Papahānaumokuākea Marine National Monument

RESEARCH Permit Application

NOTE: ***This Permit Application (and associated Instructions) is to propose activities to be conducted in the Papahānaumokuākea Marine National Monument. The Co-Trustees are required to determine that issuing the requested permit is compatible with the findings of Presidential Proclamation 8031. Within this Application, provide all information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Papahānaumokuākea Marine National Monument (Monument).***

ADDITIONAL IMPORTANT INFORMATION:

- Any or all of the information within this application may be posted to the Monument website informing the public on projects proposed to occur in the Monument.

- In addition to the permit application, the Applicant must either download the Monument Compliance Information Sheet from the Monument website OR request a hard copy from the Monument Permit Coordinator (contact information below). The Monument Compliance Information Sheet must be submitted to the Monument Permit Coordinator after initial application consultation.

- Issuance of a Monument permit is dependent upon the completion and review of the application and Compliance Information Sheet.

INCOMPLETE APPLICATIONS WILL NOT BE CONSIDERED

Send Permit Applications to:
Papahānaumokuākea Marine National Monument Permit Coordinator
6600 Kalaniana'ole Hwy. # 300
Honolulu, HI 96825
nwhipermit@noaa.gov
PHONE: (808) 397-2660 FAX: (808) 397-2662

SUBMITTAL VIA ELECTRONIC MAIL IS PREFERRED BUT NOT REQUIRED. FOR ADDITIONAL SUBMITTAL INSTRUCTIONS, SEE THE LAST PAGE.

Papahānaumokuākea Marine National Monument
Permit Application Cover Sheet

This Permit Application Cover Sheet is intended to provide summary information and status to the public on permit applications for activities proposed to be conducted in the Papahānaumokuākea Marine National Monument. While a permit application has been received, it has not been fully reviewed nor approved by the Monument Management Board to date. The Monument permit process also ensures that all environmental reviews are conducted prior to the issuance of a Monument permit.

Summary Information

Applicant Name: George A. Antonelis
Affiliation: National Marine Fishesies Service, Pacific Islands Fisheries Science Center

Permit Category: Research
Proposed Activity Dates: May 1, 2009 to September 30, 2009
Proposed Method of Entry (Vessel/Plane): Vessel and/or plane (based on availability)
Proposed Locations: FFS

Estimated number of individuals (including Applicant) to be covered under this permit:
Up to 10 but no more than 3 at any one time
Estimated number of days in the Monument: 180

Description of proposed activities: (complete these sentences):

a.) The proposed activity would… monitor predation on Hawaiian monk seal pups by Galapagos sharks and deploy shark deterrent gear around selected FFS pupping sites.

b.) To accomplish this activity we would ….observe shark activity at FFS (from ground and tower) and install visual, auditory, magnetic and electromagnetic deterrent devices on island, in small boats anchored offshore, or suspended in the water column using floating tubes or floats

c.) This activity would help the Monumen**t** by … contributing to recovery of the Hawaiian monk seal, which is a keystone species within the Monument and is a protected species under provisions of both the ESA and MMPA. The Papahanaumokuakea Marine National Monument is home to approximately 94% of the entire population of endangered Hawaiian monk seals and is therefore critical to the future prospects of the species.

Other information or background: Predation on Hawaiian monk seals by Galapagos sharks has resulted in the loss of 15-21% of the annual cohort born at FFS in recent years. This behavior has not been observed at other breeding sites in the NWHI. This year, NMFS proposes to continue with the experiment (begun in 2008) to test the efficacy of various non-lethal alternatives for mitigating this mortality source and salvaging the reproductive potential of these pups.

Section A - Applicant Information

1. Applicant

Name (last, first, middle initial): Antonelis, George A.

Title: Chief, Protected Species Division

1a. Intended field Principal Investigator (See instructions for more information):
Shawn Farry

2. Mailing address (street/P.O. box, city, state, country, zip):

Phone:

Fax:

Email:

For students, major professor's name, telephone and email address:

3. Affiliation (institution/agency/organization directly related to the proposed project):
NOAA, NMFS
Pacific Islands Fisheries Science Center (PIFSC)
Protected Species Division (PSD)

4. Additional persons to be covered by permit. List all personnel roles and names (if known at time of application) here (e.g. John Doe, Research Diver; Jane Doe, Field Technician):
Charles Littnan, PIFSC,
John Henderson, PIFSC,
Robert Dollar, PIFSC,
Shawn Farry, PIFSC
Mark Sullivan, PIFSC Contractor;
Chad Yoshinaga, PIFSC,
Kathleen Gobush, PIFSC,
Additional technicians (TBD) under the supervision of Shawn Farry

Section B: Project Information

5a. Project location(s):

		Ocean Based	
☐ Nihoa Island	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Necker Island (Mokumanamana)	☐ Land-based	☐ Shallow water	☐ Deep water
☒ French Frigate Shoals	☒ Land-based	☒ Shallow water	☐ Deep water
☐ Gardner Pinnacles	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Maro Reef			
☐ Laysan Island	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Lisianski Island, Neva Shoal	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Pearl and Hermes Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Midway Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Kure Atoll	☐ Land-based	☐ Shallow water	☐ Deep water
☐ Other			

NOTE: There is a fee schedule for people visiting Midway Atoll National Wildlife Refuge via vessel and aircraft.

