Project 8 Final Report

Evaluation of Variable Strength Hooks to Reduce Serious Injury Pilot Whale Interactions with the North Carolina-Based Pelagic Longline Fishery

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Abstract

The number of interactions between shortfin and longfin pilot whales *Globicephala melaena* and *G. macrorhynchus* (hereafter collectively "pilot whales") with commercial pelagic longline fishing gear has apparently increased in recent years, especially around the southern portion of the Mid-Atlantic Bight (MAB) statistical area off North Carolina's Outer Banks that was designated as the "Special Research Area" in 2006 by the Atlantic Pelagic Longline Take Reduction Team. This southern MAB area is also the primary fishing grounds for a local pelagic longline fleet operating throughout the year out of Wanchese, North Carolina, as well as seasonal fishing effort from the rest of the U.S. Atlantic fleet. If the current rates of pilot whale interactions continue, the entire U.S. Atlantic pelagic longline fishery may face more restrictive regulatory measures in these traditionally productive fishing grounds, resulting in serious economic cost to the industry. Preliminary work in 2007 and 2008 (Bayse and Kerstetter 2010) suggested that fishing hooks designed to straighten when hooked on a pilot whale might be a feasible means for reducing fisheries interactions. During 2010 and 2011, eight trips were taken aboard cooperating pelagic longline fishing vessels in the North Carolina-South Carolina offshore areas of high historical rates of interactions with pilot whales, testing two weaker (thinner wire gauge) versions of the industry-standard size 16/0 and 18/0 circle hooks. No significant reduction of target catch, target catch weight, or bycatch was observed during these trials. However, the recent imposition of a weak hook regulation in the Gulf of Mexico by the NOAA Fisheries Service for bluefin tuna bycatch reduction has resulted in an unwillingness of the local fleet to continue even limited field trials, based on the premise that similar regulations would be imposed upon the North Carolina-South Carolina offshore yellowfin tuna/swordfish pelagic longline fishery.

Introduction

The U.S. pelagic longline fishery in the western Atlantic Ocean has historically had a high frequency of bycatch interactions with istiophorid billfish, marine turtles, sharks, and some marine mammals (Yeung 1999; Baum et al. 2003; Cramer 2003; ICCAT 2006). Several approaches have been used to reduce the frequency of bycatch and bycatch mortality in this fishery, including time/area closures, a mandatory switch in terminal gear from J-style hooks to circle hooks, minimum gangion line lengths relative to buoy line lengths, and federal safe handling and release training requirements (Watson et al. 2005). Within the National Marine Fisheries Service (NMFS or NOAA Fisheries Service) statistical area of the western

Atlantic Ocean known as the "Mid-Atlantic Bight" (MAB[1])[1]there is concern about apparently increasing interaction rates between the pelagic longline fishery and pilot whales.

In the western Atlantic, there are two species of pilot whales: long-finned pilot whales (*Globicephala melas*) and short-finned pilot whales (*G. macrorhynchus*). Both of these species are known to interact with pelagic longline gear, but their physical characteristics are very similar, making them difficult to distinguish while in the water from both boat-side perspectives and aerial surveys. Both species also have wide geographic ranges, and their populations are believed to overlap within the MAB statistical area between 35° and 39° North latitude (Payne and Heinemann 1993; Bernard and Reilly 1999).

Pilot whales primarily interact with pelagic longline gear from their depredation of caught animals and are often seen feeding on hooked fish, especially bigeye tuna (NMFS, unpubl. data; D. Kerstetter, pers. obs.). Tuna and swordfish are not a regular part of the pilot whale diet, however, which primarily consists of deep-water squid (Gannon et al. 1997a, b; Mintzer et al. 2008), and such depredation appears to be a learned behavior (DAPLTRT 2006). Pilot whales also occasionally become entangled in the mainline (Garrison 2003, 2005), with anecdotal reports of individuals "scratching" themselves on the mainline to remove ectoparasites (Captain G. O'Neill, F/V *Carol Ann* and Captain A. Mercier, F/V *Kristen Lee*, pers. comms.).

Between 1992 and 2005, there were 113 reported pilot whale interactions in the western North Atlantic U.S. pelagic longline fishery (including the Gulf of Mexico), including 61 determined as serious injuries and four observed dead (Johnson et al. 1999; Yeung 2001; Garrison 2003, 2005; Garrison and Richards 2004; Fairfield-Walsh and Garrison 2006). "Serious injury" is defined as an injury sustained by a marine mammal that will likely result in death, one definition in a set of distinct injury definitions regarding interactions with fisheries gear that was developed by a NOAA Fisheries team of veterinarians and marine mammal scientists. Injuries to individual marine mammals are determined to fall within a particular definition based upon fishery observer data and focus on whether the animal was internally hooked (or hooked in a non-visible location), how much fishing gear was still attached to the animal at release, any other apparent injuries, and the manner in which the animal swam away from the vessel (Angliss and DeMaster 1998). Of the 61 serious injuries, five were mouth hooked, 20 released with entangled gear, and 36 a combination of the two (DAPLTRT 2006). More specifically, there were 46 observed interactions with pilot whales from 2001 to 2005, of which 43 occurred within the MAB (DAPLTRT 2006). There were an estimated (i.e., extrapolated) 86 serious injuries to pilot whales from 2001 to 2005 (Waring et al. 2007). The serious injury estimates for pilot whales are extrapolated for management purposes and considered at a five year average to minimize the effect of a single "bad" year (Barlow et al. 1995). The number of serious injuries is below the potential biological removal (PBR), determined for the western Atlantic Ocean to be 249 (Wade and Angliss 1997). The status of the western Atlantic stock is unknown, but the PBR is above the insignificance threshold of 10% and therefore required a formal take reduction plan for the U.S. Atlantic pelagic longline fishery under the Marine Mammal Protection Act (MMPA; Waring et al. 2007). The Atlantic Pelagic Longline Take Reduction Team for Pilot Whales met for the first time in 2005, and the team quickly added Risso's dolphin (*Grampus griseus*) due to the frequency of occurrence along with pilot whales in the fishery. Since finalizing the Take Reduction Plan in 2007, the team continues to receive updates on incidental takes from NOAA on a quarterly basis, with in-person meetings approximately every two years.

