

**Programmatic Environmental Assessment  
Elasmobranch Bycatch Reduction in Domestic and International  
Fisheries  
Pacific Islands Fisheries Science Center, Bycatch Reduction Program  
Honolulu, Hawaii**

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## Executive Summary

The purpose of this Environmental Assessment (EA) is for the National Marine Fisheries Service (NMFS) to consider the potential environmental impacts of specific elasmobranch (sharks, rays, skates) related research activities conducted by the Fisheries Biology and Stock Assessment Division (FBSAD) at the Pacific Islands Fisheries Science Center (PIFSC). This EA fulfills the requirements of the National Environmental Policy Act (NEPA) and the National Oceanic and Atmospheric Administration's (NOAA) Administrative Order NAO 216-6 to analyze the environmental impacts of a proposed federal action, categorized in this case as 'proposed research activities' related to one another in scope, as the basis of informed decision making.

The scope of the proposed research activities primarily involves obtaining scientific data and information related to reducing the incidental and unwanted capture of elasmobranches during commercial fisheries through the undertaking of specific research activities in captivity and in the field, thereby preventing the further population declines of pelagic shark species worldwide.

The research activities analyzed in this EA involve elasmobranch bycatch reduction in domestic and foreign longline fisheries conducted by PIFSC using primarily electropositive metals ( $E^+$ ).

Electropositive metals have a strong tendency to release electrons and generate large oxidation potentials when placed in sea water. It is thought that these metals perturb the electrosensory system in sharks and rays, causing the animals to exhibit aversion behaviors away from the electric field. Building on this work, FBSAD proposes to continue and expand the current program for identifying and testing the effectiveness of various actions for reducing the bycatch of elasmobranches in domestic and international fisheries and expand that program to further that goal.

These research activities include a series of experiments examining 1) the electrochemical properties of  $E^+$  metals and magnetic deterrents, 2) the effects of  $E^+$  metal and magnetic materials on aversion behavior in different shark species, and 3) the feasibility and effects of shark capture rates when placing these metals and other repellents on commercial fishing gear. Research activities include laboratory behavioral experiments, field behavioral experiments, and laboratory experiments examining the physical and chemical properties of potential repellents.

This analysis presents information on the anticipated effects to the environment resulting from the proposed research activities. No impacts would occur to species protected under the Endangered Species Act.

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## Abbreviations and Acronyms

CFR .....	Code of Federal Regulations
CPUE .....	Catch Per Unit Effort
EEZ .....	Exclusive Economic Zone
EFH .....	Essential Fish Habitat
EIS .....	Environmental Impact Statement
ESA .....	Endangered Species Act
FAO .....	Food and Agriculture Organization of the United Nations
FMP .....	Fishery Management Plan
FONSI .....	Finding of No Significant Impact
FR .....	Federal Register
FSBAD .....	Fisheries Biology and Stock Assessment Center
HAPC .....	Habitat Area of Particular Concern
IUCN .....	International Union for Conservation of Nature and Natural Resources
MBTA .....	Migratory Bird Treaty Act
MMPA .....	Marine Mammal Protection Act
MSA .....	Magnuson-Stevens Act
NEPA .....	National Environmental Policy Act
NMFS .....	National Marine Fisheries Service
NOAA .....	National Oceanographic and Atmospheric Administration
NWHI .....	Northwestern Hawaiian Islands
PEA .....	Programmatic Environmental Assessment
PIFSC .....	Pacific Islands Fisheries Science Center (NMFS)
PIRO .....	Pacific Islands Regional Office (NMFS)
USFWS .....	U.S. Fish and Wildlife Service
WPRFMC .....	Western Pacific Regional Fishery Management Council

# 1 Chapter 1: Purpose and Need

## 1.1 Summary of the Proposed Action

The Pacific Islands Science Research Center (PIFSC) Fish Biology and Stock Assessment Division (FBSAD) has as one of its goals to identify and test the effectiveness of strategies and techniques for reducing fisheries bycatch. This analysis, conducted in compliance with the National Environmental Policy Act (NEPA), focuses on the Division's fishery bycatch research program to reduce incidental bycatch of elasmobranch (sharks, rays, and skates) in domestic and foreign longline fisheries. This research program focuses on evaluating strategies to reduce the incidental capture of primarily sharks, and secondarily rays and skates, in commercial fishing gear while preserving the catch rates of target fish species using repellents that influence the electrochemical systems of elasmobranches. Per the Magnuson-Stevens Act National Standard 9, the National Standard regulating bycatch in fisheries, (50 CFR 600.350), the first priority for reducing bycatch should be to avoid catching bycatch species where possible. To the extent that bycatch cannot be avoided, reducing bycatch is mandatory to the extent practicable while mortality of bycatch should be minimized. NMFS, rather than the Fishery Management Councils, has the responsibility to implement bycatch reduction management measures.

Understanding the sensory and behavioral ecology of sharks, rays, and skates is an important component to developing strategies aimed at reducing shark and ray unwanted and incidental capture in longline and other fisheries. Feeding behavior of elasmobranches involves the processing of various sensory systems, including their visual, chemosensory, auditory, lateral line (provides the ability to sense water movement and pressure), and electrosensory (provides the ability to sense extremely weak electrical fields). Experiments examining the use of sensory cues that influence feeding behavior are critical in the design of effective strategies for reducing unwanted bycatch of sharks, skates, and rays in fisheries.

One promising technique exploits the capability of elasmobranches to perceive electromagnetic fields. Recent experiments conducted by PIFSC to date show that Galapagos sharks (*Carcharhinus galapagensis*) are less likely to bite bait in the presence of large electric fields due to the presence of a piece of electropositive ( $E^+$ ) metal (Stoner and Kaimmer 2008, Wang et al. in prep.).

Electropositive metals have a strong tendency to release electrons and generate large oxidation potentials when placed in sea water. It is thought that these metals perturb the electrosensory system in sharks and rays, causing the animals to exhibit aversion behaviors away from the electric field. Building on this work, FBSAD proposes to continue and expand the current program for identifying and testing the effectiveness of various actions for reducing the bycatch of elasmobranches in domestic and international fisheries and expand that program to further that goal. These tests include a series of experiments examining 1) the electrochemical properties of  $E^+$  metals and magnetic deterrents, 2) the effects of  $E^+$  metal and magnetic materials on aversion behavior in

different shark species, and 3) the feasibility and effects of shark capture rates when placing these metals and other repellents on fishing gear. Research activities include laboratory behavioral experiments, field behavioral experiments, and laboratory experiments examining the physical and chemical properties of potential repellents.

The current program includes laboratory studies characterizing shark responses to electromagnetic fields created by electropositive metals that create an electric field when exposed to sea water. In addition to the laboratory studies, field studies with free-swimming sharks examine the effectiveness of repellents under more natural conditions. Also, trials on a NOAA research vessel examine the practicality of deploying gear modified with test repellents.

The FBSAD proposes to continue the current program and to expand that program to include experiments of potential repellants in fishing gear deployed by domestic and foreign vessels and on NOAA research vessels using FBSAD protocols and supervision. In addition, laboratory and field behavioral experiments would test responses of different elasmobranch species to E<sup>+</sup> metals and other repellents, the habituation of the aversive response to the repellents, and the effects of inter- and intra-specific competition on the aversion to repellents. Laboratory experiments to examine and characterize the thresholds for detecting repellent cues, the thresholds for producing behavioral responses, and for understanding the underlying mechanisms of desensitization would also be conducted to determine the optimum electromagnetic field necessary to cause the aversion response. All animal handling procedures would follow the Institutional Animal Care and Use Committee (IACUC) protocols specific to the collaborating laboratories, which govern appropriate care, use and/or husbandry of captive animals.

## **1.2 Purpose of Action**

The purpose of this research is to identify strategies to reduce the incidental capture of primarily sharks, and secondarily rays and skates, in commercial fishing gear while preserving the catch rates of target fish species using repellents that influence the electrochemical systems of elasmobranches. Such strategies enable compliance with Magnuson-Stevens Act National Standard 9, the National Standard regulating bycatch in fisheries, (50 CFR 600.350), which states that the first priority for reducing bycatch should be to avoid catching bycatch species where possible.

## **1.3 Need for Action**

This summary of the need for research regarding reducing shark bycatch in domestic and foreign longline fisheries is primarily based on Gilman et al. 2007, which summarized the known literature regarding shark bycatch in longline fisheries worldwide, with additional sources cited.

The main threats to shark populations include various fishing activities and habitat degradation and loss. The taxa at the highest risk include commercially-exploited species of deepwater sharks and coastal and freshwater sharks whose habitats overlap with fishing areas. A lack of both fundamental biological information and fishery-dependent data for most shark species means that

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there is a high degree of uncertainty in the status of these species. The biology of sharks, rays, and skates is the least understood of all the major marine vertebrate groups, and detailed information on the life history and reproductive dynamics is available for only a few species important for directed fisheries. The lack of reliable and detailed data is not sufficient to enable management of shark populations on a sustainable basis.

The primary shark species caught in pelagic longline fisheries is the blue shark (*Prionace glauca*). Data suggest (Clarke et al. 2006) that blue sharks are being captured at levels close to or possibly exceeding maximum sustained yield. Clarke et al. (2006) found that shark biomass in the fin trade is three to four times higher than shark catch figures reported by the Food and Agriculture Organization of the United Nations (FAO) (the sole existing global database). Since most sharks caught as bycatch are retrieved alive during longline fishing and nontarget sharks can make up a large proportion of the actual catch in longline fisheries targeting especially swordfish, identifying means to minimize that bycatch is critical to maintaining not only revenue for the fishery, but also maintaining the ecological balance of our oceans (Gilman et al. 2007).

