the primary, large-scale gear modification experiment calls for 520 research longline sets per year with a similar number of sets serving as the control. This number of sets is designed to allow detection of a 50% reduction in sea turtle bycatch compared to the control sample. These experiments will require about 9 full-time longline fishing vessels per year, or a larger number of vessels fishing part-time. However, Special Conditions on Permit 1303 severely limited the scope of the experiments conducted in 2002. NMFS has referred to the limited-scope experiments conducted in 2002 as "Phase I" to distinguish the work from the much larger body of work planned for "year 1". Most of the work planned for the first year of the experiments has not yet been initiated, including the large-scale testing of modified fishing gear involving the attachment of branch lines to the mainline at distances more than 40 fathoms from the float lines and the use of blue-dyed bait. Instead a variety of other experiments covered by the permit were allowed in Phase I.

Under Phase I the permit allowed limited testing of stealth (camouflaged) swordfish and tuna longline fishing gears and deep daytime swordfish fishing to evaluate whether gear modified in this manner would retain viable economic performance. If so, future testing to demonstrate turtle bycatch reduction would be proposed. This phased approach is being followed in order to minimize impacts on sea turtles until major fishing modifications with potential for bycatch reduction are first shown to be economically viable. Also allowed in Phase I was research using electronic hook timers and time depth recorders to document when and where turtle bycatch occurs in the sequence of longline deployment. This information is vital to the development of additional methods that may be tested and used to reduce sea turtle bycatch in pelagic longline fishing. In addition, a project was allowed that tests the effectiveness of large (18/0) circle hooks for catching target species. Circle hooks have been found to be less injurious to sea turtles. The circle hook testing is being piggybacked on the same research sets used for the hook timer research. As a result, there is no separate take estimate associated with the circle hook tests, and the injury to turtles taken in the hook timer experiments is reduced.

Phase I Results on Stealth (Camouflaged) and Deep Daytime Fishing Gear

Stealth and deep daytime fishing gear is described in the Permit 1303 Application. Experiments on tuna-style fishing gear were not initiated in 2002 due to a delayed start and difficulty coordinating simultaneous fishing by separate contractors. One set of stealth gear was purchased by NMFS, and the first priority was to use it to complete stealth experiments in swordfish-style fishing operations. Although the permit was issued at the end of January, 2002, contracted fishing vessels (FV's) had been told the permit might not be issued, so they waited for issuance before importing special bait (1 month delay). Other delays occurred while FV's completed ongoing fishing trips and converted to swordfish gear. The experiments began March 15, 2002. One FV made normal night-time swordfish sets (FV *Vui Vui*), another vessel made simultaneous stealth swordfish sets (FV *Captain Millions IV)* while a third vessel worked 12 hours out of phase to make deep daytime swordfish sets (FV *Sapphire).* These FV's fished within 30 nautical miles of each other for three trips totaling 33 longline sets per FV (99 sets total) and completed their contracted work at the end of May, 2002 (Table 1).

Table 1. Total fishing effort by three vessels fishing simultaneously to test stealth and deep daytime fishing methods for swordfish in comparison with normal (control) swordfish fishing.

Vessel (Treatment)	Trip #	Date	Latitude range	Sets	Hooks
Vui Vui (Control)	1	3/15-3/30	28°44-30°28	10	8133
	2	4/13-4/28	28°08-29°43	13	10025
	3	5/10-5/20	26°19-28°00	10	8400
Captain Millions IV (Stealth)	1	3/15-3/30	28°10-30°30	10	8220
	2	4/13-4/28	28°30-29°48	13	10522
	3	5/10-5/20	26°27-28°56	10	8183
Sapphire (Deep daytime)	1	3/16-3/30	28°01-30°10	10	8200
	2	4/13-4/28	28°01-29°40	13	10660
	3	5/11-5/20	26°11-27°17	10	8200

Observers on board each vessel monitored the fishing operations to ensure that each vessel followed the research protocol, and observed interactions with sea turtles and albatrosses. Conditions of Permit 1303 established by the U.S. Fish and Wildlife Service (USFWS) Biological opinion on the reseach required extensive observation and data collection on seabird interactions, and prohibited observers from conducting their usual fish data collection activities. A number of seabird mitigation measures and a seabird data analysis and reporting component were also mandated by the USFWS Biological Opinion on the research (see Appendix A on albatross interactions). Swordfish, tuna, and miscellaneous marketable species catches and revenue were monitored via vessel landings at the fish auction in Honolulu (Table 2).

The stealth fishing gear caught significantly fewer swordfish than the control gear (pairwise t-test, n=3 trips, $p<0.015$). Swordfish revenue by the stealth FV was reduced by 30% compared with the performance of the control FV. Overall revenue was reduced 39% due to reduced catches of tunas and other species (% Loss, Table 1). Past catch rates of the control and stealth fishing vessels was compared to investigate whether they perfomed equally when both FV's used normal swordfish gear. Swordfish catches per unit effort (no. fish per 1,000 hooks) were analyzed for the March-May period of 1997-2001. The stealth vessel had past performance using normal gear averaging 9.4 swordfish per 1,000 hooks (n=123 sets) and the control vessel averaged 10.4 swordfish per 1,000 hooks (n=160 sets). This difference was not statistically significant ($p>0.05$). In the experiments the stealth vessel (FV *Captain Millions IV*) averaged only 6.8 swordfish per 1,000 hooks (N=33 sets) whereas the control vessel (FV *Vui Vui*) averaged 12.2. The reduced performance by the stealth fishing vessel appears to be an effect of the modified gear and not an intrinsic difference in vessel performance.

