# DRAFT PROGRAMMATIC ENVIRONMENTAL ASSESSMENT OF POTENTIAL WHITE SHARK RESEARCH AND EDUCATION PROJECTS WITHIN THE GULF OF THE FARALLONES AND MONTEREY BAY NATIONAL MARINE SANCTUARIES

**Office of National Marine Sanctuaries**
**National Ocean Service**
**National Oceanic and Atmospheric Administration**
**U.S. Department of Commerce**

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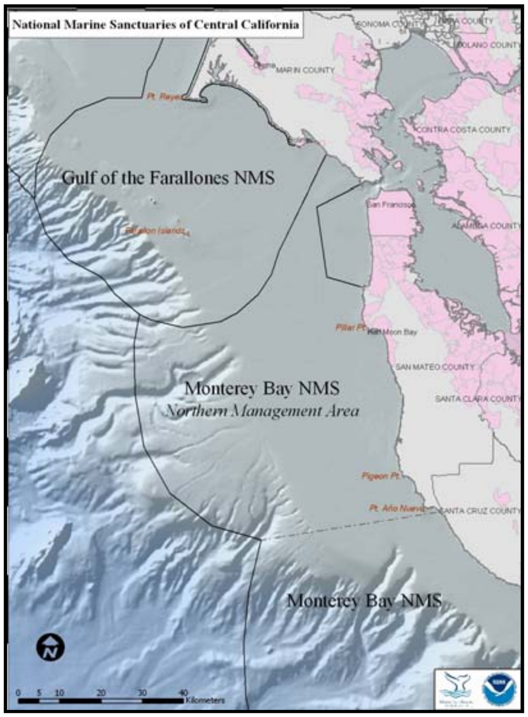
## Acronyms and Abbreviations

| | |
|---|---|
| ARGOS | Advanced Research and Global Observation Satellite |
| AWA | Animal Welfare Act |
| C | carbon |
| CDFG | California Department of Fish and Game |
| CDFW | California Department of Fish and Wildlife (formerly known as CDFG) |
| CEQ | Council on Environmental Quality |
| CFR | Code of Federal Regulations |
| CITES | Convention on International Trade in Endangered Species |
| DDT | dichloro-diphenyl-trichloroethane |
| DNA | deoxyribonucleic acid |
| EA | environmental assessment |
| Fg | recovery factor |
| GFNMS | Gulf of the Farallones National Marine Sanctuary |
| gph | gallons per hour |
| IUCN | International Union for the Conservation of Nature |
| MBNMS | Monterey Bay National Marine Sanctuary |
| MCSI | Marine Conservation Science Institute |
| Mini-PAT | Miniature Pop-up Archival Transmitting (tag) |
| mpd | miles per day |
| mtDNA | mitochondrial deoxyribonucleic acid |
| N | nitrogen |
| NAO | National Oceanic and Atmospheric Administration Administrative Order |
| NEPA | National Environmental Policy Act |
| $N_{min}$ | minimum number in a population estimate |
| NOAA Fisheries | NOAA National Marine Fisheries Service |
| NOAA | National Oceanic and Atmospheric Administration |
| ONMS | Office of National Marine Sanctuaries |
| PARS | Port Access Route Study |
| PCBs | polychlorinated biphenyls |
| Point Blue | Point Blue Conservation Science |
| PVC | polyvinyl chloride |
| $R_{max}$ | maximum recruitment rate |
| SPOT | Smart Position or Temperature (transmitting tag) |
| SWQPA | State Water Quality Protection Area |
| TOPP | Tagging of Pacific Predators |
| U.S.C. | United States Code |
| USCG | United States Coast Guard |
| USGS | United States Geological Survey |
| UNCLOS | United Nations Convention on the Law of the Sea |
| USFWS | United States Fish and Wildlife Service |

# EXECUTIVE SUMMARY

The purpose of this draft programmatic environmental assessment (PEA) is for the Office of National Marine Sanctuaries (ONMS) to consider the effects of ONMS-regulated White Shark research and education activities that are either occurring or are anticipated to occur within the Gulf of the Farallones National Marine Sanctuary (GFNMS) and the northern Monterey Bay National Marine Sanctuary (MBNMS) over the next five years. This draft programmatic 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 effects of a proposed federal action as a basis for informed decision making.




The mission of ONMS is to serve as the trustee for the nation's system of marine protected areas and to conserve, protect and enhance their biodiversity, ecological integrity and cultural legacy. Sanctuaries protect areas that encompass unique or significant natural and cultural features, and they serve as natural classrooms and research areas to promote understanding and stewardship of our oceans. Sanctuaries are also sites for recreational sport fishing and diving, and commercial industries such as tourism, fishing and shipping.

The National Marine Sanctuaries Act, along with site-specific legislation and regulations, provides the legal framework outlining activities that are allowed or prohibited in a sanctuary. A permit system is used to oversee exceptions to otherwise prohibited activities in sanctuaries. Sanctuaries then coordinate with state and other federal agencies on their respective environmental laws and regulations. For example, the Monterey Bay and Gulf of the Farallones national marine sanctuaries do not regulate the "take" of White Sharks, which includes any activity that involves their capture, mark and release. Any activity that involves the take of White Shark in state waters requires a permit from the California Department of Fish and Wildlife (formerly called California Department of Fish and Game) (CDFG; Title 14 CCR Section 670.7, *Permits to Take Fully Protected Animals for Scientific Purposes*).

GFNMS regulations at 15 Code of Federal Regulations (CFR) Section 922.82(a)(13) prohibit attracting a White Shark throughout the sanctuary, or approaching within 50 meters (164 feet) of any White Shark within the line approximating 2 nautical miles (approximately 2.3 miles) around the Farallon Islands. MBNMS regulations at 15 CFR Section 922.132(a)(13) prohibit attracting White Sharks throughout the entire MBNMS. GFNMS manages both its own sanctuary proper and the northern management area (NMA) of the MBNMS (with the exception of implementing the MBNMS Water Quality Protection Program). The NMA extends from the San Mateo / Santa Cruz County line northward to the existing boundary between the MBNMS and the GFNMS. Collectively, these two sanctuary areas are referred to as the GFNMS management area, thus, GFNMS is responsible for reviewing permit applications for White Shark attraction and approach and issuing permits for regulated activities within this entire area.

To implement sanctuary regulations to help protect and conserve the White Shark population that uses the GFNMS management area, GFNMS initiated the White Shark Stewardship Project. The regulations at 15 CFR sections 922.82 and 922.132 may allow for activities that are otherwise prohibited through the issuance of a permit if the superintendent finds, among other things, that the activity will: (1) further understanding of sanctuary resources and qualities; (2) further the educational or natural value of the sanctuary; or (3) assist in managing the sanctuary.

The scope of this PEA describes research and education projects for which sanctuary staff can reasonably expect to receive permit applications over the next five years and that may have the potential to affect White Sharks within GFNMS and the MBNMS. The analysis presents information on the anticipated direct, indirect and cumulative effects to the physical and biological environment resulting from possible permit activities related to approach and attraction. As part of the evaluation, GFNMS staff received input from the public, members of the Gulf of the Farallones National Marine Sanctuary Advisory Council, state and federal regulatory and research staffs, other White Shark scientists, and existing permit holders. The resultant alternatives are:

- *Alternative A (No Action): Allow No Exceptions to the Prohibition on White Shark Attraction and Approach*. Under the No Action alternative, permitting to attract or approach White Sharks for research and educational tourism purposes would not be allowed in the sanctuaries.
- *Alternative B (Preferred): Allow White Shark Attraction and Approach That Meet Management Goals*. This alternative would allow White Shark research to be conducted in the sanctuaries provided the applicant can demonstrate that the proposed activity would advance scientific understanding of White Shark life history or enhance White Shark conservation while implementing methods that would minimize potential effects to the sharks. This alternative would also allow White Shark tourism operators to attract White Sharks with decoys near the Farallon Islands provided the applicant can demonstrate their vessel will have trained naturalists on board and that their visitors will receive an educational benefit that dispels misperceptions about White Sharks, provides an understanding of White Shark conservation and protection efforts, and provides an understanding of the role that both White Sharks and the sanctuaries play in creating a healthy, balanced marine ecosystem.

Applicants requesting permission to approach or attract White Sharks in the sanctuary for research or education purposes will have their applications evaluated by sanctuary staff in the context of the wider analysis provided in this document. This draft PEA provides an important opportunity for the public to comment on the two alternatives related to White Shark research and education projects anticipated over the next five years in the sanctuaries. The document will be used by GFNMS to inform permit decisions. Alternatives not considered here would require separate environmental analysis before they could be permitted. GFNMS staff seeks to ensure that permitted White Shark disturbances are sufficiently minimized to: 1) allow for the support, promotion and coordination of scientific research and long-term monitoring that improves the sanctuaries' understanding, protection and management of White Sharks; and to 2) enhance the public's awareness, understanding and appreciation of White Sharks within the sanctuary to better enable their protection.

Comments received, as well as other considerations described in this document, will provide key information to assist future permit decisions. As a result, GFNMS would use this analysis to comply with the National Environmental Policy Act (NEPA) requirements for individual permit applications.

# 1 PURPOSE AND NEED

## 1.1 Background

The Gulf of the Farallones National Marine Sanctuary (GFNMS or sanctuary) consists of approximately 1,279 square miles of coastal and ocean waters and submerged lands along and off the coast of northern California (See Figure 1). The sanctuary extends to and around the Farallon Islands and includes the nearshore waters (up to the mean high water line except within wilderness areas of the Point Reyes National Seashore) from Bodega Head in Sonoma County to Rocky Point in Marin County (National Oceanic and Atmospheric Administration [NOAA], 2008a; *Federal Register*, 2010).

