7.g.i.

CETACEAN DEPREDATION IN THE HAWAII LONGLINE FISHERY: INTERVIEWS OF LONGLINE VESSEL OWNERS AND CAPTAINS

Pilot Whales (Globicephala macrorhynchus) were seen hooked in the Hawaii-based longline fishery

Photo credit: Tony Hisgett

False Killer Whales (Pseudorca crassiden) were recorded hooked and/or entangled

Photo credit: Robin Baird

Prepared for:

National Oceanic and Atmospheric Administration

National Marine Fisheries Service

Pacific Islands Regional Office

Prepared by:

TEC Inc.

1001 Bishop Street

American Savings Bank Tower, Suite 1400

Honolulu, Hawaii 96813

April 2009

This page is intentionally left blank.

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1

1.1 Depredation of Longlines by Whales 1-1
1.2 Hawaii Longline Fisheries 1-1
1.3 Species of Concern 1-2
1.4 Study Methodology 1-2

2.0 FISHERIES 2-1

2.1 Procedures 2-1
2.2 Depredation Preferences and Rates 2-1

3.0 DEPREDATION HOTSPOTS 3-1

4.0 SEASONAL DEPREDATION 4-1

5.0 CETACEAN AVOIDANCE METHODS 5-1

6.0 CAPTAINS' SUGGESTIONS 6-1

7.0 CURRENT RESEARCH ON DEPREDATION MITIGATION 7-1

8.0 ECONOMIC COST OF CETACEAN DEPREDATION 8-1

9.0 CONCLUSIONS AND RECOMMENDATIONS 9-1

10.0 REFERENCES 10-1

LIST OF FIGURES

Figure 2-1. Estimated Annual Percentage of Catch Depredated in the Hawaii-based Longline Fishery 2-2

Figure 3-1. Potential Depredation Hotspots 3-2

Figure 4-1. Months of Highest Perceived Depredation Rates in the Hawaii-based Longline Fishery 4-1

LIST OF TABLES

Table 8-1: Average Annual Variable Costs for Swordfish and Tuna Vessels in 2000. 8-1

LIST OF APPENDICES

Appendix A Interview Questions

Appendix B Interview Summaries

LIST OF ACRONYMS AND ABBREVIATIONS

° W	Degrees West
° E	Degrees East
°F	Degrees Fahrenheit
EPA	U.S. Environmental Protection Agency
FKW	False Killer Whale
ft	feet
KHz	kilohertz
NMFS	National Marine Fisheries Service
PBR	Potential Biological Removal
WPRFMC	Western Pacific Regional Fishery Management Council

This page is intentionally left blank.

1.0 INTRODUCTION

1.1 DEPREDATION OF LONGLINES BY WHALES

Depredation (removal from the hook) of bait and catch by certain species of toothed whales is a worldwide problem that is receiving increased attention from researchers due to the potential effects on the whales and the costs to the fisheries.

The Hawaii-based longline fishing industry is experiencing frequent depredation from cetaceans, specifically false killer whales (FKWs) (*Pseudorca crassidens*) and pilot whales (*Globicephala macrorhynchus*). The Hawaii-based longline fishery consists of two main components: the deep-set fishery that targets tuna, and the shallow-set fishery that targets swordfish. A survey of longline owners and captains was conducted to collect data on depredation rates in those fisheries, cetacean depredation hotspots and seasonal trends, and ideas for managing cetacean/longline interactions in a manner that is beneficial to both the longline fishery and the cetaceans. Longline fishermen have the greatest experience with cetacean-longline interactions, and thus the input of the fishermen is potentially valuable in the management process.

Depredation is costly to both cetaceans and the longline fishery. The National Marine Fisheries Service (NMFS) lists negative impacts of cetacean/longline interactions to cetaceans that include serious injury or death due to hooking or entanglements; retaliation by fishermen including shooting, throwing explosives or bottles filled with fuel; a change in prey source; dependency on longline catch; or changes in foraging behavior. Impacts on the fishery include increased costs due to loss of bait and catch, avoidance strategies which entail additional and displaced effort, reduced product quality, lost fishing gear, and a reduced window of opportunity for successful fishing (NMFS 2007).

1.2 HAWAII LONGLINE FISHERIES

Longline fishing has been conducted for many decades in Hawaii. Development of local markets and export of fresh yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*) and albacore (*Thunnus alalunga*) tuna to the U.S. mainland and Japan led to the expansion of longline fisheries in the 1980s (Gilman et al. 2006). Participation in the longline fishery increased from 37 vessels in 1987 to 88 in 1989, and then nearly doubled again to 141 vessels in 1991. In 1991, entrance into the longline fishery in Hawaii was regulated by limiting participation to a maximum of 164 vessels. The current vessels are mostly steel hulled, with shallow-setting, swordfish-targeting boats up to 30.8 meters (m) in length and smaller, deep-setting, tuna-targeting vessels measuring up to 17 m in length (NMFS 2001). Longline refers to the nylon monofilament lines used that can vary in length from 30 km to 100 km and hold 1,200 to 3,000 hooks (tuna) and 700 to 1,000 hooks (swordfish) (Gilman et al. 2007).

Of a possible 164 active vessels, there were 127 active Hawaii-based longline vessels in 2006, which set 34,895,229 hooks and made 1,427 trips targeting tuna and 106 trips targeting swordfish (Clemens 2006). The Hawaii longline fishery is the most economically productive of Hawaii's pelagic fisheries, accounting for 82% of total commercial fish landings in the state in 2006 (WPRFMC 2007). Tuna accounted for 59% of all pelagic landings (all gear types combined) (WPRFMC 2007).

Prior to 2001, the fishery was easily separated into deep-set fisheries targeting tuna, and shallow-set fisheries targeting swordfish. Swordfish became heavily regulated in order to prevent bycatch of protected sea turtles, which led to closure of the fishery from February 2002 through May 2004. Since reopened, the swordfish fishery is limited to 2,120 sets per year, or until turtle caps are reached, a limit that leads to very short seasons for swordfish fishing (Gilman et al. 2006). In 2006, the fishery reached the annual turtle cap after only three months and was closed. As a result, vessels were forced to become both deep and shallow-set equipped or to leave the islands to survive financially. In 2006 there were 92 vessels targeting tuna exclusively and 35 targeting both tuna and swordfish (WPRFMC 2007).