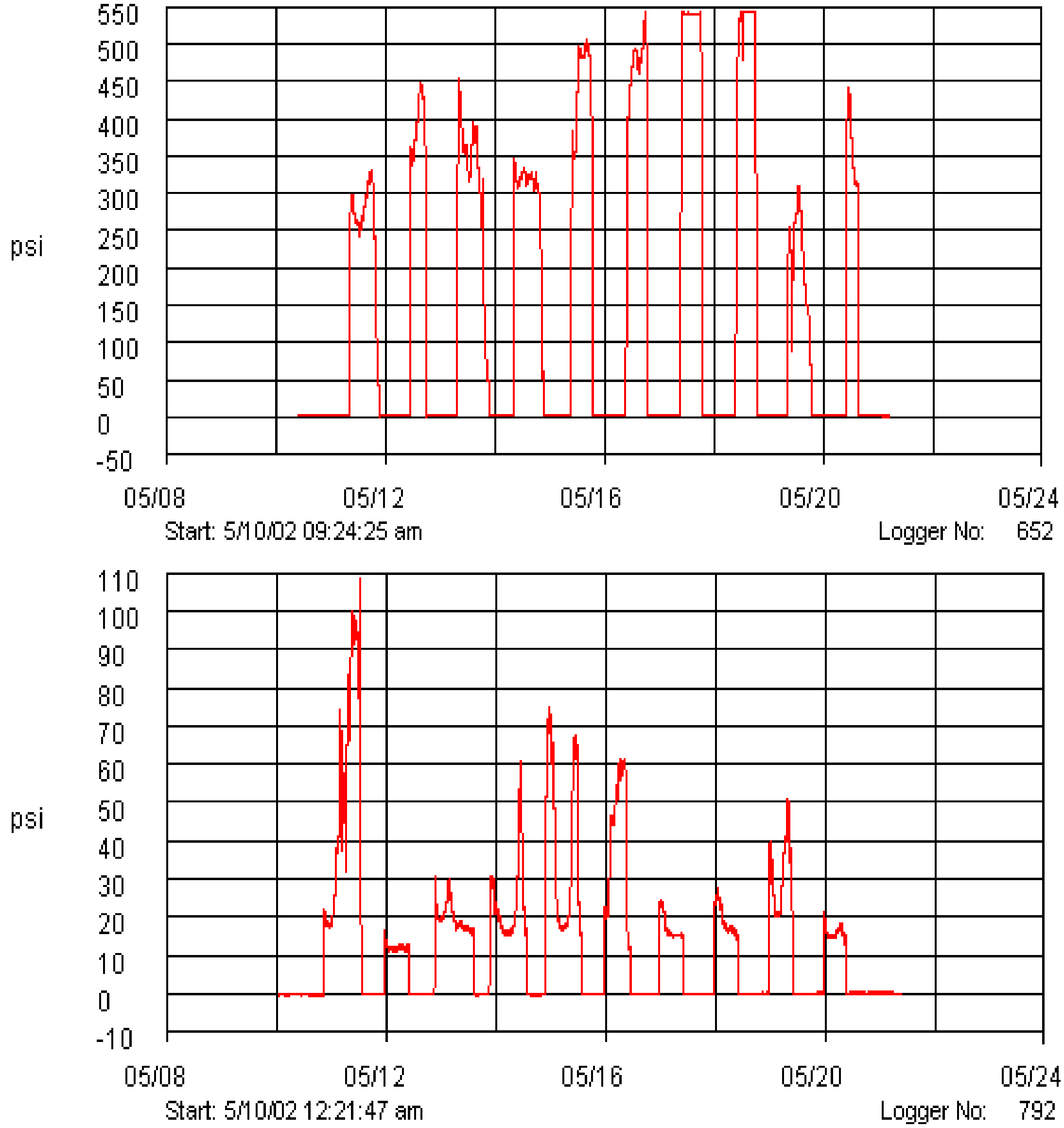
A gear modification resulting in a 30% reduction in swordfish revenue may not be economically viable in a fishery (such as the Hawaii fishery) with a profit margin under 10%. However, performance at 70% of the nominal level in a first trial indicates considerable promise for the gear modification if fishing efficiency can be increased. One possibility would be to use another type or color of light stick instead of the yellow, electronic, light-emmitting diode (LED) light sticks used in the Phase I swordfish stealth experiment. Yellow light sticks are the least preferred by fishermen. The only two colors that have been investigated with captive turtles are yellow and green. Turtles were attracted to green but not to pure yellow. We propose to continue the swordfish stealth experiment for another 30 sets using a different light stick. It would be prudent to continue testing of the swordfish stealth gear since it has not yet caught any turtles, and the gear modification shows some promise of economic viability. The turtle catch rates assumed in estimating takes for the permit (Permit 1303 Application, Table 6) predict that 2.7 loggerheads and 0.5 leatherbacks would have been caught on the 33 stealth swordfish sets if the gear had no effect in reducing turtle bycatch.

Table 2. Comparison between landings (no. fish and pounds) and revenue of control versus stealth and deep daytime fishing for swordfish, FY2002. Landings and revenue data for each vessel were collected at the fish auction in Honolulu at the completion of each fishing trip.

F/V Vui Vui (Control Swordfish Longline)										
Trip No.	**Swordfish**			**Tuna**			**Others**			**Total**
	No.	**Pounds**	**Gross $**	**No.**	**Pounds**	**Gross $**	**No.**	**Pounds**	**Gross $**	**Gross $**
1	148	17,114	48,199.15	2	255	727.70	23	479	758.00	49,684.85
2	122	13,048	26,984.00	4	689	4,011.80	119	2,223	3,370.90	34,366.70
3	56	5,105	10,879.50	19	2,432	11,939.20	49	1,683	3,622.60	26,441.30
Totals	**326**	**35,267**	**86,062.65**	**25**	**3,376**	**16,678.70**	**191**	**4,385**	**7,751.50**	**110,492.85**
F/V Captain Millon IV (Stealth Swordfish Longline)										
1	99	11,229	35,720.40	3	389	570.30	9	312	365.60	36,656.30
2	59	5,785	17,069.05	2	288	1,764.90	38	985	1,450.00	20,283.95
3	22	2,836	7,520.50	1	185	2,164.50	4	76	266.70	9,951.70
Totals	**180**	**19,850**	**60,309.95**	**6**	**862**	**4,499.70**	**51**	**1,373**	**2,082.30**	**66,891.95**
% Loss	**45%**	**44%**	**30%**	**76%**	**74%**	**73%**	**73%**	**69%**	**73%**	**39%**
F/V Sapphire (Deep Day Swordfish Longline)										
1	32	2,508	7,593.30	9	601	1,546.20	6	481	897.60	10,481.10
2	12	1,598	3,446.80	1	164	967.60	68	1,609	2,467.70	6,882.10
3	6	756	1,980.60	15	1,818	9,341.80	39	2,358	3,882.90	15,205.30
Totals	**50**	**4,862**	**13,020.70**	**25**	**2,583**	**11,855.60**	**113**	**4,448**	**7,248.20**	**32,568.50**
% Loss	**85%**	**86%**	**85%**	**0%**	**23%**	**29%**	**41%**	**-1%**	**6%**	**71%**

The deep daytime fishing trials for swordfish did not fare nearly as well the stealth fishing. The catch of swordfish was 85% less than the control gear (Table 2). The catch of tuna and other species was not as reduced as the swordfish catch. In terms of weight (but not value) the catch of other species was about the same (1% difference) as in control fishing. Overall revenue was reduced by 71% for deep daytime fishing. Pressure data from time depth recorders (TDR's) on the deep daytime and control main lines (Figure 1) indicate that much greater pressures (i.e. depths) were reached by the deep daytime gear than by the control and stealth gear.

Figure 1. Time-depth recorder (TDR) water pressure data (psi = pounds per square inch) from: (Top Panel) one TDR on FV *Sapphire*'s main line while conducting deep daytime swordfish fishing operations; and (Bottom Panel) one TDR on FV *Vui Vui's* main line while conducting control swordfish fishing operations. Note that the pressure scale (y-axis) is much narrower for the control operations which never exceeded 110 psi. Each pressure mode along the time line (x-axis) represents one day's set. Depth equivalents for these water pressures are given in Table 3.



Converting pressure to depth (Table 3) shows that the deep daytime sets averaged about 244 m, whereas control and stealth sets averaged about 19 m. The TDR's were attached to the middle of the sag in the main line between floats (typically the deepest part of the

Table 3. Depth records for the vessels involved in the concurrent trials of deep daytime and stealth swordfish fishing gear in comparison with control (normal swordfish style) fishing.