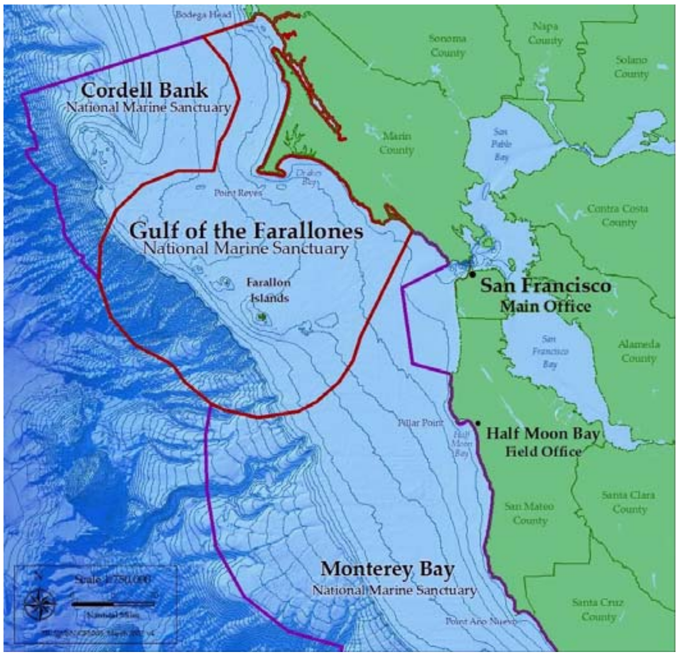


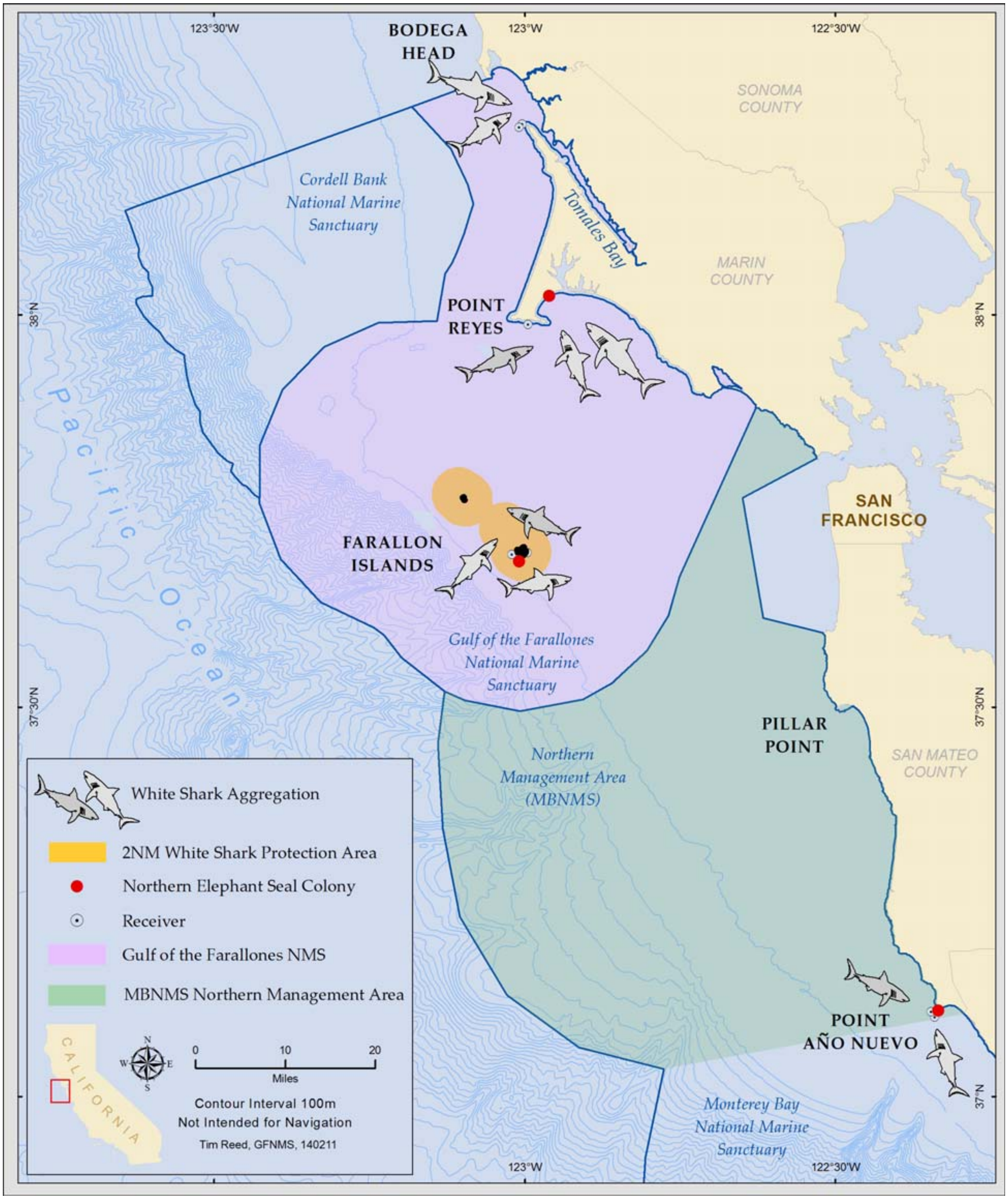

**Figure 1. Boundaries of Cordell Bank NMS, GFNMS and northern area of MBNMS.**

The Monterey Bay National Marine Sanctuary (MBNMS), which is adjacent to and south of GFNMS, encompasses approximately 6,094 square miles of ocean along 276 miles of shoreline between the Marin Headlands and Cambria and includes a non-contiguous offshore area to the south named Davidson Seamount (MBNMS, 2011) (See Figure 1). With the exception of implementing the MBNMS Water Quality Protection Program, GFNMS manages the northern area of MBNMS from Año Nuevo in San Mateo County to its northern boundary off the coast of southern Marin County (See Figure 2). Both the area within GFNMS and this northern region of MBNMS are referred to collectively as the "GFNMS management area" throughout this document.

The California Current and strong coastal upwelling make the GFNMS management area one of the most productive ocean systems in the world with a rich diversity of marine mammals, seabirds and fishes (NOAA, 2003). The waters around the Farallon Islands, Año Nuevo Island, Tomales Bay, and Point Reyes National Seashore are also known for seasonal aggregations of adult and sub-adult northeastern Pacific White Sharks (*Carcharodon carcharias*) (See Figure 2). Figure 2 shows the known aggregation sites for White Sharks within the GFNMS management area as well as permitted receiver locations (i.e. moored sensors deployed to detect acoustically tagged sharks in the vicinity). The waters around Guadalupe Island, which is offshore Baja, Mexico, is the only other location in the northeastern Pacific where adult White Sharks are currently known to regularly congregate (See Figure 3 in Section 1.5). However, in recent years it has been found that White Sharks tend to migrate to an open ocean region, located between Hawaii and North America, which is referred to as the "White Shark Café" or "shared offshore foraging area (SOFA)" (Domeier and Nasby-Lucas, 2008). The Convention on International Trade in Endangered Species (CITES) of Wild Fauna and Flora defines the northeastern Pacific

White Shark population (NEP population) as consisting of individuals from the Bering Sea and Gulf of Alaska to the Gulf of California, including Canada (British Columbia) and the entire Pacific coast of the United States (Washington, Oregon, California, Alaska), as well as much of Mexico, Panama, Ecuador, Peru, Chile, and the Galapagos Islands (CITES, 2004).

**Figure 2. White Shark Seasonal Aggregation Sites within the GFNMS Management Area.**



## 1.2 Assessing Disturbances to White Shark

In September 2008, GFNMS, MBNMS and Cordell Bank National Marine Sanctuary completed a joint management plan review to address new management actions, including the adoption of regulations related to attracting and approaching White Sharks. The new regulations specific to White Sharks were the result of seven years of study, planning and extensive public input from sanctuary advisory councils, shark biologists, shark dive operators, other wildlife recreationists, stakeholder agencies and general members of the public.

The GFNMS regulations at 15 Code of Federal Regulations (CFR) Section 922.82(a)(13) went into effect March 2009 (NOAA, 2008b) and prohibit attracting a White Shark anywhere in the sanctuary, or approaching within 50 meters (164 feet) of any White Shark within the line approximating 2 nautical miles (approximately 2.3 statute miles) around the Farallon Islands. The MBNMS regulations prohibit the attraction of White Sharks anywhere within MBNMS (15 CFR Section 922.132(a)(13)). The definition of "attract or attracting" under sections 922.81 and 922.131, means conducting or attempting to conduct any activity that lures or may lure any animal in the sanctuary by using food, bait, chum, dyes, decoys (e.g., surfboards or body boards used as decoys), acoustics, or any other means, except the mere presence of human beings (e.g., swimmers, divers, boaters, kayakers, surfers).

The intent of the regulations pertaining to White Sharks was to specifically address disturbances related to repeated encounters with humans and boats as a result of cage diving operations and other wildlife watching operations (NOAA, 2008b). They were also intended to reduce conflicts between shark researchers and shark wildlife viewing operators that existed at the time. Prior to the regulations, some operators and recreational boaters deployed surfboards to elicit strike responses from White Sharks congregating near the Farallon Islands; some operators also engaged in chumming with fish parts or oil (NOAA, 2008a).

To implement the new regulations, GFNMS initiated the White Shark Stewardship Project in late 2009, the goal of which is to protect and conserve the group of White Sharks that aggregate seasonally in the GFNMS management area (GFNMS, 2011). The White Shark Stewardship Project was created primarily to prevent disturbances and alterations to White Shark natural behaviors, including feeding, mating, aggregating and migrating but has developed into the GFNMS umbrella program for White Sharks and includes the following project components: 1) Public and boater outreach; 2) Naturalist trainings; 3) School education programs; 4) Permitting (including monitoring of research and educational tour activities); 5) Coordinating with the NOAA Office of Law Enforcement (http://www.nmfs.noaa.gov/ole/) and other partners to track vessel activity and potential disturbances throughout the Sanctuary; and 6) Coordinating with international partners on White Shark conservation efforts.

Since implementing the White Shark Stewardship Project, human disturbance of White Sharks in the GFNMS management area now occurs mainly as a result of permitted scientific research and educational tourism operations, although NOAA has received a small number of reports of potential regulatory violations of the prohibition on attracting White Sharks in the vicinity of the Farallon Islands, which are under investigation.

## 1.3 Environmental Review Requirements

This document is being prepared pursuant to the National Environmental Policy Act (NEPA; 42 United States Code [U.S.C.] §4321 et seq.), which applies to all "major" federal actions significantly affecting the quality of the human environment. A major federal action is an activity that is fully or partially funded, regulated, conducted or approved by a federal agency. ONMS scientific research or education permits are federal actions that require an environmental review under NEPA, and may qualify for a categorical exclusion unless the action involves extraordinary circumstances. Per National Oceanic and Atmospheric Administration Administrative Order (NAO) 216-6, when a proposed action that would otherwise be categorically excluded is the subject of public controversy based on potential environmental consequences, has uncertain environmental effects or unknown risks, establishes a precedent or decision in principle about future proposals, may result in cumulatively significant effects, or may have an adverse effect upon endangered or threatened species or their habitats, then the preparation of a NEPA document is required (NOAA, 1983).

In 2009, the GFNMS superintendent initiated the development of an environmental assessment (EA) to analyze the potential impacts of issuing a single research permit (issued to Dr. Domeier to allow the attraction of White Sharks for tagging in the sanctuary) after a shark was accidentally hooked in the esophagus during the capture process. The purpose of this research project is to improve our knowledge of the full migratory cycle of White Sharks by attaching satellite transmitters called "smart position and temperature" tags (SPOT tags) on White Sharks that seasonally visit the sanctuary. The initial draft EA was released to the public on September 24, 2010 and also sent to local, state, and federal agency staffs; White Shark naturalists; researchers; members of the media; and others. It was posted to the GFNMS web page on September 28, 2010, and a notice of availability was published in the Federal Register on September 30, 2010, with a 15-day comment period that ended on October 15, 2010. GFNMS received 32 public comments; 16 opposing the research, 11 in favor of the action and 5 expressing no opinion or were neutral. The comments received were wide-ranging, but primarily centered around the methods proposed during this research and the methods that could mitigate potential risks to sharks in the study. Many comments that were received related to concerns about the welfare of the animals during and after tagging events. In response to these comments, and because of the imminent expiry of other research and education projects that involve White Sharks in the sanctuaries, in 2010, GFNMS staff decided to combine and assess all potential permit actions into one programmatic document intended to more fully analyze potential disturbances to White Sharks that may occur from research and tourism activities in the GFNMS management area over the next five years. Comments from that project-specific draft EA have been incorporated into the analysis contained in this programmatic document. Additional detailed analyses about the activities that were assessed in that EA are also provided in Section 5.

This programmatic environmental assessment (PEA) serves as a more comprehensive document that considers the effects of a number of related actions or projects that have either been proposed by permit applicants since 2009 or may be anticipated over the next five years. This includes an assessment of particular methodologies, which are expected to be proposed as part of the research and education activities in the GFNMS management area. The analysis of past, present, and reasonably foreseeable future actions as well as the associated methodologies that are described in this PEA was compiled from current and past permit applications as well as communications with potential future applicants.

## 1.4 Regulatory Review Requirements

As discussed earlier, attracting or attempting to attract White Sharks within GFNMS and MBNMS is prohibited, and approaching White Sharks is further restricted in a specific zone in GFNMS. However, supporting, promoting and coordinating research, long-term monitoring and enhancing public awareness of sanctuary resources are objectives of the National Marine Sanctuaries Act. Therefore, pursuant to CFR Sections 922.83 and 922.133, the Office of National Marine Sanctuaries (ONMS) may issue a permit for White Shark activities that are otherwise prohibited, provided the GFNMS superintendent (whose authority was delegated by the ONMS Director) finds that the activity will:

- Further research or monitoring related to sanctuary resources and qualities;
- Further the educational value of the sanctuary;
- Assist in managing the sanctuary.

Among the considerations that the GFNMS superintendent must make in these permitting decisions is the consideration of the following factors:

- The applicant is qualified to conduct and complete the proposed activity;
- The applicant has adequate financial resources available to conduct and complete the proposed activity;
- The methods and procedures proposed by the applicant are appropriate to achieve the goals of the proposed activity, especially in relation to the potential effects of the proposed activity on sanctuary resources and qualities;
- The proposed activity will be conducted in a manner compatible with the primary objective of protection of sanctuary resources and qualities, considering the extent to which the conduct of the activity may diminish or enhance sanctuary resources and qualities; any potential indirect, secondary or cumulative effects of the activity; and the duration of such effects;
- The proposed activity will be conducted in a manner compatible with the value of the sanctuary, considering the extent to which the conduct of the activity may result in conflict between different users of the sanctuary, and the duration of such effects;
- It is necessary to conduct the proposed activity within the sanctuary;
- The reasonably expected end value of the proposed activity to the furtherance of sanctuary goals and purposes outweighs any potential adverse effects on sanctuary resources and qualities from the conduct of the activity; and
- Any other factors as the director (as delegated to the sanctuary superintendent) deems necessary.

As noted, sanctuary regulations only address the attraction and approach of White Sharks, however, all research methods (e.g., tag types, biological sampling, hook size, removal time, etc.) are assessed in this programmatic document because attraction would result in being able to conduct these other methods, and as such, should be evaluated as part of the sanctuary's decision in considering the potential effects of the proposed methods and procedures on White Sharks. Because White Shark aggregation sites are located in state waters, the primary responsibility for reviewing and approving scientific tagging projects lies with the California Department of Fish and Wildlife (CDFW) through a scientific collecting permit (Title 14 CCR Section 670.7, *Permits to Take Fully Protected Animals for Scientific Purposes*). The use of blubber from deceased marine mammals also requires an authorization from the NOAA National Marine Fisheries Service (NOAA Fisheries) under the Marine Mammal Protection Act (16 U.S.C. 1374). Sanctuary regulations complement the state's regulation for the protection of White Sharks; and sanctuary permits may include conditions that place limitations on certain methods proposed.

Individual research and education permit applications submitted to GFNMS, and documented to be consistent with this PEA and associated decisions, could be implemented pending appropriate permit review and compliance with NEPA (See Table 1). Any project or project-specific methods that are not specifically covered under this PEA or other NEPA documents would need additional appropriate NEPA analysis (40 CFR 1502.9).

## 1.5 Permit Categories

White Shark approach and/or attraction activities that are anticipated to occur over the next five years, and that are addressed by this PEA, are expected to fall within one of the following categories:

**Table 1. Activity Types Permitted within the GFNMS Management Area**

| Activity Type | Permit category |
|---|---|
| Educational Filming for Broadcast Media | Education |
| Educational Tourism | Education |
| Science | Research |

Since 2009, White Shark research permits have typically involved attracting White Sharks for tagging and photo identification purposes to provide information about White Shark life history and ecology, such as migration patterns, genetic isolation, site loyalty, environmental factors affecting abundance and success, and population structure, such as sex-ratios, local population estimates, and trends. Among the information requested during the review stage, applicants seeking a sanctuary research permit are required to justify why their study is necessary and are asked to provide information regarding their publication record and scientific credentials.