Location Description:
Vicinity of Trig and the Gins Islands and/or other islets within FFS where predatory Galapagos shark activity is detected

5b. Check all applicable regulated activities proposed to be conducted in the Monument:

☐ Removing, moving, taking, harvesting, possessing, injuring, disturbing, or damaging any living or nonliving Monument resource
☐ Drilling into, dredging, or otherwise altering the submerged lands other than by anchoring a vessel; or constructing, placing, or abandoning any structure, material, or other matter on the submerged lands
☒ Anchoring a vessel
☐ Deserting a vessel aground, at anchor, or adrift
☐ Discharging or depositing any material or matter into the Monument
☐ Touching coral, living or dead
☐ Possessing fishing gear except when stowed and not available for immediate use during passage without interruption through the Monument
☐ Attracting any living Monument resource
☐ Sustenance fishing (Federal waters only, outside of Special Preservation Areas, Ecological Reserves and Special Management Areas)
☐ Subsistence fishing (State waters only)
☒ Swimming, snorkeling, or closed or open circuit SCUBA diving within any Special Preservation Area or Midway Atoll Special Management Area

6. Purpose/Need/Scope ***State purpose of proposed activities:***
Recent studies have shown that shark predation has been a significant factor contributing to early pup mortality at FFS, particularly at Trig Island. A significant number of pup deaths or disappearances related to shark predation have been either directly observed or inferred from previous events associated with shark predation on pups. Intense predation on preweaned pups and recently weaned pups was first detected at Trig and neighboring Whaleskate Island in the late 1990s, when 18-28 mortalities were documented each year from 1997-99. This equated to 38-69% of the annual cohort born at those sites. Atoll-wide, from 2000-2007, there were 8-12 shark predation losses each year, equating to 12-21% of the annual cohort born at FFS. (At the time of this application, the predation data for 2008 were not yet analyzed, but should be available for review by November 15, 2008). This predation on pre-weaned pups is believed to involve a small number of persistent predators that first adopted the behavior after being attracted to the site by unusually high numbers of pup carcasses associated with two years of adult male seal aggression at Trig.

These high predation rates are incompatible with monk seal recovery at FFS, where a decrease in annual cohort size is predicted from an aging population. The proposed activities will include opportunistic monitoring of shark activity at sites where predation is detetected or suspected, and the use of several non-lethal, temporarily installed deterrents (sound, light, physical obstacles, and small work boats) to discourage predatory Galapagos sharks from sites where suckling and recently weaned pups are easily preyed upon.

7. Answer the Findings below by providing information that you believe will assist the Co-Trustees in determining how your proposed activities are compatible with the conservation and management of the natural, historic, and cultural resources of the Monument:

The Findings are as follows:

a. How can the activity be conducted with adequate safeguards for the cultural, natural and historic resources and ecological integrity of the Monument?
The PSD has assessed Hawaiian monk seal subpopulations in the NWHI annually since 1982. PSD has been monitoring shark predation on monk seal pups since 1997 and conducted shark removals from 2000 through 2007 (total of 12 Galapagos sharks removed). Through these investigations, PSD has acquired the necessary expertise for conducting research while also demonstrating a sensitivity to all other Refuge resources and procedures. There are no adverse effects anticipated for the proposed use of temporarily installed sound, light , visual, and magnetic deterrents near sites where young monk seal pups are most vulnerable to shark predaton. Regular monitoring of the deterrrent devices will occur to ensure and mitigate any unlikey negative effects to the ecosystem as a result of the actions proposed in the application.

b. How will the activity be conducted in a manner compatible with the management direction of this proclamation, considering the extent to which the conduct of the activity may diminish or enhance Monument cultural, natural and historic resources, qualities, and ecological integrity, any indirect, secondary, or cumulative effects of the activity, and the duration of such effects?
The Hawaiian monk seal is one of the keystone species within the Monument and activities that contribute to the monk seal's recovery are compatible with the objectives set forth in the Proclamation. Effects from deterring a limited number of the abundant Galapagos shark will be ephemeral and are not expected to have an effect on ecosystem functioning. Further, with the exception of the temporarily placed visual/magnetic deterrents placed in the near shore waters near monk seal mother/pup suckling sites pupping, all of the other proposed actions simulate ongoing human activities within the Atoll (e.g., engine noise from small work boats or actual small work boats at anchor). In contrast, failure to mitigate for the high predation rate (15-23% of the annual monk seal births) will have major effects on the likelihood of monk seal recovery at FFS. Mitigation for shark predation at FFS is also consistent with goal 6.b. of the U.S. Fish & Wildlife Service, National Wildlife Refuge System: "Conserve, restore where appropriate, and enhance all species of fish, wildlife, and plants that are endangered or threatened with becoming endangered."

c. Is there a practicable alternative to conducting the activity within the Monument? If not, explain why your activities must be conducted in the Monument.
Intensive Galapagos shark predation on monk seal pups is a localized phenomenon at FFS. There are no comparable sites available outside the Monument where the proposed research on shark deterrents could be conducted. Further, it is essential that these activities be conducted at the location where they are most likely to benefit monk seal survival and recovery.

d. How does the end value of the activity outweigh its adverse impacts on Monument cultural, natural and historic resources, qualities, and ecological integrity?
As noted, the positive outcomes from enhanced monk seal recovery potential outweigh any adverse but highly unlikely impacts associated with the proposed non-lethal activities. We do not believe that other, secondary, impacts are likely to result from the deterrent experiments, and no such negative impacts were observed during deterrent activities in 2008. All activities wil be monitored during regular visits to each wite where deterrents are deployed to ensure appropriate actions will be taken to mitigate any unexpected negative consequences of the proposed work.

e. Explain how the duration of the activity is no longer than necessary to achieve its stated purpose.
The activity will commence shortly before the start of the primary season so that the first sharks to begin patrolling pupping sites will encounter the deterrent devices. The activity will end at the conclusion of the pupping season.

f. Provide information demonstrating that you are qualified to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.