Vessel (treatment)	**Date**	**Max depth (psi)**	**Mean depth (psi)**	**Max depth (m)**	**Mean depth (m)**
FV *Sapphire*	5/11/02	321.8	208.5	220.5	142.9
(Deep daytime fishing)	5/11/02	332.8	281.1	228.1	192.6
	5/12/02	324.2	223.9	222.2	153.4
	5/12/02	448.3	398.2	307.2	272.9
	5/13/02	259.5	195.2	177.8	133.8
	5/13/02	454.7	355.3	311.6	243.5
	5/14/02	491.3	377.1	336.7	258.4
	5/14/02	346.1	317.8	237.2	217.8
	5/15/02	550.0	512.0	376.9	350.9
	5/15/02	508.0	433.7	348.1	297.2
	5/16/02	267.4	239.3	183.3	164.0
	5/16/02	543.4	478.3	372.4	327.8
	5/17/02	545.1	480.1	373.6	329.0
	5/17/02	543.4	541.3	372.4	371.0
	5/18/02	518.2	398.1	355.1	272.8
	5/18/02	543.9	532.8	372.7	365.1
	5/19/02	356.0	271.7	244.0	186.2
	5/19/02	311.2	201.6	213.3	138.2
	5/20/02	336.0	306.1	230.3	209.8
	5/20/02	441.6	356.6	302.6	244.4
Overall mean		**422.1**	**355.4**	**289.3**	**243.6**
FV *Vui Vui*	5/10/02	108.9	52.8	74.6	36.2
(Control fishing)	5/11/02	16.7	12.1	11.4	8.3
	5/12/02	30.5	19.9	20.9	13.6
	5/13/02	60.5	23.6	41.5	16.2
	5/14/02	74.6	38.7	51.1	26.5
	5/15/02	61.6	40.3	42.2	27.6
	5/16/02	24.8	17.1	17.0	11.7
	5/17/02	27.7	19.3	19.0	13.2
	5/18/02	50.7	30.3	34.7	20.8
	5/19/02	21.3	16.1	14.6	11.0
Overall mean		**47.7**	**27.0**	**32.7**	**18.5**
FV *Captain Million IV*	5/10/02	23.0	15.1	15.8	10.3
(Stealth fishing)	5/11/02	24.8	17.0	17.0	11.7
	5/12/02	29.9	19.1	20.5	13.1
	5/13/02	95.9	46.9	65.7	32.1
	5/14/02	85.0	33.9	58.3	23.2
	5/15/02	47.8	29.1	32.8	19.9
	5/16/02	36.3	17.0	24.9	11.7
	5/17/02	25.9	15.9	17.7	10.9
	5/18/02	129.2	63.7	88.5	43.7
	5/19/02	55.8	23.2	38.2	15.9
Overall mean		**55.4**	**28.1**	**37.9**	**19.3**

main line). The deepest hooks typically fish about 1 branch line length (ca. 17 m) deeper than the TDR and the rest of the hooks typically fish between the TDR depth and the combined float line and branch line depth (ca. 25 m). Hook depth also varies greatly due to bending of the main line by wind and current shear effects, and by caught fish pulling the line. Tracked swordfish swim at depths exceeding 400 m during the day. The deep daytime fishing vessel may have only been setting deep enough to occasionally encounter swordfish. Vessels like the one contracted have only recently learned to fish deep for tuna, and during the experiment it was learned that they are not capable of retrieving gear set deeper than 300 m in the rough northern waters where swordfish occur.

No sea turtles were caught in the deep daytime fishing experiment, although catch of 0.5 olive ridley and 0.2 leatherback turtles were expected based on catch rates used in estimating takes for the permit (Permit 1303 Application, Table 6). That deep daytime fishing was even marginally successful at catching a few swordfish suggests that with better depth targeting the modification might work better. The most important change needed is the capacity to handle the gear at greater set depths. It might be prudent to continue testing of the deep daytime swordfish gear since it has not yet caught any turtles, and because the most probable gear deficiency can be remedied. A contractor has been acquired that has greater familiarity with deep tuna sets. We propose to continue the swordfish stealth experiment for another 30 sets using this contractor.

Only one turtle was taken among the trio of fishing vessels conducting the control vs stealth and deep daytime fishing methods, and that was a loggerhead turtle taken by the control vessel. The permit 1303 application estimates a catch of 7 loggerheads and 1 leatherback turtles by these combined treatments (control versus stealth, and deep daytime for swordfish) and estimates one more leatherback will be taken in the tuna control versus stealth experiment. The tuna stealth experiment is ready to be initiated. We propose to continue concting swordfish stealth and deep daytime verexperiments in addition to conducting the tuna control versus stealth experiment, and this can be accomplished with no increase in estimated take.

Phase I Results from Hook Timer Experiments with Piggyback Project on Circle Hooks

Two vessels conducted typical swordfish fishing operations with branch lines equipped with hook timers. The work commenced on April 19, 2002, and a total of 95 sets were made (Table 4) amounting to only about half of the planned effort (181 sets) for the first year. In compliance with the conditions of the permit, all fishing experiments were stopped on July 31, 2002. The lower-than-planned effort was due to procurement and production delays in acquiring hook timers for the study.

A single leatherback turtle capture provided the only hook timer data collected so far in the study. One loggerhead was also captured but the hook timer malfunctioned. The hook timer for the leatherback indicated that it was hooked 35 minutes before being sighted on the line and 37 minutes before being brought alongside the vessel. The time of capture was 0738 HST, 1 hour after local sunrise at ca. latitude 29N longitude 174W. The leatherback threw the hook by itself and escaped.

Table 4. Fishing operations conducted by vessels equipped with hook timers. These vessels also tested 18/0 circel hooks on about 20% of the branch lines deployed in the study to test circle hook effectiveness in catching target species.

Vessel (Treatment)	Trip #	Date	Latitude range	Sets	Hooks
Queen Diamond	1	4/19-5/8	26°13-29°41	15	12375
	2	5/18-5/30	26°00-27°50	13	10025
	3	6/12-6/30	26°15-29°25	15	12368
	4	7/15-7/31	30°30-35°30	15	12041
Vui Vui II	1	5/22-3/30	26°00-27°32	12	9987
	2	6/18-7/2	27°41-29°52	13	10652
	3	7/16-7/31	29°24-35°05	13	10623

Approximately 20% of branch lines in the hook timer study were equipped with 18/0 mustad circle hooks for comparison with the catch of target species by traditional J hooks. Neither hook type was offset[1]. Effectiveness of circle hooks at catching target species was evaluated based on the ratio of swordfish and tuna caught on circle hooks versus those caught on traditional J hooks. The numbers of fish caught were adjusted based on the ratio of circle hooks to J hooks deployed on each fishing trip (Table 5) to produce a percentage (effectiveness) that represents the fraction caught by circle hooks in relation to the number caught on an equivalent number of J hooks. Over all seven trips by the two vessels circle hooks were only 40% as effective as J hooks at catching swordfish, but were 94% as effective as J hooks at catching tuna, based on the numbers of fish on each hook type recorded by the observers (Table 5). Effectiveness was also judged on the basis of the weight and value of the target species catch as monitored at auction. Almost all of the fish caught were landed and sold at auction. The average weight and price fish caught on circle and J hooks from each trip was used to convert the number of observed catches into weight and value of catches from each trip (Table 5). Based on weight, circle hooks were only 37% as effective as J hooks at catching swordfish, but were 89% as effective as J hooks at catching tuna. And based on value, circle hooks were only 33% as effective as J hooks at catching swordfish, and 82% as effective as J hooks at catching tuna (Table 5). All of the circle hook percentages for swordfish (based on number, weight, and value) were significantly lower than 100% ($n = 7$ trips, $p<0.01$). Differences between effectiveness by number, weight, and value of fish were due to a smaller average size and price for fish caught on circle hooks, but only the difference in swordfish size was statistically significant ($n=7$, $p<0.05$)

[1] Offset hooks have the point bent to the side, out of alignment with the shank. Offset hooks are preferred by some fishermen who believe that the offset point is more likely to catch and hold swordfish.

Table 5. Numbers of "J" and 18/0 circle hooks deployed in the hook timer experiments showing the relative effectiveness of circle hooks at catching the target species.