White Shark education permits have typically involved cage diving operations or boat-based White Shark viewing. These activities require a permit because the tourism operators have requested to use certain methods to attract sharks to their vessels to increase the chances their customers will see a White Shark. The tours are an opportunity to educate the public about the importance of sharks in a healthy ecosystem. Applicants seeking a sanctuary education permit for educational tourism activities are asked to provide information about their lesson plans and the qualifications of their naturalists.

Sanctuary permits may also be issued for any filming that involves approach or attraction of White Sharks. Information requested during the review of a film application includes who the targeted audience will be and the potential educational value of the film product. Educational tour operators have not been required to obtain a separate permit to film and photograph White Sharks attracted to their boats around the Farallon Islands. GFNMS staff had considered prohibiting filming for the production of broadcast media without a separate education permit for each tour operator, but concerns were raised about the enforceability of this condition. Feedback was also received from tourism operators who were concerned about their ability to control filming by their passengers (e.g. memento videos taken from pocket size cameras and posted on YouTube). Thus, separate film permits have not been required on permitted tourism vessels.

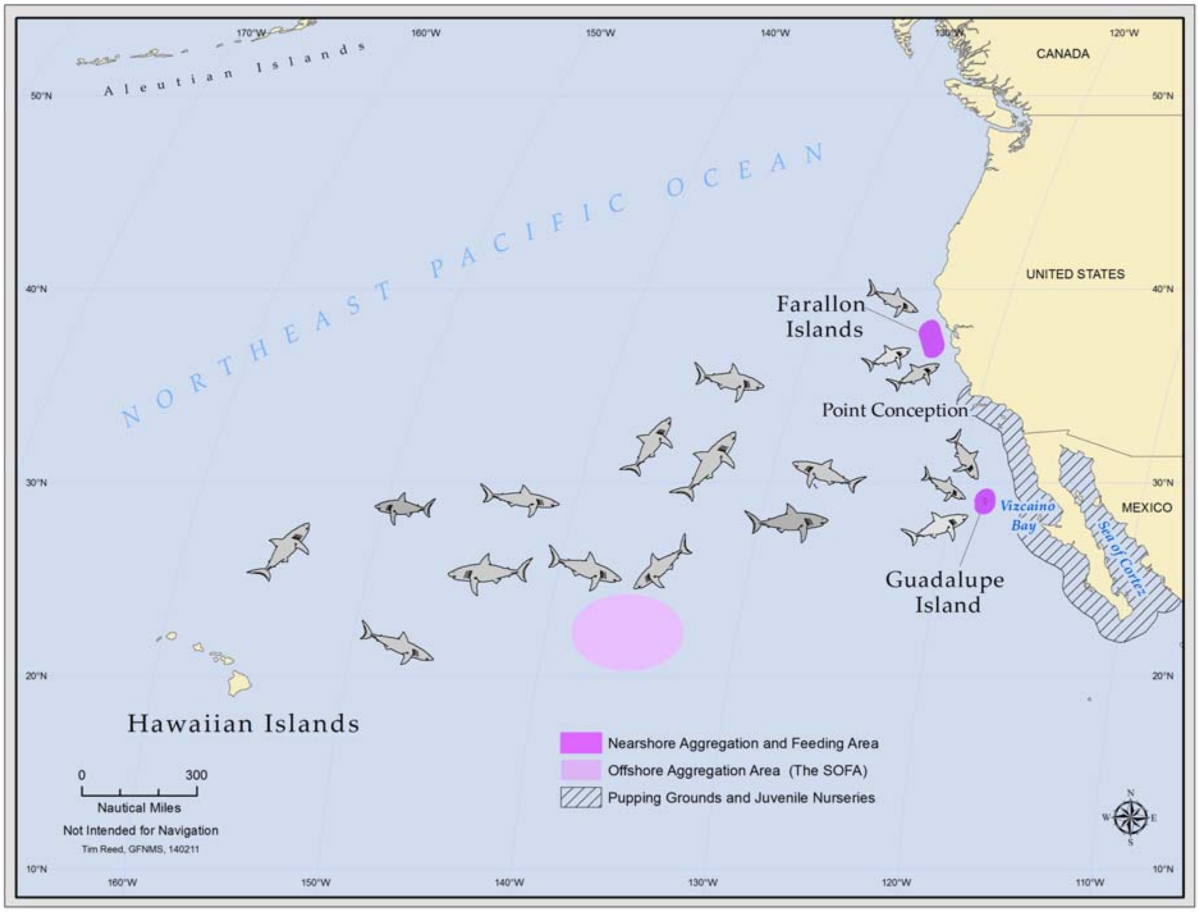
Approach has been authorized once in the GFNMS management area to make an educational film about sanctuary ecosystems. The filmmaker conducted three dives in January 2010 to film the underwater environment around the Farallon Islands. Approach was authorized to permit the filmmaker to film shark movements, if one happened to appear, but no sharks were seen. This authorization prohibited the filmmaker from approaching a White Shark during feeding activity or while the shark was at the surface.

### 1.5.1 Purpose of White Shark Research

While recent years have seen a significant increase in the amount of information available on White Sharks within the NEP population, significant knowledge gaps still remain. There is considerable uncertainty surrounding our understanding of many aspects of this population such as abundance, trends in abundance, threats, life history, and habitat use for all age and sex classes.

White Sharks that aggregate in the GFNMS management area and the White Sharks that aggregate in Mexico are genetically similar to each other and different from other White Shark populations (such as those found in Japan, Australia/New Zealand and South Africa (Jorgensen et al., 2010; Tanaka et al., 2011) (Figure 3). Tagging data shows a high level of site fidelity and no apparent migration outside of the northeastern Pacific area or mixing with other sub-populations (Domeier and Nasby-Lucas, 2008; Jorgensen et al., 2010; Anderson et al., 2011, Nasby-Lucas and Domeier, 2012). In a recent analysis of the NEP population, NOAA Fisheries has concluded that it is a distinct population segment that is discrete from the rest of the global taxon (NOAA Fisheries Service, 2013**.** However, little is known about the degree to which these two sub-populations (White Sharks that use the GFNMS management area and Mexico) may interact (social behavior, potential mating, etc). Long-distance and transoceanic migrations expose White Sharks to increased risk of mortality as they leave domestically protected waters and travel into neighboring or remote countries, sometimes located across entire ocean basins (Bonfil et al., 2005). Thus, understanding the degree of connectivity of these two northeastern Pacific groups is vital for determining their population status, the degree of intermixing, and management options (Jorgensen et al., 2012a). This information has proven difficult to obtain largely due to the inherent difficulties of working in a marine environment with such an elusive species (Pardini et al., 2000). Compounded with this is a general lack of population trend information on sharks worldwide, thus it can be difficult to ascertain if a population is increasing or decreasing.

**Figure 3. White Shark Nearshore and Offshore Migratory Patterns in the Northeast Pacific Ocean.**




Little is also known about the White Shark's life cycle, particularly when and where they mate, where different populations give birth, and the duration of gestation. Decades of fisheries catch data show that newly born White Sharks of the smallest size class (<5 feet), come only from coastal southern California and Northern Baja, suggesting that this is where White Sharks that migrate to the GFNMS management area are born (Klimley, 1985; Francis, 1996; Bizzaro et al., 2009a; Bizzaro et al., 2009b; Galván-Magaña, 2010; Santana-Morales et al., 2012) (See Figure 3).

White Shark migratory habits were virtually unknown prior to the use of satellite-linked tagging devices (Bonfil et al., 2010). Long-term studies on White Sharks in the GFNMS management area, which began during the early 1980s, determined that they return regularly to this area at predictable times of the year (Le Boeuf, 2004). When satellite tagging began on this group of White Sharks in the 1990s, it was then revealed that they make long-range migrations, although it remains unknown why they travel more than 2,500 miles between Hawaii and California and why they spend such a large part of the year in the middle of the Pacific Ocean where the typical prey type they have been observed to consume near the coast does not seem to be abundant. This long-term residency in the open ocean has not been described for White Sharks from regions other than the northeastern Pacific, although similar large-scale movements have been reported elsewhere in the world (Nasby-Lucas et al., 2009; Bonfil et al., 2005; Boustany et al., 2002) (See Figure 3).

GFNMS has allowed researchers to attract White Sharks for the purpose of attaching different types of tags to the sharks to help determine essential habitat use and to monitor future population trends. Still and video cameras are also used to collect fin morphology images to identify individuals for cataloging and further monitoring. Researchers have also been granted additional authorizations by NOAA Fisheries to use marine mammal blubber, and by the CDFW to collect biological samples for genetic and blood hormone studies, as well as for the capture of White Sharks to conduct the tagging activities. These are separate authorizations that must be obtained prior to receiving a sanctuary permit.

The purpose of conducting this research in the GFNMS management area has been to: 1) determine White Shark population size and trajectory; 2) determine essential habitat, migration patterns and ecological niche; 3) investigate the physiological and environmental determinants of the White Shark niche; and 4) examine the genetic structure of the northeastern Pacific population of White Sharks. The different types of tags that have been used in the GFNMS management area and the type of information that can be generated from each are summarized in Table 2. More detailed information about these tags is provided in Section 4.

**Table 2. Summary of Tag Types Deployed within the GFNMS Management Area (1999-2012)**

| Tag type | Number deployed | Data retrieval | Information obtained | Estimated tag battery life | Estimated deployment duration |
|---|---|---|---|---|---|
| Acoustic Monitoring | 144 | Data are sent to listening devices that are moored on the seabed, then this information is retrieved on site | Determining residency and site fidelity | 4.5 years | 1-3 years |
| Pop-up Archival Transmitting | 113 | Data are stored on the device, which must be retrieved | Tracking fine scale and large scale movements | Up to 500 days | Up to 400 days |
| Mini Pop-up | 1 | Data are stored on the device, which must be retrieved | Tracking fine scale and large scale movements | Up to 500 days | At least 1 year |
| Real-time Satellite Tracking (SPOT) | 2 | Data are uplinked to and downloaded from satellite | Tracking large scale movements | 3-5 years | 2-4 years |
| Intragastric | 0 | Data are stored on the device, which must be retrieved | Determining energy budgets | Up to 14 days | ~7 days |

Analyses of photo-identification records (through the 2011 season) indicate that both the acoustic monitoring and pop-up archival transmitting tagging events (257 in total) between 1999 and

2012 represent 102 individual White Sharks. Eighteen animals carried double tags (i.e., acoustic monitoring tags and pop-up archival transmitting tags). The use of these types of tags is intended for the ongoing monitoring of coastal movements of individual White Sharks.

Long-term tracking devices called Smart Position or Temperature (SPOT) tags have been attached to two sharks within the GFNMS management area. This type of tag can transmit a shark's position location and other data to the researchers in real time via satellites. SPOT tags are referred to in this document as "real-time satellite tags" to differentiate them from the pop-up archival transmitting, or PAT tags, in which data is retrieved after the tag detaches from the animal. Information from SPOT tags can be sent while the tag is still attached to the shark via satellite to a system called the Advanced Research and Global Observation Satellite (ARGOS) array, where data can be downloaded by researchers. It is important to note that the data signal from these tags can only be sent when the shark's dorsal fin is at the surface, thus, while the data transmission occurs in real-time, it is not being delivered continuously but rather periodically during a White Shark's annual migration since White Sharks may stay submerged for long periods of time. To date, two SPOT tags have been deployed on White Sharks within the GFNMS management area. A recent status review report by NOAA Fisheries to assess whether or not to list White Sharks under the federal Endangered Species Act (ESA) recommends the deployment of more satellite tracking SPOT tags on mature female sharks in order to better understand their long-term movements (NOAA Fisheries, 2013).

GFNMS has also permitted the use of bait to deploy intragastric or stomach tags, but this has not yet occurred within the GFNMS management area as of the completion of the 2012 research season. The purpose of these tags is intended to determine when the shark is feeding and how much energy it is expending.

The collection of blood and tissue samples allows for the ongoing genetic study of population structure and analyses of blood hormone levels to better understand the reproductive biology of the White Shark.

Photography and video records taken of the sharks allow for a type of "mark-recapture" modeling system that can be used to estimate the abundance of White Sharks in the GFNMS management area. This technique uses sighting data of different sharks to estimate abundance (Chapple et al., 2011). The photographic images and video records are used to determine gender and identify unique features on each shark's fin. The data can then be used to help validate population modeling assumptions by determining the rate of change within this framework. This is important to better understand whether the population is trending upwards or whether additional efforts need to be taken to protect the range of White Shark habitat. Estimating the number of tags shed will also improve the ability to provide accurate models of how many sharks are present. If the number of tagged sharks is consistently maintained each year, this would improve the model's accuracy by accounting for the population of sharks in the GFNMS management area. The combined use of acoustic tagging with photo identification is being used to develop a Bayesian model to determine how many animals are in the population that visits the GFNMS management area.