The PSD at PIFSC has conducted field assessments of monk seals in the NWHI annually since 1982, and is recognized as being central to Hawaiian monk seal research. PSD has been engaged in shark monitoring and shark removals at FFS since 1998 and 2000, respectively. PSD has individuals on-staff with many years of experience and advanced expertise in monk seal ecology and marine ecosystems. We also have consulted, and will continue to consult, with other individuals, both in the scientific and private communities, having expertise in shark behavior and potential deterrent methodology. To this end, NMFS convened a workshop on Shark Predation on Hawaiian Monk Seals in January 2008, to solicit input on shark behavior, shark deterrent technology, and other information pertinent to this situation. The workshop and our other ongoing consultations have also included contact with Native Hawaiian cultural practitioners.

g. Provide information demonstrating that you have adequate financial resources available to conduct and complete the activity and mitigate any potential impacts resulting from its conduct.
The PSD has annually received funding adequate to perform the activity, and anticipates that 2009 funding levels will continue to suffice. If additional funds are required to mitigate any unexpected impacts, resources would be available from PIFSC or NMFS Office of Protected Resources.

h. Explain how your methods and procedures are appropriate to achieve the proposed activity's goals in relation to their impacts to Monument cultural, natural and historic resources, qualities, and ecological integrity.
As noted in item f, NMFS has solicited and received input from a broad spectrum of scientists and managers as we have developed plans for an effective shark deterrent system. Throughout development, we have sought low-impact methods that may be temporarily deployed and removed with minimal or no impact to the reef ecosystem. While some quasi-permanent structures (obstructions to shark movements) were discussed at the January predation workshop, no such structures or devices are proposed for use in 2009. The deterrent methods proposed herein will introduce some non-natural visual and auditory elements to the ecosystem, but those elements will be localized at focal predation sites, will be removed at the end of the monk seal pupping season, and are not expected to result in any permanent modification to the physical or biotic environment within the Monument.

i. Has your vessel has been outfitted with a mobile transceiver unit approved by OLE and complies with the requirements of Presidential Proclamation 8031?
The NOAA vessel R/V Oscar Elton Sette has been so equipped.

j. Demonstrate that there are no other factors that would make the issuance of a permit for the activity inappropriate.
The deterrent activities proposed for 2009 are a continuation of the deterrent work initiated in 2008. All aspects of the PIFSC shark project have undergone extensive review in-house, by members of the Monk Seal Recovery Team, by the USFWS, and by the State of Hawaii. Unlike the shark mitigation activites permitted by the Monument prior to 2008, the current application does not seek authorization for lethal removal of

Galapagos sharks and, in that light, may be less controversial than the previously permitted activities.

8. Procedures/Methods:

This project encompasses three main components:

a) shark observation/monitoring,
b) shark deterrents using visual stimuli (random low level lights and other) and/or magnetic field deterrents (produced from metallic magnets or electromagnetic fields), and auditory shark deterrents using outboard random outboard motor sounds, and
c) focused hazing and tagging of sharks observed in close proximity to monk seal pupping areas, or exhibiting distinct predatory behavior toward monk seal pups.

A. Shark Observation/Monitoring

An effective monitoring system is required for documenting changes in shark activity at pupping sites, detecting instances of shark predation on monk seal pups, and assessing shark response to deterrent devices. In 2000, NMFS developed a standardized system for collecting and recording quantitative and behavioral data on sharks exhibiting predatory behavior toward monk seal pups. This system, called "time scan sampling" involved intensive, continuous observation of shark activity in the nearshore waters surrounding major pupping sites (a detailed description of the monitoring protocols are available in previous reports or upon request). Observations were historically conducted from both the ground and from an elevated tower on Trig Island. Continuous monitoring has proven less effective in recent years as sharks became increasingly wary of human presence and most patrolling and predation occurred at night. However, intensive monitoring may be reinvoked in 2009 because multiple deterrent systems will be deployed and it is essential that the effectiveness of each component be assessed. This will also enable us to progressively refine such aspects of the system as physical placement, timing, etc., and also to ascertain whether there are any undesirable effects associated with deterrent application We therefore propose to conduct intensive monitoring, including possible use of the observation tower, if the shark team concludes that the monitoring will help to assess the efficacy of each device.

Overnight camping: NMFS staff may request permission for overnight camping (1-3 nights at a time) in order to collect information during dawn/dusk periods. Overnight stays may be requested to evaluate the effectiveness and possible negative effects of the deterrents, or in response to an increase in shark activity or predation incidents. During overnight observations, the shark monitoring team may employ night-vision goggles to enable observations in low-light conditions (nocturnal and pre-dawn hours). No more than 2 people will overnight at study sites, campsites will involve minimum requirements typically used for backpacking (e.g., food, small, low profile tents and sleeping bags) and all waste material will be removed and transported to Tern Island for disposal in an appropriate manner. Such short camps have been successfully

completed at Trig Island on numerous occasions in the past without causing harm to the environment or the wildlife.

Monk seal population assessment personnel will continue to visit Trig Island on a daily or near-daily basis so that missing pups, shark-injured pups, or elevated shark activity will be immediately detected. Personnel will also visit the Gins on a regular basis, where 4 possible predation losses and multiple shark sightings occurred in 2008. Additional trips may occur specifically for maintenance of deterrent devices, or in response to shark incidents (sightings, woundings, or other). If sharks are observed, monitoring intensity will be immediately increased to evaluate the predation risk and to observe shark reaction to deterrent devices.

B. Deterrent Devices

Although data from the 2008 shark deterrent project have yet to be fully analyzed, preliminary evidence suggests that the devices were effective in reducing predation losses. At Trig Island, where deterrent devices were deployed at the greatest intensity, there were no losses over a 54 day period corresponding to maximum deployment of the deterrent system.

NMFS proposes to deploy 4 main classes of devices in 2009. These devices are comparable to those used in 2008, with the exception of the light source (1a, below) which was withdrawn from consideration in 2008 until technical details were resolved.