				Swordfish									Tunas								
			J/C Hook Ratio	"J" Hooks Catch			"C" Hooks Catch			"C" Effectiveness			"J" Hooks Catch			"C" Hooks Catch			"C" Effectiveness		
Trip No.	Sets	Hooks		No.	Ave. Wt. (Lbs)	$ Price (per Lb)	No.	Ave. Wt. (Lbs)	$ Price (per Lb)	No.	Pounds	Value	No.	Ave. Wt. (Lbs)	$ Price (per Lb)	No.	Ave. Wt. (Lbs)	$ Price (per Lb)	No.	Pounds	Value
F/V Queen Diamond																					
1	15	12,375	4.42	136	98	$2.02	18	100	$1.99	58%	60%	59%	12	70	$2.26	8	78	$2.38	294%	326%	344%
2	12	10,025	3.90	157	99	$2.10	24	109	$2.16	60%	66%	68%	10	115	$3.97	1	80	$1.00	39%	27%	7%
3	15	12,368	4.00	187	99	$2.95	21	80	$2.16	45%	36%	27%	21	120	$3.45	5	129	$3.53	95%	102%	104%
4	15	12,020	4.04	203	102	$2.48	10	88	$2.50	20%	17%	17%	21	153	$3.99	2	175	$2.47	38%	44%	27%
Total	**57**	46,788	**4.10**	**683**	**100**	**$2.44**	**73**	**96**	**$2.16**	**44%**	**42%**	**37%**	**64**	**119**	**$3.60**	**16**	**106**	**$2.54**	**103%**	**91%**	**64%**
F/V Vui Vui II																					
1	12	9,987	4.04	145	95	$2.20	11	61	$1.90	31%	20%	17%	6	102	$5.85	1	145	$6.90	67%	96%	113%
2	13	10,652	4.72	180	102	$2.96	11	84	$2.76	29%	24%	22%	24	118	$1.90	3	109	$2.74	59%	55%	79%
3	13	10,623	6.01	137	89	$1.84	11	81	$1.90	48%	44%	45%	13	128	$2.40	3	135	$3.69	139%	146%	225%
Total	**38**	31,262	**4.83**	**462**	**96**	**$2.41**	**33**	**76**	**$2.25**	**35%**	**27%**	**26%**	**43**	**118**	**$2.65**	**7**	**123**	**$3.74**	**79%**	**82%**	**116%**
Both Vessels Combined																					
Total	**95**	78,050	**4.37**	**1,145**	**98**	**$2.43**	**106**	**90**	**$2.18**	**40%**	**37%**	**33%**	**107**	**119**	**$3.26**	**23**	**112**	**$3.02**	**94%**	**89%**	**82%**

Table 6. Take of endangered species under Permit 1303 from January-July, 2002.

# of Turtles	Life Stage	Species/DPS Population/DSU	Take Activity							Take Details			
			Vessel (and Treatment)	Date & Location	Hook Type	Hook No.	Float No.	Light Color	Light Pos.	Details Location	Hook Removed	Condition	Disposition
1	sub-adult	loggerhead turtle	Vui Vui (Control fishing for Swordfish)	3/24/02 30^{o} 06’N 162^{o} 13’W	J	2	20	Yellow	1	Injested (visible in mouth)	No (line broke)	Injured (very active)	Released (assumed 0.27 post release* mortality)
1	sub-adult	loggerhead turtle	Queen Diamond (Fishing with hook timers & 20% C hooks)	4/30/02 29^{o} 37’N 173^{o} 21’W	J	3	52	Green	1	Injested (4 inches into turtle)	Yes	Injured (very active)	Released (assumed 0.42 post release* mortality)
1	sub-adult	leatherback turtle	Queen Diamond (Fishing with hook timers & 20% C hooks)	6/26/02 28^{o} 37’N 173^{o} 55’W	C	3	29	Green	1	Mouth (not) injested)	Yes (fell out by itself)	Injured (very active)	Escaped (assumed 0.27 post release* mortality)
1	(?) 5-6 m in length	sperm whale	Vui Vui (Control fishing for Swordfish)	4/21/02 28^{o} 32’N 164^{o}22’W	Not	NA	85	NA	NA	Main line around body, no branch lines seen	Main line cut (whale freed)	Injured (swam away)	Escaped (with no main line attached

* Delayed post-hooking mortality was estimated using NMFS official procedure where 0.27 lightly hooked + 0.42 deeply hooked turtles were assumed to suffer delayed mortality (Fox et al., Feb 15, 2001 Decision Memorandum).

The number of sea turtles estimated to be taken by the hook timer experiments per year was 3 leatherbacks, 15 loggerheads, 2 olive ridleys, and 1 green. The hook timer experiments took only 1 leatherback and 1 loggerhead turtle (Table 6) and should proceed as planned in the application for Permit 1303. The effort shortfall during the first year should be rectified by increasing fishing effort in year 2 to achieve the required total number of loggerhead turtle take observations (30 loggerheads) as originally planned for the end of the second year.

Summary of Phase I Takes of Endangered Species

Three sea turtles were taken during the bycatch reduction fishing experiments allowed under Permit 1303, and all were released alive. One loggerhead turtle was hooked during the control fishing conducted as part of the deep daytime and stealth experiments, and one loggerhead and one leatherback turtle were hooked in the hook timer experiments (Table 6). In addition there was a single interaction with a marine mammal: a sperm whale that was wrapped in main line midway between its head and dorsal fin. The swimming whale was approached by the FV but the whale maintained a distance. So the main line was cut and the whale swam away. Afterwards, the other free end of the main line was recovered, indicating that the whale was no longer entangled by it.

Differences Between Atlantic and Pacific Experiments with Moved Branch Lines

Fishing experiments designed to evaluate longline fishing methods to reduce sea turtle bycatch in the Atlantic Ocean also tested moving branch lines that are nearest to float lines to positions further away from the float lines, as proposed in the Pacific experiments. However, because of differences in longline fishing gear configurations used in the two oceans, in the Atlantic experiments the branch lines were moved only 20 fathoms away from the float lines. The Atlantic experiments also tested the use of blue-dyed bait to reduce pelagic longline bycatch of sea turtles.

The gear modifications tested in the Atlantic experiments apparently failed to reduce sea turtle bycatch (Watson 2002). Examination of schematics portraying the arrangement and dimensions of longline gear in the Pacific and Atlantic experiments helps to explain why moving branch lines away from float lines to reduce sea turtle bycatch has not yet been adequately tested (Figure 2). The design for the Pacific modification removes the branch line adjacent to the float (Figure 1a) and replaces it among the other deep hooks (Figure 1b) below the hypothesized turtle layer and out of the apparent 40 fathom attraction zone of the float. Tracking of sea turtles indicates they spend a majority of time at depths less than 40 m (Polovina et al., 2002). Atlantic fishermen fish a different habitat and use shallower gear with fewer hooks between float lines (Figure 1c). The Atlantic gear modification moved the float line only 20 fathoms away from the adjacent hook by moving it 20 fathoms closer to the preceding hook (Figure 1d). Thus, the average distance from the float line to the nearest two branch lines remained unchanged in the Atlantic modification. In the Atlantic experiment, more hooks ended up in the hypothesized 40 fathom attraction zone, and more hooks ended up in the shallow, 40 m depth zone than in the control fishing mode.