### 1.5.2 Purpose of White Shark Education Tours

An important part of the sanctuaries' role is to educate the public about the importance of White Sharks in a healthy and balanced ecosystem. Public attitudes are changing about sharks and there is an increased understanding of the need for sharks to help maintain a healthy, functioning ecosystem. White Shark tourism is a recreational activity that has become popular over the past decade around the Farallon Islands. White Shark enthusiasts from around the world sign up for tours to view White Sharks in the wild from the deck of a boat or from inside an in-water steel cage. These tours provide passengers with the potential for close encounters with White Sharks in the wild while also helping to dispel common misperceptions about White Sharks. The trips are intended to educate and bring awareness to the public about the challenges and conservation needs of White Sharks.

Between 2009 and 2012, commercial White Shark expeditions to the Farallon Islands have started as early as September 13 and have concluded as late as November 30. During this same period, the number of permits applied for and issued to commercial operators each year ranged from two to four, with as many as five expressing interest. The operators offer passengers the opportunity to view sharks from in-water cages and on deck or only from the deck of the vessel. Prior to the implementation White Shark approach and attraction regulations, as many as eight White Shark tourism operations were reported around the Farallon Islands (NOAA, 2008a). Currently, no commercial White Shark tourism operation is known to derive all of its income from shark diving or viewing operations in the GFNMS management area primarily because the White Shark season is short and the weather is unpredictable. As such, income derived from commercial operations around the Farallon Islands supplements income from other activities (such as shark diving and adventure operations in Mexico or the Bahamas) or from other business activities such as recreational charter fishing. Film crews have also hired these operators to obtain White Shark footage for educational films.

### 1.5.3 Purpose of White Shark Educational Filming

Research permits issued for White Shark attraction during the conduct of scientific tagging studies prohibit facilitating or aiding in the creation of marketable or publicly broadcast photo or video products. Researchers must obtain a separate education permit to have their work filmed for public dissemination. Photos or video footage specific to the research activity are allowed for photo-identification purposes and the sharing of these images is allowed provided no compensation is given to the permit holders or other authorized personnel for such uses. Broadcast filming of research activities is considered when there is a conservation and educational benefit associated with the film product. For example, an educational film project by Monterey Bay Aquarium focused, in part, on tagging work near the Farallon Islands. This film was used to update their visitor program about White Shark conservation research.

An example of a stand-alone film project was *Sanctuary in the Sea: A Gulf of the Farallones Experience*, which features footage of the sanctuary and its wildlife: whales, seabirds, sea lions and sharks. This film was featured for visitors at the California Academy of Science, has been seen in other venues around the country, and is available for viewing on YouTube.

## 1.6 Need for this Programmatic Analysis

Over the past five years, requests have been made by researchers to increase the number of sharks tagged as well as utilize new types of tags to track and monitor White Shark movements. Questions have been raised by the public as to whether these studies are necessary and if the sharks are being harmed. Requests have also been made by White Shark tour operators to use chum and other types of attractants to increase the possibility of passengers seeing White Sharks in the wild. Concerns have been raised as to whether the use of chum and other scent attractants has the potential to increase disturbances and alter White Shark behavior.

This programmatic document investigates potential White Shark research and education activities to assess the individual and cumulative effects of permitted activities on the subpopulation of northeastern Pacific White Sharks that seasonally aggregate in the GFNMS management area. This analysis is needed for GFNMS staff to review White Shark-related permit applications in the GFNMS management area and to ensure that the sharks' long term health and survivorship are not adversely affected by otherwise prohibited activities.

Management decisions about White Sharks need to be supported by information on the dynamics of local movements and interactions, and the extent to which these are affected by large-scale movements. While there is good knowledge about adult coastal habitat, juvenile habitat, residency, and population structure, important questions remain about the relationships among sharks in Mexico and sharks in U.S. waters and other areas. Understanding these highly migratory species could improve international management efforts. There is also limited understanding of White Shark population trends, their natural and/or anthropogenic threats, and the potential for effects to occur from oceanographic changes such as during El Niño events. Key gaps remain about the White Shark's life cycle, such as locations where females give birth or why White Sharks seasonally migrate thousands of miles into deep pelagic habitat. An accurate estimate of the number of White Sharks that congregate in the GFNMS management area is also needed.

Likewise, the sanctuary is a place where the public can learn scientifically accurate information about White Sharks and their conservation needs through educational tours, which are intended to help dispel misconceptions about White Sharks and encourage the public to protect these animals in the wild. Management decisions need to address the potential benefits of these educational tours relative to other White Shark educational opportunities or programs, such as films, exhibits, school programs, museum lectures, media articles and books, as well as to any adverse effects to sanctuary resources and qualities.

The EA analysis will be used by GFNMS staff to ensure that permitted White Shark disturbances are sufficiently minimized to: 1) allow for the support, promotion and coordination of scientific research and long-term monitoring that improves the sanctuaries' understanding, protection and management of White Sharks; and to 2) enhance the public's awareness, understanding and appreciation of sanctuary White Sharks to better enable their protection.

# 2 AFFECTED ENVIRONMENT

## 2.1 Overview

The Gulf of the Farallones and Monterey Bay national marine sanctuaries protect one of the most diverse marine ecosystems along the coast of North America. Within this area, the Farallon Islands, Año Nuevo Island, and the rocks off Point Reyes are unique habitats that provide breeding and resting sites for seabirds and pinnipeds. Historically, the animals in these areas were decimated by hunting. Today, the Farallon Islands are protected by the Farallon National Wildlife Refuge. Año Nuevo Island and the adjacent mainland are managed by California State Parks. The Point Reyes Peninsula is within the National Park Service's Point Reyes National Seashore. The waters and natural resources surrounding these areas are further protected by the National Marine Sanctuaries Act and other laws.

The Farallon Islands consist of a group of seven islands and large rocks that extend across an 8-mile area, located approximately 27 miles west of San Francisco, California. The islands are located near the outer edge of the continental shelf along a part of a submarine ridge that extends for approximately 34 miles between the Farallon Islands and Cordell Bank (NOAA, 2008c). The sanctuary seafloor gently slopes offshore along the continental shelf before dropping off abruptly to depths of 6,000 feet west of the islands (NOAA, 2010; Figure 4).

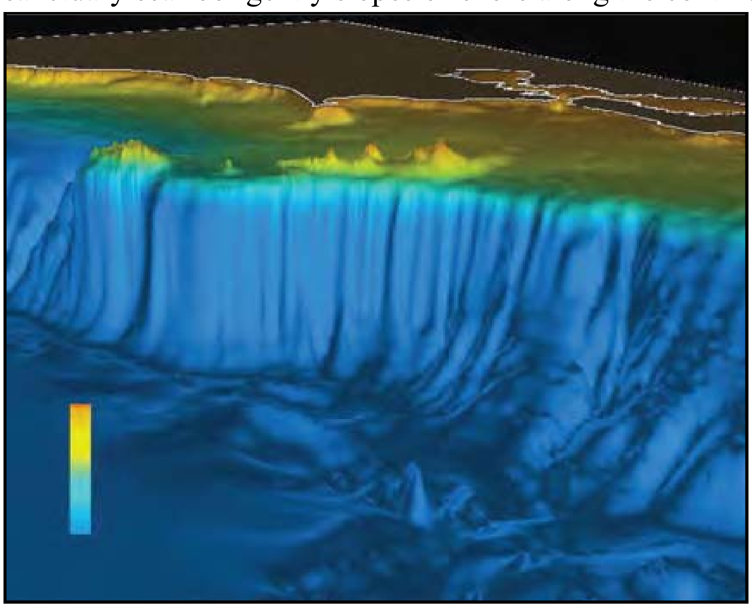


**Figure 4. Computer imagery shows the topography of the sanctuary seafloor and the steep drop-off of the continental slope west of the Farallon Islands. (Image source: ONMS, 2010.)**

Although the Farallon Islands cover a land mass of only 104 acres, the islands support the largest concentration of breeding seabirds as well as one of the most important seal rookeries, in the contiguous 48 states. A vast number of other bird species visit the islands, often many miles outside their normal ranges. Pinnipeds, including the threatened Steller sea lion (*Eumetopias jubatus*), haul out on the islands and forage in the sanctuary. More than a hundred species of fish and several species of marine turtles, including the endangered green (*Chelonia mydas*) and leatherback (*Dermochelys coriacea*) turtles, swim near the islands (United States Fish and Wildlife Service [USFWS], 2009).

Point Reyes and Tomales Point jut out from the westernmost and northernmost extent, respectively, of the Point Reyes Peninsula (See Figure 1). After being absent for more than 150 years, elephant seals (*Mirounga angustirostris*) returned to the sandy beaches of the Point Reyes Headlands in the early 1970s. In 1981, the first breeding pair was discovered near Chimney Rock. Since then, researchers have found that the colony is growing at an annual average rate of

16%. At the peak of the 2011 season, there were a total of 1,451 elephant seals at Point Reyes (National Park Service, 2011). Although White Sharks don't often enter enclosed bays or estuaries, they do hunt for seals and sea lions that frequent the area near the mouth of Tomales Bay (NOAA, 2008a).

Point Año Nuevo is a low rocky point, located approximately 56 miles south of San Francisco. Año Nuevo Island lies about one-half mile from shore. The 4,000-acre Año Nuevo State Reserve, including Año Nuevo Island just offshore, provides significant habitat for the harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*) and Steller sea lion. The area supports the largest mainland breeding colony in the world for the northern elephant seal. The elephant seal breeding season is from December through March when there are approximately 4,000 adults and pups in this area (Tomkins, 2011). Other marine mammals, including the Steller sea lion, come here to rest, mate, and give birth. California sea lions mainly breed on offshore islands, ranging from southern California's Channel Islands south to Mexico, although a few pups have been born on Año Nuevo and the Farallon Islands (Marine Mammal Center, 2011). In the 1980s, the first sea otter mothers and pups returned to Año Nuevo after an absence of more than a century (California Department of Parks and Recreation, 2011). White Sharks have been reported to cause substantial mortality on sea otters (Klimley, 1985).

The following sections describe the physical and biological resources around the Farallon Islands, Año Nuevo and Point Reyes. No component of the proposed White Shark research or educational tourism would affect terrestrial activities or submerged cultural resources; therefore, the terrestrial environment and cultural resources are not discussed in this EA.

## *2.2 Physical Environment*

### 2.2.1 Air Quality

The main sources of air pollution from within the GFNMS management area are generated by diesel exhaust from ship engines and from incineration of garbage on vessels (NOAA 2008a). Larger ships tend to use diesel engines, while smaller boats may use gas-powered engines. Pollution emissions that are released when vessels are underway are influenced by a variety of factors including power source, engine size, fuel use, operating speed, and load. Table 3 shows the quantity of mobile air emissions estimated from ocean-going vessels and harbor craft on the outer continental shelf out to 24 miles. The vessels that would be used for research and education activities under a GFNMS permit would be considered harbor craft.

**Table 3. 2008 Estimated Annual Emissions from Mobile Sources on the Outer Continental Shelf out to 24 miles from San Francisco County (in pounds).**

| Pollutant | Ocean-Going Vessels | Harbor Craft |
|---|---|---|
| Carbon Monoxide | 620,500 | 547,500 |
| Nitrogen Oxides | 7,927,800 | 1,700,900 |
| Sulfur Oxides | 4,584,400 | No value given |

Source: California Environmental Protection Agency, 2009.

### 2.2.2 Water Quality

Water quality within GFNMS and MBNMS is generally considered to be good due to the rural character of the coastline (i.e., there are no major industrial discharges) and the coastline's exposure to strong currents of the open ocean. Nevertheless, there are several potential threats to water quality, including the discharge of potential contaminants from San Francisco Bay Estuary and agricultural waste products (GFNMS, 2010). These discharges may periodically have an effect on the GFNMS management area waters, depending on coastal currents. Other potential threats to water quality include floating trash and debris, accidental spills, and residual materials from historical ocean dumping (GFNMS, 2010).

The State Water Resources Control Board has designated the waters surrounding the Farallon Islands, Point Reyes Headlands and Año Nuevo as Areas of Special Biological Significance. In 2003, the State of California reclassified these waters as State Water Quality Protection Areas (SWQPAs). California's Ocean Plan prohibits waste discharges into SWQPAs unless authorized by an exemption (State Water Resources Control Board, 2009). The offshore region near the Farallon Islands is at a slight risk from non-point source pollution, because of its proximity to the mainland. Point Reyes Headlands is located downstream of a rural watershed and is also at slight risk from non-point source pollution. Point Reyes Headlands is considered a California Critical Coastal Area, which has the dual goal of improving degraded water quality and providing extra protection from non-point source pollution to marine areas with recognized high resource value (California Department of Fish and Game, 2007). The main discharges to Año Nuevo are from rural watersheds including direct non-point discharges from agricultural fields (State Water Resources Control Board, 2003).

The discharge of fish, fish parts, or chumming materials (bait) can affect water quality. GFNMS prohibits the discharge of these types of materials unless it is during the conduct of lawful fishing activity (15 CFR Section 922.82(a)(2)). California Ocean Sport Fishing Regulations (2012-2013) define chumming as, "Placing any material in the water, other than on a hook while angling, for the purpose of attracting fish to a particular area in order that they may be taken." However, fishing is fully prohibited in California State Marine Reserves. Currently, there is a Marine Reserve surrounding the Southeast Farallon Island and the eastern portion of the North Farallon Island. More information about the specific locations can be found at http://www.dfg.ca.gov/mlpa/.