The incidental capture of sharks in longline fisheries worldwide is estimated at over 300,000 metric tons annually (Bonfil 1994). In some fisheries, such as the Hawaii-based longline fisheries, shark species such as blue sharks make up 33% of the total catch (Walsh and Keibler 2001). Some of the sharks are released alive, some are landed and sometimes finned, and some are discarded dead. Reports suggest that certain shark populations, such as scalloped hammerhead sharks (*Sphyrna lewini*), oceanic whitetip sharks (*Carcharhinus longimanus*), and tiger sharks (*Galeocerdo cuvier*), have decreased between 60% and 99% in some areas (Baum et al. 2003, Baum et al. 2004).

In longline fisheries where target species do not include sharks, sharks may comprise a large proportion of total catch as bycatch (Gilman et al. 2007, Bonfil 1994). For instance, sharks comprise >25% of the total catch in the Australia longline tuna and billfish fishery and Fiji longline tuna fishery. Sharks comprised 50% of the catch of the Hawaii-based longline swordfish fishery prior to a prohibition on the use of squid for bait. Now that the fishery uses mackerel bait, sharks comprise 32% of the catch. Blue sharks comprise the largest proportion of shark species caught in all twelve of the fisheries included in this study, ranging from 47% to 92% of shark catch in fisheries where this information is available. For fisheries where shark catch rates are available, these catch rates range from 0.7 to 17 sharks per 1000 hooks (from Gilman et al. 2007), although it must be recognized that this document evaluates both tuna (deep-set) and swordfish (shallow-set) longline fisheries.

Bycatch raises ecological concerns, as some bycatch species of marine mammals, seabirds, sea turtles, sharks, and other fish species are particularly sensitive to increased mortality above natural levels because of their life history traits, including being long-lived, having delayed maturity, and having low reproductive rates (Musick et al. 2000; Bonfil 2002; Gilman et al. 2005, Gilman et al. 2007). High levels of bycatch at unsustainable levels can alter marine biodiversity by removing large proportions of populations of top predators, such as sharks, which have limited biological



capability to recover. High levels of bycatch can also alter foraging habits of scavenger and predator species that learn to take advantage of high levels of discards from fishing vessels (Myers et al. 2007).

Discarded bycatch is a social issue relating to waste of meat that could be used for feeding humans (Gilman et al. 2007). Alverson et al. (1994) estimated that, in 1994, about 27 million metric tons (27% of the world catch), ranging between 17.9 and 39.5 million tons of fish per year, were discarded at sea. FAO (1999) estimated that 1998 discards of fish in global marine fisheries totaled 20 million metric tons. Also, the increases in shark finning, with its resultant mortality, is driven by rapid economic growth in China, and the fins are being sourced globally through market channels concentrated in a few Asian trading centers, with Hong Kong being the largest shark fin center. The shark biomass represented by the global fin trade is estimated at between 1.2 and 2.3 million tons per year, based on a market study (Clarke et al. 2006). High demand for fins in Asian markets means that few sharks caught in pelagic longline fisheries where finning is not prohibited are released alive. Legislation prohibiting the removal of shark fins and discarding the remainder of the shark at sea in pelagic longline fisheries has been passed in Australia, Italy, South Africa, and the United States. In Australia, a rule that prohibits possession, carrying, and landing of shark fins unless attached to the trunk of the shark has likely substantially reduced shark fishing mortality, as now about 75% of caught shark are released alive. As many as 76% and 64% of caught sharks were finned in the Hawaii tuna and swordfish fisheries, respectively, prior to the finning prohibition. Since the prohibition, in 2006, over 90% of all sharks caught were released alive. However, large-scale finning is still occurring in many global longline fisheries, and few international fisheries have implemented measures to manage shark catch levels (Gilman et al. 2007).

In some pelagic longline fisheries, especially in fleets that have restrictions on shark finning, unwanted shark bycatch and depredation by sharks on target fish caught on gear pose substantial ecological, economic, and social problems. In fisheries with high levels of elasmobranch bycatch, the costs from shark interactions may exceed benefits from revenue from captured sharks, due to (Gilman et al. 2007):

- Depredation;
- Damage and loss of gear;
- Reduced catch of marketable species due to baited hooks being occupied or removed by sharks;
- Risk of crew injury from handling caught sharks and being hit by weights when branch lines containing sharks break during gear retrieval; and
- Reduced fishing efficiency due to the time required to remove sharks from gear for discarding and to repair and replace gear.

Per the Magnuson-Stevens Act National Standard 9, the National Standard regulating bycatch in fisheries, (50 CFR 600.350), the first priority for reducing bycatch should be to avoid catching

bycatch species where possible, and, to the extent that bycatch cannot be avoided, minimizing mortality of such bycatch; reducing bycatch is mandatory to the extent practicable; and NMFS, rather than the Fishery Management Councils, has the responsibility to implement bycatch reduction management measures.

Therefore, research on the methods to reduce bycatch of elasmobranches, with an emphasis on sharks, is critical for sustainable fishery management, both biologically and economically, and promotes compliance with National Standard 9.

## **1.4 Scope of Analysis of this EA**

### **1.4.1 Temporal Scope**

This programmatic Environmental Assessment (PEA) provides the detailed descriptions of ongoing and proposed National Marine Fisheries Service research programs conducted by the Pacific Islands Fisheries Science Center, (PIFSC) Fish Biology and Stock Assessment Division (FBSAD) and for continuing and possibly expanding the program for reducing bycatch of elasmobranches, which include sharks, rays, and skates. Elasmobranches are caught in many fisheries, including demersal (bottom) longline, drift gillnet, and purse seine fisheries. Any techniques found promising during PIFSC research, which primarily uses longline fishing techniques, may be applied to field studies of other types of gear, such as demersal longline, drift gillnet, and purse seine fisheries, with no additional NEPA analysis as long as the actions are consistent with the studies described in this PEA in Chapter 2 and the impacts are within the bounds predicted in Chapter 3 of this PEA.

This PEA has no termination date; it is intended to provide the basis for long-term continuation and potential expansion of existing research activities. As long as individual projects are conducted as described in Chapter 2 and the actual impacts associated with implementation remain within the range of impacts as identified in Chapter 3, this document remains current. As per NOAA policy, the decision for this PEA will be reviewed for consistency and appropriateness at least every 5 years.

### **1.4.2 Permit Requirements**

As sharks, rays, and skates are not currently listed under the Endangered Species Act, no scientific research or incidental take permit for take of elasmobranches is required.

No work is proposed for the Papahānaumokuākea Marine National Monument (hereafter referred to as the Monument); therefore no permit for the Monument would be required.

The State of Hawaii has requirements regulating longline fishing conducted within State waters. All FBSAD research involving elasmobranch bycatch reduction strategies will be conducted in compliance with applicable State and federal regulations, and international agreements and permit requirements regarding scientific research and trials within state and federal waters and within the

EEZs of other cooperating nations. All laboratories used for FBSAD-sponsored-research must also demonstrate that all necessary permits are obtained and kept current.

### **1.4.3 Spatial Scope of this PEA**

**Longline fisheries conducted in any ocean or laboratory:** All countries or domestic or foreign entities that choose to cooperate with NMFS PIFSC in conducting elasmobranch bycatch studies related to pelagic longline fishing in the field are included within the scope of this EA. FSBAD may also cooperate with various research facilities either holding captive elasmobranches or having the capability of holding captive elasmobranches that have appropriate permits and meet Institutional Animal Care and Use Committee protocols, such as those at the University of Hawaii or the Virginia Institute of Marine Science. FSBAD may also directly catch elasmobranches in nearshore areas, such as Kaneohe Bay, Hawaii, Chesapeake Bay, or bays in Baja, Mexico for short term field studies, using modified longline gear with barbless hooks and short soak times to minimize adverse impacts to capture animals.

### **1.4.4 Scope of Decisions to be Made**

The Responsible Program Manager (RPM; the Director of the PIFSC) will use this PEA to make the following decisions:

1. Might the current and proposed PIFSC research activities as described have significant impacts requiring analysis in an Environmental Impact Statement?
2. Should the PIFSC continue to conduct existing research for reducing elasmobranch bycatch, with a focus on electromagnetic deterrents, in the laboratory and in longline and other appropriate fisheries on a programmed and consistent basis?
3. Should the PIFSC expand the existing research program for reducing elasmobranch bycatch in longline fisheries?

### **1.4.5 Species caught as bycatch not included in scope of decision with rationale**

**Marine mammals caught as bycatch in worldwide longline fisheries:** The Hawaii commercial longline fishery is identified by NMFS as a Category I fishery per the Marine Mammal Protection Act because it has frequent incidental mortality and serious injury of marine mammals, including bottlenose dolphins (*Tursiops truncatus*), false killer whales (*Pseudorca crassidens*), humpback whales (*Megaptera novaeangliae*), Risso's dolphins (*Grampus griseus*), short-finned pilot whales (*Globicephala macrorhynchus*), pantropical spinner dolphins (*Stenella longirostris*), and sperm whales (*Physeter macrocephalus*). As a Category I fishery, the Hawaiian-based longline fishery is subject to the Marine Mammal Protection Act (MMPA) and, when triggered, is subject to requirements for vessel registration, observer coverage, and take reduction plans. Similar levels of marine mammal bycatch are also found in similar-sized foreign longline fisheries. Analysis of

studies of gear modifications for reducing bycatch of marine mammals is not included within this programmatic EA, as research on effective bycatch reduction methods for cetaceans is not yet planned by PIFSC and therefore the action is not ripe for decisionmaking. Analysis of potential impacts of research and gear modifications for minimizing elasmobranch bycatch on certain marine mammals is found in Chapter 3.

**Sea turtles caught as bycatch in international fisheries:** PIFSC research focusing on reduction of sea turtle bycatch in domestic and international longline fisheries is being evaluated in another programmatic EA currently in preparation by FBSAD and is therefore not included in this PEA. Potential impacts of elasmobranch bycatch reduction on sea turtles are evaluated in Chapter 3.