[1] Regional and area names signify National Marine Fisheries Service (NMFS or NOAA Fisheries Service) pelagic fishery statistical area boundaries and do not necessarily relate to distinct geographical areas (Richards 1999).

The majority of the current U.S. Atlantic fishery uses one of two types of hooks: the forged "strong" hook, which is oval in cross-section, and the bent-wire "weak" hook, which is made of bending a cylinder of metal and thus circular in cross section. The forged "strong" hook straightens out at a higher pull force than the bent-wire "weak" hook. Pilot whales' weight commonly exceeds 227 kg, and can reach 1300 kg as adults, whereas yellowfin and bigeye tuna are rarely caught above 90 kg (Collette and Nauen 1983; Nakamura 1985; Wynne and Schwartz 1999; Jefferson et al. 2008). Although swordfish can achieve a maximum size of over 450 kg/995 lb, swordfish of that large size are extremely rare in the U.S. fishery; the majority are much smaller, with a pelagic observer-measured average whole weight in 1997 being only 15.4 kg (Cramer and Adams 1999; this minimum size has since increased). Weak hooks would presumably straighten when attached to a large animal such as a pilot whale; this straightening effect could allow the animal to escape more quickly, both reducing the amount of time hooked and decreasing the potential of entanglement in the leader monofilament, which is relatively stronger than the bending strain of the hook (181 kg/400 lb test strength)

In particular, the MAB statistical area – ranging from around Cape Hattaras, North Carolina to a line near Rhode Island – is primarily a mixed yellowfin tuna/swordfish fishery. It is fished throughout the year by a local fleet of small pelagic longline and greenstick[2] gear vessels based out of Wanchese, North Carolina, as well as seasonally by many other larger vessels in the U.S. Atlantic pelagic longline fleet. Anecdotal reports suggest that when the bent-wire hooks were tried in this local fishery, a number of them were retrieved straightened, and despite not knowing what animal had straightened them, fishermen became so concerned about losing potential catch that the fleet went all to the forged "strong" hook (Captain D. Hemilright, F/V *Tar Baby*, pers. comm.). Through a combination of several factors, including this potential loss of target catch, the fishery now primarily uses strong hooks.

Terminal gear changes are not new in the U.S. Atlantic pelagic longline fishery. Research has consistently shown that the change from J-style hooks to circle hooks has shown to decrease bycatch interactions and mortality in pelagic longline fisheries while not significantly changing the catch rate of most target species (Hoey 1996; Falterman and Graves 2002; Watson et al. 2005; Kerstetter and Graves 2006). Despite some ambiguity regarding swordfish catch rates, NOAA Fisheries made the change to circle hooks mandatory for the U.S. pelagic longline fishery in 2004. More specifically for pilot whale interaction research, the fishery is now familiar with hook comparison research and research protocols. Given the difference in hook strength between the forged "strong" and bent-wire "weak" hook types, a terminal gear change could take advantage of the size disparity between pilot whales and target species by using a weaker strength hook that retains the target fish species, yet releases the much larger pilot whales by straightening the hook. Evidence of little or no change in catches could support a precautionary change within the MAB fishery to weaker hooks, thereby decreasing the number of observed interactions involving pilot whales.

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[2] "Greenstick" gear involves the use of a large, carbon-fiber or fiberglass pole (colored green by the original Japanese manufacturer, hence the name) that mounts to the top of the wheelhouse and drags a 25-pound "bird" approximately 300 yards behind the vessel. From this line is a number of drop lines, which each dangle bait at the water surface. It was first used in the United States by the Hawaiian troll fishery. The gear is anecdotally very effective at targeting yellowfin tuna, although catch rates – including bycatch rates – in the U.S. Atlantic fisheries that use it are poorly known. (An on-going study by NOAA Fisheries is working to quantify these catch rates, but these data are not yet available.) Many of the small pelagic longline vessels in the Wanchese-based fleet also use greenstick gear during transits to and from the pelagic longline fishing grounds to maximize ex-vessel revenue, although none of the three vessels during this project did so.

The only published study to date examining the use of weaker hooks for marine mammal interaction reduction is a pilot study by Bayse and Kerstetter (2010).[3] This research conducted 21 pelagic longline sets targeting yellowfin tuna and bigeye tuna in the MAB using alternating forged "strong" and bent-wire "weak" size 16/0 hooks. Nine additional research sets targeting swordfish in the South Atlantic Bight (SAB) NOAA Fisheries statistical area with size 18/0 hooks were also conducted the same alternating hook methodology. Results for the tuna targeting sets showed no significant reduction in total catch ($\alpha < 0.05$) of any target species, although weak hooks exhibited higher catch per unit effort (CPUE) for both tuna and swordfish. The only species to show a significant difference in total catch between "strong" and "weak" 16/0 hooks was the pelagic stingray, with more individuals caught by the "strong" hook. The size 18/0 hook sets had similar catches for all species except the target species swordfish. Swordfish CPUE was non-significantly higher for the "strong" hook, while also having significantly higher total catches. Seven weak hooks were retrieved straightened over the course of all 30 sets, and one of these hooks was observed being straightened by a pilot whale at boatside during the haulback of the gear. While not conclusive, such results do strongly suggest further research into weak hooks for the reduction of marine animal bycatch in the pelagic longline fishery.

The use of weak hook technology for reducing the bycatch of large fishes (e.g., bluefin tuna *T. thynnus*) has long been discussed, and an on-going project by NOAA Fisheries in the northern Gulf of Mexico is examining this very idea. However, the potential reduction of other marine bycatch species has not been thoroughly examined other than the Bayse and Kerstetter (2010) pilot study. This study in the MAB region further compared the catch rates of target and non-target species caught with two different models of strong and weak circle hooks in the North Carolina-based Atlantic pelagic longline fishery to further assess the utility of these hooks for reducing the interaction rate with pilot whales.