### 2.2.3 Habitat Quality

**Noise**

The level of noise pollution in the oceans has increased dramatically during the last 50 years with the primary source of ocean noise coming from commercial shipping. Significant noise pollution can create temporary or permanent hearing loss in marine mammals and other organisms. Disorientation and hearing loss may account for cases in which ships collide with marine mammals that are apparently unaware of an approaching vessel. Most strikes occur in coastal waters of the continental shelf where large marine mammals concentrate to feed and where vessels are more concentrated due to transits to and from coastal ports (Airamé et al., 2003).

The Farallon Islands, Point Reyes National Seashore and Año Nuevo Island provide important seabird and pinniped breeding habitat. As such, their presence creates a relatively high level of ambient noise, but the greatest potential to harm or disturb breeding seabirds can occur from various anthropogenic sources including recreational boating and diving activities (Reyna et al., 2007). Accidents, such as groundings or spills, can also result in abandonment of nesting sites (Thayer et al., 1999). The majority of seabird disturbances from boats occur when vessels approach within 328 feet (100 meters) of active nesting areas and remain in the area for extended periods. Effects from human disturbance can also exacerbate reductions in breeding success and survival by natural or other anthropogenic sources such as oil spills and fishery mortality (Reyna et al., 2007). Seals are most vulnerable during breeding and molting, with recovery rates depending on disturbances from human activities.

Restrictions on human activity are in place to curtail anthropogenic sources of disturbance to wildlife. For example, the following state regulations apply to boating and water-based access near the Southeast Farallon Island, the largest island in the group and where most of the proposed activity would likely occur:

- A special closure is designated within 300 feet of any shoreline at Southeast Farallon Island except at Fisherman's Bay and East Landing. This closure exists year-round except for a seasonal closure on the southeast side of Saddle (Seal) Rock from December 1 to September 14 (Section 630(b)(71), Title 14, California Code of Regulations).
- All vessels are required to observe a 5-nautical-mile-per-hour speed limit within 1,000 feet of any Southeast Farallon Island shoreline (Section 630(b)(71), Title 14, California Code of Regulations).

**Marine Debris**

Marine debris also threatens sanctuary resources. Land-based sources of marine debris include litter washed into San Francisco Bay through storm drains and outflow from combined sewer treatment systems; garbage from landfills; litter from shoreline recreational activities; improper handling of garbage in transport and on-site storage; and plastic resin pellets discharged from plastics manufacturing facilities into storm drains and nearby waterways (NOAA, 2010). Ocean-based sources generally include lost fishing gear and dumping of garbage at sea by vessels (NOAA, 2010). Plastic waste can remain in the marine environment for a very long time before fully degrading. Small plastic fragments have been found to adsorb pollutants and these can then be ingested by marine organisms (NOAA, 2010).

Currently, many of the tags that are used by White Shark researchers are released or shed from the sharks. More than 80% are not recovered and are lost in the marine environment as marine debris. Acoustic tags are typically shed from tagged animals within one to three years after application. Pop-up archival transmitting tags are programmed to detach within a year or less. Real-time satellite tags have not yet been designed to automatically detach, but they have been found to be missing from the shark's dorsal fin over time.

## 2.3 Biological Environment

The high marine productivity that occurs near the Farallon Islands, Point Reyes and Point Año Nuevo, in particular, attracts a diverse assemblage of fish, seabirds, sea turtles and marine mammals, which are described below.

### 2.3.1 White Sharks

White Sharks aggregate seasonally in the GFNMS management area (although White Sharks have been sighted year-round throughout the sanctuary). They typically arrive during the summer months to the nearshore aggregation areas in the vicinity of large pinniped haul-out and breeding colonies between Año Nuevo in San Mateo County, the Farallon Islands, Tomales Point at the north end of the Point Reyes peninsula, and Bodega Headlands in Sonoma County (NOAA, 2010) (See Figure 2). White Sharks are known to feed in the vicinity of the Farallon Islands from August through November (Klimley and Anderson, 1996; Pyle et al., 2003; Weng et al., 2007). Generally, the sharks leave the GFNMS management area, migrate into the open ocean during winter months, and tend to remain far offshore into the summer (Boustany et al., 2002; Weng et al., 2007; Jorgensen et al., 2010). It has been found that the sharks share this central Pacific open ocean region, known as the shared offshore foraging area (SOFA) and located between Hawaii and North America, with White Sharks from Guadalupe Island (Domeier and Nasby-Lucas, 2008) (See Figure 3). Acoustic and satellite tagging data have also revealed that some adult White Sharks from both the north-central California region and Guadalupe Island also travel to the Hawaiian Archipelago before returning to their respective coastal aggregation sites in north-central California and Guadalupe Island (Boustany et al., 2002; Weng et al., 2007; Domeier and Nasby-Lucas, 2008; Jorgensen et al., 2010).

It is thought that this apex predator aggregates in the coastal areas to exploit the seasonal presence of pinnipeds (Long and Jones, 1996). Juvenile White Sharks eat bony fish, rays and other sharks (Laroche, 2006), but when White Sharks grow larger than about eight to ten feet their diets shift to other species of sharks and fish, seals, sea lions and small cetaceans (Castro and Peebles, 2011). Immature seals are considered to be the preferred prey of adult White Sharks (Anderson, 2001). Observations indicate that White Sharks eat young elephant seals seven times more frequently than they eat other pinnipeds, such as California sea lions and harbor seals (Anderson, 2001). Predation rates around the Farallon Islands have been found to increase or decrease depending upon current seal population numbers (Brown et al., 2010). Adult White Sharks are also known to feed on whale carcasses (Casey and Pratt, 1985; Long and Jones, 1996; Dicken, 2008; Anderson et al., 2008). Bonfil et al. (2010) suggest that large-scale migrations of White Sharks to areas frequented by whales (such as White Shark records from the Hawaiian Islands coinciding with the humpback whale calving season), might be caused by the sharks exploiting windfall feeding opportunities.

White Sharks are considered to be a relatively uncommon species, given that they are apex predators, and their tendency to congregate or return to certain sites on a regular basis for feeding, breeding, or for other purposes can leave them vulnerable within localized areas. White Sharks have a trans-boundary migratory life history that moves them between national and international waters, and between the waters of adjacent states before they return to major aggregation sites (Wildlife Conservation Society, 2004).

**Status of the Stock**

White Sharks are federally managed under the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1883). Within the Exclusive Economic Zone (3 to 200 nautical miles from shore) offshore the states of Washington, Oregon, and California, White Shark management requirements are specified in the Highly Migratory Species Fishery Management Plan, which prohibits the commercial fishing of White Sharks. If a fisherman catches a White Shark, it must be released immediately unless other provisions for its disposition are established, such as for scientific study (Pacific Fishery Management Council, 2007).

White Sharks have been protected from "take" in all California state waters (i.e., from shore to 3 nautical miles) since January 1994, which means that White Sharks cannot be landed under a sport fishing license and commercial fishing operations are not allowed to target White Sharks. The take of White Sharks – which refers to their capture, mark and release – can be allowed through a scientific collecting permit issued by CDFW (Title 14 California Code of Regulations [CCR], Sections 650 and 670.7).

White Sharks are not listed as an endangered or threatened species under either the federal Endangered Species Act (16 U.S.C. 1531) or the California Endangered Species Act (Title 14 CCR, Sections 2070-2079). Both NOAA National Marine Fisheries Service (NOAA Fisheries) and the CDFW determined, in September 2012 and January 2013, respectively, that two recently filed petitions contain sufficient scientific information to indicate that the NEP population may warrant listing under the respective Endangered Species Acts (ESA). NOAA Fisheries subsequently formed a Biological Review Team (BRT) of fisheries scientists to review the best available scientific and commercial information concerning the population structure, biological status, and threats facing White Sharks in the northeastern Pacific. Threats identified to White Sharks in this report included 1) fisheries mortality in U.S., Mexican and international waters, 2) loss of prey due to overharvesting, 3) small population effects (such as human-caused wildlife disturbances), 4) disease and predation, 5) habitat degradation linked to contaminants, and 6) global climate change. Their final status review report, released in June 2013, concluded that the NEP population was a distinct population segment but that it did not warrant listing at this time (NOAA Fisheries Service, 2013). CDFW is currently conducting its own "scientific-based review of the subject species" to determine whether listing as endangered or threatened under the state ESA is or is not actually warranted. Their process and final decision are expected to be completed in March 2014.

A number of international mechanisms also contain provisions for the conservation and management of White Sharks. These include the listing of White Sharks as vulnerable on the Red List of Threatened Species by the International Union for the Conservation of Nature (IUCN) and Natural Resources (Fergusson et al., 2005). The IUCN Red List of Threatened Species is recognized as a comprehensive approach for evaluating the conservation status of plant and animal species globally.

In 2004, White Sharks were listed under Appendix II of the Convention on International Trade in Endangered Species or CITES, which provides a legal framework to monitor and control the international trade in species that are overexploited by such trade. Appendix II is reserved for species that could become threatened if trade is not controlled; trade in these species is closely monitored and allowed only after exporting countries provide evidence that such trade is not detrimental to populations of the species in the wild (CITES, 2011).

White Sharks are also listed in Appendix I (Highly Migratory Species) of the United Nations Convention on the Law of the Sea (UNCLOS), which is one of the main legal frameworks for the conservation and management of marine resources. It grants coastal states rights and responsibilities for the management and use of fishery resources within their national jurisdictions (i.e., their Exclusive Economic Zones). This means that the parties to UNCLOS are expected to protect marine biodiversity, monitor fishing levels and stocks, provide accurate reporting of and minimization of bycatch and discards, and gather scientific data as the basis for management decisions.

In February 2010, the United States and other parties signed a Memorandum of Understanding (MOU) on the Conservation of Migratory Sharks under the United Nations Environment Programme's Convention on Migratory Species. Seven shark species, including White Sharks, are covered by this MOU. The document is not legally binding although the parties agree to follow a number of objectives for the conservation and protection of migratory sharks including: 1) improving the understanding of migratory shark populations through research, monitoring, and information exchange; 2) ensuring the protection of critical habitats and migratory corridors and critical life stages of sharks; 3) increasing public awareness of threats to sharks and their habitats, and enhancing public participation in conservation activities; and 4) enhancing national, regional, and international cooperation (United Nations Environment Program, 2010).

The Shark Conservation Act (SCA) of 2010 was signed into law (P.L. 111-348) on January 4, 2011. It amended the High Seas Driftnet Fishing Moratorium Protection Act and the Magnuson-Stevens Fishery Conservation and Management Act in order to improve existing domestic and international shark conservation measures.

Because White Sharks are distributed globally, they remain vulnerable to sport fishing, bycatch from commercial fisheries, and other activities. Juvenile White Sharks are regularly killed as bycatch in the Southern California gill net fisheries (Lyons et al., 2013), averaging 10 per year from 2007 to 2010 (Lyons et al., 2013). The level of White Shark catch in subsistence fishing is unknown because it is largely unmonitored, however, reports of their capture in subsistence fisheries exist (CITES, 2004; Galván-Magaña et al., 2010). Increasing tuna cage farming operations around the world contribute to White Shark deaths when the sharks break into the cages to feed and are killed by cage operators (CITES, 2004). Another threat to White Shark young is from habitat degradation of their inshore pupping and nursery habitats (Camhi et al., 2009).

Known hotspots of illegal, unreported and unregulated shark fishing occur off Central and South America and in the Western and Central Pacific (Camhi et al., 2009). There is also a lucrative trade in their fins, jaws and teeth. Demand for shark fins is acknowledged to be a driver of shark mortality, especially in international waters (Camhi et al., 2009). The total amount of shark fins of all species passing through the Hong Kong fin market, which imports 50% to 85% of the world's fins, is estimated to equate to the taking of 26 to 73 million sharks annually (Clarke et al., 2006). In October 2011, California Governor Jerry Brown signed into law a bill banning the sale, trade and possession of shark fins. The ban took effect on January 1, 2012, and is similar to other bans that have been approved in eight U.S. States (including Hawaii, Washington, Oregon and Guam). In California, existing stocks of on-hand shark fins could only be sold until July 1, 2013 after which sales were no longer allowed (California Senate Committee on Natural Resources and Water, 2011).

**Abundance Estimates**

Individual White Sharks can be identified by distinctive trailing fin patterns and other body marks. This has led to a catalog of photo identifications for eastern Pacific White Sharks (Anderson and Pyle, 2003; Domeier and Nasby-Lucas, 2007; Anderson et al. 2011; Chapple et al. 2011). Photo-identification records of individual sharks visiting Guadalupe Island and the GFNMS management area have revealed that males return to their respective coastal aggregation sites every year (Anderson and Pyle, 2003; Domeier and Nasby-Lucas, 2007; Chapple et al., 2011). Mature females differ from the males in that they may not visit their respective adult aggregation site each year, but have demonstrated both an every-year, and an every-other-year visitation pattern (Anderson and Pyle, 2003; Domeier and Nasby-Lucas, 2007; Domeier and Nasby-Lucas, 2012).