Proposed Amendment 18 to the Fishery Management Plan, Pelagic Fisheries of the Western Pacific Region, proposes increasing the turtle interaction cap to 46 loggerheads and 19 leatherbacks per year, as well as removing the shallow-set effort limit (2,120 sets/yr). The Western Pacific Regional Fishery Management Council (WPRFMC) proposes the regulation change due to decreased turtle interactions that have resulted since the use of mackerel-type bait and circle hooks was required in 2004 (50 CFR Part 665.33). The Amendment is under review, and no change has been made to regulations at the time of this report.

1.3 SPECIES OF CONCERN

False Killer Whales are found in tropical and warm-temperate waters throughout the world. In the North Pacific Ocean, FKWs are found from the eastern tropical Pacific to areas of southern Japan and Hawaii. The Hawaiian stock of FKWs is reproductively isolated from other stocks found throughout the eastern tropical Pacific (Carretta 2006). While not listed as threatened or endangered under the Endangered Species Act, FKWs are considered a strategic stock under the Marine Mammal Protection Act because the rate of mortality and serious injury in the Hawaii-based longline fishery exceeds the potential biological removal (PBR), the number of individuals that can be removed from the population without interfering with the ability of the whales to support an optimal sustainable population. The stock is estimated at only 268 individuals (Baird and Gorgone 2005).

In the Hawaii-based longline fishery between 1994 and 2004, 18 FKWs were recorded hooked and/or entangled, with 4-26% of all effort observed (Carretta 2006). During this time period, 11 other cetaceans, possibly FKWs, were also hooked or entangled (Carretta 2006).

Like FKWs, pilot whales are found in all oceans, mostly concentrated in tropical and warm-temperate waters. The Hawaiian stock of pilot whales is also reproductively isolated from other stocks in the eastern Pacific, and is found near the main Hawaiian Islands and the Northwestern Hawaiian Islands (Carretta 2006). Mortality and serious injury in the Hawaii-based longline fishery does not exceed the PBR for this species, thus they are not listed as depleted or strategic under the Marine Mammal Protection Act. Six pilot whales were seen hooked in the Hawaii-based longline fishery between 1994-2004, with 4-26% of all effort observed.

Along with cetaceans, fishermen also suffer from shark depredation. Depredation is easily distinguished between sharks and cetaceans because sharks eat only the bottom half of the fish and do not always eat all the catch. Whales usually eat everything except the head and will often eat up to 99% of the catch.

1.4 STUDY METHODOLOGY

Informal dockside interviews were set up with longline fishing vessel captains and owners. Each interview consisted of 21 questions that can be found in Appendix A. Interviews were conducted between November 2007 and January 2009 and lasted thirty to sixty minutes. Interview notes, including specific interview dates, may be found in Appendix B.

Twenty-two longline captains and owners were interviewed. The ethnicities of the interviewees were six Vietnamese, seven Caucasians, eight Koreans and one Chinese. Interpreters were required for interviews with the Korean and Vietnamese longline captains and owners. Our Vietnamese interpreter was Thu Huong Crumpton and our Korean interpreter was Taisuk Hahn. Both provided outstanding support in arranging the interviews and very professional assistance in conducting the interviews. Prior to the interviews, both interpreters were briefed on the problem and the intent of the study. It was important to establish with the interviewees that the intent was to gather information about potential solutions to the depredation problem, not to gather evidence that would be used to impose further regulations on the fishery. To our interpreters' credit, they were successful in transmitting that message and consequently we believe the responses we received were truthful and provided in a constructive spirit. That's not to say there wasn't a fair measure of suspicion as to NMFS' intentions and apprehension about how the issue ultimately would be resolved. Nevertheless, the severity of the problem and dearth of obvious solutions has left the fishermen feeling helpless and hopeless. They are fearful of the whales, but fearful of NMFS as well.

In the following sections, results of the interviews are summarized, along with historical and economic information on the longline fishery.

This page is intentionally left blank.

2.0 FISHERIES

2.1 PROCEDURES

Deep-set fishermen start to set lines at sunrise or shortly thereafter at depths ranging from 300 to 600 feet (ft). Deep-set lines target tuna, but are known to hook oil fish, monchong, shark and other species as well. The majority of the deep-set fishermen interviewed began hauling lines at about 5pm.

All captains interviewed operated steel-hulled vessels and were in agreement that the greatest noise they created was the sound of the engine. Some pointed out, however, that the high pitched noise of the hydraulics during hauling the line could be an attractant.

From January through March, tuna fishing is concentrated between latitudes 15° N and 35° N and longitudes 150° W and 180° W. From April through June tuna fishing expands to the south and spreads further east and west to about longitudes 145° W and 170° E (Gilman et al. 2007). The fishery is open year-round.

Shallow-set fisherman set lines in the evening at depths ranging from 50 to 150 ft and are fishing for swordfish. Lines are typically hauled at sunrise. The shallow-set fishery is limited to 2,120 sets annually, or until turtle interaction caps are reached, whichever occurs first. In 2006, the turtle interaction cap of 17 loggerheads and 16 leatherbacks was reached after only three months, closing the fishery for the remainder of the year (Gilman et al. 2007). Proposed Amendment 18 to the Fishery Management Plan, Pelagic Fisheries of the Western Pacific Region (see Section 1.2), is under review, but no change has been made to this regulation at the time of this report.

The swordfish fishing effort is concentrated to the northeast of the Hawaiian Island Chain, in the North Pacific Transition Zone (Gilman et al. 2007). Five of the six Vietnamese-American owned and operated vessels switched back and forth between swordfish and tuna targeting. All of the remaining vessels targeted tuna. No vessel was reported to fish exclusively for swordfish.

Of the 22 owners and captains interviewed, no one had personal experience hooking a cetacean. All agreed that the procedure, if it were ever to occur, would be to cut the line as near as possible to the cetacean. All agreed that while the FKWs sometimes seem to get tangled in the line, hooking one is extremely rare.