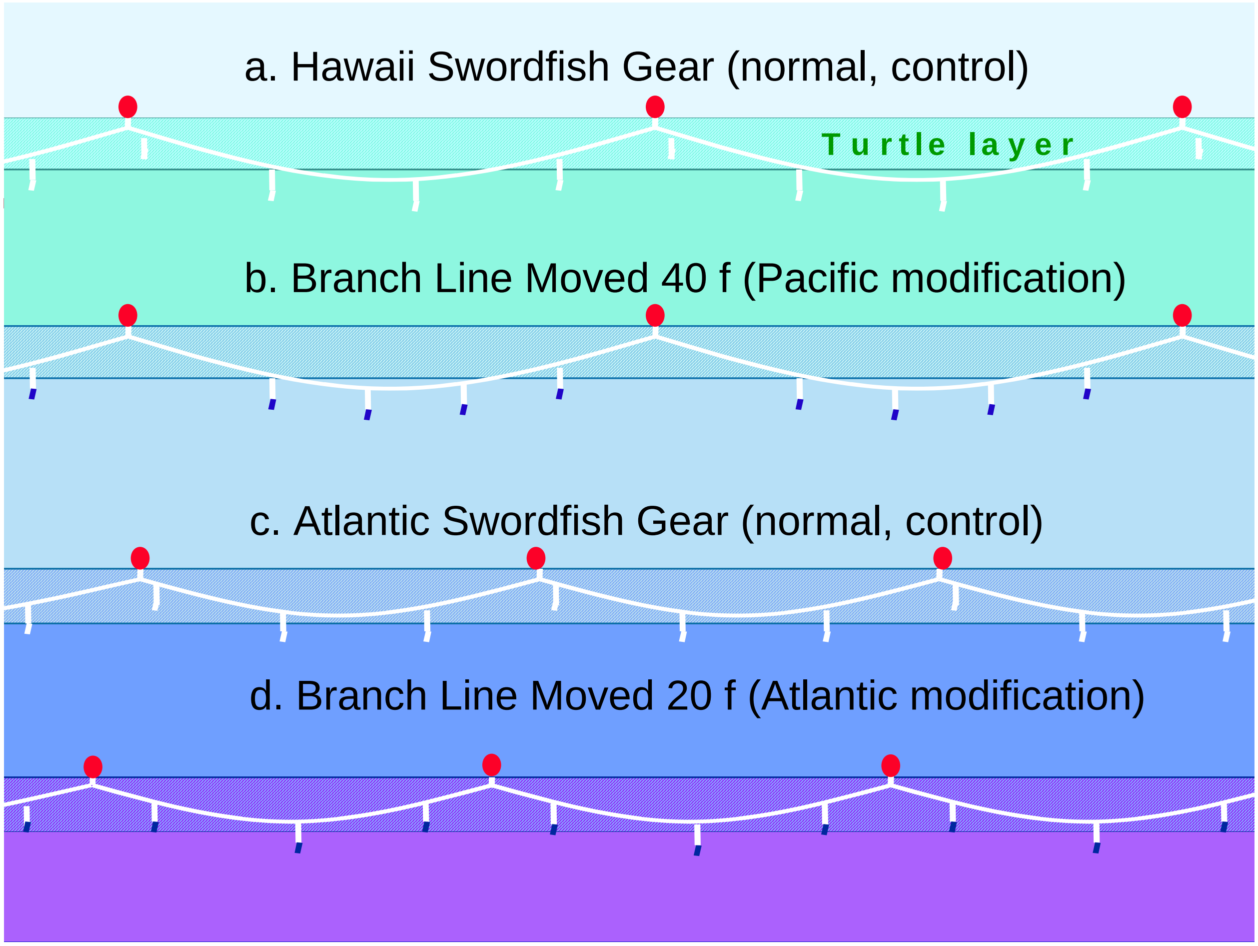


Figure 1. Comparison between Pacific and Atlantic experiments with moved branch lines and blue dyed bait. The branch line adjacent to the float in normal Hawaii swordfish gear (a) is removed and replaced among the other deep hooks (b) below the hypothesized turtle layer. Atlantic fishermen use fewer hooks between float lines (c). The Atlantic gear modification moved the float line only 20 f away from the adjacent hook by moving it back 20 f closer to the preceding hook (d) and most hooks are set within the shallow 'turtle layer'.

Why the Proposed Experiments Must be Done in the Pacific

Separate Pacific experiments are required because pelagic longline fishing strategies and tactics differ between the Atlantic and North Pacific Oceans. These differences in fishing strategies and tactics are related to fundamental differences in oceanic structure and ecology between the two oceans. The Atlantic fishery operates primarily at edges of the Gulf Stream in an ecosystem influenced by relatively near shore environments and comparatively shallow habitats, whereas the North Pacific operates in two mid-ocean ecosystems that are markedly different from the Atlantic.

In the Atlantic Ocean, targeting submarine features, front edges, and warm-core ring edges that occupy a small geographic area makes it important for the Atlantic fishery to concentrate branch lines close together. In the coastal "northeast distant" (NED) and mid-Atlantic bight (MAB) areas where most turtles are caught in the U.S. Atlantic fishery (Hoey

2000) the target species (swordfish) are often found in association with the shelf-break thermal front (Podesta, et al. 1991). In these habitats swordfish commonly spend the day on shallower banks, feeding on bottomfish. (Scott and Tibbo 1968. Submarine canyons on the edge of the shelf are good regions for swordfish catch rates, and fishermen often target these specific locations. (Carey and Robison 1981). In the NED most turtle captures are associated with thermal fronts along the Grand Banks, especially in late summer and fall when warm-core Gulf Stream eddies bring temperatures higher than 20o C into the area (Hoey 2000). In contrast to the Atlantic fishery, the Pacific fishery is not oriented to bathymetric features. In the Pacific Ocean there are virtually no banks or shelves to provide target habitats for swordfish fishing by the Hawaii-based fleet, which operates primarily over bottom depths of >4000 m (Bigelow et al. 1999).

The swordfish fishery responsible for most of the longline turtle catch by Hawaii-based longliners, occurs primarily at the southern edge of the North Pacific Transition Zone, (Bigelow et al. 1999, Roden G.I. 1991). The southern edge of the zone, called the subtropical frontal zone (STFZ) is characterized by salinity fronts throughout the year and by temperature gradients of about 3 C/100 km from late fall through early summer. The STFZ temperature gradients and frontal dynamics described by Roden (1991) are more diffuse and less dynamic than those in the Atlantic fishery (Podesta et al. 1993). Therefore Pacific fishermen have increased the distance between branch lines to about 40 fathoms in order to explore a wider area per unit of fishing effort.

In the NED fishing grounds where the Atlantic experiments are being conducted, water temperatures are often close to the cold extreme for loggerhead sea turtle habitat. Results of the Atlantic experiments indicate significant increases in turtle bycatch in portions of longline sets hauled in the afternoon (Watson 2002). This may reflect a temperature-based increase in foraging activity due to afternoon warming at the sea surface. Loggerhead turtles are observed basking at the surface in the NED fishery. In the Pacific subtropical convergence zone fishery turtles typically experience warmer temperatures than in the Atlantic NED fishery. Observer data analyses indicate only a weak relationship between time of haulback and loggerhead turtle bycatch. The primary mitigation method now being tested in the Atlantic fishery involves shortened soak time to reduce the amount of gear hauled in the afternoon. Evidence suggests this measure would not be very effective in the Pacific fishery because of ecosystem differences.

The foraging ecology and behavior of loggerhead and leatherback turtles caught in the Pacific and Atlantic fisheries may be different. The failure of the Atlantic fishery testing of blue dyed bait may be related to behavioral dietary differences between oceans, or to ocean color differences between the deep blue oligotrophic central Pacific and the greener and more productive waters of the NED fishery. We recommend continuing to test the efficacy of blue-dyed bait to reduce pelagic longline bycatch of sea turtles in the central North Pacific.Turtle feeding habits may exhibit unknown differences in the two ecosystems and blue dyed bait may appear different to turtles because of the difference in productivity and ocean color in the two fisheries.