Only recently has an initial effort been made to estimate the abundance of White Sharks that aggregate near the Farallon Islands and Tomales Point, which is part of the Point Reyes Peninsula (Chapple et al., 2011). Through identification surveys over three field seasons, approximately 219 adult and sub-adult White Sharks are estimated to seasonally visit this region. The model estimate ranged between 130 and 275 individual adult or sub-adult White Sharks that are believed to aggregate in the Gulf of the Farallones region. This number is not a population estimate, however, because it does not include the number of pups, young-of-the-year (YOY) and juveniles, nor other adults that may not aggregate in this region. Adult sharks that may congregate in other areas such as Año Nuevo were not included in the estimate. Sub-adults are also known to exist in other areas of the northeastern Pacific White Shark range (such as in southern California) that would not be likely to be observed in the GFNMS management area (Domeier, pers. comm., 2011).

An estimate of 339 adult and sub-adult White Sharks has been developed for the entire NEP population based on the Chapple et al. study (2011) and another study completed at Guadalupe Island (Sosa-Nishizaki et al. 2012); however, this figure also does not account for pups, YOY, juveniles or other White Sharks that may be found at yet unknown aggregation sites. The recent status review report by NOAA Fisheries has attempted to develop a more complete population estimate for the entire NEP population that includes all age classes based on available data and modeling. The report estimates the total number of White Sharks in the NEP population may be as high as 3,000; however, the authors acknowledge a significant degree of uncertainty based on limited data (NOAA Fisheries, 2013). More research is needed to calculate a more accurate population estimate for the NEP population. In general, however, this group is not expected to be abundant given the rarity of White Sharks throughout their known ranges.

With the limited information available, it is not yet possible to establish accurate trends in the NEP population. Historical population levels are also unknown so it cannot be determined with currently existing information whether the population is increasing or decreasing. Some evidence suggests that the population may be increasing because of an increasing trend of incidental catches of juvenile White Sharks in commercial fisheries (Lowe, 2011) as well as from the protections that have been afforded to White Sharks in U.S. waters. NOAA Fisheries has determined that the NEP population is likely stable or possibly increasing based on a number of observations, including increasing bycatch of White Sharks in California net fisheries, increasing evidence of predations on pinnipeds and sea otters along the California coast, and an increasing number of White Sharks being documented through photo-ID studies at Guadalupe Island (NOAA Fisheries, 2013).

**Migratory Behavior**

Adult White Sharks leave the GFNMS management area every winter and migrate to Hawaii and to an area in the central Pacific (the SOFA or "White Shark Café") located halfway between the coast of North America and Hawaii (Jorgensen et al., 2010) and it is possible that both foraging and mating may occur in this area (Jorgensen et al, 2012a). Despite long-distance transoceanic movements by whites sharks in South Africa and Australasia[1] (Pardini et al., 2000; Bonfil et al., 2005) and California/Mexico and the Hawaiian Islands (Boustany et al., 2002; Domeier and Nasby-Lucas, 2008), the northeastern Pacific White Shark population is genetically distinct from White Shark populations in South Africa and Australia/New Zealand (Jorgensen et al., 2010, NOAA Fisheries Service, 2013). The reasons for open-ocean migrations by White Sharks remain poorly understood, and determining the causes and consequences of individual movements could provide important insight as to how the behavior of individuals influences the spatial dynamics of the White Shark population (Jorgensen et al., 2010).

Departure dates from the GFNMS management area can be influenced by other environmental variables. For example, there is a known instance of orca (*Orcinus orca*) killing a White Shark in 1997 that was followed by the nearly complete disappearance of White Sharks around Southeast Farallon Island (Pyle et al., 1999). After this predation event there were two more White Shark sightings, but only 12 White Shark observations in total in 1997, while there had been an average of 48 sightings per year during the other years from 1987 through 2009 (Tietz, 2009).

**Life History**

Any characteristic that affects the survival and reproduction of an animal, such as growth rate, reproduction, migration, or intrinsic rate of population increase, is part of that species' life history pattern.

It is commonly observed that catches of sharks have a preponderance of one sex or the other, or are composed of animals of limited size range (Hoenig and Gruber, 1990). The sex ratios in the GFNMS management area are not well known, but appear to be male biased. Anecdotal information provided in a letter during the sanctuary's review of the previous draft EA, reports of male to female sex ratios during one field season near the Farallones as high as 12:1 (Anderson, 2010), however, a study by Chapple et al., (2011) over three seasons indicates that often the sex of many sharks cannot be determined. In that study, the sex ratio was stated as 3.6:1 (69 males and 19 females) but the gender of 42 of the sharks could not be discerned. The ratio could likely be skewed towards males because confirming the presence of claspers (i.e., the male sex organs)

[1] Australasia is a region consisting of Australia, New Zealand, the island of New Guinea, and neighboring islands in the Pacific Ocean.

can be relatively easy, but fully confirming their absence to verify the shark as female is difficult. This can lead to a reporting high numbers of unknown gender. In a study by Jorgensen et al. (2010) covering the years 2000 to 2008, they were able to identify 87 males (48%), 49 females (27%) and 43 of unknown gender (24%). This equates to 1.8:1 based on the ratio of known males to known females (Jorgensen et al., 2010).

Male White Sharks become sexually mature around nine to 10 years of age. Females become mature around 14 to 16 years of age and can have between two and 14 pups per litter (Wilson and Patyten, 2008). The gestation period for female White Sharks is believed to be in excess of one year, with available data suggesting a 14- to 18-month gestation period (Mollet et al., 2000), indicating that female White Sharks may breed only once every two years. Incidental gillnet bycatch of YOY White Sharks indicates that female White Sharks give birth between April and August, prior to their arrival at adult aggregation sites such as Guadalupe Island and the Farallon Islands (Domeier, 2012a). Unpublished reproductive hormone data indicate that females at the Guadalupe adult aggregation site (and in the GFNMS management area by inference) are not pregnant (Domeier, 2011).

Long-term tracking data have shown that northeastern Pacific White Sharks are also sexually segregated, but the motivation for this separation is unknown (Domeier and Nasby-Lucas, 2012). Studies have shown that males annually migrate to the SOFA, but females unpredictably roam over a much larger pelagic area and are more likely to be found in this same offshore region during the autumn when the males are at the coastal aggregation sites (Jorgensen et al., 2010; Nasby-Lucas et al., 2009; Domeier, 2012a). Males exhibit one-year migration patterns spending up to nine months of that time offshore while mature females are capable of remaining offshore for up to 15 months as part of a biennial migration pattern. The information suggests that the spatial distribution of mature male and female White Sharks may only overlap for 90 to 120 days over a two-year span (Domeier and Nasby-Lucas, 2012).

Where female White Sharks that seasonally aggregate in the GFNMS management area give birth is currently unknown. Pregnant females are rarely reported in the scientific literature or from catch reports by fishermen. No pregnant female White Shark has ever been observed in the northeastern Pacific (Pyle et al., 2003). The rarity of pregnant females may be explained by: 1) spatial separation from other White Sharks during pregnancy, 2) their sheer size precludes capture by most fishing gear, or 3) because of their low fecundity there are relatively few adult females pregnant at any one time (Food and Agriculture Organization, 1984). These factors remain speculative because other reports indicate females and juveniles frequent coastal areas that are generally more accessible to fishermen (CITES, 2004).

Although White Sharks have been protected in California since 1994 and are not directly targeted, juvenile sharks are taken incidentally in a range of fishing gear and commercial fishermen are allowed to land incidentally caught White Sharks. Juvenile White Sharks are occasionally captured by commercial gillnets targeting nearshore species such as California halibut (*Paralichthys californicus*), Pacific angel shark (*Squatina californica*), and white seabass (*Atractoscion nobilis*). Anecdotal, but consistent, localized sightings of juvenile White Sharks over multiple years suggest that juveniles may have very localized preferred sites/hotspots within the Southern California Bight (Domeier, 2012a). A large number of YOY incidental captures suggests another hotspot in Vizcaino Bay, Mexico (Domeier, 2012a) (See Figure 3). Three individual adult White Sharks from the GFNMS management area have also been detected around Guadalupe Island, but it is not known if there is extensive mixing or not (Jorgensen, unpubl. data, 2012).

White Shark life history parameters such as late maturity, low fecundity, low natural mortality, and longevity (Table 4) indicate that this species has a particularly low intrinsic rate of population increase. For this document, the annual rate of population increase for the northeastern Pacific population is assumed to be 4.8%, which is the average of the values shown in Table 2. This, combined with the vulnerability of the species due to other factors, makes it particularly prone to depletion (Wildlife Conservation Society, 2004). Relatively little information on White Sharks exists worldwide and the data presented in Table 4 are only used to show the known range of life history traits and are not specific to the northeastern Pacific White Shark population

**Table 4. Estimated Life History Parameters of White Sharks**

| | |
|---|---|
| Age at maturity (years) | female: 12-18, male: 8-10 |
| Size at maturity (feet) | female: 13.12 – 16.4, male: 11.48-13.45 |
| Longevity (years) | ≥23-60 |
| Maximum size (feet) | ≥21 (females are larger than males) |
| Size at birth (feet) | 3.58-5.41 |
| Average reproductive age (years) | >20? |
| Gestation time (months) | >12-18 |
| Reproductive periodicity (years) | 2 or 3 |
| Litter size | Approximately 2-14 pups/litter (average ~7) |
| Intrinsic annual rate of population increase | 0.04-0.056 |
| Natural mortality | 0.125 |

Reproduced from CITES, 2004, and Wilson and Patyten, 2008

Current evidence suggests that White Sharks in the northeastern Pacific begin their life in the nearshore shallow waters of the Southern California Bight and Baja California (Domeier, 2012a) (See Figure 3). During their first winter, they may migrate to the warmer waters of coastal Baja California. As the juveniles grow, they gain the ability to remain in cooler water, exploiting deeper depths, and migrating north of Point Conception. As they continue to grow, their coastal diet changes from one dominated by fish and invertebrates, to one dominated by marine mammals. As White Sharks approach maturity, males begin annual migrations and females begin biennial migrations to the SOFA and to known adult aggregation sites in the GFNMS management area and near Guadalupe Island. It is not known where White Sharks breed because this event has not been observed in nature, however, some evidence exists that supports the possibility that breeding may occur at the SOFA and/or Guadalupe Island (Domeier, 2012a, Jorgensen et al., 2012a). After an approximately 18-month gestation period, pregnant females return to the southern California/Baja California nursery area to give birth, primarily between May and August, before returning to one of the two adult aggregation sites (Domeier, 2012a).

## Predation Patterns

Around the Farallones and Año Nuevo Island, White Sharks primarily feed on pinnipeds (Ainley et al., 1981; Ainley et al., 1985). Near Point Reyes, they appear to be feeding mostly on harbor seals and California sea lions (Anderson et al., 2008). White Sharks are considered ambush hunters, since they quickly approach their prey before they can be seen. Sharks often hunt by approaching at depth and attacking from a vertical angle at high speeds. This type of hunting may result in the sharks launching themselves out of the water during an attack. They have also been known to breach the water to strike at decoys. In a study by Laroche et al. (2007), they found that more than 85% of the initial sightings of White Sharks approached from directly below the observer and the majority of these were approaches that were made towards the seal-shaped decoy as opposed to the bait floating nearby.

Evidence suggests that White Shark predatory behavior is relatively inflexible at the earliest stages of attack and then highly complex and variable at later stages (Martin et al., 2005). Once the prey has spotted the predator the element of surprise is lost (Johnson et al., 2008). The longer a predation bout continues or the more numerous capture attempts a White Shark makes, the lower its chances of making a successful kill. This suggests that once a shark has launched its initial strike and the seal realizes its whereabouts and intentions, the odds greatly favor the seal (Martin et al., 2005). When a pinniped has been alerted to a shark's presence or an attack does not occur, seals have been known to harass and swim around the sharks in a "mobbing" manner (Johnson et al., 2008). Even when a hunt is successful, the shark may not consume all of its prey at one time and sharks have been known to leave their prey before it is completely consumed.

It is believed that White Sharks use the GFNMS management area primarily to feed and that one predation event likely provides a White Shark only a couple of weeks of caloric energy (Semmens et al., 2013). It is also feasible that the sharks are also in the area to mate (Domeier, 2012a). The evidence that they are in the area for mating is based on the close proximity of males and females only when they are at the aggregation sites, the presence of conspecific bite marks (which indicate mating) on females who are not sighted again at the aggregation sites the following year, and the presence of reproductively mature males (Domeier, 2012a).

Tracking studies have documented movement patterns of individual White Sharks around the Farallon Islands (Anderson, 2001). These movement patterns indicate that each shark has a home range that it covers by zigzagging back and forth. It is believed that these sharks are not swimming aimlessly, but rather hunting, since they increase their odds of finding seals by looking in familiar areas where they have previously been successful. The largest sharks that were tracked covered the smallest home ranges, generally less than one square mile, and the smallest sharks covered the largest home range, several square miles (Anderson, 2001).

High tides and large swells have been found to affect the rate of White Shark predation on pinnipeds in the area. Significantly more attacks are observed when large swells are combined with high tides. During periods of high tides and large swells, many elephant seals are forced to move from their haul-out space. For example, during the fall, a surge channel called Breaker Cove at southeast Farallon Island can have 20 to 30 seals lounging in the water at one time. Large swells, combined with a high tide, force the seals to move out of the channel and into deeper water or, possibly, to leave the area, because the force of the waves makes it impossible for the seals to stay in Breaker Cove. This displacement of seals may explain why two or three predation events sometime occur in one day at southeast Farallon Island when high tide and large swell conditions exist (Anderson, 2001).