**Seabirds as bycatch in longline fisheries:** Mortality in longline fisheries is the most critical global threat to most albatross and large petrel species, including in the Hawaii-based longline fishery (Gilman and Kobayashi 2007). For Hawaii-based longline fisheries, regulations requiring seabird avoidance methods were first adopted in June 2001, decreasing total seabird captures from over 2,400 captures in 2000 to 88 in 2006. Current regulations require setting gear with weighted hooks over the side of the boat rather than at the stern with a bird curtain; discharging decoy offal off the opposite side of the boat to the actual deployment of the longline gear, and using weighted hooks baited with completely thawed blue-dyed bait to distract birds and/or minimize the time that baited hooks are in the air and near the surface (Gilman 2007). Similar actions were also adopted by the Western and Central Pacific Fisheries Commission for implementation by all Commission members, Cooperating non-members, and participating Territories, with the addition of the use of tori lines with streamers, night setting, and deep setting line shooters (Western and Central Pacific Fisheries Commission 2007). Since these highly effective measures are substantially different than those considered for reduction of elasmobranch bycatch, the effectiveness of circle hooks are unknown for further reducing seabird bycatch, and seabird bycatch mostly occurs above 23°N and below 23°S latitude in areas where PIFSC research does not occur (Agreement on the Conservation of Albatrosses and Petrels 2007), seabird bycatch will not be considered in this PEA.

## **1.5 Issues Not Considered in Detail with Rationale**

**Essential Fish Habitat (EFH)/Habitat Areas of Particular Concern (HAPC) in areas fished by foreign longline fleets:** The Magnuson-Stevens Fishery Conservation and Management Act identifies EFH as those waters and substrates necessary to fish for spawning, breeding, feeding, and growth to maturity. HAPC is defined as areas where the ecological function of the habitat is important, habitat is sensitive to anthropogenic degradation, development activities are or will stress the habitat, or the habitat type is rare. Marine organisms managed by the Magnuson-Stevens Act in Fisheries Management Plans involving the water column include highly migratory and pelagic fish species. Marine organisms managed by the Act on the ocean bottom include bottomfish and seamount groundfish, precious corals and coral reef ecosystems, and crustaceans.

Because both the fishing tempo and the type and length of gear used in the field would be limited in the experiments, the number of sharks taken is anticipated to be less than that caught as bycatch without the deterrent on the gear. Therefore, no impacts to EFH or associated HAPC would occur. No other protected marine organisms, such as sea turtles or cetaceans, are anticipated to be taken as bycatch on the experimental gear fished by FBSAD. No adverse impacts to any aspect of the water column, including by electromagnetic materials (Section 3.4), would occur, nor to any benthic habitats, because experimental gear on the ocean bottom would be extremely limited and short-term. EFH and HAPC have not been identified in areas fished by foreign participating fleets and therefore will not be considered in detail. All experiments are conducted within the laws and regulations of the participating nation, including regarding discharges from vessels. Therefore, no adverse impacts to EFH or associated HAPC are anticipated to occur and this issue will not be considered further.

**Unique, Historic, Archaeological, and Protected Resources:** Some of the proposed research is being conducted in a controlled laboratory setting, and as such will not affect historic or archaeological resources nor will it affect the general public. The field research will: (1) take place far from any marine historic and archaeological sites, such as shipwrecks; and (2) involves fishing techniques, well-studied and published in peer-reviewed journals, that pose no threat to public health or safety. As such, the existing program and proposed expansion regarding reducing bycatch of elasmobranchs would have no effect on archaeological, social or cultural resources; scientific, historic or cultural sites; or public health or safety. It would not affect National Scenic or National Historic Trails, Wild and Scenic Rivers, National Marine Sanctuaries, or National Estuarine Research Reserves. It would not have a disproportionate environmental or health effect on low-income or minority populations, nor would it impinge on the religious freedom of any group. In addition, to eliminate the possibility of introduction of non-indigenous species, the field research will utilize sterile gear and/or gear that has been used only in the environment in which it would be deployed for this research. As such, it would not contribute to the introduction or spread of nonindigenous species. Therefore, these issues will not be considered further.

**Papahānaumokuākea Marine National Monument (hereafter referred to as the Monument):** This Monument protects the endangered Hawaiian monk seal, coral, seabirds, the threatened green sea turtle, and other important resources. FBSAD has no plans for conducting any elasmobranch bycatch research within the Monument and therefore, impacts to the Monument and its resources will not be considered further in this PEA.

## **1.6 Anticipated Use of this PEA for Future Research Program Actions**

Any documented research project implemented within the described program can be implemented without further compliance with the National Environmental Policy Act (NEPA). However, any site-specific and/or project-specific actions that would be added to the program long-term, such as testing any potentially-effective deterrent chemical or other material and not specifically covered

under this PEA or other PIFSC PEAs, will need additional NEPA analysis. If such new actions feature potential adverse environmental impacts other than those contemplated in this PEA, they will need to be analyzed either in a supplement to this PEA (40 CFR 1502.9) or in a new environmental assessment. Any supplement to this PEA or new NEPA documentation shall not affect the analysis or decisions in this original PEA nor any other proposed project consistent with this PEA or any other PIFSC PEAs unless specifically stated in the subsequent supplement or NEPA document.

Any site-specific or project-specific actions that are not covered in this PEA or another NEPA document and that would not have any additional environmental considerations that have not already been addressed in this PEA or a previous EA, or that are purely administrative, conducted entirely within a laboratory without the use of live subjects, or purely technical in nature can be addressed in the research project implementation plan and protocol for the specific project. Possible examples include computer modeling and data analysis and technical support and advice. For any short-term project not analyzed in this PEA that has the potential for environmental impacts, a categorical exclusion memorandum may be prepared, if in compliance with NAO216-6, 6.03.3(a) or (d), and having no exceptions to the use of a categorical exclusion.

## 2 Description of Alternatives

### 2.1 Alternative 1: No Action

This alternative involves PIFSC undertaking no field research to assess the use of electropositive metals to reduce elasmobranch bycatch in longline fisheries. In-office work on this issue, such as analysis of previously collected data or data obtained by other researchers, may occur. Research performed by other institutions on the use of electropositive metals to reduce elasmobranch bycatch in longline fisheries may continue to the extent that those institutions determine to undertake such research.

### 2.2 Alternative 2: Current Program

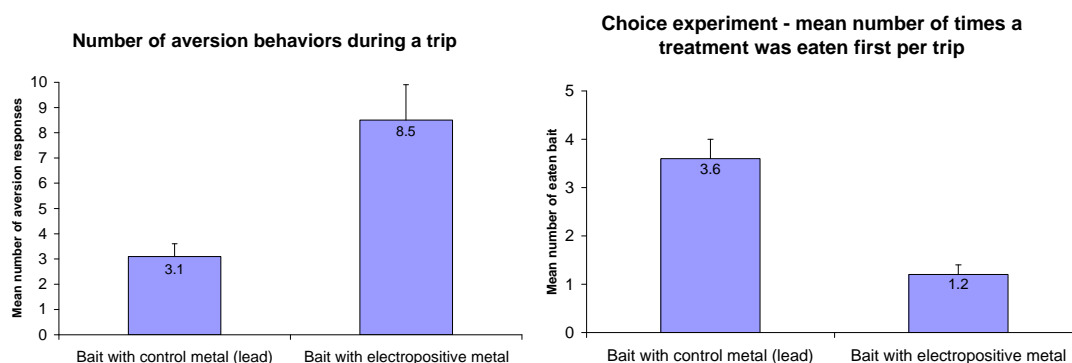
Research on elasmobranchs was initiated within the PISFC FBSAD in 2006 to examine the effects of a variety of sensory cues on the feeding behavior of elasmobranchs. Current research activities include laboratory behavioral experiments, field behavioral experiments, and laboratory experiments examining the physical and chemical properties of potential repellents. Prompting aversive reactions to electromagnetic fields appears to be the most promising system for repelling sharks and, potentially, other elasmobranchs caught in longline fisheries. Therefore, to date, all FSBAD bycatch reduction efforts for elasmobranchs have focused on electropositive materials that create an aversion response associated with elasmobranch capability of detecting weak electric fields.

#### 2.2.1 Behavioral experiments examining the effects of electropositive materials on elasmobranch feeding behavior

This program tests the ability of electropositive metals to deter free-swimming wild sharks from feeding on opelu baitfish (*Decapterus macarellus*). In paired experiments, bait is attached to ends of wooden poles so that one fish is adjacent to either a piece of lead (control metal) or a piece of electropositive ( $E^+$ ) metal. In waters off the North Shore of Oahu, PIFSC utilized a shark-viewing cage to film and observe shark choice experiments in which both bait treatments are provided to the wild sharks to score the behavioral characteristics of aversion responses exhibited by the sharks as they approach the bait. While Galapagos sharks are the most commonly observed sharks in the area, our experiments include interactions with sandbar sharks (*Carcharhinus plumbeus*) and tiger sharks (*Galeocerdo cuvier*). These shark species are in the same family (Family Carcharhinidae) as sharks which commonly interact with pelagic longline fisheries, such as blue sharks and oceanic whitetip sharks. Results from this study indicate that baitfish associated with a piece of inert lead metal will be preferentially eaten over baitfish associated with an electropositive metal. These results suggest that electropositive metals do influence feeding behavior in sharks (Figure 1). In addition, sharks exhibit significantly more aversion behaviors when approaching bait associated with electropositive metals than with bait associated with lead. All experiments adhere to the

University of Hawaii Institutional Animal Care and Use Committee (IACUC) protocols, which govern appropriate care, use and/or husbandry of animals.

**Figure 1. Shark response to control and electropositive metals**



### 2.2.2 Field trials in Baja California, Mexico, examining the effects of electropositive metals on elasmobranch aversion behavior

In Bahia de los Angeles, Baja California, Mexico, FSBAD is conducting field experiments focused on developing methodologies to test the effects of electropositive metals ( $E^+$  metals) on the catch rates of sharks and rays. Tonic immobility trials are used to screen for metals indicating potential as shark deterrents. The tonic immobile state in the sharks is created by flipping them upside down. In this state, sharks become quiescent, allowing researchers to attach tags and even perform minor surgery. Noxious stimuli will cause the sharks to bend away from the source of the stimuli and even at times break the tonic immobility state. By measuring the degree in which the sharks bend away from the stimuli, we can determine the effectiveness of electropositive metals as a potential shark deterrent for several shark species as well as determine the potential range of repulsion. Immediately after experiments are completed, sharks completely recover after being flipped back onto their belly and released. Sharks are held in a tonic immobile state for no more than five minutes.