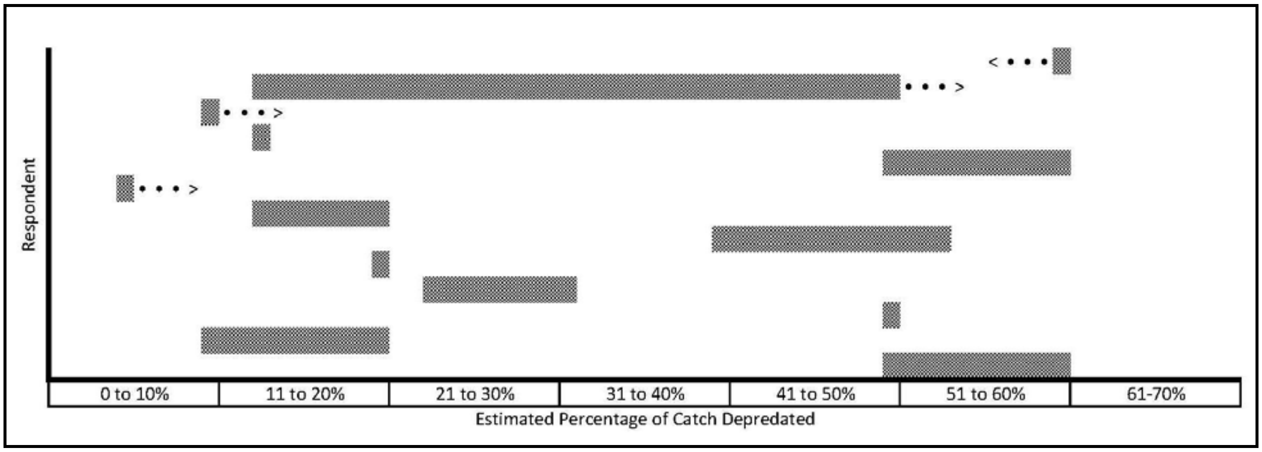
2.2 DEPREDATION PREFERENCES AND RATES

The majority of captains interviewed agreed that they were equally likely to lose their bait or catch to whales during all stages of fishing, the set, soak and haul, but previous studies have shown that the whales often wait for the hauling process to eat, presumably to avoid having to dive too deep (Gilman et al. 2006).

Interviewees were consistent in reporting that bigeye and yellowfin tuna are the favorites of the whales, and that large ahi are too fast for whales to catch, but once they are hooked the whales eat them even if they are still alive. While the whales prefer ahi, they also eat mahimahi, ono, and a variety of other hooked fish, but do not eat shark.

All fishermen interviewed routinely experience problems with depredation, although their estimates of the range of the annual landings lost to depredation vary considerably. At the high end, three interviewees estimated that up to 60% of their annual catch is lost to whales. At the other end of the spectrum, an estimate as low as 5% was given. Figure 2-1 shows graphically the individual estimates of percentage of catch depredated for interviewees who provided an answer to that question. An average was calculated by summing the mean of each estimated range and the point estimates and dividing by the number of respondents. The average estimate thus calculated was 31%. The median of these estimates was 27%. So, from this very limited survey it appears that the perception of owners and captains is that they lose about 30% of their annual catch to whales.

Figure 2-1. Estimated Annual Percentage of Catch Depredated in the Hawaii-based Longline Fishery



There are not currently any vessels in Hawaii that limit fishing to shallow-sets because of the limited number of sets permitted, thus it was not possible to separate the depredation rate for the shallow-set fishery from that of the deep-set fishery. It was clear from the interviews that the shallow-set lines are not hit as frequently by the whales, and depredation in that sector of the fishery was much less of a problem. Swordfish fishing grounds are in cooler water about 800-1,000 miles north of Hawaii, in areas that captains believe whales are less likely to be found.

Assuming the estimate of the quantity of fish lost is reasonable, we should be able to make a “back-of-the-envelope” estimate of the minimum depredating whale population by the amount of fish consumed and the amount of fish required to sustain a healthy whale. Let’s assume that total annual Hawaii longline landings are 25 million pounds, but 5 million pounds of that is sharks, swordfish and incidental catch in more northern latitudes where depredation is not a significant problem. That leaves 20 million pounds of tuna and incidental catch in more southern latitudes where depredation losses were 30%. The total amount of hooked fish would have been 28,571,429 pounds, giving roughly 8.57 million pounds depredated.

For simplicity, let’s assume that FKW was the only species responsible for the depredation. If an adult male FKW weighs a maximum of about 1,500 pounds, let’s assume the average weight of a depredating whale is 1,000 pounds, assuming females and juveniles engage in the activity. Trites et. al. (1997) estimated the daily rations of large baleen whales at 1.1% of body weight and that of small dolphins at 4.5%, so a FKW, falling somewhere between those extremes might have a daily ration of 3% of body weight. If so, over the course of a year, the average whale would consume 10,950 pounds of fish. Dividing the annual amount of hooked catch depredated by the annual FKW ration yields a total of about 783 whales. This number of FKW could be sustained wholly on longline depredated catch. It is most unlikely that any FKW subsists wholly on longline depredation; more likely, the depredated catch represents a food subsidy to a larger number of whales. The largest unknown in this scenario of course is the FKW’s share of the depredation. Presumably some portion of the depredation is done by pilot whales or perhaps other species as well. Given the great disparity in size between FKW and pilot whales, it should be relatively easy to distinguish between those two species. Eight of nine respondents who answered the question do you see the whales when they depredate your catch answered affirmatively. Unfortunately, information regarding the size of the whales observed was not collected. Several interviewees suggested that observers record numbers and species of whales seen, and other interviewees suggested adding space for this information on the logbook form. Several interviewees who were familiar with the population estimates for the FKW thought that the population surveys were being done in the wrong places and the resulting numbers were too low. The whales are where the fish are, which is where the fishing effort is. One respondent thought that random transects across the ocean for FKW were like "looking for tilapia in a parking lot."