1. Visual: to include 3 subtypes
    a. Light source projected from shore or anchored boat
    b. Boat anchored in nearshore water
    c. Assorted visual stimuli (floats and other) deployed in association with the magnetic and electro-magnetic deterrents
2. Auditory: underwater loudspeaker system to broadcast boat noise
3. Magnetic: permanent magnets deployed in water column at strategic access points
4. Electro-magnetic: powered system that emits a low level electrical field

The types of deterrents proposed for use in 2009 are based on input received at the 2008 Shark Predation on Hawaiian Monk Seal Workshop or in private consultations. Experience gained during the first year of the project (2008) will help to refine the deterrent system so that is designed and deployed in the most effective manner possible. The main difference between the work conducted in 2008 and that proposed for 2009 is that additional devices will be deployed near the Gin complex (Gin and Little Gin Islands) where 4 possible shark losses occurred in 2008. As in 2008, we anticipate that some aspects of the system will require modification in either technology or deployment as field teams observe shark responses to each deterrent application and adapt the system for maximum effectiveness at each islet. The objective is to identify that suite of devices which proves most efficient and effective in eliminating shark predation at each site, while at the same time minimizing any environmental hazards or secondary effects on non-target species. This is likely to be an iterative process, and some flexibility will be necessary to ensure success.

All devices will be checked daily for 2 days following initial deployment. Thereafter, devices will be checked during regular seal monitoring activities. Seal monitoring will occur approximately 5 days per week at Trig Island, at least 3 days per week at East Island, and at least 2 days per week at Gin/Little Gin Islands. Experience gained in the 2008 deployments will enable personnel to gauge the safety, stability and durability of the deterrent devices, and the maintenance schedule may be adjusted to accord with those observations. Also, some circumstances (e.g., storm events or other work demands) may result in slightly longer intervals between visits.

1). Visual deterrents and Combination (Visual + Magnetic or Visual + Electromagnetic)

Random lights
This deterrent type consists of a beacon or spotlight situated either onshore (1-2 high points on island) or in a small boat anchored near shore. The light(s) would be programmed to turn on/off at random or preselected times. If feasible, the light will be capable of rotating or changing orientation to minimize possible habituation to this stimulus. Portable solar panels and/or 12V battery arrays will be used to supply power for the lights.

All devices will be checked daily for 2 days following initial deployment. Thereafter devices will be checked during regular seal monitoring activities. Seal monitoring will occur approximately 5 days per week at Trig Island, at least 3 days per week at East Island, and at least 2 days per week at Gin/Little Gin Islands.

Anchored Boat
The hypothesis that a boat anchored offshore near pupping sites will serve as a passive deterrent is based on direct observation of sharks patrolling nearshore waters in previous years. NMFS personnel have found that patrolling sharks tended to leave the area as a boat approached, and also tended to avoid the area near where boats were anchored. Further, the fact that in recent years, most shark predation has occurred during times when no humans were present at the island, suggests that sharks may have used visual cues to detect when humans were present and adjust their predatory behaviors accordingly. Based on these observations, NMFS believes that a decoy boat placed in the water may help to deter shark predation. Because boats are commonly used at FFS, this type of visual stimulus is an accepted part of the regular operations at FFS and does not introduce any novel environmental risks to the system. No fuel, batteries or other risk factors will be left on board the anchored boat. As with all of the deterrents, this deterrent type will be suspended if any unforeseen risk is detected.

Visual stimuli deployed with magnetic and electro-magnetic deterrents
These stimuli include various types of floats, streamers and buoys to be deployed in conjunction with the magnetic and electro-magnetic deterrent devices. These will be placed on the surface or within the water column and will serve the dual purpose of providing an attachment point for the other devices, while at the same time serving as additional visual stimuli. These visual stimuli are intended to either deter sharks directly or warn them of the presence of other stimuli that deliver an unpleasant sensation. These devices will consist of standard, over-the-counter devices (such as fishing buoys, fishing floats, water “noodles” and similar objects) made from plastics or

other inert materials. Observations in 2008 indicated that PVC tubing is preferable to plastic "noodles" because the latter material accumulates algae and degrades over 4-6 weeks time. These devices will resemble objects already commonly found in the water or on the beaches at FFS and will not introduce any novel environmental risks to the system. The arrays will be deployed in such a fashion that no entanglement hazards will be created. That is, each segment of the line will be far enough away from the next adjoining segment that there will be no possibility of cross contact. As with all of the deterrents, this deterrent type will be modified or suspended if any unforeseen risk is detected.

2). Auditory Stimuli
This stimulus will consist of amplified boat noise to mimic the sound of a small boat approaching the island. As with the anchored boat, the objective is to displace predatory sharks by imparting the impression that humans are in the vicinity. The unit used in 2008 was a Lubell LL916 transmitter, having a maximum output of 180dB @ 1k Hz, and frequency range of 200 Hz to 20 kHz. However, NMFS is investigating the use of more powerful amplifier and speaker system that is capable of broadcasting the simulated boat noise for a greater distance underwater.

Many shark sensory biologists refer to the combination of inner ears and lateral lines as the acoustico-lateralis system. Field and laboratory experiments have demonstrated that sharks can hear sounds with frequencies ranging from about 10 Hertz (cycles per second) to about 800 Hertz, but are most responsive to sounds less than 375 Hertz. Therefore, the Lubbell LL916 transmission will overlap the upper end of sharks frequency range (200 Hz – 800 Hz), however will not transmit in the low frequency of sharks hearing range (10 Hz to 200 Hz). The absence of transmissions in this range may be advantageous as some biologists speculate that low frequency sound may in fact attract sharks.