In addition, utilizing bottom longlining, fishing with rod and reel, gillnetting, fish traps, and dip netting while snorkeling, using only fish for bait, the distribution and species type of elasmobranchs in the Bahia de los Angeles area located in Baja California, Mexico was evaluated. Using bottom-set longline, we also compared the catch rates of elasmobranchs on hooks with praseodymium-neodymium (Pr-Nd) alloy ingots (electropositive metals) and hooks with lead controls. Two species of sharks are typically caught: brown smooth hounds (*Mustelus henlei*) and the Pacific sharpnose shark (*Rhizoprionodon longurio*), while one species of ray was captured (*Urobatis halleri*). To date, overall elasmobranch catch rates in Bahia de los Angeles have been very low, making it difficult to determine the effectiveness of shark deterrents. All experiments adhere to the University of Hawaii IACUC protocols and under permit from the Mexican government for conducting research.



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### **2.2.3 Field Trials in Kaneohe Bay, Oahu, Hawaii, examining the effects of electropositive metals on elasmobranch catch rates**

The program is initiating field trials examining the effects of elasmobranch deterrents on the catch rates of elasmobranches in and around Kaneohe Bay, Oahu, Hawaii. Sharks and rays that are typically caught in Kaneohe Bay include sandbar sharks (*Carcharhinus plumbeus*), tiger sharks (*Galeocerdo cuvier*), scalloped hammerhead sharks (*Sphyrna lewini*), and Hawaiian stingrays (*Dasyatis lata*). The sharks are part of the requiem shark family and are closely related to the sharks that interact with the Hawaii-based and other pelagic longline fleets and may therefore be a good model for examining methods of reducing shark interactions with fishing gear.

The study utilizes techniques similar to those used by University of Hawaii shark researchers to successfully and safely catch sharks and rays. Relatively short lengths of bottom (demersal) longlines with approximately 100 hooks baited with fish will be set in areas known to have historically high shark catch rates. In order to limit stress and mortality to captured animals, soak times for the longline will only last 3 to 5 hours before being hauled in and large 16/0 circle hooks with the barbs removed will be deployed. These hooks will limit the number of deep-hookings (hooks that are swallowed and caught in the esophagus or digestive tract) and ensure easy removal of mouth hooks with dehooker tools. Longlines are deployed using small boats (15 to 17 feet long) and baited with either tuna or mackerel bait. Similar fishing operations are used effectively to monitor shark and ray populations in Kaneohe Bay and are used in a variety of catch, tag and release studies by University of Hawaii researchers. The project expects to catch and release no more than 400 sharks per year.

On experimental longlines, FBSAD is planning experiments in which hooks with electropositive metals are alternated with hooks associated with inert lead controls. All experiments fall within the University of Hawaii IACUC protocols.

### **2.2.4 Laboratory trials to test the ability of electropositive metals to deter juvenile sandbar sharks from simulated landline gear**

Juvenile (1 to 3 years old) sandbar sharks held in captivity at the Virginia Institute of Marine Science (VIMS) are used in tests to determine the potential that the presence of a praseodymium-neodymium alloy (Pr-Nd, E<sup>+</sup> metal) ingot will repel this species of shark. Sharks are brought into captivity after being captured in the Chesapeake Bay by a modified longline operation, with captured sharks safely transported to the lab. Numerous trips occur throughout the summer to catch approximately 10 to 15 individuals per year, with a maximum of 20 sharks per year.

Sharks remain in captivity for a maximum of 4 weeks, during which time they are used in behavioral choice experiments. Specifically, ingots of different electropositive metal types are placed on simulated longline droppers at fixed positions above pieces of menhaden bait. These two simulated longline droppers are presented simultaneously to the sharks (but approximately 4 meters apart) in their holding tank and the time required for the bait to be removed recorded.

In a second laboratory test, tests are conducted to measure the maximum distance over which ingots of Pr-Nd can induce an aversive response in swimming sharks. These experiments are performed in a four-meter diameter/one meter deep pool with individual animals. The swimming paths of the sharks as they approach the metal bars are recorded using a digital video system including a camera, a computer, and a USB interface, noting any deflections in path or abrupt changes in swimming speed. The video documentation of the sharks' swimming paths and speeds are quantified using software specifically designed for animal behavior and motion path analyses (LoliTRACK PC software, available from Loligo Systems, Inc.).

At the end of these trials, the sharks are safely transported back to their capture location and released to the wild. Captive animals are held according to the VIMS IACUC animal husbandry protocols throughout the course of their time in captivity.

### **2.2.5 Laboratory tests of electrical fields created by electropositive metals and relationship to elasmobranch sensory systems**

This work involves a complete quantification and characterization of the physical characteristics, including electrical characteristics, of select lanthanide elements and alloys in seawater and their interactions with shark sensory systems. The data and information resulting from this work are used to determine the potential utility of lanthanide metals as effective shark deterrents that can then be used to reduce the incidental capture of sharks in fishing gear.

To accomplish this task, various electrodes are positioned in a seawater tank with controlled temperature, salinity and conductivity. Output from the electrodes is filtered, differentially amplified, digitized and simultaneously monitored and stored on computer. In addition to the reference values, electric field measurements (including distance values) are also conducted in the presence of lanthanide and non-lanthanide metals (including fish hooks, neodymium (Nd), and a Pr-Nd alloy). The measured voltage is plotted against distance for all three samples. The entire procedure is repeated using different environmental parameters. From these results, it will be possible to calculate a model of best fit for electric field intensity for metal, salinity, and temperature. These results are intended to demonstrate the proof-of-concept that electric fields can be measured for metals in seawater.

### **2.2.6 Field tests of electropositive metals on longline gear to determine logistical and operational practicality**

This work involves testing the practical application of employing potential repellents, with emphasis on electropositive metals, during an actual longline operation on research vessels under controlled conditions. The test involves deploying repellent metals or chemicals near the vicinity of the baited hook and ensuring that the repellent can successfully and practically be incorporated into the operation and gear deployment. In the case of  $E^+$  metals, we tested the ease at which the metal ingots can be efficiently incorporated into the setting operation, and then investigated the rate of

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dissolution of the metal ingot as a function of sea water temperature, hook/metal depth, and duration of submersion using Temperature/Depth Recorder (TDR) data logging devices that record temperature and depth near the baited hook. Data were collected from these devices after they were retrieved during the hauling operation. In the case of chemicals, we tested the ability to release chemicals above the bait for the duration of the submerged baited hook (approximately 8 hours). Results from both methods suggest that metals as well as chemicals placed in a gel matrix do not interfere with the fishing operations and that both methods could, with some adaptation, allow for efficient operation of the fishery while potentially reducing the incidental capture of sharks. Additional tests similar to these tests may be conducted in the future as needed.

### **2.3 Alternative 3: Expansion of Current Program (Proposed Action)**

The proposed action expands the work conducted in the current elasmobranch bycatch reduction research program to further test the effectiveness of electropositive materials in causing aversion behavior in the vicinity of fishing gear. NOAA Fisheries has recognized shark bycatch as a national and international fisheries challenge. The 2001 Final U.S. National Plan of Action for the Conservation and Management of Sharks states: “[M]anagement entities should invest in elasmobranch research, fishery monitoring, reduction of bycatch and bycatch mortality, minimization of waste, and enforcement” (National Marine Fisheries Service 2001). The expanded program would further contribute to improved management of elasmobranch populations while reducing bycatch and bycatch mortality consistent with the 2001 plan while building on the successes of the current program.

The proposed studies involve laboratory studies with both characterization of elasmobranch and chemical electromagnetic fields, as well as comparative field tests of bycatch reduction effectiveness of electromagnetic materials on domestic- and foreign-contracted fishing vessels under controlled conditions.

#### **2.3.1 Laboratory tests examining the effects of electropositive metals and other deterrents on shark behavior**

Laboratory behavioral experiments to test the responses of different elasmobranch species to  $E^+$  metals and other deterrents, the habituation of the aversive response to the repellents, and the effects of inter- and intra-specific competition on the aversion to the repellents would be conducted in several different research facilities, including, but not limited to, the Chula Vista Nature Center (located in San Diego, CA), the University of Hawaii at the Hawaii Institute of Marine Biology, and NOAA facilities.

Experiments would be conducted in large saltwater tanks using video tracking software (Loligo Systems) to determine the how elasmobranches react to  $E^+$  metals, with inert lead used as the control. The video tracking system would help determine whether the elasmobranches alter their swimming patterns by exhibiting aversion behavior when either lead (control) or  $E^+$  metals in

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placed in their test tank. Additionally, the maximum distance over which Pr-Nd ingots can induce an aversive response in swimming elasmobranches would be measured. Habituation experiments would last from several hours up through 24 hours. Testing multiple animals in a tank would be used to determine the effects of competition for food in changing behavior.

Captive-reared elasmobranches of many species, including leopard sharks (*Triakis semifasciata*), horn sharks (*heterodontus fransisci*), grey smoothhound sharks (*Mustelus californicus*), bat rays (*Myliobatis californica*), round stingrays (*Taeniura grabata*), and hornback rays (*Raja clavata*), would be utilized to characterize these behaviors. Wild-caught sharks, rays, and skates would also be used as test subjects. Wild elasmobranches would be caught on longline operations modified to limit stress and injury to the animals, including using large diameter barbless circle hooks with the gear only soaked for 3 to 5 hours and using fish for bait. Animals would be brought on board, placed in a specialized oxygenated seawater tank and transported to a holding facility. No more than 50 animals per year would be captured and utilized in this manner. The animals would remain in captivity for a maximum of four weeks, during which time they would be used in behavioral food choice experiments. At the end of these behavioral experiments, the elasmobranches would be safely transported back to their capture location and released to the wild. Animals would be handled in accordance to the research facility's protocols and the University of Hawaii IACUC animal husbandry protocols throughout the course of their time in captivity and use in experiments.