Some of the interviews touched on the respondent's impression of long-term trends in depredation. Several respondents believe interactions with FKWs are increasing. One captain said that of the 13 sets he makes per trip, three to four are lost to depredation, while in his previous experience only one to two sets per trip were lost to depredation. Other interviewees did not believe the whale depredation was increasing and one said it has been a problem for decades. A captain who regularly makes 15 sets per trip and loses two or three of these sets to depredation believes some boats have more problems with depredation than others, but does not think the problem is getting worse overall. Another captain, who reports depredation of 50% of his catch, says that the whales will eat all the catch on half of his sets, but that every set usually has some loss. Sometimes the whales eat only a few fish, but the majority of depredation events take the entire set, and only heads are hauled in. The worst depredation experience relayed during the interview process was when a captain pulled up 220-230 fish heads near Palmyra Island, a set that would have been his best of the year. After that, his next 11 sets were depredated.

This page is intentionally left blank.

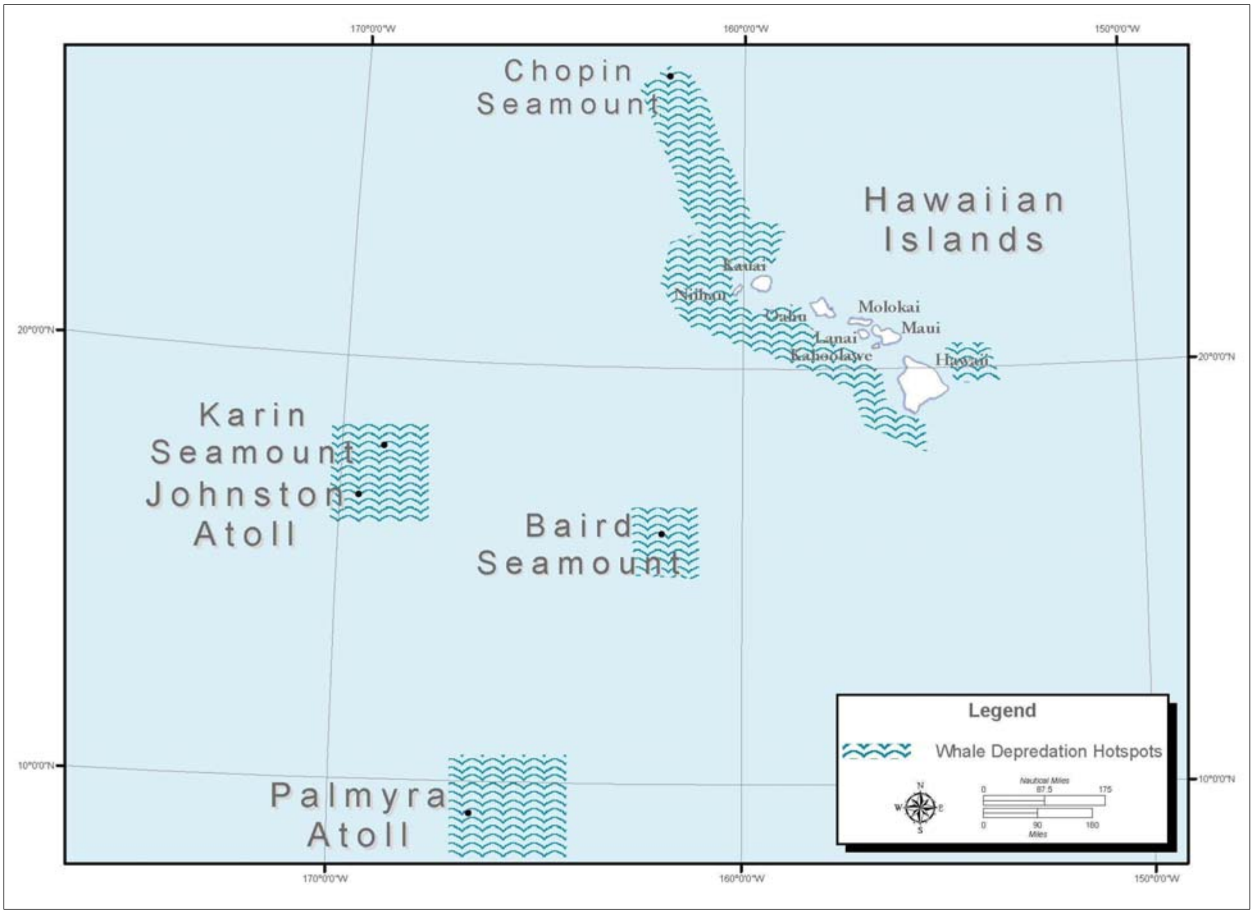
3.0 DEPREDATION HOTSPOTS

There was no agreement among the interviewed captains about the locations of whale concentrations, and in fact there were some inconsistencies and contradictions. Nevertheless, captains generally agreed that whales are not a problem north of Hawaii. The following represent the various opinions offered:

- Depredation is worse to the south and north of Kauai, and south of the Big Island.
- High concentrations of whales southwest of Oahu, east of Hilo, and anyplace to the south of the Hawaiian Islands.
- The greatest concentration of whales is near Palmyra Island and west to 168°, not north or northwest of the Hawaiian Islands.
- Palmyra is the worst area, and people no longer fish there.
- Skalpin Island [unable to locate on a map] near Johnston Island is an area of concentration.
- Musicians Range.
- East of the Big Island and near Maui.
- Baird Sea Mount, Karin Sea Mount, West Mount and JFM.
- The area west and southwest of Oahu, not so much to the east.
- Northwest and east of the islands, but mostly to the southwest.
- Whales are not usually present in waters below 67-68°F.

The hotspots suggested by interviewees are mapped on Figure 3-1.