**Stress, Injury and Healing**

Stimuli that create stress can disturb the normal physiological equilibrium or homeostasis of an animal by forcing a reallocation of energy within its system. Any response or adaptation to stress requires energy that could otherwise be utilized for maintaining normal body functions such as growth, digestion, disease resistance, healing, and reproduction (American Fisheries Society, 2004). Factors such as anatomy, behavior (when faced with a threat), and the physiologic threshold and relative effects to cope with stress vary by species. No information is available to assess the physiological consequences of stress in White Sharks. In general, the ability to modulate physiological functioning and survive capture events varies substantially across taxonomically similar species. Some species are very resilient, while others are particularly sensitive to capture (New England Aquarium, 2011).

In a study to assess post-release survival in blue sharks following their accidental capture in commercial fishing gear, sharks that had been landed in a lethargic and unresponsive condition were euthanized. Of the remaining sharks, a subset was then tagged with pop-up archival transmitting tags (Moyes et al., 2006). Only 11 of the 23 tags reported data, but they showed that the sharks that had been categorized in good condition were alive at least three weeks after their release. Only four of the 11 tags reached their programmed pop-off date although a premature release does not mean that the shark died because sharks are negatively buoyant and will sink when they die. These tags would have been jettisoned at depth and that data would have been recorded. The analysis suggests that sharks landed in an apparently healthy condition are likely to survive in the long term (Moyes et al., 2006). The study then compared the blood chemistry of the surviving sharks with the moribund sharks. The findings indicate the possibility that even those that were landed in a bad condition may have survived if released and that severe changes in physiology are not necessarily lethal for the animal. For example, severe blood loss was common in the captured sharks and this stressor would be expected to have profound effects on an active animal; however, one shark had a hematocrit level of 14%, yet survived at least 244 days before its tag jettisoned. Similarly, a shark that had struggled violently might be expected to incur some degree of muscle damage but the study found that sharks survived long term even when they exhibited the greatest degree of muscle damage. One surviving shark had blood plasma levels six-fold greater than the highest levels seen in any of the euthanized sharks, which indicates that sacrificed sharks might have survived despite their lethargic appearance. The study suggests that many physiological variables are likely to change dramatically as a result of capture, but that these perturbations are not necessarily lethal or irreversible.

Another study by Heberer et al. (2010) looked at capture induced stress parameters in the common thresher shark (*Alopias vulpinus*). The common thresher is typically caught by hooking them in the caudal (or tail) fin, which reduces their ability for forward locomotion and the capacity for ram ventilation, which is the way these sharks breath by causing oxygenated water to flow over their gills. Eight of the captured sharks were found to have plasma lactate and hematocrit levels that were significantly elevated based on increasing capture times. The findings indicate that large, tail-hooked common thresher sharks with prolonged capture times (≥85 min) exhibit a heightened stress response, which may contribute to an increased mortality rate (Heberer et al., 2010).

White Sharks have also been documented to recover from significant injuries within a relatively short amount of time (i.e., one year or less). In South Africa, a 7.5-foot male shark was observed in 2008 with a large, open wound believed to have been caused by a boat propeller (Towner et al., 2010). The wound measured approximately 10x12x5 inches. It was anterior to the dorsal fin and next to the shark's vertebral column. Nine months later, a scar was seen, but the wound had completely healed (Towner et al., 2010; also refer to video images at: https://www.youtube.com/watch?v=y88x0gggWjE).

### 2.3.2 Other Fish

Numerous other sharks, including the Blue Shark (*Prionace glauca*) Common Thresher Shark, Mako Shark (*Isurus oxyrhinchus)* and Basking Shark (*Cetorhinus maximus)* are common residents of the GFNMS management area. Several species, including Spiny Dogfish (*Squalus acanthias)* and Leopard Shark (*Triakis semifasciata)* are common in shallow bays where they eat invertebrates and fish (Airamé et al., 2003). The GFNMS management area, and the continental shelf and slope, in particular, are highly productive areas for commercial fisheries. The comparatively wide continental shelf and configuration of the coastline are also vital to the health and existence of Chinook (*Oncorhynchus tshawytscha*) and Coho (*O. kisutch*) Salmon, Northern Anchovy (*Engraulis mordax),* rockfish (*Sebastes* sp.), and flatfish populations. The extension of Point Reyes and the resulting current patterns tend to retain larval and juvenile forms of these and other species within the GFNMS management area, thereby easing recruitment pressures and helping to ensure continuing populations. Sanctuary waters surrounding the Farallon Islands serve as an offshore habitat for shallow and intertidal fishes that further enhance finfish populations (NOAA, 2010).

Two orders dominate the types of fish found along the northeastern Pacific coast: perch (Perciformes) and rockfish (Scorpaeniformes). Each of these exhibits different biogeographic patterns. Perch are generally distributed south of Point Reyes, which is the most distinct biogeographic transition among members of this taxon. In contrast, rockfish are distributed widely along the western coast of North America, from Baja California to the Bering Sea. In addition to the changes in latitudinal distributions, the composition and abundance of fish species changes with increasing depth with the greatest numbers of species occurring in water depths less than 650 feet (Airamé et al., 2003).

The fish community near the Farallon Islands is dominated by an assemblage of rockfish with more than 48 species inhabiting rocky banks in water depths greater than 180 feet. Shortbelly rockfish (*Sebastes jordani*) are found in greatest abundance here, particularly in waters deeper than 400 to 700 feet. At the mid-depth or mesopelagic range over sand and mud bottoms, Chilipepper Rockfish (*S. goodie*), Widow Rockfish (*S. entomelas*), and Pacific Hake (*Merluccius productus*) are common. Large predatory finfish such as sharks, tunas, and mackerel are found in nearshore pelagic areas. Concentrations of sardines, Northern Anchovies (*Engraulis mordax*) and Pacific Herring (*Clupea pallasi*) are a critical food source for birds and marine mammals (NOAA, 2010).

The composition of fish species in the pelagic zone varies throughout the year with migration and spawning, as well as from environmental fluctuations that vary year to year. A small number of migratory pelagic species dominate the fisheries of central and northern California, including

Northern Anchovy, Pacific Sardine (*Sardinops sagax*), Pacific Hake, and Jack Mackerel (*Trachurus symmetricus*). These pelagic species spawn in the Southern California Bight and migrate into waters off central and northern California, but the composition of larval fish species varies with oceanographic conditions (NOAA, 2008c).

### 2.3.3 Other Wildlife

**Seabirds**

The Farallon Islands are the most important area for nesting seabirds in the region and home to the largest concentration of breeding seabirds within the contiguous United States (NOAA, 2010). Seabirds also nest on coastal rocks and islands off California, but no other site is used by as many different bird species than the ones that breed on the Farallon Islands (Airamé *et al*., 2003). During the height of breeding season (roughly May through July), the total number of birds breeding on the South Farallon Islands is approximately 200,000 (including the North Farallon Islands, the total number is around 300,000) (McChesney, 2013). These and other birds are highly dependent on the sanctuary's productive waters.

Twelve of the 16 species of seabird known to breed along the U.S. Pacific coast have breeding colonies on the Farallon Islands and feed in the sanctuary. These include Ashy and Leach's Storm-petrels (*Oceanodroma homochroa, O. leucorhoa*); Brandt's Cormorant (*Phalacrocorax penicillatus*), Pelagic Cormorant (*P. pelagicus*); Double-crested Cormorants (*P. auritus*); Western Gulls (*Larus occidentalis*); Common Murres (*Uria aalge*); Pigeon Guillemots (*Cepphus columba*); Cassin's Auklets (*Ptychoramphus aleuticus*); Tufted Puffins (*Fratercula cirrhata*); and Rhinoceros Auklets (*Cerorhinca monocerata*) (NOAA, 2010). These birds are present on the islands in response to upwelling that occurs in the late winter and early spring, which brings nutrients to the surface, creating a plankton bloom that supports the fish and krill that allow the seabirds to successfully raise their young.

The rocky islets and cliffs of Año Nuevo are important roosting sites for the California Brown Pelican (*Pelecanus occidentalis*). Western Gulls, Pigeon Guillemots, Pelagic Cormorants and Black Oystercatchers (*Haematopus bachmani*) have always been seen at Año Nuevo since monitoring began there. Others include Cassin's Auklet, Rhinoceros Auklet, Brandt's Cormorant, Double-crested Cormorant, Common Raven (*Corvus corax*), European Starling (*Sturnus vulgaris*), Ashy Storm-petrel (*Oceanodroma homochroa*) (suspected in small numbers), and Heermann's Gull (*Larus heermanni*) with only two breeding attempts in the 1990s (Oikonos, 2011).

General human-caused threats to bird populations include competition for food with commercial and recreational fisheries, entanglement in fishing gear, ingestion of marine debris, disturbance of roosting and breeding birds by watercraft, aircraft and human visitors, and oil spills. In addition to human impacts, changes in climate and oceanographic conditions affect bird populations (GFNMS, 2010).

**Marine Mammals**

At least 36 species of whales, dolphins, seals and sea lions have been observed within the boundaries of the GFNMS (NOAA, 2010). The MBNMS is also home to 33 species of marine mammals (NOAA, 2005).

The GFNMS management area serves as a breeding ground for 20% of California's harbor seals (estimated at 32,000 in 2005; NOAA, 2010). It also contains one of the last populations in California of the threatened Steller sea lion, which appears year-round. This threatened population has decreased dramatically in the southern part of its range. The population in the Gulf of the Farallones region has declined by 80% compared to population numbers from 50 years ago (NOAA, 2010).

The California sea lion is the most conspicuous and widely distributed pinniped in the GFNMS management area. It is found year-round within GFNMS, with the population increasing at least 8% to 12% each year (Carretta et al., 2007).

The northern elephant seal is the largest pinniped species in the GFNMS management area and has a total breeding population of about 13,000. They are primarily found at Point Reyes, the South Farallon Islands, Point Año Nuevo, and Año Nuevo Island (NOAA, 2010). Immature (one- and two-year-old) northern elephant seals arrive at the Farallon Islands beginning in September and continuing through November. The small pocket beaches and surge channels around the islands offer undisturbed haul-out sites and resting areas. The arrival period of the White Shark coincides with the seals' arrival (Anderson, 2001), which are known to be a critical food source for White Sharks (Brown et al., 2010).

During the winter, Steller sea lions haul out at Point Reyes and on the rocky islands off the Sonoma coast. Cordell Bank is a primary feeding area for this species, possibly because of the abundance of rockfish and sardines around the bank (NOAA, 2010).

Guadalupe fur seals (*Arctocephalus townsendi*), a threatened species under the ESA, have been documented at the Farallon Islands and Año Nuevo, however, they are very rare (USFWS, 2009).

For more than 170 years prior to 1996, northern fur seals (*Callorhinus ursinus*) had not been known to breed on the Farallon Islands, but in recent years, a colony has resumed breeding on the South Farallon Islands during the summer. As of August 2012, this colony was estimated to contain 521 individuals, 201 of which were pups (Point Blue, 2012). From November through June, thousands of female and immature fur seals migrate through the western edge of the sanctuaries along the continental shelf (NOAA, 2010).

Seals are most vulnerable during breeding and molting, with recovery rates known to fluctuate based on disturbances from human activities (NPS, 2006).

Twelve cetacean species are seen regularly in the sanctuary, and of these, the minke whale (*Balaenoptera acutorostrata*), harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), and Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) are considered year-round residents. The harbor porpoise is the most abundant small cetacean in the Gulf of the Farallones, with 16,000 residing throughout northern and central California. The GFNMS management area serves as a nursery for harbor porpoises and Pacific white-sided dolphins (NOAA, 2010).

The GFNMS management area is a destination feeding ground for endangered blue (*Balaenoptera musculus*) and humpback (*Megaptera novaeangliae*) whales, which feed in the sanctuaries between April and November. Their arrival to the GFNMS management area each year represents one of the largest concentrations of these whales in the Northern Hemisphere. Humpback whales are one of the few recovering populations of baleen whales found throughout the world (NOAA, 2010). Within the national marine sanctuaries of the Pacific coast, humpback whales are the most common whale species and Pacific white-sided dolphins are the most common delphinid (Forney, 2007).

The GFNMS management area is also part of a major migration route for gray whales (*Eschrichtius robustus*), which migrate from Alaska southward through the sanctuaries from December through February. Their northward migration through the sanctuaries begins at the end of February and peaks in March, but a few gray whales remain in the GFNMS management area year-round. Other large baleen and toothed whales migrate to the region to feed in its nutrient-rich waters during the summer and fall months (NOAA, 2010).

**Sea Otters**

Southern sea otters (*Enhydra lutris nereis*) range from San Mateo County to Santa Barbara County. They live in nearshore waters along the mainland coast, generally in waters less than 65 feet deep, and rarely more than a mile offshore (Riedman and Estes, 1990). The population of sea otters was drastically reduced from its historic numbers of 15,000 animals in California to as few as 50 individuals in 1914. Otters have been shown to be a keystone species, with predation on sea urchins, which allows for the growth of giant kelp forests and associated species. However, it has also been found that the loss of sea otter populations may contribute to increased red abalone density and size (California Department of Fish and Game, 2007). Sea otters are listed as threatened under the Endangered Species Act, depleted under the Marine Mammal Protection Act, and are considered a "fully protected species" by CDFW (California Department of Fish and Game, 2007). Twice annual sea otter counts are conducted by U.S. Geological Survey Western Ecological Research Center. Based on the spring 2010 survey, the three-year running average of the total count is 2,711, representing a drop of 3.6% from 2009 of 2,813. This appears to indicate that the southern sea otter population is in a period of decline (United States Geological Survey, 2011). The northern boundary of the sea otter's range has also shifted from about Tunitas Creek to a point 1.2 miles southeast of Pigeon Point (United States Geological Survey, 2011), which is just north of Año Nuevo. Scientists were unable to complete their 2011 surveys because of heavy fog, poor visibility, and strong winds throughout the spring and summer (Landis, 2012).