Boat noise is different in character from biological noise (Gerstein 2002). Underwater it has two domains, or operating conditions: noncavitating and cavitating noise. The frequency and power of boat noise is directly related to the speed of the vessel. The faster the propeller rotation, the more cavitation is created. As tiny bubbles form and collapse, they produce a broad range of frequencies above prevailing ambient conditions at frequencies up to 20,000 Hz. Conversely, when the rotation of the propeller is reduced and a boat is traveling slowly, the turbulence is minimal, and both the frequency and power spectrum of the noise are significantly reduced. The dominant noise spectra are below 1,000 Hz. As stated above the upper hearing threshold for sharks is 800 Hz.

Ambient noise generally ranges from 60 to 90 decibels, over a frequency range of 1 to 20,000 hertz, but levels can reach 130 decibels during heavy rain or in industrial areas. The critical ratio compares the intensity of a signal at the moment it is just detectable (the masked threshold) to the intensity of the background noise. The size of the critical ratio has important significance, as high ambient levels could conceivably raise detection thresholds beyond the absolute acoustic energy emitted by many boats or our proposed sound transmissions. Therefore, while our sound transmissions may occasionally be masked at distance by ambient sounds, we believe they may still prove to be a deterrent in close proximity to the speaker within the shallow confines of the Trig lagoon.

Information on the auditory systems of pinnipeds and cetaceans and exposure risks from auditory stimuli are provided in Appendix A. Based on the auditory sensitivity information provided therein, the salient conclusions are:

- Pinnipeds: Our proposed sound output would be approximately 50% of that known to cause injury in pinnipeds.
- Cetaceans: The recommended pressure criterion for injury is 230 dB, approximately 50 dB above our maximum speaker output and 120 dB greater than our maximum desired output of 120dB (a boat at high speed overhead).

3). Magnetic Deterrents
Much of the seminal work on the use of magnetic deterrents on sharks has been conducted by Shark Defense (PO Box 2593 Oak Ridge, NJ 07438, (877) 571 – 2207 http://www.sharkdefense.com), founded in 2001 by Eric and Jean Stroud. The following information has been largely extracted from information provided by Shark Defense.

Elasmobranchs (sharks, rays, and skates) have a unique sensory adaptation that allows them to detect electric fields in the marine environment. This sensory ability is referred to as electroreception and the sensory organ associated with electroreception is the Ampullae of Lorenzini. The ampullae are gel-filled pores homogenously distributed around the nose and mouth. The sensory system is designed to detect weak electric fields generated by mechanical muscle movement (e.g., swimming muscles or a beating heart). In the presence of an electric field, the electric potential at the surface of the animal will vary from the electric potential of the interior of the animal. This potential difference is then detected by the sensory cells that line the ampullae. Once the voltage differential is recognized, the sensory information is transmitted to the brain via afferent neurons (Adair et al. 1998).

SharkDefense has found that flux per unit area of certain permanent magnets, particularly Neodymium-Iron-Boride and Barium-Ferrite magnets, corresponds closely with the detection range of the Ampullae of Lorenzini. A permanent magnet with the correct specifications is hypothesized to over-stimulate the Ampullae of Lorenzini, and may therefore be used as selective shark repellent. The fields generated by these permanent magnets decreases at the inverse cube of the distance from the magnet. Therefore, at distances of a few meters from the magnet, the field exerted is less than the Earth's magnetic field.

For our application, the most important fact is that animals which lack an Ampullae of Lorenzini organ do not display aversive behavior in close proximity to the magnetic field, making this technology selective to sharks and rays (elasmobranchs). Thus behavior of elasmobranchs which do not prey on monk seals (e.g. reef sharks, rays) may also be affected, causing them to avoid areas where stimuli are deployed. Bony fish (teleosts), marine mammals, and turtles do not contain these electroreceptors, thus the use of permanent magnets is a selective repellent technology that should have no effects on non-elasmobranch species within the Monument. However, as with all of the deterrents, this deterrent type will be modified or suspended if any unforeseen risk or reactions are detected.

During 2008, NMFS deployed 20 of these magnet floats, and would like to increase the number deployed around Trig to approximately 40. This will ensure that the density is sufficient to act as a deterrent along all of the primary channels and around the major pupping zones.

4). Electro-Magnetic Deterrents
Five Shark Shield units were deployed in 2008. Although all five units eventually failed due to manufacturer defects, these devices appeared to have the greatest potential for deterring sharks away from key pupping areas. NMFS is consulting with the manufacturer to design custom units with longer battery life (up to 7 hours), and improved capacity for continuous, long-term immersion and operation.

The Shark Shield units utilize "electronic wave-form" technology invented by the Natal Shark Board of South Africa (http://www.shark.co.za/). The physiological basis for this technology, like the magnetic deterrents described above, is the Ampullae of Lorenzini, the gel-filled sacs located in the shark's snout which are used to pick up the electrical signals emitted by the nerve impulses from living creatures. The Shark Shield produces a three-dimensional electronic wave form which creates an unpleasant sensation impacting the shark's Ampullae of Lorenzini. When the shark comes into proximity with the electronic wave form (around 8 meters in diameter) it experiences non-damaging but uncontrollable muscular spasms causing it to flee the area. The field is projected from the unit by two electrodes, which create an elliptical field that surrounds the unit. Both electrodes must be immersed in the water for the field to be created. The electrode configuration depends on the model of the Shark Shield unit. From testing, the closer the shark is to the Shark Shield field, the more spasms occur in the sharks' snouts. This becomes intolerable and the shark then veers away, and usually doesn't return. Electro-magnetic deterrents, like magnetic deterrents, do not select among elasmobranches, so non-target elasmobranch species such as reef sharks and rays may also alter their behavior.

A distinct advantage of the unique electronic wave-form is that it deters sharks and does no lasting harm to the shark. Once the shark is out of the affected area, it no longer feels the effect of the electronic wave form.