Figure 3-1. Potential Depredation Hotspots



4.0 SEASONAL DEPREDATION

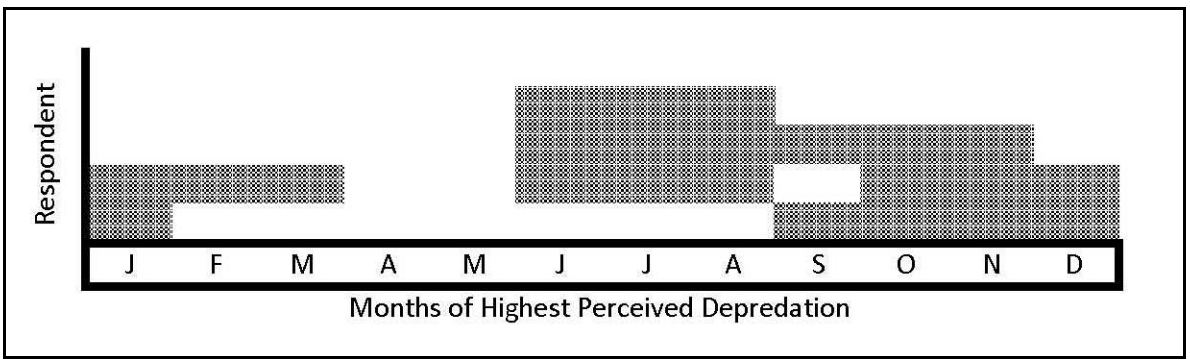
Interviewees were not consistent about seasonal fluctuations in whale depredation. Fifty percent of those who offered an opinion said there was no seasonal pattern. The following estimates of the months of maximal depredation were received from those who thought there was seasonality:

- June and July;
- Summer and fall (assumed to mean June through November);
- October through March worst, but summer also; and
- September through January.

A plot of these data is shown on Figure 4-1. The most frequently mentioned months were October and November and the summer months. The only months not mentioned by anyone were April and May. February and March were mentioned by only one respondent. This very limited amount of data suggests that depredation rates are highest from June through December and taper off from December through March to their lowest values in April and May.

Two respondents thought that depredation rates varied throughout the month rather than annually, with more depredations happening when skies are clear and the moon is bright.

Figure 4-1. Months of Highest Perceived Depredation Rates in the Hawaii-based Longline Fishery



This page is intentionally left blank.

5.0 CETACEAN AVOIDANCE METHODS

Fisherman face depredation around the world; and many methods of cetacean depredation avoidance are used with varying amounts of success. In Taiwan, tuna and swordfish longline captains report that the majority of depredation occurs when hauling. The methods that have been used to prevent depredation include harpooning, hanging cetacean parts on the longline and making noise with metal pipes; all have had very limited effectiveness (Donoghue et al. 2002).

Off the coast of Georgia, longline captains face killer and sperm whale depredation in the Patagonian toothfish fishery. Hotspots of depredation events were noted in this fishery, and avoidance methods tried included seal bombs, tying magnets to the longline, interrupting and delaying hauls when cetaceans were present, and offal retention when hauling (Donoghue et al. 2002). Adequate research has not been done to determine the effectiveness of any of the methods used in the Patagonian toothfish fishery.

Other methods that have been used to deter birds, turtles and mammal depredation include acoustic deterrents, vessel noise reductions, animal predation sounds, pyrotechnics (including seal bombs), dyed bait, novel bait species, thawed bait, alternative methods of offal discharge, decreased soak time, weighted lines, decoy deterrents, vessel chasing, break-away lines, and line shooters (Werner et al. 2006). While not all are designed for use in the longline fishery, these methods may have the potential for effective cetacean mitigation with further research. Some methods, such as quick-release metal wire or mesh bags that surround the bait line after a fish is captured, are not operationally or financially feasible in the longline fishery.

Previous studies have suggested fishing at depths greater than 400 m to reduce depredation; however, this would not prevent the whales from eating the catch as it is hauled in (Donoghue et al. 2002). Also, pilot whales have been observed diving to depths of 600-800 m for feeding, so deeper fishing depths are unlikely to mitigate depredation (McPherson et al. 2003).

In the Hawaii-based fishery, interviewed captains were unsure of what attracts the whales to their vessels. Some believe it might be the engine, hydraulics or shaft noise, while others believe the smell of the fish or the boat itself attracts the cetaceans. Others think that the bottom sounder is the trigger attracting the whales. When numerous boats are in the same vicinity, it seems that they are easier for the whales to find.

One of the captains interviewed once turned off all the lights on the vessel and was able to get away from the whales. The same captain also said that he sometimes uses a fish-finder during a set, but that it doesn't seem to affect the whales.

Respondents were nearly unanimous in their response to the presence of whales (the sole exception was a captain who had only been fishing for about three months). If whales are sighted before the set begins, the captain will move away. On rare occasions this movement might be as short as a few hours. Usually, to successfully elude the whales, the movement will require a full 24 hours or more. Responses included durations of one to one and a half days and one to two days. If whales are sighted during the set, the common strategy is to cut the line, move and set the remainder at some distance away. One of the captains interviewed stated that when he spots whales while steaming, he will change his course by 45° and try to move at least 20-25 miles from the whales' track.

Various tactics for whale avoidance have been tried by the interviewed captains without success. Some of these unsuccessful attempts include:

- Turning off the vessel's lights,
- Chemical deterrents,
- Shooting flare guns under water,
- Seal bombs, and
- Aiming powerful sonar at the whales.

All of the captains interviewed agreed that there seemed to be some luck involved in eluding the whales, and that there was no way of knowing if the whales were going to hit. No successful methods of avoiding or deterring the whales have been found by the interviewed captains.

6.0 CAPTAINS' SUGGESTIONS

One of the interviewed captains reported that Japanese longline vessels fish in the areas with whales and do not seem to have problems, so further research may include interviews with the Japanese captains to ascertain if they have better methods of avoidance. Some think that Japanese boats use a long metal leader that reduces their problems with depredation, but one Hawaii-based captain said he uses a wire leader for his bait and it is not a deterrent. Others have heard that the Japanese use a noise-maker to scare away whales within a 20-30 mile area.

Many of the interviewed captains said that the Vietnamese fishermen put nails in the bait so that the whales will sense the metal and not eat the bait. One of the captains interviewed has tried this method with some success, but it added to the set time too much for him to do it regularly. Captains suggest that more research be conducted on nails in bait as a form of cetacean deterrence. Some respondents suggested that dropping a metal wire alongside the bait that would wrap around the catch as it twisted on the line might be a deterrent. A variation of that would be to use a metal wire strung with beads.

It has been reported that some boats shoot the whales in an effort to save their catch, although none of the captains interviewed have done so. Other fishermen have suggested catching the whales using a net as a possible solution to the depredation problem.