### **2.3.2 Laboratory tests of physiological mechanisms contributing to elasmobranch aversion behavior**

To examine the neurophysiological mechanisms responsible for the aversion behaviors to the E<sup>+</sup> metals and other repellant cues, physiological experiments would be conducted in laboratories with wild-caught captive sharks and rays. Experiments would be designed to examine and characterize the thresholds for detecting repellant cues, the thresholds for producing behavioral responses, and for understanding the underlying mechanisms of desensitization. Sharks utilized for this work would be handled according to standard physiological preparation protocols and IACUC protocols. No more than 20 animals per year will be utilized for these experiments.

### **2.3.3 Field tests of modified longline gear to reduce bycatch of elasmobranches**

The program plans to conduct field trials of experimental gear containing shark repellants. Such field trials would compare experimental gear with standard gear (controls). Initially, the proposed studies would involve testing the effects of electropositive (E<sup>+</sup>) metals on shark catch-per-unit-effort (CPUE) in domestic and foreign fisheries, including longline, gillnet and potentially other fisheries. This research could be expanded to test other types of substances, none of which are regulated by the federal and state law due to their lack of toxicity. The experimental and standard gear would be tested in a controlled and unbiased (systematically staggered and ordered) fashion using contracted fishing vessels on which the crew conducts the tests per the PIFSC protocols. FBSAD would

observe, record, and analyze catch results. The trial fishing operations would otherwise be carried out in the normal manner as the rest of the commercial or research fishing operations.

In the near future, FSBAD proposes to conduct this work in pelagic commercial fisheries (primarily targeting tunas, swordfish and sharks) in Ecuador and Hawaii, and possibly other cooperating countries, and on NOAA research vessels in the North Pacific Ocean. We do not expect to interact with more than 1,000 elasmobranches per year working in these fisheries. Because our research piggybacks upon normal fisheries operations and does not add to fishing effort, elasmobranches caught as bycatch during this research would have been caught regardless of PIFSC research activities.

## ***2.4 Alternatives Not Considered in Detail***

**Testing gear or methods proven to reduce CPUE of target species that is not offset by an increase in revenue due to substantially reduced bycatch:** The costs from elasmobranch interactions can be due to depredation on hooked target species, the damage and loss of gear from catching sharks, reduced catch of target species because sharks are either hooked or have damaged the gear, safety risks to crew from handling sharks during gear retrieval, and reduced fishing efficiency due to time required to remove sharks from gear and repairing and replacing gear (Gilman et al. 2007). Therefore, some gear and techniques that reduce CPUE in favor of reducing bycatch may actually have increased economic benefits. Any gear or techniques that decrease target CPUE to the point where revenue is not counterbalanced by decreases in bycatch would have virtually no chance of being adopted in domestic or foreign fleets and therefore is not considered in detail.

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## 3 Environmental Consequences

### 3.1 *Alternative 1: No Action*

This alternative involves no PIFSC FBSAD fieldwork to test the efficacy of using electropositive metals to reduce elasmobranch bycatch in longline fisheries. As such, no environmental impacts are anticipated. Some in-office analysis (e.g., computer analysis of existing data and report writing) may be conducted that would have no direct environmental impact.

However, not undertaking PIFSC FBSAD field research for reducing elasmobranch bycatch would have serious potential impacts to the ability to understand population status of shark species caught in fisheries, as well as causing NMFS to fail to comply with the Magnuson-Stevens Act. As described in Section 1.2, some shark and ray populations make up considerable bycatch in longline fisheries, as well as other pelagic fisheries such as those using drift gillnets. As sharks and rays have slow rates of sexual maturity and low fecundity, many pelagic shark and ray populations are susceptible to population declines due to high fishing pressure, potentially approaching, and possibly surpassing maximum sustained yield for those populations (Clarke et al. 2006, Gilman et al. 2007). Limited data are available for detailing population status and trends of most pelagic shark and ray species. Major reductions in shark populations as apex predators have apparent cascading effects on marine ecosystems (Myers et al. 2007). NMFS also has responsibility for reducing bycatch under the Magnuson-Stevens Act per National Standard 9 (50 CFR 600.350). PIFSC has the capability and authority for working cooperatively with domestic and foreign longline and other fishing fleets. As such, failing to undertake this research would contribute to NMFS' failure to comply with Magnuson-Stevens Act provisions.

### 3.2 *Alternatives 2 and 3: Current Program and Expansion of Current Program (Proposed Alternative)*

The current research program (Alternative 2) and proposed expansion of this program (Alternative 3, proposed action) are intended to further investigate ways to effectively reduce the bycatch of elasmobranch species in domestic and foreign fishing fleets using electropositive materials. National Standard 9 of 50 CFR 600.350 (e), regulations implementing the Magnuson-Stevens Act, recognizes that Fishery Management Councils, in preparing Fisheries Management Plans, must consider the impact of conservation and management measures on living marine resources other than fish, per the Marine Mammal Protection Act and the Endangered Species Act. Therefore, the impacts in this chapter evaluate potential impacts on marine mammals, sea turtles, and shark populations.

As the proposed action expands current research initiated in 2006, the following impact analyses apply to both Alternative 2 and Alternative 3 as specified in the analysis.

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### 3.2.1 Potential Impacts to Marine Mammals from FSBAD Deterrent Research

#### 3.2.1.1 Introduction: Marine mammal interaction with longline fishing gear

Interactions between marine mammals and fishing involve almost all existing fishing gear, including hooking and entanglement of the marine mammal in the gear, removing hooked marine mammals and bait from fishing gear (depredation) and marine mammals damaging or removing gear. The latter problems can often lead to deliberate injury and mortality of the depredating mammal by the affected fisher. Most longline interactions are thought to be the result of toothed cetaceans such as dolphins being attracted to the gear or boat because of the potential for food, with the animals learning to home in on the vessel or gear based on familiarity with its sounds. Accidental entanglement or hooking of baleen whales (cetaceans with baleen instead of teeth) has also occasionally been reported in longline gear, probably as a result of their swimming paths accidentally encountering gear. Most depredation of catch or bait is believed to occur during hauling rather than setting of the gear (Gilman et al. 2006).

Between 1992 and 2004, a total of 200 interactions between marine mammals and U.S. Atlantic pelagic longline gear were observed. Of these, there were 10 observed mortalities and 94 observed serious injuries. One hundred of the observed interactions were with pilot whales, 64 were with Risso's dolphin, and all other species had six or fewer observed interactions (Garrison 2007).

The Hawaii commercial longline fishery is identified by the National Marine Fisheries Service as a Category I fishery per the Marine Mammal Protection Act because it has frequent incidental mortality and serious injury of marine mammals, including bottlenose dolphins, false killer whales, humpback whales, Risso's dolphins, short-finned pilot whales, spinner dolphins, pantropical spinner dolphins, and sperm whales (72 FR 124 June 28, 2007). Sperm and humpback whales are listed under the Endangered Species Act.

In the tropical Pacific, numerous observations of fishery interactions with false killer whales, pilot whales (*Globicephala* spp.), and killer whales (*Orcinus orca*), and at least eight species of dolphin have been observed in the vicinity of longline gear. Endangered sperm whales have also been observed taking fish from gear (Gilman et al. 2006).

Most of the endangered Hawaiian monk seals live in the Northwestern Hawaiian Islands, with an increasing number of sightings and births recently occurring in the main Hawaiian Islands. At least 45 seals were known to occur in the MHI in 2000, at least 52 in 2001, and a total of 77 in 2005. Although these counts are well below total abundance because they do not account for animals in the water and not every seal on land can be detected, the increasing numbers indicate an increasing population in the MHI, based on aerial surveys of all MHI coastlines supplemented by sightings of seals from the ground.

While monk seals have been seen on all the main Hawaiian islands, the largest numbers likely occur on Niihau (a privately-owned island where ground access for research activities is currently prohibited), and the number of sightings tends to decrease moving to the southeast along the MHI

island chain toward the islands with higher levels of development and human densities and activities. On all islands, seals tend to frequent remote areas where human presence or access is limited, although individual seals may use public beaches or become habituated to human presence and even interaction. While it would be reasonable to assume that monk seals utilize Kaneohe Bay, there have been few confirmed sightings and no interactions between sea turtle researchers who routinely monitor the bay (Stacey Kubis, PIFSC, July 2008, pers. comm.). It is thought that the high use of the Bay by pleasure boaters and fishers and for military exercises contributes to the apparent avoidance of Kaneohe Bay by monk seals.

### **3.2.1.2 Potential environmental impacts to marine mammals**

PIFSC experiments involving fishing to test the effectiveness of shark deterrents by comparing catch per unit effort (CPUE) in both limited field trials in Kaneohe Bay and field trials conducted on domestic and foreign fishing fleet vessels would attempt to avoid areas with either reports of high marine mammals presence or when the vessel has already caught a cetacean on gear. Catching one cetacean indicates that more cetaceans may be present, as cetaceans often occur in groups. Known ocean areas with cetaceans that have habituated to seeking out fishing vessels as a source of food would also be avoided. All vessels involved in field studies would have equipment for safely dehooking and disentangling any cetaceans caught in gear, used by researchers experienced in the effective use of the gear. No field studies would be conducted in the Hawaiian Islands Humpback Whale Marine Sanctuary during the winter season when humpbacks are present.