Swordfish fisheries in the north Atlantic occur in waters of higher productivity compared to north Pacific swordfish fisheries.The Atlantic and Pacific swordfish fisheries are concentrated at the junctures of two provinces in each ocean defined by (Longhurst et al. 1995, see illustration p. 1252) based on primary productivity regimes. In the Pacific the fishery is concentrated at the juncture between the North Pacific Subtropical Gyre (NPST) and 2) the North Pacific Tropical Gyre (NPTG). In the Atlantic, the fishery is concentrated at the juncture between the Northwest Atlantic Continental Shelf (NWCS) and the Gulf Stream (GFST). Productivity is high in the NWCS, moderate in the GFST and NPST and low in the NPTG. Comparing relative productivity (grams of carbon per meter squared per day) of these provinces indicates that the Atlantic NWCS is about 5 times that of the Pacific NPTG, and the Atlantic GFST is about 2 times that of the Pacific NPTG (Longhurst et al. 1995). Specifically, high production and turbidity in the NWCS results from oceanographic and topographic factors absent from the Pacific fishery ecosystem. These factors include but are not limited to: 1) coastal upwelling and algal blooms along the southwest coast of Nova Scotia, 2) a consistent shelf break front that results from instability between shelf and slope water masses and 3) a shallow continental shelf which retains nutrients in the photic zone thereby maintaining relatively high primary production with a concomitant decrease in water clarity. In contrast, the less productive provinces are increasingly more oceanic and occur in the westerly wind (GSFT and NPST) and trade winds domains (NPTG).

In summary, the water where the U.S. Pacifc fishery takes place is more blue, indicative of less productive oceanic waters, than the waters where the U.S. Atlantic fishery takes place, and therefore blue dye may have a better chance of obscuring the bait from turtles view in the Pacific. Furthermore, because turtles are less densely congregated in the Pacific fishery, any mitigation measure that makes bait less visible may have more impact than in the Atlantic fishery, where the dense distribution of turtles may make them much more likely to encounter the gear due to chance or olfactory cues.

Unlike the North Atlantic, the North Pacific ecosystem also includes endangered and protected albatrosses. Fishing regulations require the use of blue dyed bait to prevent longline interactions with albatrosses by the U.S. fishery in the subtropical convergence zone. This mitigation measure is also being promoted for foreign longline fisheries in the region. Information on the effect of blue dyed bait on sea turtle bycatch is more important for the Pacific than the Atlantic.

A highly significant increase in leatherback sea turtle bycatch on branch lines attached 0 fathoms (control) and 20 fathoms (branch line moved) from float lines was observed in the Atlantic NED experiments (Watson 2002). This finding strongly supports the need to conduct the 40 fathom moved branch line experiment designed for the deeper Pacific fishery. Scientists responsible for designing and analyzing both the Atlantic and Pacific turtle longline bycatch experiments met in Honolulu in September to review these results and make recommendations for future work. A report of this meeting is in preparation. The available information from the Atlantic experiments, from analyses of Pacific observer data, from experiments with captive sea turtles, and from our understanding of ecosystem differences between the Atlantic and Pacific fisheries strongly support the completion of all the experiments proposed under the permit for research in the Pacific.

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Appendix A: USFWS Permit Conditions to Monitor and Report on Interactions with Protected Albatrosses

No short-tailed albatross were taken in the study during 2002. One albatross caught was identified by the observer in the field as a short-tailed albatross. This bird was returned to Honolulu and positively identified as a black-footed albatross (BFA). Therefore the number of black-footed albatross in the original data was increased by +1, and the original datum on the short-tailed albatross was ignored. There were numerous interactions with black-footed and Laysan albatross (LA) during the study. No other species of birds were taken. The results have been summarized[2] and an analysis of variance (ANOVA) was conducted on the results from the three vessels that conducted simultaneous operations using different deterrents:1) night setting (control fishing for swordfish); 2) night setting and blue dyed bait (stealth fishing for swordfish); and 3) neither night setting nor blue dyed bait (deep daytime fishing for swordfish). Although not designed to test seabird mitigation strategies the research did provide interesting results regarding these deterrents.

All other requisite deterrents from the "reasonable and prudent alternatives" (RPAs) for swordfish-style fishing by the USFWS Biological Opinion on the effects of the experiments on short-tailed albatross were utilized in all of the experimental sets conducted under permit 1303. Albatross interactions during the hook timer experiments were summarized but not analyzed in relation to other treatments. Data from the trio of vessels using different sets of deterrents provided the best available data for such a comparison. Data from the hook timer work is best used as additional descriptive information for the general style of swordfish fishing that would have been allowed under the USFWS Biological Opinion's RPAs for the swordfish fishery (had that fishery not been closed).

Seabird Interaction Results for the Trio of FVs Involved in Simultaneous Fishing with Different Gear Modifications.

Observers were required to watch and record all bird interactions whenever there was enough light to see. Under the USFWS Biological Opinion on this research a take is defined as any contact with fishing gear. Attempts were defined as birds making directed approaches to within 2 meters of the gear and are not considered to be takes (Appendix Tables 1-3).

Appendix Table 1. Interactions with night setting during treatment 1 (normal fishing for swordfish, FV *Vui Vui*)

Species	Trip	Total hooks	Sighted	Attempts to strike	Contact hook	Hooked	Entangled	Injured	Dead
BFA	1	8133	959	170	57	0	0	0	0
	2	10025	1130	386	107	4	0	3	1
	3	8400	467	106	23	0	0	0	0
	Total	**26558**	**2556**	**662**	**187**	**4**	**0**	**3**	**1**
LA	1	8133	203	11	5	0	0	0	0
	2	10025	193	165	56	1	1	2	0
	3	8400	43	23	5	0	0	0	0
	Total	**26558**	**439**	**199**	**66**	**1**	**1**	**2**	**0**

[2] Data on albatross interactions on a set by set basis is available upon request

Appendix Table 2. Interactions with night setting and blue dyed squid (2 combined deterrents) during treatment 2 (stealth fishing for swordfish, FV *Captain Millions IV*).

Species	Trip	Total hooks	Sighted	Attempts to strike	Contact hook	Hooked	Entangled	Injured	Dead
BFA	1	8220	1475	41	2	0	0	0	0
	2	10522	737	71	4	0	0	0	0
	3	8183	284	9	0	0	0	0	0
	Total	**26925**	**2496**	**121**	**6**	**0**	**0**	**0**	**0**
LA	1	8220	292	9	1	0	0	0	0
	2	10522	185	56	6	0	0	0	0
	3	8183	42	0	0	0	0	0	0
	Total	**26925**	**519**	**65**	**7**	**0**	**0**	**0**	**0**