Many fishermen suggested that observers record nearby species whenever possible. One captain suggested following up with scientists, such as those at Sea Life Park, to determine what might scare the whales. He also said that a powerful sonar device would help scare the whales away. Putting a noise source on the floats might also be a deterrent, but he questioned the cost-effectiveness of these two options.

Other suggestions included putting shark repellant on the bait, feeding the whales birth control pills, shooting them, and experimenting with alternative baits.

The captains were in agreement that the whales are very intelligent and that attempts at preventing depredation were futile. The whales would likely get used to any single deterrent and it's likely that a series of deterrents would be needed to be successful. The captains also agreed that further research is needed to determine an effective method of cetacean avoidance.

This page is intentionally left blank.

7.0 CURRENT RESEARCH ON DEPREDATION MITIGATION

Research on cetacean depredation within the Hawaii fishery is on the rise. Currently, mitigation measures have only short-term success, if they are successful at all. More research on vessels reporting fewer interactions with cetaceans should be done to analyze how they differ from those facing more frequent and costly depredation (Gilman et al. 2006).

The NMFS Pacific Islands Fisheries Science Center website reveals a large number of relevant ongoing research projects just by this one agency. Additionally, a recent study at the University of Hawaii, Department of Zoology tested the SaveWave Longline Saver acoustic deterrent on a trained FKW. The device proved to disrupt the echolocation capabilities of the FKW, but further study is required to determine whether the FKWs would acclimate to the sound or if the SaveWave would indeed disrupt the echolocation required to adequately find longlines (Mooney et al. 2009).

Depredation occurring outside of the Hawaii longline fishery is a problem as well. Mitigation measures researched for use in the Coral Sea, off the northeast coast of Australia, include acoustic depredation mitigation methods. Suggested approaches currently being researched include acoustic disguise of vessels and fish-finding devices, modification and conditioning of cetacean behavior, and chemical modification of cetacean behavior (McPherson et al. 2003). Pingers, acoustic deterrent devices that can be hung on a longline, have proven to deter porpoises in California fisheries (Reeves et al. 2001), thereby reducing bycatch. Further research on cetacean response to pingers is underway in various locations. It’s likely that maximal deterrence would be achieved by using impulsive pings of ultrasonic range between 20 and 100 KHz. Long intervals and variation would be required to preclude habituation (Reeves et al. 2001).

This page is intentionally left blank.

8.0 ECONOMIC COST OF CETACEAN DEPREDATION

While depredation in longline fisheries is a worldwide problem, few attempts have been made at quantifying the problem. Existing research suggests that some fisheries are experiencing substantial adverse economic effects as a result of depredation.

The longline fishery is the largest of Hawaii's commercial fisheries, and in 2006 generated revenues of $54.4 million. The average price per pound for the longline fishery landings was $2.62. In 2006, bigeye tuna accounted for $34.2 million in revenue, with yellowfin being the next largest source of revenue at $7.9 million. Swordfish generated $5.2 million in revenue. From 2005 to 2006, total tuna landings decreased by 9% and total swordfish landings decreased by 27%, likely a result of the short duration of the fishery season (WPRMFC 2007).

Sometimes the whales eat only two or three fish, but more frequently they eat the whole catch and only heads are pulled up. When this happens the economic loses can total more than $2,000 for a single set.

Longline captains interviewed reported a wide range of estimated whale incidents per trip, as well as a wide range of estimated annual percentages of catch lost to depredation. The mean and median of the estimates of depredated catch were about 30%. For cost analysis purposes, a 30% loss is assumed.

Longline-whale interactions also damage fishing gear, cause lost fishing time and increase operating costs of vessels (Gilman et al. 2006). The annual cost of repair of damaged gear is difficult to estimate, because not all interactions are reported. Gear is included in the variable costs summarized in Table 8-1. The annual cost of time lost by forced relocation of a vessel is also difficult to estimate, but must be considered as a loss to total annual revenue.

Table 8-1: Average Annual Variable Costs for Swordfish and Tuna Vessels in 2000.

Item	*Swordfish Vessel Average Cost (US$)*	*Tuna Vessel Average Cost (US$)*
Fuel	60,933	40,342
Oil	2,016	1,860
Ice	10,857	13,692
Bait	47,810	32,898
Lightsticks	28,058	0
Provisions	16,044	13,525
Gear Resupply	16,462	12,782
Daily Maintenance	10,970	15,401
Fish Processing	365	1,465
Communications	14,900	26,750
Sales	34,518	45,573
Total	242,933	204,288
Source: O'Malley and Pooley 2001		

Annual costs to longline fishing vessels can be classified as fixed or variable. Annual repairs, while somewhat dependent upon the number of trips, are considered fixed for the purpose of this study because they are likely to occur annually regardless of the catch volume. Capital costs, including the purchase price of the boat and its upgrades for longline fishing, are also considered fixed for the purpose of evaluating the affects of whale interactions and decreased catch. Variable trip costs are incurred on a trip basis, and are proportionate to the number of days a vessel spends at sea. Variable trip costs include fuel, oil, bait, daily maintenance and provisions. A complete list can be found in Table 8.1. Daily maintenance includes minor engine repair, paint, and replacement of wire and line (O'Malley and Pooley 2001).

Variable trip costs are most likely to be affected by longline-whale interactions, and must be evaluated to quantify the cost of whale depredation to longline fisherman.

In 2000, labor was the most costly expense to longline vessels, and fuel was the most costly variable expense for large vessels. Table 8-1 shows the average annual variable costs for swordfish and tuna vessels in 2000.

In 2006, 127 Hawaii-based longline vessels took a total of 1,399 trips, 1,339 tuna trips and 60 swordfish trips. Dividing the number of trips by the number of longline vessels leads to an average of 11 trips per vessel, per year. Interviewed captains reported varying durations of trips, with an average being 21 days for tuna vessels and 30 days for swordfish, and an average of 10 sets per trip for tuna and 17 sets per trip for swordfish (Gilman et al. 2007). The annual variable cost per day at sea is estimated based on the annual variable cost total divided by the average number of days spent at sea. The tuna-targeting vessels were at sea for 231 days, on average. Annual variable cost for a tuna vessel is estimated at $204,288. The variable cost of one day at sea can be estimated at $884.36.