Little information is available on the mortality of cetaceans that have been hooked or entangled in gear (Y. Swimmer, NMFS Bycatch Program, July 2008, pers. comm.). Studies conducted in commercial fisheries would be expected to have cetacean bycatch no higher than that experienced by the commercial fisheries under typical conditions. This is because the FSBAD field studies conducted during normal commercial fishing operations would either be equal to or less than what would occur on the domestic and foreign fishing vessels without the field study. It is highly possible marine mammal mortality would be decreased on domestic and foreign vessels because of the availability of dehooking equipment and experienced research personnel. For studies conducted in Kaneohe bay, sea turtle researchers who routinely monitor the bay and marine mammal presence report few sightings of marine mammals, including Hawaiian monk seals, and no interactions between marine mammals and between sea turtle research activities (Stacey Kubis, PIFSC, July 2008, pers. comm.) It is thought that the high use of the Bay by pleasure boaters, fishermen, and for military exercises contributes to avoidance of the Bay by cetaceans.

Garrison (2007) identified modifications to fishing gear to reduce marine mammal interaction rates. The most important modification is the suggested reduction of the length of the mainline to less than 20 nmi. All FSBAD field trials using modified gear, with the exception of those conducted on the NOAA Fisheries research vessel, use less than 2 nmi of main line. Main lines used on the NOAA research vessel do not exceed 30 nmi in length. Therefore, research activities not involving commercial fishing activities would substantially reduce the potential for interactions with marine



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mammals. Those using commercial domestic or foreign vessels would not catch more than would be caught under normal conditions without the research activities.

Monk seals are not expected to interact with any field trials in Kaneohe Bay. All longline fishing in Kaneohe Bay would use large diameter barbless hooks that would be unlikely to result in a monk seal hooking. It is not expected that Hawaiian monk seals would be associated with any open ocean areas within which field trials would be conducted. In recent years, under the current PIFSC research program, there have been few instances of monk seals observed interacting or having interacted with fishing gear. The use of barbless hooks by FBSAD also contributes to making the risk of any potential interaction negligible.

Therefore, the existing and proposed actions should have no effect on endangered sperm whales, humpback whales or Hawaiian monk seals, or any other species protected by the MMPA.

### **3.2.2 Potential Impacts to Sea Turtles from FSBAD Deterrent Research**

#### **3.2.2.1 Introduction: Sea turtle population status, pelagic habitat use, and mortality in longline fisheries**

All populations of sea turtles are in decline, except for some olive ridley subpopulations (*Lepidochelys olivacea*), which appear to be increasing, and the Hawaiian green turtle population (*Chelonia mydas*), which is known to be increasing (Spotila et al. 2000, Kamezaki et al. 2003, Limpus and Limpus 2003, Chaloupka and Balazs 2007). Primarily due to human activities on land and in the sea, most sea turtle species are threatened with extinction and are listed as either threatened or endangered under the U.S Endangered Species Act.

Green, hawksbill (*Eretmochelys imbricate*), loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*) and olive ridley turtles are highly migratory or have a highly migratory phase in their life history, and also occur in habitats that overlap with marine conditions sought out by fisheries target species, which makes them susceptible to incidental capture by open ocean longline and other fisheries (Polovina et al. 2000; Polovina et al. 2004, Gilman et al. 2007, Beverly and Chapman 2007). Sea turtle tracking studies indicate that they spend a majority of their time at depths less than 131 feet, the same level as shallow-set longline gear targeting swordfish (*Xiphias gladius*)(Polovina et al. 2003, Polovina et al. 2004, Beverly and Chapman 2007). Hawaiian green sea turtles are often found in nearshore areas in the Hawaiian Islands (Chaloupka and Balazs 2007).

Turtles may become hooked by biting a baited longline hook, by being snagged in passing, or becoming entangled in the line. Leatherbacks cannot swim backwards, so they are especially vulnerable to becoming entangled. If the branch line is not long enough to allow the hooked or entangled turtle to reach the surface to breathe, the turtle will drown. Sea turtles feeding on hooked bait may swallow the hook as well as the bait, with the hook becoming snagged in the esophagus or stomach, especially when squid is used for bait. The mortality rate of hooked sea turtles is a product of the capture rate and the mortality rate of released turtles, with fully ingested hooks most likely to cause mortality (Watson et al. 2005, Gilman et al. 2007, Read 2007).

Summaries of records of turtle bycatch in shallow-set longline fisheries compiled by Beverly and Chapman (2007) document that most sea turtles hauled in alive are released alive, with the potential for increased mortality in turtles that had swallowed the hook. Modified gear (large diameter circle hooks with fish bait instead of squid bait) and dehooker equipment onboard with trained crew, such as is required in the Hawaii-based longline fishery, substantially reduced sea turtle bycatch and mortality of bycaught turtles (Read 2007, Gilman et al. 2007, Gilman and Kobayashi 2007; Figure 2).

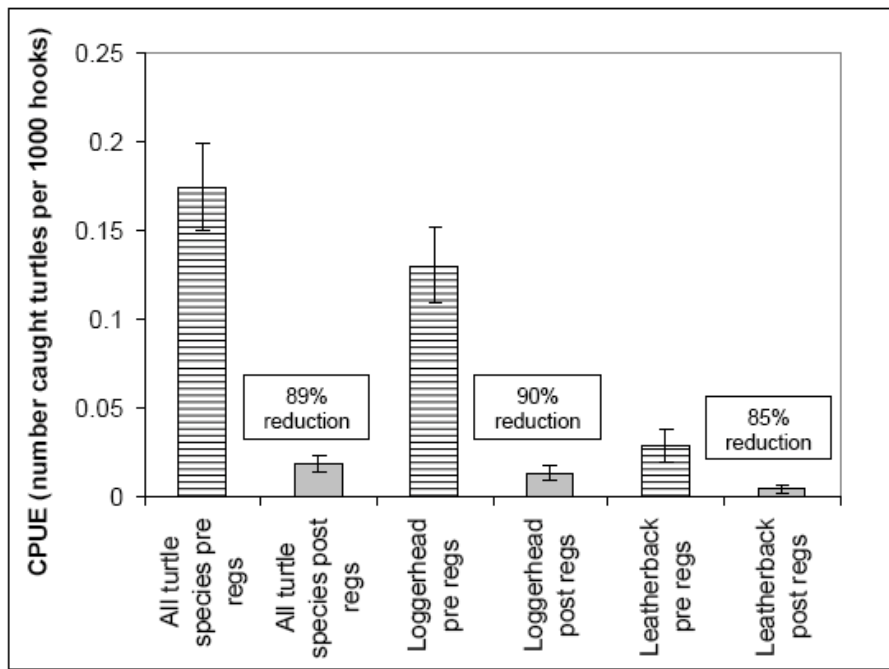


Fig. 1. Sea turtle capture rates in the Hawaii-based longline swordfish fishery pre and post sea turtle regulations.

### Figure 2. Change in Sea Turtle Capture After Implementation of Bycatch Regulations in Hawaii Swordfish Longline Fishery

A higher proportion of sea turtles were lightly hooked, rather than deeply hooked, after the Hawaii-based fishery regulations requiring the use of circle hooks were implemented (Gilman and Kobayashi 2007, Figure 3, Figure 4), which results in an apparent decrease in post-release mortality, although mortality rates are difficult to determine long-term (Ryder et al. 2006, Beverly and Chapman 2007). These general trends were also found in studies conducted in Italy, Brazil, Uruguay, and Indonesia (Boggs and Swimmer 2007).

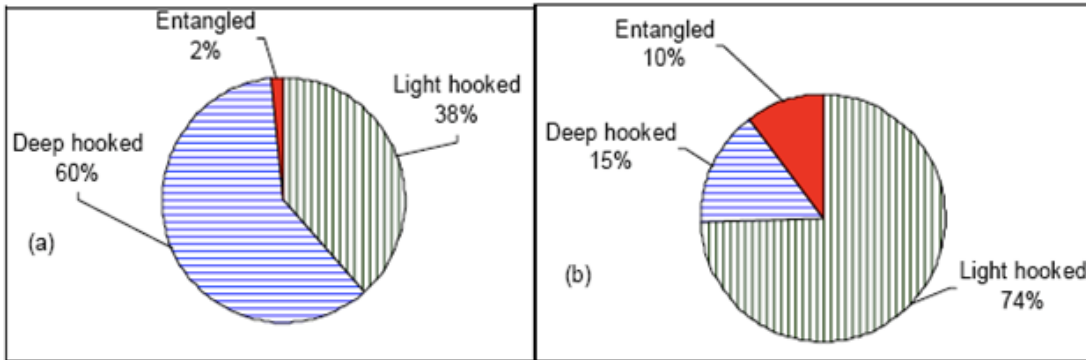


Fig. 3. Proportion of hardshelled sea turtles caught in the Hawaii longline swordfish fishery that were lightly hooked vs. deeply hooked vs. entangled (a) before and (b) after sea turtle regulations came into effect.

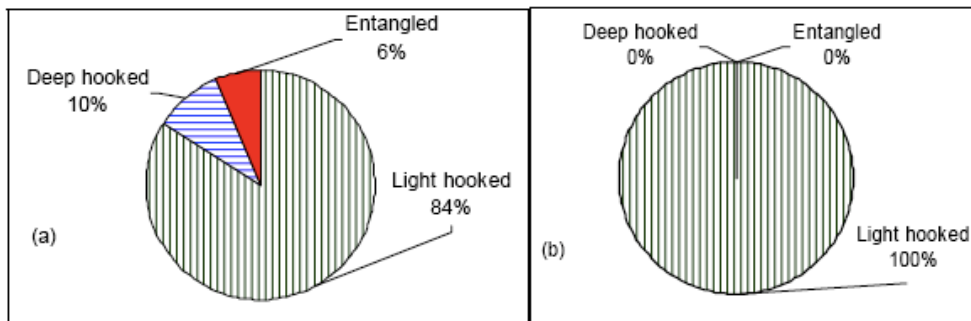


Fig. 4. Proportion of leatherback sea turtles caught in the Hawaii longline swordfish fishery that were lightly hooked vs. deeply hooked vs. entangled (a) before and (b) after sea turtle regulations came into effect.