Research Goals and Objectives

Goal 1: To identify a means by which the North Carolina-based pelagic longline fleet can continue to operate in its traditional fishing grounds by using a different type of terminal gear (i.e., hook model) that will reduce interactions with pilot whales.

The primary objective of this work was to identify a means by which the U.S. Atlantic pelagic longline fleet (including North Carolina vessels) can continue to fish in its traditional grounds by using a different type of gear that will reduce interactions with pilot whales. This project proposes to further assess the utility of so-called "weak" hooks to bend and thus release from contact with large marine mammals. This would therefore reduce the number of interactions classified as "serious injuries" between pilot whales and commercial pelagic longline fishing gear, particularly in the southern portion of the MAB statistical area where such interactions are an important management concern. The work by Bayse and Kerstetter (2010) supports the previous anecdotal hypothesis that weak hooks may straighten and release large animals over 300 pounds, such as pilot whales and other large marine mammals.

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[3] A research project funded jointly by the NOAA Fisheries Service and the New England Aquarium Consortium for Wildlife Bycatch Reduction examined similar weak versus control hooks in the Honolulu-based pelagic longline fishery targeting bigeye tuna in the fall of 2010. This work was subsequently presented at the International Circle Hook Symposium in Miami, Florida in May 2011 and was published in the Bulletin of Marine Science in 2012: Bigelow, K.A., D.W. Kerstetter, M.G. Dancho, and J.A. Marchetti. Catch rates with variable strength circle hooks and the potential to reduce false killer whale injury in the Hawaii-based tuna longline fleet.

Goal 2: To quantify any differences in catch rates between the experimental hook models for the target fishes in this commercial fishery, primarily swordfish and yellowfin tuna, but also the high-value bigeye tuna. Such quantified comparisons will also include non-target (bycatch) species of special recreational or ecological concern.

A secondary goal of this project is to quantify any differences in catch rates for the target fishes in this commercial fishery, primarily swordfish and yellowfin tuna, but also the high-value bigeye tuna. If catch rates for the target fishes show no difference between these two hook types, then the weak hooks may be suggested to management for consideration as an interaction rate reduction method in simply a precautionary manner within the southern MAB area, as such a move would therefore likely have minimal economic effect to the impacted fishery. More importantly, the quantification of these catch rates is important for assessing the impact of proposed management action, as opposed to relying on anecdotal data or extrapolation from other, non-experimentally tested hook models.

Along with this quantification for target species, these same weak hooks may also show catch rate differences for large bycatch species with recreational fishery importance, such as blue marlin *Makaira nigricans*. They may also show differences in catch rates for species with depleted population levels or other ecological importance, including sea turtles. While pilot work by Bayse and Kerstetter (2010) did not find any significant differences in catch rates, that work was hampered by relatively low sample sizes and limited temporal replication. This proposed hook work may therefore show differences in catch rates not apparent in the Bayse and Kerstetter (2010) prior research.

Goal 3: To evaluate the effectiveness of the NOAA Fisheries Service-approved dehooking and disentanglement protocols for pilot whales, as well as document the rates and types of depredation on commercial pelagic longline catches.

Finally, the research was intended to qualitatively evaluate the effectiveness of the NOAA Fisheries Service-approved dehooking and disentanglement protocols for pilot whales. All of the captains to be involved with this research were certified on current dehooking and disentanglement protocols and equipment, and yet the current limited exposure with fisheries observers may have prevented the transmission of some insight or improvement in current procedures. As part of current POP protocols, this research also intended to document the rates and types of depredation on commercial pelagic longline catches within this area of special concern for pilot whale interactions.

Materials and Methods

This study alternated weak hooks (hooks that straighten at *ca.* 200 pounds pull strength) and the status quo “strong” hooks (*ca.* 350 pounds test strength) along the length of the mainline set, similar to the pelagic longline research described in Watson et al. (2005) and Kerstetter and Graves (2006). In comparison with those projects, which gauged fishing efficiency between hook types, the objective of this proposed work was to evaluate the number of pilot whales still attached to the gear at haulback, the standard of whether an interaction is included in the NOAA Protected Resource Division quarterly and annual accounting.[4]

Hook Types

[4] If a pilot whale is hooked during the “soaking” of the gear, but then subsequently straightens the hook and is not present on the gear at haulback, there is technically no documented interaction.

This work tested two different models of "weak" hooks, both manufactured by O. Mustad & Son A.S. (Gjövik, Norway): 1) the experimental size 16/0 Mustad 39988D (the same hook being tested in the Gulf of Mexico for reduction in bluefin bycatch), which straightens out at ~100 lb/45 kg (C. Bergman, NOAA Fisheries, unpubl. data) and 2) the stock size 18/0 Mustad 39960, which straightens out at ~225 lb/102 kg (Bayse and Kerstetter, 2010).[5] The "strong" hook model in both cases was the same size hook (i.e., 16/0 "weak" to 16/0 "strong") forged model LPCIRBL from Lindgren-Pitman, Inc. (Pompano Beach, FL), which has shown itself through the fishery as almost impervious to straightening, even during times that it hooks marine mammals and manta rays *Manta* spp. Technically, the size 16/0 hook straightens ~250 lb/113 kg, while the size 18/0 hook straightens ~350 lb/159 kg (Bayse and Kerstetter, 2010). Both O. Mustad & Son A.S. and Lindgren-Pitman, Inc. hook types are commonly used in the U.S. Atlantic fishery, although the LPCIRBL model is much more frequent within the North Carolina fleet.