On its web site, the manufacturer describes results from laboratory and field tests of Shark Shield devices. According to the manufacturer, the devices pose no risk to humans and will not affect the behavior of non-Elasmobranch species:

> *Direct contact with, or very close proximity to the antenna, may cause twitching of the surface muscles of the skin, in time with the slow pulsing of the signal. The conductive field readily travels through seawater, it being a better conductor than the human body. Thus the field tends to surround the body rather than penetrate it. Scientific tests show that the type of signal generated by the Shark Shield is unable to pass through body tissues, unlike radio waves or microwaves that readily penetrate the body, and therefore it poses no health problems for users.*
>
> *… One of the distinct advantages of this unique electronic wave-form is that it only repels predator sharks and members of the Elasmobranch family including Rays and Skates. Elasmobranch animals all have Ampullae of Lorenzini.*

According to Paul Ludd, Shark Shield Sales Manager "the waveform has absolutely no affect on marine life and this is why we use it in aquaculture, particularly the tuna industry around pens, the pearling industry, and on the cod-end of prawn trawler nets to prevent sharks attacking the net and loss of catch."

The Shark Shield units have an output of approximately 80 volts. For comparison, an electro-shocking device used to non-lethally collect fish utilizes a DC current of 3-7 amps and 100-250 volts in fresh water. At high conductivities (i.e. marine environments) salt water is less resistive than fish and the electro-shocking current will flow around them. Another important parameter is the temperature. There is a 40% reduction in conductivity when the water temperature is reduced from 20˚c to 0˚c therefore colder water will increase the fishing efficiency. Therefore, for our application, the lower voltage (80 volts) and high conductivity of warm salt water support the manufacturer's claim of minimal impact on fish.

As with all other deterrent devices, the efficacy of these devices must be assessed by direct observation, and should any adverse effects to other species be detected, their use will be modified or suspended.

Risks due to Deterrent Systems

No negative effects on non-target species due to the deterrent system were observed in 2008. Nonetheless, when designing the deterrent systems to be deployed in 2009, the risk of negative impacts associated with each system remains a prime consideration. Such negative effects could include: entanglement (by monk seals or other species), undesired deterrent effects on non-target species, detachment and/or loss of the equipment, attraction to the islet from novel auditory or visual stimuli, and unintended damage to coral or other system resources. Each device will be evaluated according to each type of risk, and no device will be deployed unless the risks are determined to be negligible. Further, as noted in the section on Shark Monitoring/Observation (section A, above) both the effectiveness and risks associated with each device will be assessed by direct observation. Additionally, deployment of all deterrents will be incremental to allow assessment and evaluation, after which deployment may be suspended, modified, or expanded.

C. Hazing and Tagging of individual sharks

In 2008, NMFS personnel observed several sharks engaged in distinct predatory behavior. In these cases, the sharks were either patrolling in shallow water immediately offshore or were observed making direct approaches towared monk seal pups. Galapagos sharks were involved of these incidents, although a tiger shark was observed patrolling at Trig Island in early August. On three occasions, NMFS personnel hazed the shark away from the islet, either by throwing coral or "herding" the shark from the boat. In each instance, the shark was persistent and resisted displacement. In 2009, NMFS proposes to continue this focused hazing because it appeared successful in providing an immediate, albeit temporary, redress for a high risk situation.

In association with the hazing, NMFS requests authorization to deploy “spaghetti tags” on individual sharks observed in predatory activity. This will enable reliable identification of individual sharks, and will assist in determining the number of sharks engaged in focused pup predation.

D. Native Hawaiian Practices and Participation

Prior to deployment, NMFS will consult with a Native Hawaiian cultural practitioner to determine if any miitigation efforts proposed for 2009 are deemed inappropriate or inconsistent with Native Hawaiian cultural considerations. All scientists participating in these activities will receive a Native Hawaiian cultural briefing before departure to the NWHI. In addition, the primary permittee, chief scientist, and other appropriate personnel look forward to consulting with the Office of Hawaiian Affairs (OHA) and the Monument's Native Hawaiian program coordinator on proper conduct while in the NWHI, on cultural sensitivities associated with the proposed activities and locations, and on the applicability of the results of this research to the role of OHA as one of the NWHI management agencies.

E. Activity reports

Periodically throughout the period covered by this permit, NMFS will submit progress reports describing preliminary findings on the success of the deterrent systems. These reports will also describe any negative effects observed for each system, and will summarize shark activity at FFS:

- Number of pups born and currently present at each islet
- Date and location of shark related pup injuries, deaths and disappearances at all sites;
- Summary of observed shark activity at each site
- Any other information pertinent to the ongoing evaluation of this project

F, Project Evaluation

The ultimate goal of the project is a reduction in shark-related pup mortality at French Frigate Shoals, with particular emphasis at Trig Island. Given this goal, the number of pup mortalities will be the primary measure of project success (specifically, a decline in the number of losses as compared to prior years). In addition to this measure, other direct observations are key to evaluating project success. These include: the apparent deterrent effect of different types of devices, the manpower required to install and maintain each device, the cost of each device (both initial and ongoing), and any evidence of undesirable secondary effects associated with each class of device. These observations will be critical as we continue to refine the deterrent system for future application.

NOTE: If land or marine archeological activities are involved, contact the Monument Permit Coordinator at the address on the general application form before proceeding, as a customized application will be needed. For more information, contact the Monument office on the first page of this application.

9a. Collection of specimens - collecting activities (would apply to any activity): organisms or objects (List of species, if applicable, attach additional sheets if necessary):

Common name:

Scientific name:

& size of specimens:

Collection location:

☐ Whole Organism ☐ Partial Organism

9b. What will be done with the specimens after the project has ended?

9c. Will the organisms be kept alive after collection? ☐ Yes ☐ No

• General site/location for collections:

• Is it an open or closed system? ☐ Open ☐ Closed

• Is there an outfall? ☐ Yes ☐ No

• Will these organisms be housed with other organisms? If so, what are the other organisms?