A summary of sea turtle bycatch studies compiled by Beverly and Chapman (2007) and a study conducted by Bartram and Kaneko (2004) found that the Hawaii-based longline fishery bycatch (measured in terms of bycatch per unit effort; BPUE) of all sea turtle species was 0.06 compared to foreign longline fishery fleets, which had much higher BPUEs, varying from 0.3 to almost 20 turtles per 1,000 hooks.

### 3.2.2.2 *Potential impacts to sea turtles in nearshore and pelagic habitats from FSBAD elasmobranch deterrent research*

Fishing for shark using longline and possibly hook and line gear has been conducted as part of the current program (Section 2.2) and is proposed as part of the expanded program (Section 2.3). Catching sharks for laboratory studies in Kaneohe Bay, Chesapeake Bay and Baja, Mexico would involve modified longline gear with a short mainline and fewer than 100 large circle hooks baited with fish. Thus far, sea turtles have not been caught on longline gear during experiments at any of these locations. Also, no sea turtles have ever been caught using modified gear (no more than 30 nmi of main line, large circle hooks, short soak times, and fish for bait) on the NOAA research vessel in Hawaiian longline fishery areas in the past 8 years.

Fishing with modified longlines by FBSAD in nearshore areas of Hawaii and the mainland U.S. should continue the trend of having no sea turtle bycatch in the current and proposed programs, regardless of the fishing location. If, in the unlikely event that a sea turtle is captured, all research vessels have dehooking equipment and trained and experienced personnel. FBSAD is required to comply with all applicable federal regulations regarding incidental take of listed species and fishery operations. Therefore, no impact is anticipated to occur to sea turtles from the FBSAD fishing with modified gear in nearshore areas.

The habitat for the Hawaiian population of green sea turtle is located primarily nearshore. Since all PIFSC research-related fishing in Kaneohe Bay is and would continue to be conducted with large diameter barbless circle hooks, fish for bait, with a short mainline with fewer than 100 hooks, the potential for adverse interaction with sea turtles with any of the existing and proposed research activities in Kaneohe Bay would be negligible. In the highly unlikely event that there is an interaction with a green sea turtle during FBSAD research activities, FBSAD researchers are fully trained to safely handle the turtle interaction with no risk of adverse impact. Therefore, there would be no impact to the threatened Hawaiian green sea turtle in Kaneohe Bay.

As studies are transferred from Hawaii and mainland US to foreign fleets that do not have the stringent regulations to avoid incidental bycatch of sea turtles found in the Hawaii-based fleet, it is possible that sea turtle bycatch could occur. However, all studies would be conducted on contracted vessels using protocols developed by and implemented under the control and supervision of FBSAD. The use of circle hooks would be required, but either fish or squid could be used as bait, dependent on the fishery and circumstances, as agreed by the participating country and NMFS. Therefore, it is possible that more sea turtles could be caught than in fisheries using only fish for bait, and more could be deeply hooked, than that found in Hawaii-based fisheries and studies conducted directly by PIFSC, potentially resulting in higher mortality of caught and released turtles than found in U.S. fisheries and studies. However, levels of sea turtle bycatch would be no higher than that experienced by the foreign fleet under typical fishing operations, and would probably be substantially lower because of the use of circle hooks and study protocols intended to meet study objectives while minimizing sea turtle bycatch. Analyses have been conducted on the effect of the longline fishery on sea turtle populations (Western Pacific Regional Fishery Management Council 2008) and no additional analysis is necessary given that the activities proposed herein fall within the management regime in place.

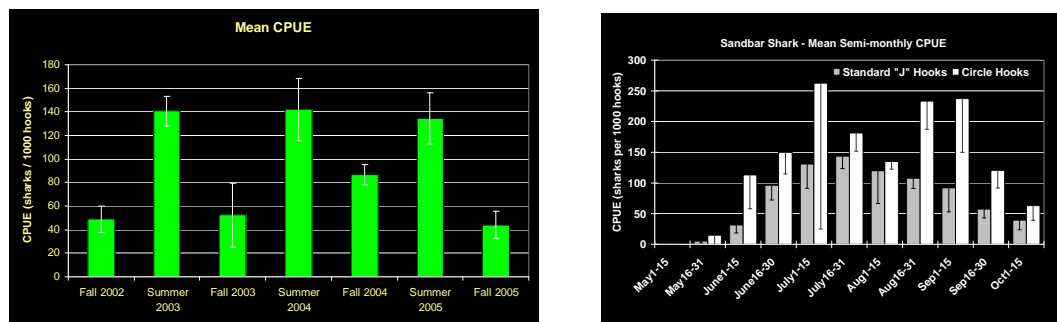
No critical habitat has been designated for the loggerhead, olive ridley or Kemp's ridley sea turtle. Critical habitat for leatherback (St. Croix, US Virgin Islands), green (Culebra Island, Puerto Rico), and hawksbill sea turtles (Puerto Rico) are all designated for protection of important nesting beaches and would not be within areas identified for longline fisheries. None of these areas would be involved in any of the existing or proposed research activities. Therefore, there would be no impact to sea turtle critical habitat.

### 3.2.3 Potential Impacts to Shark Populations from FSBAD Deterrent Research

The current program and proposed expanded program involve experiments to be conducted in which elasmobranches would be caught on longline fishing gear using barbless hooks and short soaking times. The potential impact of shark interactions with PIFSC experiments involve either sharks interacting with fishing gear located in nearshore waters of Kaneohe Bay and Chesapeake Bay or sharks interacting with fishing gear deployed in pelagic commercial fisheries, both domestic and foreign.

#### 3.2.3.1 Impacts on shark populations in Kaneohe Bay, HI and Chesapeake Bay, VA

Shark populations in the proposed study locations (Kaneohe Bay, Oahu, Hawaii and Chesapeake Bay, Virginia) are believed to be robust. Figure 5 shows results from shark surveys in which modified baited longlines (fewer than 100 hooks) were deployed in Kaneohe Bay and Chesapeake Bay, respectively (Grubbs 2008). These catch rates indicate a seasonal variability to the population structure of sharks in nearshore waters as well as robust numbers of sharks within these near shore waters, as evidenced by high relatively CPUE (e.g., 140 sharks per 1,000 hooks in Kaneohe Bay during summer months).



**Fig. 5. Catch Rates of Sharks IN Kaneohe Bay, HI and Chesapeake Bay, VA.**

It is unlikely that interactions with sharks during modified longline fishing for research purposes in Kaneohe Bay and Chesapeake Bay would adversely influence these two populations for a number of reasons. First, the shark populations in these areas appear to be healthy. Second, standard operating procedures designed to minimize the mortality, injury and stress to hooked sharks, including using large circle hooks with the barbs removed, are required. Circle hooks help to prevent the ingestion and subsequent more harmful gut-hooking of sharks (see Cooke and Suski 2004). Barbless hooks limit the damage to soft tissue and help to expedite the removal of the hooks, thereby limiting injury to the shark during dehooking. The fishing lines would be soaked for a relatively short period of 3 to 5 hours (compared to a typical soak of over 8 hours in a commercial fishery), ensuring that sharks caught on the line are not overly stressed when removed from the hooks. Dehooking devices will also be carried on board at all times to expedite the removal of hooks as quickly as possible, thereby reducing handling of the sharks. Post-hooking survivorship

analyses suggest that sharks landed in apparently healthy condition are likely to survive long-term if released (Moyes et al. 2006).

Despite the required precautions, there is a high likelihood that some mortality of sharks will occur, potentially up to 10% of the sharks captured (J. Wang, FBSAD, pers. observations, July 2008).

Current rates of shark mortality on commercial longlines are estimated to range between 5% and 24% (Walsh et al. 2002). This indicates that the expected level of mortality on the experimental longlines would be well within the norms of commercial fisheries and cannot be avoided.

In addition, sharks used in laboratory experiments would be released alive back to the area in which they were captured, using standard procedures that have proven to be effective.

### **3.2.3.2 Impacts on shark populations during pelagic longline tests using domestic and foreign vessels**

Population assessments of the status of pelagic sharks are generally limited. However, in numerous longline fisheries throughout the world, blue sharks are the most commonly caught species (see Simpfendorfer et al. 2002, Gilman et al. 2007). Despite this interaction with fisheries, safe-handling procedures often result in very high rates of post-release survivorship (Moyes et al. 2006). In the Northwest Atlantic, blue sharks are usually hauled alive approximately 80% of the time and mako sharks greater than 75% of the time (Beerkircher 2005). This is consistent with survival levels found in other fisheries (Gilman et al. 2007). With regards to the ability of a shark to survive interaction, the most important component is likely to be duration of handling. The proposed experiments would follow standard operating procedures that maximize a shark's probability of survival through minimal handling. In Hawaii's shallow-set (swordfish-directed) fisheries, in which sharks are quickly released from fishing line, survivorship of the most commonly-caught species has been estimated at 95%, 76% and 92% for blue sharks, short fin mako sharks, and oceanic white tip sharks, respectively (Walsh et al. 2002).

In addition, estimate of shark catch rates indicate that between 26 and 73 million sharks are traded each year, with an overall median of between 38 and 62 million per year, using calculations based on trade records in commercial markets. The FAO database for global captures indicates that in 2000 the capture rate for all sharks, skates and rays totaled 869,544 tons (Clarke et al. 2004). The proposed experiments, which are designed to examine strategies to decrease shark catch rates, would interact with a comparatively very small number of sharks, certainly fewer than the contracted vessels would catch without the shark deterrent modified gear. As such, the impacts on shark populations due to FSBAD experiments would be negligible.

### **3.2.4 Potential Impacts to Water Quality from Corrosion of E<sup>+</sup> and Other Repellent Materials**

Electropositive metals (E<sup>+</sup>) are reactive in seawater and produce a measurable electric field that may be repulsive to electroreceptive fishes such as sharks. E<sup>+</sup> metals, which include lanthanide metals, reside towards the left side of the periodic table (Figure 6) and undergo spontaneous hydrolysis in

the presence of seawater. By measuring the electric fields of the metals, it is possible to understand the responsible characteristics for this electrorepulsion and thus simulate those characteristics to deter sharks and other elasmobranchs from accessing and biting on baited hooks.