Data Collection

Hooks were alternated "strong-weak-strong-weak-strong" for each five-hook "basket" (hooks between floats), with the next basket alternated "weak-strong-weak-strong-weak"; this deployment method guarantees equal hook placement across all positions within the basket (see Kerstetter and Graves 2006). All other gear configurations remained consistent with regulations for the U.S. Atlantic pelagic longline fishery (e.g., leader lengths must be ≥ 100% of buoy floatline length; NMFS 2006). Hook spacing was relatively uniform within each set, and the choices of gangion and buoy line lengths and set locations were typical of the fishery. A mixture of squid (*Illex* spp.) and Atlantic mackerel (*Scomber scombrus*) bait was used during all experimental sets. All vessels had NOAA-required live-release equipment, and the captains and crews were certified on the techniques used to release bycatch species with minimal injury.

Two graduate students were trained as fisheries observers by the NOAA Fisheries Pelagic Observer Program (POP). The observers used standard POP data sheets to record data on all caught animals, including: identification to species, measured length, hook type, location of the hook on the organism, and disposition (alive or dead) at gear retrieval. Fish that did not move while hooked in the water or on deck were conservatively considered "dead" (per Falterman and Graves 2002 and Kerstetter and Graves 2006). Hooking location was recorded per POP protocol and collated into three categories for analysis: mouth hooked, foul hooked, or gut hooked. Also as per POP protocol, the lengths of large bycatch species was estimated, as was the lengths of target species that were damaged from sharks, marine mammals, or other causes (e.g., squid). Dressed weights were recorded for headed-and-gutted fish, but only for species that were weighed individually for sale (only tunas and swordfish).

The completed POP forms and data were shared with the POP in accordance with prior fisheries research, although all confidentiality protocols regarding these data remain in effect regarding preventing public disclosure of identifiable information. These data went through normal POP QA/QC procedures to ensure the accurate documentation of all catches and associated vessel data. In additional to the biological data on all caught fishes, all marine mammal and sea turtle interactions were to be documented with both photographs and standard POP reporting forms for later confirmation of species identification and injury location, if applicable. Fisheries observers and captains also engaged in

[5] The project also intended to test an experimental size 18/0 Mustad 39960 model made with the 5.0 mm wire rather than the standard 5.2 mm wire, which should straighten out at a lesser force than the stock 18/0 size hook at between ~150-200 lb/68-91 kg (J. Pierce, O. Mustad & Son A.S. (USA), pers. comm.). However, the minimum size order of 10,000 hooks and at least a six-month lead time for such a custom order precluded the inclusion of this hook model.

qualitative evaluations of the effectiveness of dehooking and disentanglement equipment and techniques.

Data Analyses

Data analyses were conducted similarly to Bayse and Kerstetter (2010) and Kerstetter and Graves (2006) using paired (i.e., by set) comparisons of Catch-Per-Unit-Effort (CPUE) values, which are generally expressed in the pelagic longline fishery as unit catch per 1000 deployed hooks. T-tests were used to compare between hook types for individual fish lengths and dressed weights. All statistical significance was assessed at the $\alpha < 0.05$ level. All of these methods have been used in previous peer-reviewed literature on similar paired gear comparison research (e.g., Kerstetter and Graves 2006 and Bayse and Kerstetter 2010). All statistical analyses were conducted using SAS (v.9.1; Cary, NC).

Vessels

The vessels participating in this project were subject to a lengthy set of requirements (detailed in Appendix I of the original proposal; not included here) that was similar to other cooperative pelagic longline research, including standardized gear configurations and practices that are in accordance with those operating parameters of the fleet in this geographic area. The vessels were also required to have scientific personnel (i.e., student observers) aboard during each set to record data on POP-standard forms, as well as agree to collect biological samples when possible. Regardless of home port locations, any participating captains and vessels had all traditionally fished in the study area on at least a seasonal basis.

Results

Trip Details

Eight trips were conducted, six in 2010 and two in 2011 (Tables 8-1A and 8-1B) testing both size 16/0 and 18/0 hooks aboard a total of three vessels. The gear summary details for the trips based on hook size are found in Tables 2A and 2B. A total of 747 fishes were caught by the gear, although primarily yellowfin tuna and swordfish – both target species in this fishery.

Catch rates and characteristics

The catch rates (as catch-per-unit-effort or CPUE; expressed as catch per 1000 hooks) are listed in Tables 8-3A and 8-3B. The CPUEs for the target species – yellowfin tuna for size 16/0 hooks and swordfish for size 18/0 hooks – are the highest among the catches (see Figures 8-1A and 8-1B for size 16/0 hooks and Figure 8-2 for size 18/0 hooks). For the size 16/0 hooks, no significant differences in CPUEs were seen for “All swordfish” ($p>0.21$), “All yellowfin tuna” ($p>0.70$), “Retained tunas” ($p>0.87$), or “Retained swordfish” ($p>0.67$). For the size 18/0 hooks, there was no significant difference in CPUE for swordfish ($p>0.38$). Figures 8-3A and 8-3B detail the length and weight comparisons between the “weak” and “strong” hook types for size 16/0 hooks, although there were no significant differences between the hook types in either comparison.

Hook deformation

Of all the 747 fishes caught, only five hooks came to the vessel with visible deformation and all were size 16/0 (see Table 8-4 and Figure 8-4); no deformed 18/0 hooks were seen in this study.

Discussion

Catch and Catch Composition

The catch rates and catch composition were as expected for this fishery and these target species. Although higher numbers of individuals would have increased the statistical power of the results, the statistical analyses suggest that even an increase in power would have resulted in very similar findings.

Research Goals and Objectives

Goal 1: To identify a means by which the North Carolina-based pelagic longline fleet can continue to operate in its traditional fishing grounds by using a different type of terminal gear (i.e., hook model) that will reduce interactions with pilot whales.

Although these research sets did not catch any pilot whales, these results continue to suggest that so-called "whale safe" hooks may have utility for reducing pilot whale bycatch in this fishery. However, as detailed below, it is unlikely that the fleet operating off North Carolina will adopt these weaker hooks voluntarily.