• Will organisms be released?

10. If applicable, how will the collected samples or specimens be transported out of the Monument?

11. Describe collaborative activities to share samples, reduce duplicative sampling, or duplicative research:
Representatives from PIFSC have been actively engaged in dialog with other labs and investigators to design field and laboratory research studies that specifically address our species

and field situation. These researchers include: Eric Stroud of Shark Defense (private firm) who has studied the use of chemical agents and permanent magnetics to deter shark predation, and John Wang who has conducted field trials on the north shore of Oahu testing the efficacy of E+ metals (lanthanides) to deter shark feeding (including Galapagos sharks). In the former case, we provided Dr. Stroud with a Galapagos shark carcass to test the repellent effect associated with semiochemicals present in the carcass. We have also been actively involved with researchers at California State University (Lowe and Weatherby) and the Hawai'i Inst. of Marine Biology (Meyer and Holland) to conduct behavioral studies of Galapagos sharks at FFS. We will continue to interact with these and other researchers to develop lab and field studies more specific to our situation with Galapagos shark predation at FFS.

12. List all specialized gear and materials to be used in this activity:
As described above (*Procedures/Methods* section), the primary deterrent devices to be deployed in 2009 include an auditory system; multiple visual deterrents (a light source, anchored boat, and in-water visual deterrents used in combination with magnetic deterrents); magnetic deterrents situated at primary shark access points around predation sites; and a commercial electric deterrent system (Shark Shield). Each of these device types is described below and may be used in combination or separately as deemed appropriate by the field staff. The specific models mentioned below are contingent upon availability and additional research prior to deployment.

Visual Deterrent Gear:
Type 1: Light Source:
Primary device: One to two single 12-volt light sources, placed at high points on Trig or the Gins Islands and mounted on short metal poles 6-12 in off the ground or mounted to the anchored boat offshore. The light source will be shielded to prevent damage and programmed to turn on and off randomly during the night.
Additional Requirements: 12V battery, solar panel, pelican case, and timer.

Type 2: Boat Decoy
An unused boat will be left anchored at Trig and/or the Gins. The boat could be periodically moved about the island and in conjunction with sound emissions, may act as a deterrent. Visual deterrents will be immediately removed if entanglement or attraction potential is identified and the boat will be anchored securely with heavy duty moorings and anti chaffing gear.

Type 3: In-water visual deterrents
Objects such as PVC tubing or foam floats may be attached to magnet array (see Magnetic Deterrents, below) to act as additional visual deterrent.

Auditory Deterrent Gear:
Primary device: The device used in 2008 was a Lubell Labs Model LL919 Diver recall system. The technical specifications indicated a 500m omnidirectional recall range, or up to 1 mile under ideal conditions; with up to 180 db output, using a 12v battery operation. The speakers and sound system/batteries will be secured in either a fixed boat or a fenced on- island location and will be removed at the end of the season or should any adverse non-target impacts be identified.

Based on observations in 2008, NMFS proposes to use a higher amperage device, capable of delivering the stimulus over a longer distance.

Magnetic Deterrent Gear:
Of the deterrent apparatuses, the only component that might be considered highly specialized is the magnets. The recommended magnet type is: Grade C8 Barium-Ferrite permanent magnets (15.24 cm x 10.1 cm x 1.27 cm). The cost, size, and handling safety make the use of this type of magnet very desirable over rare-Earth magnets of the same size. The strength of flux is sacrificed with a flux per unit area of at least one order of magnitude weaker at a Barium-Ferrite's magnet's surface than a rare-Earth magnet. However, despite this limitation, the wide-area flux created by these magnets may, especially at distances less than 20cm, orient the sharks away from the magnets.

Commercial Electric Deterrent Gear (Shark Shield)
Five Shark Shield units were deployed in 2008, and, as noted above, all units eventually failed. The causes of the failures are unknown at this time. However, NMFS is consulting with the manufacturer to design custom units that have longer battery life (up to 7 hours) and which can better withstand continual, long term immersion and operation. The technical details of the custom devices have yet to be determined, but they should be similar to the current commercially available *Mariner* units (15m exclusion zone), but powered externally using solar panels or battery arrays. Additional specifications are available at the company's web site: (http://www.sharkshield.com). The following information is extracted from that site:

> *The field generated by the Shark Shield poses no danger to the user, to sharks or to the environment. The field can be detected if the electrodes come into very close contact with the skin.*
>
> *Direct contact with, or very close proximity to the antenna, may cause twitching of the surface muscles of the skin, in time with the slow pulsing of the signal. The conductive field readily travels through seawater, it being a better conductor than the human body. Thus the field tends to surround the body rather than penetrate it. Tests show that the type of signal generated by the Shark Shield is unable to pass through body tissues, unlike radio waves or microwaves that readily penetrate the body, and therefore it poses no health problems for users.*
>
> *From the tests conducted to date, the Shark Shield does not harm the shark. The majority of initial testing was carried out by a team of marine biologists at the Natal Sharks Board of South Africa.*
>
> *Scientific tests, as well as observations, show the field emitted by the Shark Shield causes discomfort to the shark, which can eventually lead to muscular spasms. However once the shark leaves the area, there is no lasting detrimental effect to the shark.*
>
> *One of the distinct advantages of this unique electronic wave-form is that it only repels sharks and members of the Elasmobranch family that have have Ampullae of Lorenzini.*

Shark Tagging Gear:
The shark tags will be standard "spaghetti" (external, colored tags) suitable for large marine fishes. They will be deployed using a jab stick.

13. List all Hazardous Materials you propose to take to and use within the Monument:
The only components of the deterrent system that might be considered hazardous are a) the 12V batteries that will power the audio and light deterrents, and b) the Shark Shield system. Please refer to the preceding question (item 12a) for material pertaining to the safety of the Shark Shield system. The batteries will be sealed and secured so that there is negligible chance of leaking any hazardous materials (i.e., battery acid) into the environment.