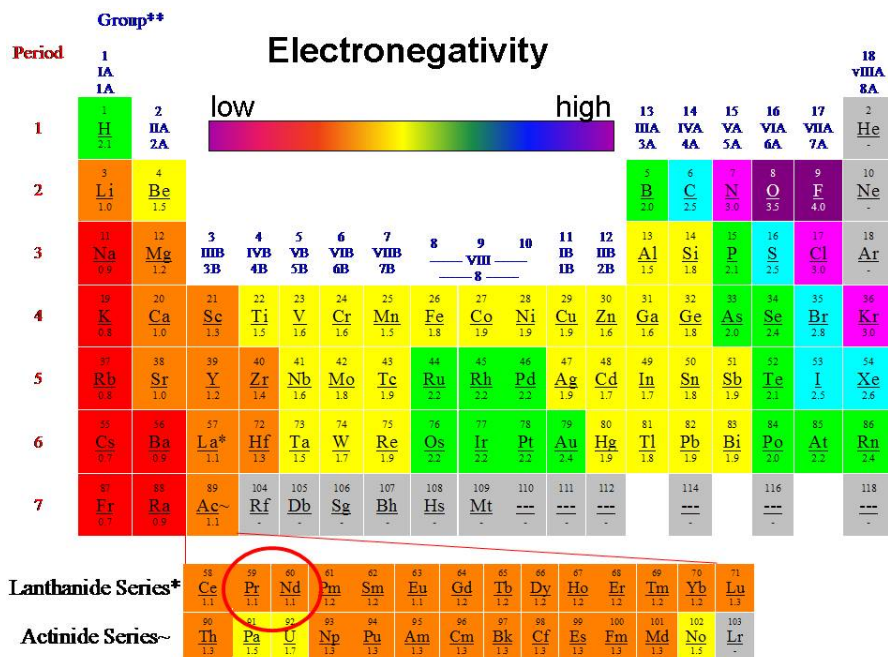


Figure 6. Periodic table with lanthanide series highlighted

E<sup>+</sup> metals used in these experiments include lanthanide elements, specifically neodymium (Nd) and praseodymium (Pr). According to the Hodge-Sterner classification system, lanthanide elements (rare earth elements) are generally considered to be of low toxicity (Haley 1965). According to MSDS information, the lanthanide metals, neodymium and praseodymium, have a low to moderate acute toxicity rating (MSDS, Haley 1965). Toxicological studies indicate that the metals and their oxides have little toxicity to organisms (Haley 1965). A recent review indicates that lanthanide elements are used as animal feed performance boosters. Along with performance enhancing effects, rare earth elements also present very low oral toxicity, even in long-term feeding trials. Additionally, hardly any accumulation was noticed in animal tissues. On this basis, rare earth application as feed additives is considered to be safe for both animals and humans. In addition, lanthanide elements appear to be used in a variety of medicinal products (see review Redling 2006). These chemicals or their oxides do not appear on the following lists and are therefore not regulated: the Clean Water Act’s Priority Pollutants, OSHA’s Air Contaminants, Clean Air Act’s Regulated Toxic, Explosive, or Flammable Substances, Clean Air Act’s Criteria Air Pollutants, Superfund’s Extremely Hazardous Substances, Resource Conservation and Recovery Act’s Hazardous Constituents, Safe Drinking Water Act’s Maximum Contaminant Levels, or the Clean Air Act Toxic Release Inventory program (TRI) list.

As such, the use of these E<sup>+</sup> metals (Nd and Pr) as elasmobranch deterrents would have little if any toxicity to the environment, to any organisms, or to fishers handling the ingots. With regards to other chemical compounds that may have elasmobranch deterrent properties, these same lists would be searched and any chemical that is found on a list that could potentially cause an impact to organisms, humans or the environment would have standard operating procedures developed to minimize any potential adverse effects or would not be used.

### **3.2.5 Cumulative Impacts**

Protection afforded sharks through cooperative international actions, especially bans on finning, has had a limited level of positive effect on pelagic shark populations. However, bycatch of sharks, skates, and rays on the high seas by international commercial fisheries has had little regulation, international cooperation, or improved fishing gear and methods until recently. Throughout the world, the Hawaii-based longline fishery counts of shark bycatch are well below total shark abundance because this fishery is likely the most regulated fishery in the world. However, the implementation of circle hooks for reducing sea turtle mortality sometimes results in higher catches of sharks, especially in the shallow-set swordfish fishery (Gilman 2007).

The current and proposed expanded elasmobranch bycatch reduction research program supports Magnuson-Stevens Act mandates per National Standard 9 for reducing bycatch, the U.S. final Plan of Action for the Conservation and Management of Sharks (National Marine Fisheries Service 2001), and international laws for the conservation and recovery of sharks. As detailed in Chapter 2, the FSBAD research focuses on testing electromagnetic deterrents effective for elasmobranchs in the laboratory and, increasingly, in the field, using NOAA research vessels and cooperating vessels in domestic and foreign fisheries.

As presented in Chapter 3, research on electromagnetic deterrents and, potentially, other chemical repellents as identified in the future, is not anticipated to have a detectable impact on other marine organisms, nor on people handling the materials. The number of sharks caught as bycatch in fisheries conducted on domestic and foreign cooperating vessels would be expected to be lower because of the deterrent materials attached to portions of the gear. Also, shark populations would not be adversely impacted by the limited number of sharks removed alive for laboratory experiments and returned to the sea following completion of the tests (Sections 2.2, 2.3, and 3.2)). As discussed in Section 3.2, sea turtle populations in the northern Pacific Ocean would also not be adversely impacted by FSBAD research activities within the context of other activities adversely impacting sea turtles, such as nesting habitat loss, and egg, hatchling, and adult mortality caused by humans and predators.

Other PIFSC research that involves species discussed in this PEA include research on the Hawaii green sea turtle in Hawaii nearshore waters, and Hawaiian monk seals in the Northwestern Hawaiian Islands, where longline fishing would not occur. Therefore, no cumulative effects would be anticipated among PIFSC research activities.



The past, present, and future research activities are not likely to have had or have any adverse cumulative effects on the environment. Further, research results have begun to indicate that the use of electromagnetic materials may be effective in reducing elasmobranch bycatch without increasing bycatch of other nontarget species and maintaining or improving CPUE of target fish. Therefore, the existing and proposed research programs conducted by FBSAD in the laboratory and on cooperating domestic and foreign vessels as currently conducted and as expanded are not anticipated to detrimentally affect endangered or threatened cetacean and sea turtle populations, individually or cumulatively. The electropositive metals used are not expected to have any adverse impacts on humans handling the materials, either in the laboratory or in the field (Chapter 3).

### **3.2.6 Potential Impacts Related to Global Climate Change**

Ocean climate fluctuations that change the habitat quality or the prey availability of ocean resources have the potential to affect their short- or long-term distribution and abundance. Changes in oceanographic conditions may alter rates of direct and incidental takes of ocean resources in commercial fisheries as well as research. Rises in sea levels would not adversely affect populations of sharks or marine mammals. Rises in sea level might adversely impact important nesting habitat for sea turtles, but no analyses of these impacts are available. The magnitude of potential effects is uncertain, but as applied to the smaller scale nature of the research considered here, is not likely to affect the analysis presented. As indicated in Section 1.6, any changed circumstances that would have environmental relevance would require additional analysis and appropriate management changes that might be integrated into the FSBAD research program as appropriate.

## 4 List of Preparers

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Dr. Yonat Swimmer has been researching marine turtles and for over 20 years, and she has been involved in fisheries bycatch reduction research since 2001. Her primary focus has been on reduction of sea turtle bycatch in longline fisheries, but she has also conducted research in gill net fisheries and more recently in research on sharks. Yonat continues to do research in the areas of physiological, chemically, sensory and behavioral ecology with the aim of identifying means to improve the selectivity of marine fisheries. Yonat has a Bachelor's Degree in Biology from the University of California, Santa Cruz, and a Master's Degree and a Ph.D. in Wildlife Ecology from the University of Michigan.

### **Dr. John H. Wang, Ph.D.**

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Dr. John H. Wang's research interests are focused on the sensory systems of marine animals. He has examined the sensory cues used during orientation and navigation, studied the neurobiological basis of magnetic orientation and determined how animals use the Earth's magnetic field to locate their geographic position. In addition he has examined how sensory cues can be used to understand why marine animals interact with fishing gear. John is currently working with NOAA Fisheries Service, Pacific Island Fisheries Science Center, Fish Biology and Stock Assessment Division to investigate the sensory cues that lead sea turtles and elasmobranchs to interact with various fisheries. Based on these studies, he has developed strategies that could be useful in reducing bycatch fisheries and has conducted field trials to determine their efficacy. John received his B.Sci. from Duke University and his Ph.D. from the University of North Carolina at Chapel Hill.

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Ms. Lee has over 30 years of experience developing and implementing environmental planning strategies for and managing complex and often-politically-charged environmental impact statements and environmental assessment leveraging the expertise of highly-skilled agency professional staff. Ms. Lee specializes in facilitating cross-functional and inter-organizational interdisciplinary teams through the NEPA planning process, resulting in well-supported decisions and long-term positive inter- and intra-agency relationships. She prepares the document concurrently with the progress of the analysis, using a self-correcting review process and an easy-to-read and understand format. Her education and experience in the natural resource management field and with National Marine Fisheries Service projects and programs through the preparation and review of many documents and presentation of highly-tailored workshops provides a strong foundation for the agency's planning efforts. She has prepared several NEPA documents for PIFSC research programs, and workshops for the NMFS Pacific Islands Regional Office and Northwest Regional Office. Ms. Lee received her B.S in Wildlife Management from the University of Maine, Orono, and her B.S. in Wildlife Biology from Utah State University, Logan.

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