Goal 2: To quantify any differences in catch rates between the experimental hook models for the target fishes in this commercial fishery, primarily swordfish and yellowfin tuna, but also the high-value bigeye tuna.

The low catch rates of bigeye tuna precluded meaningful statistical analyses, but the results for swordfish and yellowfin tuna in the size 16/0 hooks, and swordfish in the size 18/0 hooks, suggest no difference in catch rates or other characteristics (i.e., weight and length) between the weak and strong hooks.

Goal 3: To evaluate the effectiveness of the NOAA Fisheries Service-approved dehooking and disentanglement protocols for pilot whales, as well as document the rates and types of depredation on commercial pelagic longline catches.

Although pilot whales were observed around the vessels during some of the trips, none were hooked by the gear, so this goal could not be addressed.

Practical Aspects of Research Proposal
The planned research protocols generally worked as expected. The only substantial problem encountered during this project regarded fishing effort, which was at the sole discretion of vessels within the North Carolina permanent or seasonal fleet. As described during prior reporting periods, there was simply no compensation available under this research project budget to convince vessel captains to take an observer and test this alternative terminal gear if it was likely that pilot whales would be caught and observed (even though such interactions would not be included on later catch extrapolations by the NOAA Fisheries Service). We ended up trying all sorts of alternative arrangements to induce participation in the project, including adding observer per diem and the occasional purchase of small amounts of gear (e.g., a 50# spool of monofilament mainline), some of which worked, but never consistently enough to provide a rationale for continuation. The other factor that hindered fishing efforts was the unusually active storm season during 2011 (see Table 8-5), which particularly affected the small-vessel fleet out of Wanchese, North Carolina. Much more recently (and ironically), the fleet has been encountering very high interaction rates with pilot whales in their traditional fishing grounds, forcing many vessels to participate in other fisheries (e.g., bottom longline for tilefish).

Submission of Final Data

Finally, all data associated with the project are currently being compiled into an electronic format for submission as an accompanying data CD with a hard-copy version of the final report to the Consortium. This compilation will include: a) preliminary and final versions of the field datasheets, and b) scanned (.pdf-format file) deck-level datasheets from each completed fishing night. If there are any other raw data your office would request from this project, please let us know as soon as possible.

Impacts and Benefits

This work likely was hampered by the similar research on weaker-strength hooks being conducted by the NOAA Fisheries Service Pascagoula Laboratory in the northern Gulf of Mexico pelagic longline fishery for yellowfin tuna; early word got out to the U.S. Atlantic fleet that catches of larger fish were less, and several captains indicated that they were unwilling to participate in a project where they absolutely believed they would catch less fish in North Carolina as well. Additionally, several captains wished to avoid being the ones who participated in the research that resulted in management regulations decreasing the catch of the whole fleet (especially in a close-knit community like Wanchese). The impact of the results in this project will be presented at the upcoming fall conference call meeting of the Atlantic Pelagic Longline Take Reduction Team ("Team"), although it is unclear what the Team – especially the environmental NGOs and the NOAA Fisheries Service representatives – will do regarding the apparent unwillingness of the fishery to participate in funded collaborative research like this program.

Extension of Results

The North Atlantic swordfish and yellowfin tuna stocks remain very important sources of revenue for the U.S. domestic pelagic fishery, despite the pelagic longline gear type being currently excluded from several of the historically productive fishing grounds in the Florida Straits for this species as well as the gear restrictions currently in place off the North Carolina coast in the Special Research Area. The extension of the results will likely be minimal, however, given the current antagonism within the U.S. Atlantic pelagic longline fleet regarding the mandatory use via NOAA Fisheries Service regulations of weaker-strength circle hooks for the reduction of pilot whale bycatch.

The final analyses of the project data, particularly regarding the behavior of the gear during the fishing period, are still ongoing and those results may be used within other collaborative work on gear behavior and pilot whale interactions within the North Carolina-based pelagic longline fishery and researchers at Duke University. We expect these results to be converted into a scientific manuscript for submission to a peer-reviewed journal within the next 12 months.

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Tables 8-1A and 8-1B. Trip summary details for eight pelagic longline "whale safe" gear research sets with size 16/0 (Table 2A, above) and 18/0 (Table 2B, below) circle hooks within the North Carolina-based fishery.

2010

Trip #	Type of Experimental Hook Used	# of Experimental Hooks Depeloyed	Start Date of Trip	Number of Sets	Vessel	Port of Departure
N06003	16/0	270	9/10/10	1	F/V Sea Bound	Cape Hatteras, NC
N06004	16/0	327	9/13/10	1	F/V Sea Bound	Cape Hatteras, NC
N06005	16/0	1050	9/23/10	3	F/V Jamie B	Wanchese, NC
N06006	16/0	1311	10/7/10	4	F/V Jamie B	Wanchese, NC
N06007	16/0	845	10/17/10	3	F/V Jamie B	Wanchese, NC
N06008	16/0	975	10/22/10	3	F/V Jamie B	Wanchese, NC

2011

Trip #	Type of Experimental Hook Used	# of Experimental Hooks Depeloyed	Start Date of Trip	Number of Sets	Vessel	Port of Departure
N06009	16/0	2355	8/17/11	8	F/V Jamie B	Wanchese, NC
Z06003	18/0	2767	4/15/11	7	F/V Shady Lady	Cherry Point, SC

Tables 8-2A and 8-2B. Gear summary details for pelagic longline "whale safe" gear research sets with size 16/0 (Table 2A, above) and 18/0 (Table 2B, below) circle hooks within the North Carolina-based fishery.