Swordfish-targeting trips occurred much less frequently. If a captain were to target swordfish exclusively, 11 trips of 30 days would mean 330 days at sea. The annual variable cost for a swordfish vessel is estimated at $242,933, which would amount to $736.16 per day.

When whales are spotted and a captain is forced to relocate, traveling an average of 24 hours before setting again, an additional 24 hours worth of expenses are incurred by the vessel in addition to the lost potential income of the set that did not occur. The total cost to the vessel includes labor and other variable costs.

Longline tuna landings in 2006 totaled 12,628,000 pounds, and swordfish landings totaled 2,590,000 pounds. When divided by the number of trips, it can be estimated that each tuna trip landed 9,431 pounds. The average tuna-targeting trip consists of 10 sets, which puts the average set landing at 943 pounds of tuna. Using total 2006 swordfish landings of 2,590,000 pounds, it can be estimated that each of the 60 swordfish-targeting trips landed an average of 43,167 pounds. The average swordfish-targeting trip consists of 17 sets, which makes the average set landing equal to 2,539 pounds of swordfish.

When a tuna-targeting captain chooses not to set in an area where whales have been spotted and spends another 24 hours relocating, the vessel incurs an additional $884.36 in expenses. When a tuna set is depredated by whales, it loses an estimated 943 pounds of tuna. The price per pound for tuna in 2006 was $3.02. After auction fees of 10%, the revenue per pound is actually $2.72. Thus, when a set is depredated by whales, on average, $2,565 in revenue is lost.

When a swordfish-targeting captain chooses not to set where whales have been spotted and spends another 24 hours relocating, the vessel incurs an additional $736.16 in expenses. When a set is depredated by whales, it loses an estimated 2,539 pounds of swordfish. The swordfish price per pound in 2006 was $2.01. After auction fees of 10%, actual vessel revenue per pound was $1.81. Thus, when a set is depredated by whales, an average of $4,596 in revenue is lost.

Making some coarse assumptions we can calculate the potential annual losses to the fleet. Assuming a tuna trip consists of 10 sets and three sets are depredated. As the captains almost always see the whales, let's say they have to move twice to avoid the whales, lengthening each trip by two days. The value of the catch lost would be three times $2,565 and the extra days at sea would cost two times $884. For the 1,339 annual trips this would amount to $12.7 million. Assuming depredation is less a problem for swordfish vessels, we can assume they lose one set per trip ($4,596) and they move once ($736) each trip for a total loss of $5,332 per trip, or $319,920 over the 60 trips in the subject year. Together these losses sum to about $13 million per year for the fleet.

Taking a different approach, we can check this by simply assuming a 30% reduction of the fleet's annual catch due to depredation. If the annual value of the 2006 longline landings was $54.4 million, then the value in the absence of depredation would have been $77.7 million, a $23.3 million difference. This large difference in the projected annual losses to the fleet, $13 million vs. $23 million, is a reflection of the crudeness of the assumptions used. In particular, it is not known if depredated sets or sets delayed or interrupted by the presence of whales are made up on the trip, or are foregone. The current survey was aimed at learning what the captains and owners did or thought could be done to deter depredation. It was not designed to generate quantitative economic data. If this is of further interest, a subsequent survey could be designed to answer basic questions such as the number of sets delayed but still made, the number of sets not made because of a concern for the quality of boated fish, lack of ice, lack of bait, etc.

This page is intentionally left blank.

9.0 CONCLUSIONS AND RECOMMENDATIONS

Depredation negatively affects the fishing industry and, despite the food subsidy, may negatively affect the whale populations as well. Although, according to the interviewees, it is extremely rare that a whale is hooked, they sometimes do get tangled in the lines, and this may lead to injury and/or mortality. The availability of bait and hooked catch has altered the whales' foraging strategy. While it is unknown what proportion of the whales' annual ration is being provided by depredation, a crude calculation indicates that the estimated losses could wholly support a FKW population of nearly 800 whales. This is significantly more FKWs than scientific surveys have reported around Hawaii. A significant unknown in this calculation is the proportion of the observed depredation being done by FKWs as opposed to other species.

Depredation of the bait and catch of Hawaii-based longline vessels is and likely has been for decades a serious economic hardship on longline fishermen. The estimates of annual losses to depredation vary widely, but the mean and median of the estimates were both about 30%. Very crude calculations put the annual economic loss to the Hawaii-based longline fleet in the range of $13 to $23 million.

Some respondents believe that depredation rates are increasing; some don't. If depredation is increasing, it could be due to increasing whale populations or the wider spread of a learned behavior. While depredation may occur during any phase of fishing: the set, the soak or the haul, the haul may be most susceptible to depredation. One respondent likened it to a "rotary sushi restaurant." When depredation occurs, generally every hooked fish is eaten, with only heads and gills remaining. Ahi are preferred by the whales, but other incidental catch is also eaten, with only sharks being consistently avoided by the whales.

Depredation is much more of a problem in warmer waters where tuna-targeting vessels fish than in colder, more northern waters where swordfish-targeting vessels fish. There was some indication that areas nearer land and over seamounts may have higher incidences of depredation.

Half of the respondents did not believe there was seasonality in the depredation rate, while others thought depredation was highest in the second half of the year. Several believed moon phase to be more important than annual seasonality.

Hawaii-based longline fishermen have tried, without notable success, to reduce their losses from whale depredation with various avoidance or deterrent techniques, including "stealth" maneuvers such as turning off all lights to get away from the whales and turning off the engine to wait for the whales to leave the area, as well as chemical, acoustic, pyrotechnic, and metallic deterrents. The unanimous conclusion of the owners and captains interviewed is that the whales are too smart to be fooled and will adapt to any deterrent short of physical harm.

Recommendations for further work include the following:

1. Conduct whale population surveys in areas where they are most expected to be seen, i.e., where prey are concentrated.
2. Have NMFS observers record numbers and species of whales seen when lines are depredated, and the number of fish depredated off the line.
3. Add a space on the longline logbook forms to record the number and species of whales seen.
4. Undertake research to understand the techniques of other fleets if they are successful.
5. Experiment with the concept of wires that deploy around the catch and give a metallic signal to the whales.
6. Consult with cetacean behavioral experts to understand what would scare a whale.