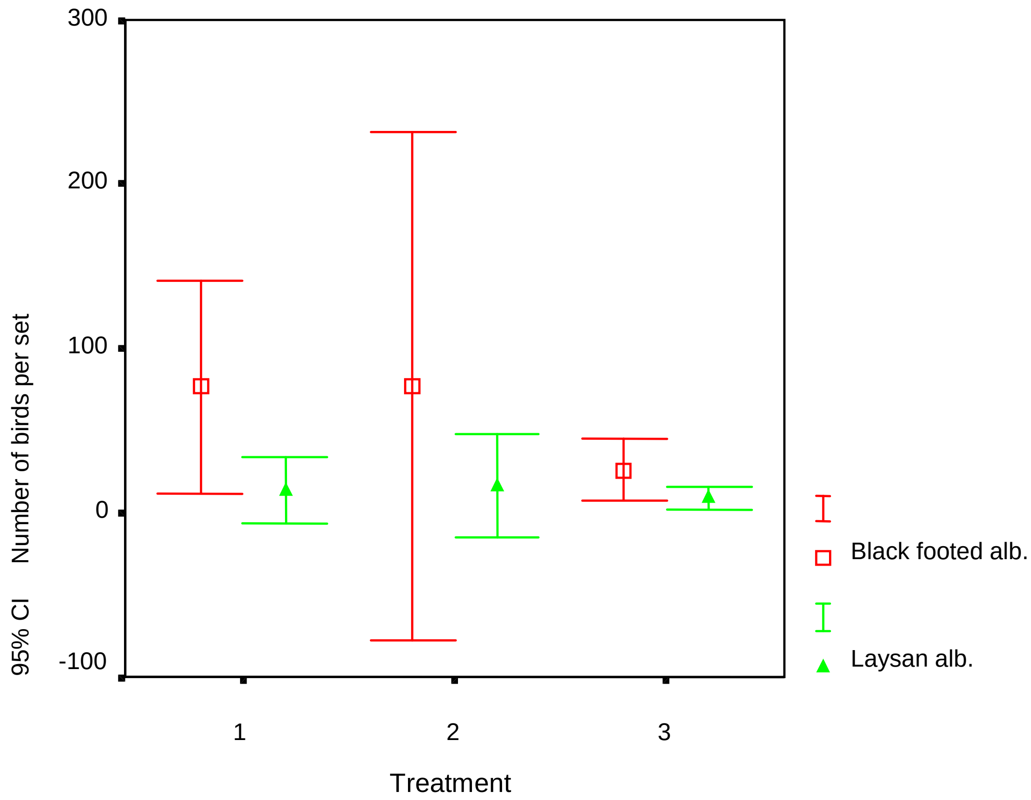
Appendix Table 3. Interactions with day setting and with normal squid bait during treatment 3 (deep daytime fishing for swordfish, FV *Sapphire*).

Species	Trip	Total hooks	Sighted	Attempts to strike	Contact hook	Hooked	Entangled	Injured	Dead
BFA	1	8200	336	601	367	23	1	0	24
	2	10660	331	651	497	50	0	0	50
	3	8200	186	283	249	26	0	0	26
	Total	**27060**	**853**	**1535**	**1113**	**99**	**1**	**0**	**100**
LA	1	8200	118	146	95	1	0	0	1
	2	10660	113	291	211	5	0	0	5
	3	8200	57	59	48	2	0	0	2
	Total	**27060**	**288**	**496**	**354**	**8**	**0**	**0**	**8**

A total of 1306 balck-footed albatross (BFA) and 427 Laysan albatross (LA) contacted the gear. Actuall catches totalled 104 BFA and 10 LA hooked or entangled in the gear. A total of 3 injured BFA and 2 injured LA were released alive. The other birds were dead when retreived (Appnedix Tables 1-3). No significant difference was found in the numbers of birds sighted between treatments for either BFA or LA (Appendix Table 4, Appendix Figure 1). This result was expected, since the three boats operated as a trio fishing within 30 miles of each other every day.

Appendix Table 4. Summary of the number of birds sighted during all observations throughout each trip, expressed as the ratio of birds sighted to the number of sets conducted.

Treatment		Trip		Mean number of Black footed albatross per set	Mean number of Laysan albatross per set
Night setting (Turtle control)	1	1		95.90	20.30
		2		86.92	14.85
		3		46.70	4.30
			Mean	76.5077	13.1487
Night setting and blue bait (Stealth)	2	1		147.50	29.20
		2		56.69	14.23
		3		28.40	4.20
			Mean	77.5308	15.8769
Day setting and normal bait (Deep daytime)	3	1		33.60	11.80
		2		25.46	8.69
		3		18.60	5.70
			Mean	25.8872	8.7308

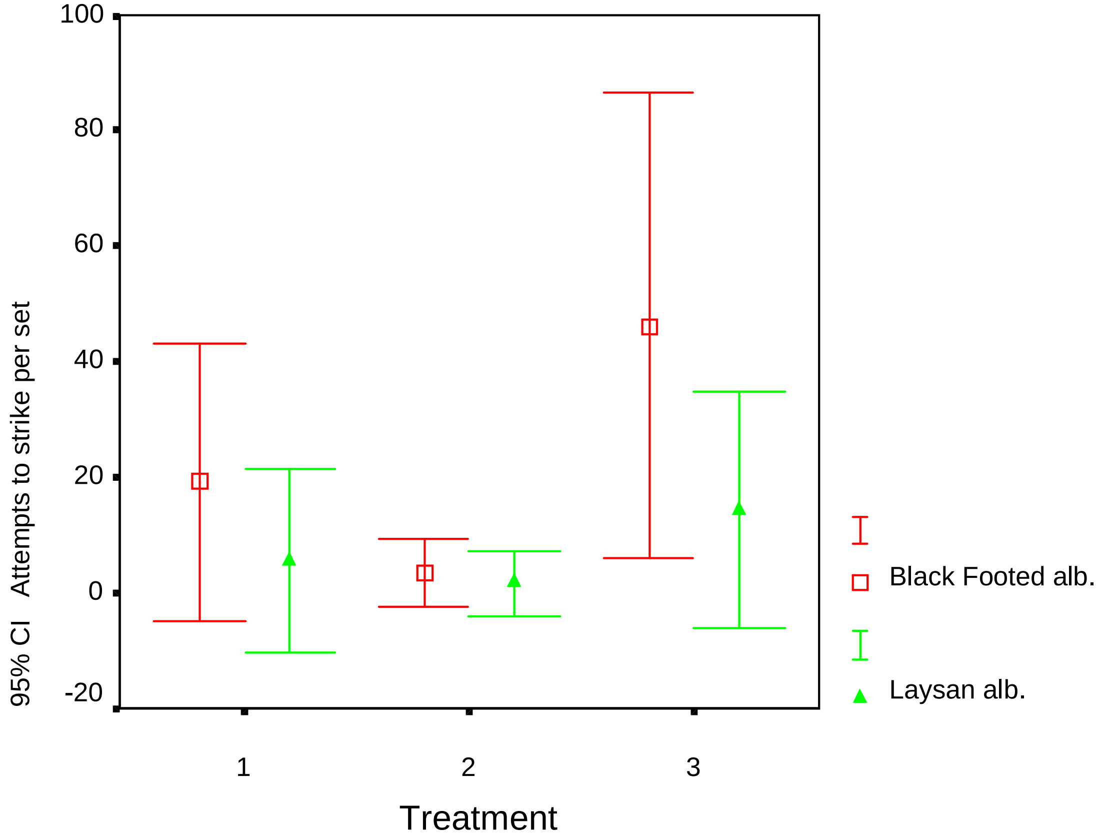


Appendix Figure 1: Mean number of birds sighted per set (confidence interval of mean): Control (normal) = 1; "Stealth" (camouflaged) = 2; Deep daytime = 3.

Attempts by BFA to strike at the gear were significantly different between the three treatments (n=3 replicates per treatment, p=0.09). Least significant differences indicated that BFA attempts were significantly lower during night setting (p=0.003, 62% reduced) and with night setting and blue dyed squid combined (p=0.024, 92% reduced) when compared to daytime setting (Appendix Table 5 and Appendix Figure 2) . Although not significant, attemps by LA were reduced by 62% (night setting) and 88% (night setting and blue squid).