Gear Summary for Trips using 16/0		**+/- stddev**
Total Set Weak Hooks (Q hook)	7133	-
Total # of Trips	7	-
Total # of Sets	23	-
# of Individuals Caught	414	-
Total # of Straightened Hooks	19	-
Straightened Hooks with Unknown Catch	14	-
Straightened Hooks with Kept Catch	5	-
Straightened hook rate per 1000 hooks	0.27%	-
Straightened hook rate without catch	0.20%	-
Bait	100% Illex	-
Average Set Duration	1.94	0.34
Average Haul Duration	4.53	0.58
Hooks per set	620	101
Hooks between floats	5	-
Weighted Average of Gangion+Leader Length(ft)	40.08	5.713142743
Weighted Average of Dropline length(ft)	43.62	2.89

Gear Summary for Trips using 18/0		**+/- stddev**
Total Set Weak Hooks (Q hook)	2767	-
Total # of Trips	1	-
Total # of Sets	7	-
# of Individuals Caught	113	-
Total # of Straightened Hooks	0	-
Straightened Hooks with Unknown Catch	0	-
Straightened Hooks with Kept Catch	0	-
Straightened hook rate per 1000 hooks	0	-
Straightened hook rate without catch	0	-
Bait	45% Illex, 55% Mackerel	
Average Set Duration	4.1	0.21
Average Haul Duration	7.4	1.84
Hooks per set	790	19.11
Hooks between floats	5	-
Floatline (m)	30	-
Branchline (m)	34	-

Tables 8-3A and 8-3B. Analyses of catch-per-unit-effort (CPUE; catch per 1000 hooks) for pelagic longline "whale safe" gear research sets within the North Carolina-based fishery. Table 3A (top) shows CPUE for size 16/0 hooks. Table 3B (bottom) shows CPUE for size 18/0 hooks.

16/0 Weak Hook		
Species	Weak Hook	Strong Hook
Yellowfin Tuna	18.6	17.4
Blackfin Tuna	6.3	5.3
Swordfish	5.9	3.6
Bigeye Tuna	0.7	1.1
Albacore	1.1	0.8
Unknown thunnid	1.4	0.8
Scalloped Hammerhead	1.8	2.4
Pelagic Stingray	1.7	1.3
Unidentified Shark	1.7	1.3
Little Tunny	1.4	1.0
Blue Shark	1.4	0.7
Silky Shark	1.0	0.7
Billfish	1.1	0.6

18/0 Weak Hook		
Species	Weak CPUE	Strong CPUE
Swordfish	6.87	8.67
Blueshark	2.89	1.81
Dolphin	1.81	2.17
White Marlin/Spearfish	2.17	2.17

Table 8-4. Changes in hook structure with catch. Experimental hooks were size 16/0 circle hooks in the North Carolina-based pelagic longline fishery; no deformed size 18/0 hooks were found during experimental work.

Species Retained	lbs	Bent Hook Gape (cm)	Standard Gape (cm)	Gape Size Increase (%)
YFT	41	4.8	2.5	92%
YFT	45	4.6	2.5	84%
YFT	55	3.7	2.5	48%
SPL	57	4	2.5	60%
SPL	256	4.6	2.5	84%

Table 8-5. List of tropical storms and hurricanes encountered during 2011 field season, with two-week preferred fishing periods around full moon for North Carolina-based pelagic longline fleet indicated in green font. **Bold Dates–** Dates were wave height reached over 7 ft recorded by buoy 150 miles off coast of NC indicating unlikely fishing with participating fleet. GREEN Dates – Indicate 1 week before and 1 week after each full moon for months of fishing activity