This page is intentionally left blank.

10.0 REFERENCES

Baird, R. and Gorgone, A. 2005. False Killer Whale Dorsal Fin Disfigurements as a Possible Indicator of Long-Line Fishery Interactions in Hawaiian Waters. *Pacific Science 59*(4):593-601.

Carretta, J.V., K.A. Forney, M.S. Lowry, J. Barlow, J. Baker, D. Johnston, B. Hanson and M.M. Muto. 2008. Draft. U.S. Pacific Marine Mammal Stock Assessments: 2008. U.S. Department of Commerce, NOAA, NMFS-SWFSC.

Clemens, A. 2006. Annual Report on Seabird Interactions and Mitigation Efforts in the Hawaii Longline Fishery for Calendar Year 2005.

Forney, K.A. and D.R. Kobayashi. 2007. Updated Estimates of Mortality and Injury of Cetaceans in the Hawaii-Based Longline Fishery, 1994-2005. NOAA Technical Memorandum, NMFS, SWFSC. November.

Donoghue, M., R. Reeves and G. Stone. 2002. Report of the Workshop on Interactions Between Cetaceans and Longline Fisheries. Apia, Samoa. November.

Gliman, E., N. Brothers, G. McPherson and P. Dalzell. 2006. A Review of Cetacean Interactions with Longline Gear. *Journal of Cetacean Resource Management 8*(2):215–223.

Gilman, E., S. Clarke, N. Brothers, J. Alfaro-Shigueto, J. Mandelman, J. Mangel, S. Petersen, S. Piovano, N. Thomson, P. Dalzell, M. Donoso, M. Goren and T. Werner. 2007. Shark Depredation and Unwanted Bycatch in Pelagic Longline Fisheries: Industry Practices and Attitudes, and Shark Avoidance Strategies. Western Pacific Regional Fishery Management Council, Honolulu, USA.

McPherson, G., P. Turner, C. McPherson and D. Cato. 2003. Testing of Acoustic Tracking System for Toothed Whales Around Longline and Gillnet Fishing Gear, and Preliminary Trials of Depredation Mitigation Devices for Longline Fisheries. Project Report R02/0923. September.

Mooney, T., P. Nachtigall, A. Pacini and M. Breese. 2009. Acoustic Deterrents Reduce False Killer Whale (*Pseudorca crassidens*) Echolocation Abilities but Only So Much. Department of Zoology and Hawaii Institute of Marine Biology**,** University of Hawaii.

O’Malley, J. S. and Pooley. 2001. Economic and Operational Characteristics of the Hawaii-Based Longline Fleet in 2000. SOEST March.

Reeves, R., A. Read and G. Notarbartolo-di-Sciara. 2001. Report of the Workshop on Interactions between Dolphins and Fisheries in the Mediterranean: Evaluation of Mitigation Alternatives. Instituto Centrale per la Pecerca Applicata al Mare, Rome, May.

Trites, A.W., V. Christensen and D. Pauly. 1997. Competition Between Fisheries and Marine Mammals for Prey and Primary Production in the Pacific Ocean. *J. Northw. Atl. Fish. Sci. 22*:173-187.

U.S. Environmental Protection Agency (EPA). 2008. Letter from Goforth, K.M., Environmental Review Office, Re: Draft Supplemental Environmental Impact Statement (DSEIS) for Amendment 18 to the Fishery Management Plan, Pelagic Fisheries of the Western Pacific Region, Management Modifications for the Hawaii-based Shallow-set Longline Swordfish Fishery, Proposal to Remove Effort Limits, Eliminate the Set Certificate Program and Implement New Sea Turtle Interaction Caps (CEQ #20080320). September 26.

U.S. National Marine Fisheries Service (NMFS). 2001. Endangered Species Act Section 7 Consultation Biological Opinion: Authorization of Pelagic Fisheries under the Fishery Management Plan for the Pelagic Fisheries of the Western Pacific Region.

U.S. National Marine Fisheries Service, 2006. Administrative Report AR-PIR-04-06. Pacific Islands Regional Office, Honolulu, HI, USA.

U.S. National Marine Fisheries Service Pacific Island Regional Office (PIRO). 2007. Possible Mitigation Approaches to Reduce FKW Predation in Hawaii-based Longline Fishery. Marine Mammal Advisory Committee. Feb, 2007.

Werner, T., S. Kraus, A. Read and E. Zollett. 2006. Fishing Techniques to Reduce the Bycatch of Threatened Marine Animals. *Marine Technology Society Journal 40*(3). Fall.

Western Pacific Regional Fisheries Management Council (WPRFMC). 2007. Pelagic Fisheries of the Western Pacific Region 2006 Annual Data Report. June 30.

APPENDIX A
INTERVIEW QUESTIONS

This page is intentionally left blank.

Survey of Hawaii Longliners Regarding False Killer Whale Depredation

1. Is your bait or catch sometimes taken from the hook?
2. When does this happen – when setting, soaking, hauling?
3. How much bait, catch and gear do you lose because of this problem?
4. Does it happen more in certain locations or areas (hotspots)?
5. Does it happen more at certain times of the year?
6. Do you know if the lost fish is due to whales or sharks?
7. Are some types of fish more likely to be eaten off the line?
8. Do you see whales around the longline?
9. What do you do if you see whales while setting, soaking or hauling (e.g., move away before setting, delay hauling, etc.)?
10. Do boats tell each other when and where whales are present?
11. Do you ever try to scare the whales away? If so, how?
12. What do you do when a whale is hooked?
13. What type of hull does your boat have – steel, wood or fiberglass?
14. Do you use the echo sounder before, before, during or after setting the line?
15. What other electronics do you run?
16. What are the loudest noises from your boat?
17. How does the noise change during setting and hauling?
18. Has there been any attempt to reduce noise from your boat? If so, what was done?
19. What depth do you fish at?
20. What is your typical daily set schedule (what time set, what time haul)?
21. Do you dump fish heads or guts, non-market fish or old bait when whales are around?

This page is intentionally left blank.