14. Describe any fixed installations and instrumentation proposed to be set in the Monument:
All devices (including light deterrents, auditory deterrents, visual deterrents, magnetic deterrents, and electric deterrents) will be temporary and removed at the end of the season or at any point when they cannot be regularly monitored (daily when first deployed, and a minimum of every 2 days thereafter).

15. Provide a time line for sample analysis, data analysis, write-up and publication of information:
As noted in item 8 (Procedures and Methods), during the field season, NMFS will submit periodic progress reports describing preliminary findings on the success of the deterrent systems. At the conclusion of the study (on or before Nov 15, 2009), NMFS will prepare a report summarizing all findings from the season, including number of observed predation incidents, predation trends as compared to previous years, observed numbers of sharks at each site, observed reaction to deterrent devices of each type, problems encountered, preliminary conclusions about the efficacy of the deterrent system, and recommendations for future mitigation using the same deterrents or other methods.

16. List all Applicants' publications directly related to the proposed project:
Annual progress reports have been prepared by NMFS during each year of the shark predation mitigation project, 2000-2007. Also, a manuscript describing the predation situation and prior mitigation efforts has been submitted for publication to the journal Ecology and Society: *Galapagos Sharks And Monk Seals: A Conservation Conundrum* (A. Harting, G. Antonelis, B. Becker, S. Canja, D. Luers, and A. Dietrich).

With knowledge of the penalties for false or incomplete statements, as provided by 18 U.S.C. 1001, and for perjury, as provided by 18 U.S.C. 1621, I hereby certify to the best of my abilities under penalty of perjury of that the information I have provided on this application form is true and correct.

_____

Signature Date

SEND ONE SIGNED APPLICATION VIA MAIL TO THE MONUMENT OFFICE BELOW:

Papahānaumokuākea Marine National Monument Permit Coordinator
6600 Kalaniana'ole Hwy. # 300

Honolulu, HI 96825
FAX: (808) 397-2662

DID YOU INCLUDE THESE?

- ☐ Applicant CV/Resume/Biography
- ☐ Intended field Principal Investigator CV/Resume/Biography
- ☐ Electronic and Hard Copy of Application with Signature
- ☐ Statement of information you wish to be kept confidential
- ☐ Material Safety Data Sheets for Hazardous Materials

Appendix A: Auditory Capabilities of Selected Marine Species

Pinnipeds

- Auditory bandwidth of pinnipeds in water (75 Hz – 75kHz).
- For Hawaiian monk seals, the frequency range of greatest auditory sensitivity is from 12 kHz to 28 kHz (Thomas et al., 1990).
- Non pulses – TTS (temporary threshold shift) on harbor seal at 25 min exposure to 152 dB, California sea lion 174 dB, Northern elephant seal 172 dB. While the TTS of monk seals is likely just within the range of the 180 dB maximum output of our proposed speaker, our target output is 80-100 dB, would be much shorter in duration, (<5 min, and as the animals are not captive they could easily move away from the sound source.
- Approx >20 dB over TTS is required to induce PTS (permanent threshold shift i.e. injury) onset.
- For pinnipeds in water, the recommended pressure criterion for injury from exposure to nonpulsed sounds is the same value applies to pulses: an unweighted value of 218 db. **Therefore, our proposed sound output would be approximately 50% of that required to cause PTS in pinnipeds.**

Cetaceans

- For cetaceans, published TTS data are limited to the bottlenose dolphin and beluga. Schlundt , C.E., Finneran, J.J., Carder, D.A., & Ridgway, S.H.(2000). Temporary shift in masked hearing thresholds (MTTS) of bottlenose dolphins and white whales after exposure to intense tones. *Journal of Acoustical Society of America, 107, 3496-3508.*
- Schundt et al. (2000) reported TTS in five bottlenose and 2 belugas using non-pulsed sound at frequencies of 3 kHz, 10, kHz and 20 Khz SPL (sound pressure levels) with TTS onset at 192-201 dB. This is above our maximum speaker output of 180 dB, our maximum desired output of 120dB (a boat at high speed overhead) and our average target output (a boat at slow speed) of 80-100 dB.
- **For all cetaceans exposed to nonpulses, the recommended pressure criterion for injury is 230 dB, the same criterion as for single pulses. This is 50 dB above our maximum speaker output and 120 dB greater than our maximum desired output of 120dB (a boat at high speed overhead).**
- The minimum distance of speaker deployment to any cetaceans is likely to be >1 mile at Trig with spinner dolphins occasionally seen north of the island outside of the reef. At the Gins, spinner dolphins are occasionally seen with ¼ mile on the west side of the islets. To further reduce possible impacts speakers may be oriented toward the island and away from open water. Bottlenose dolphins are occasionally observed within the atoll typically at distances of several miles from the proposed deployment locations.

*If not otherwise cited, all exposure information is from Southhall et al 2007

Literature Cited

Adair, R.K, R.D. Astumian, and J.C. Weaver. 1998. Detection of weak electric fields by sharks, rays and skates. Chaos 8(3): 576-587

Gerstein, E.R. 2002. Manatees, Bioacoustics and Boats - Hearing tests, environmental measurements and acoustic phenomena may together explain why boats and animals collide. American Scientist 90(2): 154-163.

Southhall, B. L., A.E. Bowles, W.T. Ellision, J.J. Finneran,, R.L. Gentry, C.R. Greene, D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P. Tyack. 2007. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations, Aquatic Mammals, 33(4).

Thomas, J. A., P. Moore, R. Withrow, and M. Stoermer. 1990. Underwater audiogram of a Hawaiian monk seal (*Monachus schauinslandi*). J. Acoust. Soc. Am. 87 (1): 417-419.