4/10/2011-4/24/2011

5/10/2011-5/24/2011

06/19/11

6/8/2011-6/22/2011

06/21/11-06/30/11

07/07/11-07/10/11

7/8/2011-7/22/2011

07/15/11

July 17-22 Tropical Storm Bret

07/26/11

July 20-22 Tropical Storm Cindy

08/04/11-08/08/11

August 1-7 Tropical Storm Emily

8/6/2011-8/20/2011

August 14-16 Tropical Storm Gert

August 20-28 Major Hurricane Irene

08/26/11-08/28/11

August 28-29 Tropical Storm Jose

August 29- September 10 Major Hurricane Katia

09/06/11-09/10/11

9/5/2011-9/19/2011

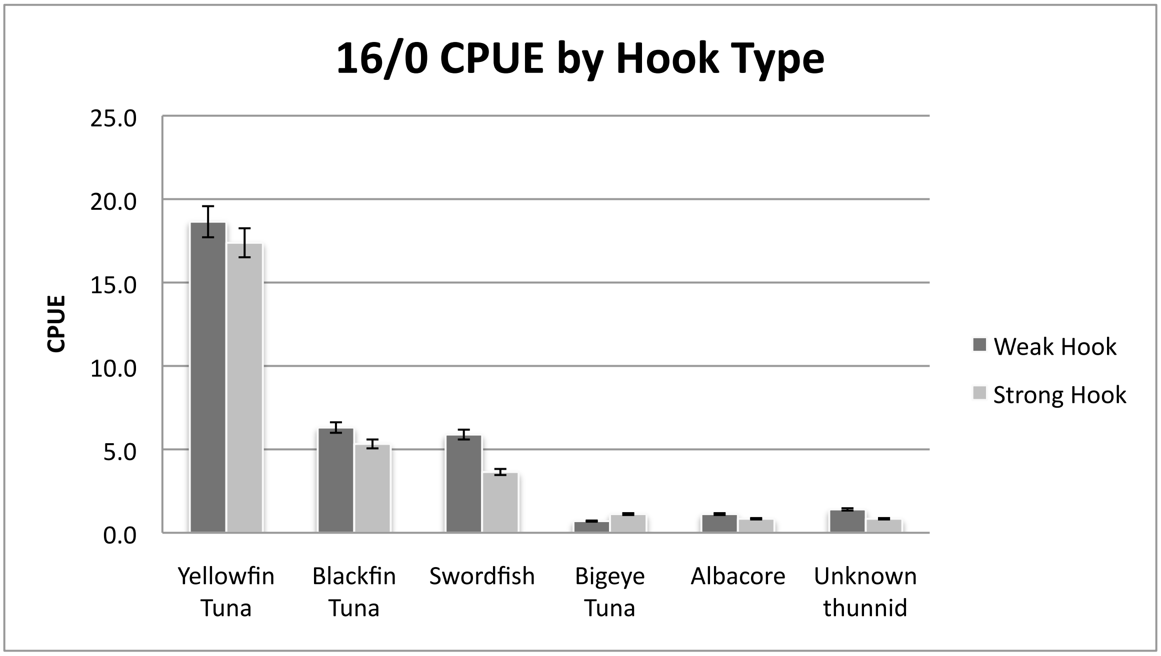
September 6-16 Hurricane Maria

09/16/11-09/19/11

September 21-October 3 Major Hurricane Ophelia

09/25/11

Figures 8-1A and 8-1B. Analyses of catch-per-unit-effort (CPUE; catch per 1000 hooks) for pelagic longline "whale safe" gear research sets with size 16/0 hooks within the North Carolina-based fishery. Figure 1A (top) shows CPUE for target swordfish and tuna species. Figure 1B (bottom) shows CPUE for non-target fish species.



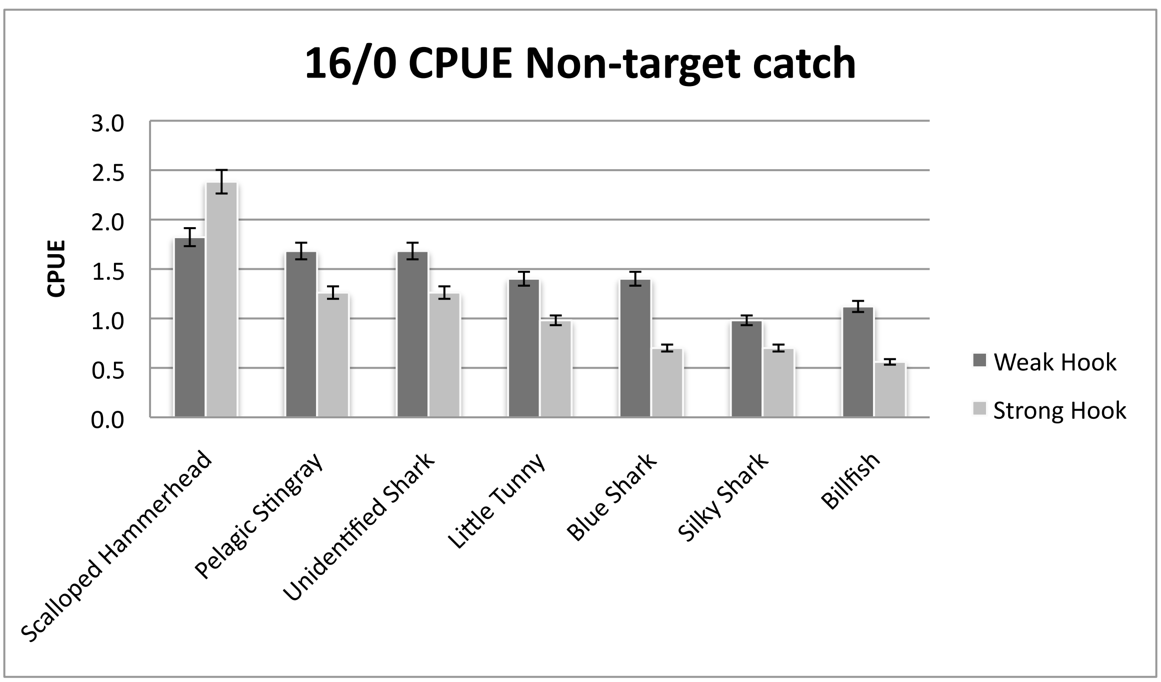
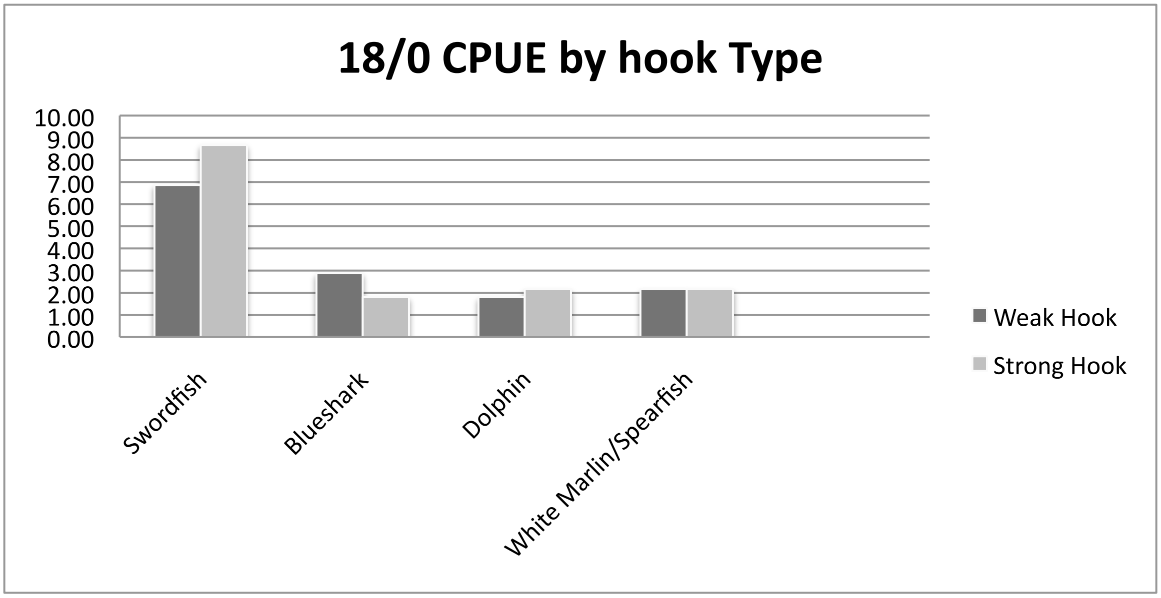
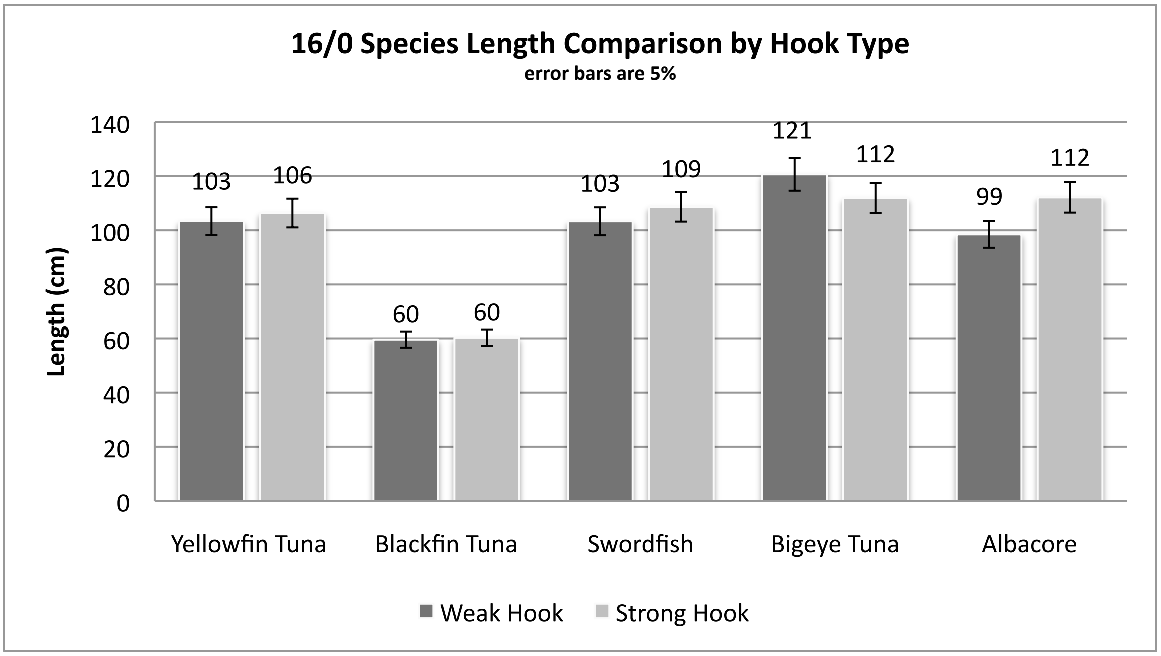