Appendix Table 5. Summary of the number of birds attempting to strike the gear during all observations throughout each trip, expressed as the ratio of attempts to the number of sets conducted.

Treatment		Trip		Mean number of BFA attempts to strike per set	Mean number of LA attempts to strike per set
Night setting (Turtle) control)	1	1		17.00	1.10
		2		29.69	12.69
		3		10.60	2.30
			Mean	19.09	5.36
Night setting and blue bait (Stealth)	2	1		4.10	0.90
		2		5.46	4.31
		3		0.90	0.00
			Mean	3.48	1.73
Day setting and normal bait (Deep (daytime)	3	1		60.10	14.60
		2		50.08	22.38
		3		28.30	5.90
			Mean	46.15	14.29



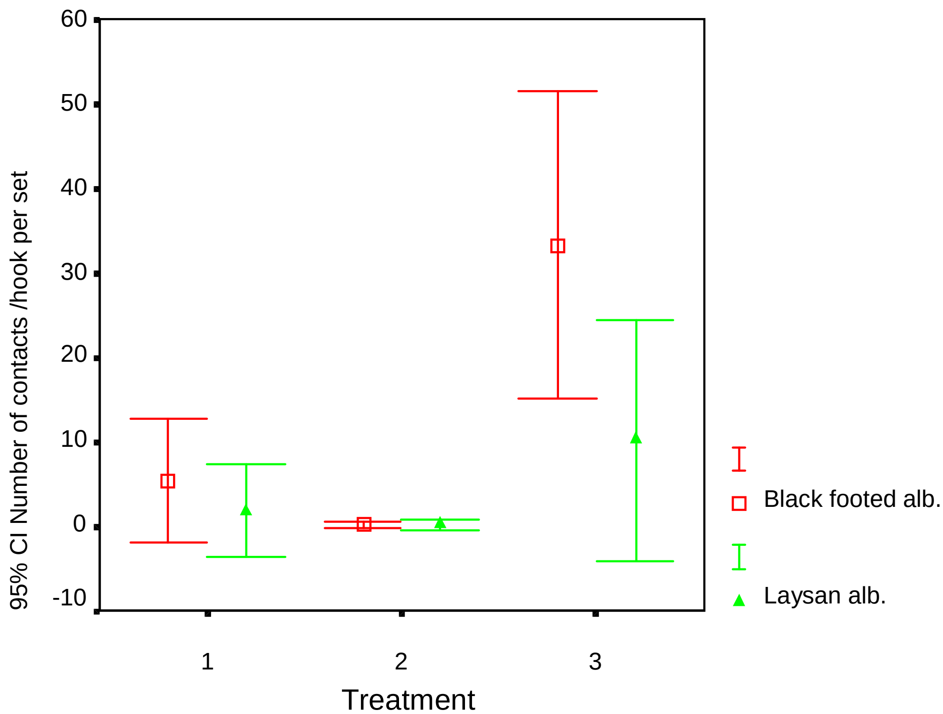
Appendix Figure 2: Number of attempts to strike per set (confidence interval of mean) : Control (normal) = 1; "Stealth" (camouflaged) = 2; Deep daytime = 3

Contacts with hooks were significantly different between the three treatments for both albatrosses (n=3 replicates per treatment, p<0.0005 for BFA, p=0.028 for LA). Least significant differences indicated that BFA contacts were significantly lower during night setting (p<0.0005, 84% reduced) and with night setting and blue dyed squid combined (p<=0.0005, 99% reduced) when compared to daytime setting (Appendix Table 6 and Appendix Figure 3). Contacts by LA were also significantly reduced by 83% (p=0.027) for night setting, and by 98% (p=0.014) for night setting and blue squid. An earlier study (Boggs 2001) found that blue dyed squid reduced contacts with baits by about 90% for both species of albatross. The results of the two studies suggest that night setting and blue dyed squid deterrents may have additive effects in reducing take. For example, 84% reduction by night setting would result in16% of the take that would have occured without this deterrent. When reduced by an additional 90% with the use of blue dyed squid (Boggs 2001) the expected result would be a 98% reduction, exactly as found in the current study.

The reduction in seabird catches with night setting and with night setting in combination with blue dyed bait was parallel to the results for albatross contacts with bait. Only 4 BFA and 2 LA were caught during night setting, a reduction of 96% (BFA) and 75% LA). These results strongly validate the inclusion of both deterrents in the USFWS Biological Opinion's RPA's for the swordfish fishery.

Appendix Table 6. Summary of the number of birds contacting hooks during all observations throughout each trip, expressed as the ratio of attempts to the number of sets conducted.

Treatment		Trip		Mean number of BFA contacting hooks per set	Mean number of LA contacting hooks per set
Night setting (Turtle) control)	1	1		5.70	0.50
		2		8.23	4.31
		3		2.30	0.50
			Mean	5.4103	1.7692
Night setting and blue bait (Stealth)	2	1		0.20	0.10
		2		0.31	0.46
		3		0.00	0.00
			Mean	0.1692	0.1872
Day setting and normal bait (Deep (daytime)	3	1		36.70	9.50
		2		38.23	16.23
		3		24.90	4.80
			Mean	33.2769	10.1769



Appendix Figure 1: Number of contact with hooks per set (confidence interval of mean): Control (normal) = 1; "Stealth" (camouflaged) = 2; Deep daytime = 3.

Seabird Interaction Results for the other FVs Involved in the Hook Timer Study and Total Seabird Takes in 2002.

A total of 205 BFA and 367 LA contacted the gear in the hook timer experiments (Appendix Table 7) bringing the total for all experiments conducted in 2002 to 1511 BFA and 794 LA. Actuall catches totalled 28 BFA and 21 LA hooked or entangled in the hook timer experiments, bringing the total for all experiments in FY 2002 to 132 BFA and 31 LA. Injured birds released alive in the hook timer experiments totalled 9 injured BFA and 15 injured LA, 12 BFA and 17 LA released injured. In all experiments conducted in FY 2002, 111 BFA and 14 LA were dead when retrieved (Appendix Table 7).

Appendix Table 7. Interactions with FVs fishing with hook timers (FVs *Queen Diamond* and *Vui VuiII*) and summary of interactions over all experiments in 2002.

Spp.	Vessel and trip	Total hooks	Sighted	Attempts to strike	Contact hook	Hooked	Entangled	Injured	Dead
BFA	Queen D.								
	1	12375	1414	102	60	12	9	3	9
	2	10025	441	32	21	2	0	1	1
	3	12368	1181	50	9	0	0	0	0
	4	12041	196	23	0	0	0	0	0
	Vui Vui II								
	1	9977	901	484	110	2	1	3	0
	2	9836	894	100	5	2	0	2	0
	3	10613	498	0	0	0	0	0	0
BFA	**Total**	**77235**	**5525**	**791**	**205**	**18**	**10**	**9**	**10**
LA	Queen D.								
	1	12375	1907	280	198	7	2	7	2
	2	10025	253	26	14	2	0	1	1
	3	12368	1322	40	6	2	0	0	2
	4	12041	163	4	1	0	0	0	0
	Vui Vui II								
	1	9977	889	619	146	5	0	5	0
	2	9836	1395	119	2	2	1	2	1
	3	10613	1	0	0	0	0	0	0
LA	**Total**	**77235**	**5930**	**1088**	**367**	**18**	**3**	**15**	**6**
	All Vessels								
BFA	**2002 Total**	**157778**	**11430**	**3109**	**1511**	**121**	**11**	**12**	**111**
LA	**2002 Total**	**157778**	**7175**	**1848**	**794**	**27**	**4**	**17**	**14**