Figure 8-2. Analyses of catch-per-unit-effort (CPUE; catch per 1000 hooks) for pelagic longline “whale safe” gear research sets with size 18/0 hooks within the North Carolina-based fishery.



Figures 8-3A and 8-3B. Analyses of catches by pelagic longline "whale safe" gear research sets with size 16/0 hooks within the North Carolina-based fishery. Figure 1A (top) shows CPUE for target swordfish and tuna species. Figure 1B (bottom) shows CPUE for non-target fish species.



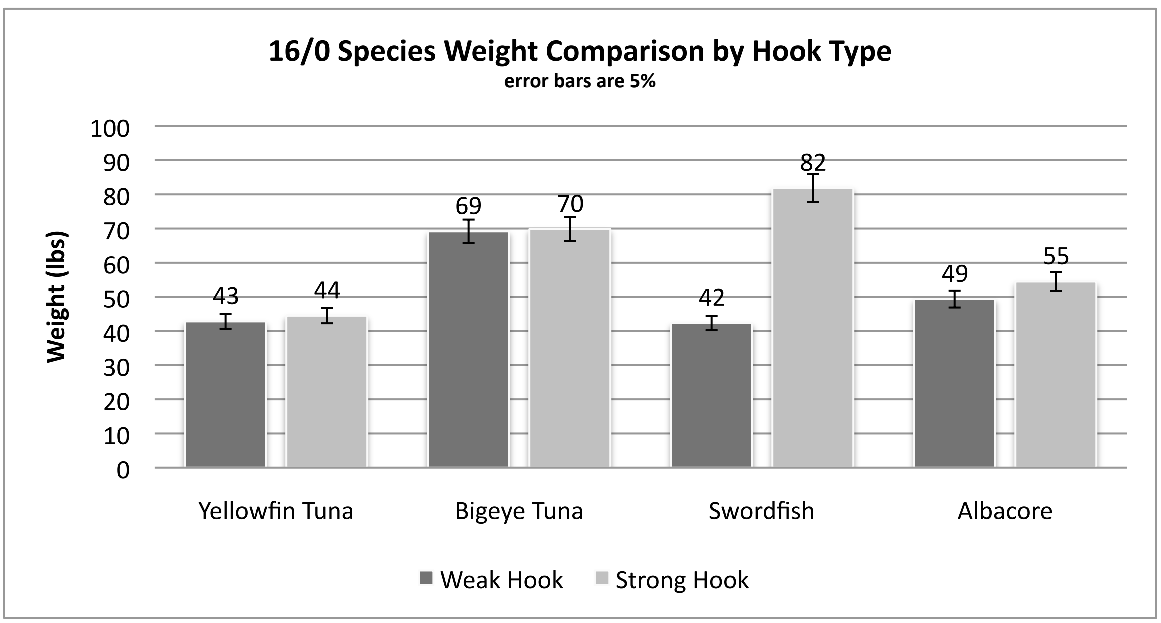


Figure 8-4. Hook deformity of size 16/0 circle hook with weight of individual animal from pelagic longline fleet off North Carolina. This graph shows the measured increase in deformity from standard hook gape of 2.5 cm. Example: YFT (BH1)**:** Standard gape of 39988D 16/0: 2.5 cm, Bent Hook 1 Measured Gape: 4.8cm; therefore: (4.8cm-2.5cm)/ (2.5cm) =.92*100=<u>92%.</u>