Significant changes in abundance and distribution of sea otters, Steller sea lions, and northern fur seals can be attributed to human activities including hunting that drove these populations in California to near extinction. All three taxa are carnivores that can have considerable influence on lower levels of the food chain, and their removal can greatly affect community structure (NOAA, 2010).

**Sea Turtles**

All sea turtles occurring in U.S. waters are listed under the Endangered Species Act and are under the joint jurisdiction of NOAA Fisheries and U.S. Fish and Wildlife Service (NOAA Fisheries, 2011). Both the green and leatherback turtles are known to occur near the Farallon Islands (USFWS, 2009). Leatherback turtles can sometimes be seen in MBNMS (NOAA, 2005).

Green turtles are among the largest sea turtles, able to attain a size of four feet in length and weigh up to 450 pounds. When ready to mate, females may migrate more than 1,200 miles across the ocean to the beach where they originally hatched (NOAA, 2005). In the northeastern Pacific, green turtles have been sighted from Baja California to southern Alaska, but are most common from San Diego and southward. In the central Pacific, green turtles occur around most tropical islands, including the Hawaiian Islands (NOAA Fisheries, 2011).

The leatherback is the largest turtle as well as the largest living reptile in the world. It is the only sea turtle that lacks a hard, bony shell. Although they are commonly known as open ocean animals, they also forage in coastal waters (NOAA Fisheries, 2011). Current research has shown that leatherbacks clearly target the dense aggregations of brown sea nettle (*Chrysaora fuscescens)* that occur near the central California coast and north through Washington during summer and fall, but this timing may vary due to oceanographic conditions (NOAA Fisheries, 2010). In January 2012, NOAA Fisheries published a final rule that revised critical habitat designation for leatherback turtles, which included a large nearshore area from Point Arena to Point Arguello east of the 3,000-meter (9,843-foot) depth contour (NOAA Fisheries, 2012).

## *2.4 Socioeconomic Environment*

### 2.4.1 Tourism and Education

White Sharks often have been portrayed in popular media as blood-thirsty killers that hunt humans as prey. In fact, White Shark attacks on people offshore California are rare, consisting of 13 fatal cases in the past 95 years (Wilson and Patyten, 2008). These encounters are hypothesized to be examples of humans being mistaken for the sharks' preferred pinniped prey.

In 2006, 71 million people representing nearly a third of U.S. residents age 16 or older, participated in some form of wildlife watching, with approximately 23 million traveling a mile or more away from home to view wildlife (USFWS et al., 2006.). Wildlife watching increased nationwide by 8% between 2001 and 2006, outstripping participation rates in hunting and fishing (Anderson et al., 2010). White Sharks in the wild provide an economic value for tourism, such as viewing from a boat or underwater in a cage, which is a relatively recent but rapidly expanding industry. Commercial passenger fishing vessels (party boats) have responded to increased public interest in tourism and directed more effort toward whale-watching, seabird and shark tourism trips (NOAA, 2010). It is also estimated that there are at least 15 boats that regularly participate primarily in whale watching activities each year within the North Central Coast region of California between Alder Creek and Pigeon Point (California Department of Fish and Game, 2007).

During the months of August through November (when the White Sharks are typically congregating within the GFNMS) an average of approximately 132 vessel trips each year were recorded at the Farallon Islands between 2004 and 2012 for the purposes of wildlife sight-seeing, recreational fishing (prior to the implementation of the State Marine Protected Area around the islands), or shark viewing containing a total average of 789 passengers each year (Point Blue and ONMS, 2013, Unpubl. data) between 2004-2012.

An important part of the sanctuaries' role is to educate the public about the importance of White Sharks in a healthy and balanced ecosystem. From 2009 through 2013, between two and four companies were permitted to attract White Sharks near the Farallon Islands as part of their tourism operations. The cage-diving operations, which are specifically marketed to seeing White Sharks in the wild, are also known as "adventure tourism." As a condition of the permits, the sanctuary requires that trained naturalists be on board the vessels. The training involves a GFNMS-sponsored workshop that provided information on presenting a scientifically accurate portrayal of White Sharks to the public, as well as ways to communicate conservation messages about the protection of White Sharks and other wildlife in the GFNMS management area.

**Figure 5. Boat-mounted underwater diving cage with diver (Courtesy of Jane Reifert)**

Other educational opportunities or programs about White Sharks include films, exhibits, school activities, museum lectures, media articles and books. For example, the Sharkmobile, a public-private partnership between GFNMS and Farallones Marine Sanctuary Association, is a classroom program that focuses on the biology, natural history and conservation of sharks. The Sharkmobile program is for grades 4 through 6 and has reached more than 10,000 students since it was implemented in 2004. The film, *Sanctuary in the Sea: A Gulf of the Farallones Experience*, features footage of GFNMS and its wildlife.

Viewing White Sharks in the wild has become increasingly popular over the past decade in the GFNMS management area, specifically around the Farallon Islands. White Shark enthusiasts from around the world sign up for tours to view White Sharks from the deck of a boat or from inside an underwater steel cage. Film crews also hire these operators to obtain White Shark footage.

### 2.4.2 Sport and Commercial Fishing

Commercial fisheries for deep-sea fish occur on the continental slope. The species targeted include deep-sea rockfishes such as Blackgill Rockfish (*Sebastes melanostomus*), thornyheads (*Sebastolobus* sp.), sablefish (*Anoplopoma fimbria*), and Dover Sole (*Microstomus pacificus*). Many of these species occupy similar habitats and generally are caught together (NOAA, 2010). Some rockfish populations are depleted (overfished). When combined with poor recruitment, overfished rockfish populations (bocaccio (*Sebastes paucispinis*), Canary Rockfish (*S. pinniger*), cowcod (*S. levis*), Darkblotched Rockfish (*S.crameri*), Pacific Ocean Perch (*S. alutus*), Widow Rockfish (*S. entomelas*), and Yelloweye Rockfish (*S. ruberrimus*)) have been severely impacted along the West Coast of the United States. To help rebuild these depleted populations a Rockfish Conservation Area has been established, and this process has resulted in an area closure of the groundfish fishery (NOAA, 2010).

The commercial Dungeness crab (*Metacarcinus magister*) fishery is managed by limited entry. Additionally, only the male crabs with a carapace width larger than 6.25 inches can be harvested commercially. The minimum size limit is designed to protect sexually mature male crabs from harvest for at least one season. During the 2013 fishing season, the CDFW also implemented a Dungeness Crab Trap Limit Program which set caps on the total number of Dungeness crab traps allowed each year for all permit holders (California Department of Fish and Wildlife, 2013).

Recreational or sport fishing primarily targets rockfish species, lingcod (*Ophiodon elongates*), California Halibut, Striped Bass (*Morone saxatilis*), salmon species, Albacore Tuna (*Thunnus alalunga*), surfperch species, and Dungeness crab. A recreational fishery for Humboldt squid (*Dosidicus gigas*) has recently begun (NOAA, 2010).

### 2.4.3 Recreational and Commercial Vessel Traffic

For recreational boaters, the sanctuary can provide a magnificent setting for cruises to the vicinity of the islands during mild weather, but often this passage is turbulent and landings on the islands are not allowed. For any recreational boater in distress, the islands would be unable to provide a safe port of refuge (California Department of Boating and Waterways, *n.d.*). The Farallon Lighthouse is located on Southeast Farallon Island and an anchorage that is in about 50 feet of water just north of the lighthouse is considered a “fair weather berth” (Fagan, 2002).

The GFNMS management area contains some of the West Coast’s busiest shipping lanes with the fifth largest port in the nation located in San Francisco Bay (California Department of Boating and Waterways, *n.d.*). Three major shipping lanes converge in GFNMS just west of the Golden Gate Bridge at the entrance to San Francisco Bay. The volume of large vessel traffic in and out of San Francisco Bay totaled more than 6,000 inbound and outbound transits in 2004 (GFNMS, 2010) (See Figure 6).

Shipping traffic can affect marine life via direct collisions (particularly to cetaceans) and from contaminants dispersed into the air and the sea. Vessel traffic is increasing, which results in increased effects from noise, dredging of shipping lanes, discharges of ballast and wastewater from cargo vessels and cruise ships, and increased potential for large oil spills. However, increased management and enforcement activities have helped reduce the amount of acute and chronic oil pollution from sunken vessels and illegal discharges from oily bilge water (NOAA, 2010). GFNMS regulations prohibit any vessel engaged in the trade of carrying cargo within an area extending two nautical miles near Southeast Farallon Island [15 CFR Section 922.82(a)(6)].

To minimize the risk of collisions and groundings of large, oceangoing vessels, the U.S. Coast Guard's Vessel Traffic Service was established in 1972. The system designates separated traffic lanes, a Precautionary Area, and seven regulated Navigation Areas, to coordinate the flow of deep-draft traffic into, out of, and within the central portion of the bay (California Department of Boating and Waterways, *n.d.*). The established traffic lanes, which are northeast and southeast of the Farallon Islands, are shown on Figure 6.

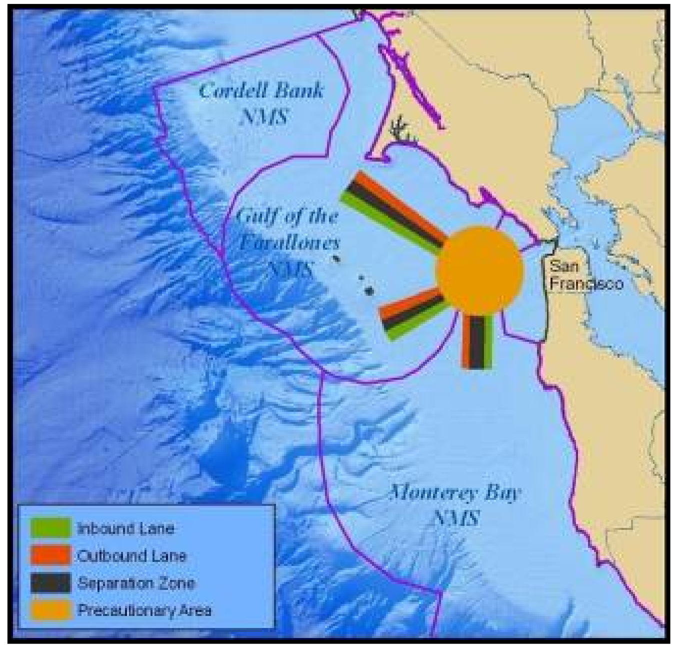



**Figure 6. Commercial vessel traffic lanes offshore San Francisco in the Gulf of the Farallones.**

# 3. DESCRIPTION OF ALTERNATIVES

This programmatic environmental assessment (PEA) analyzes two alternatives (summarized in Table 5) based on an analysis of research and education projects for which sanctuary staff can reasonably expect to receive permit applications over the next five years. As part of the process of developing these alternatives, GFNMS staff received input from the public, members of the GFNMS Advisory Council, state and federal regulatory and research staffs, other White Shark scientists, and existing permit holders. The resultant alternatives are:

- *Alternative A (No Action): Allow No Exceptions to the Prohibition on White Shark Attraction and Approach*. Under Alternative A, permitting to attract or approach White Sharks for research and educational tourism purposes would not be allowed in the sanctuaries.
- *Alternative B (Preferred): Allow Certain White Shark Attraction and Approach That Meet Management Goals*. Under Alternative B, the following would be allowed:

  (a) attracting White Sharks using decoys and/or bait, chum, or scent for research purposes provided the applicant can demonstrate that the proposed activity would advance scientific understanding of White Shark life history or enhance White Shark conservation while implementing methods that minimize potential effects to the sharks; and

  (b) attracting White Sharks near the Farallon Islands using decoys for education tour operators provided the applicant can demonstrate that the proposed activity will provide the public with an educational benefit that dispels misperceptions about White Sharks, provides an understanding of White Shark conservation and protection efforts, and provides an understanding of the role that both White Sharks and the sanctuaries play in creating a healthy, balanced marine ecosystem.

**Table 5: Summary of Alternatives**

| Alternative | Description |
|---|---|
| Alternative A (No Action) | • No changes to prohibition on attracting White Sharks in the GFNMS and MBNMS regulations<br>• No permits would be issued to attract or approach White Sharks within the GFNMS management area |
| Alternative B<br>(Preferred Alternative) | • No changes to prohibition on attracting White Sharks in the GFNMS and MBNMS regulations<br>• Permits would be issued to attract White Sharks using decoys and/or bait, chum, or scent for research purposes on a case-by-case basis<br>• Permits would be issued to attract White Sharks near the Farallon Islands using decoys only for educational purposes on a case-by-case basis<br>• Allow approach of White Sharks on a case-by-case basis for research or educational filming purposes |

## 3.1 Alternative A: Allow No Exceptions to the Prohibition on White Shark Attraction and Approach (No Action Alternative)

Under Alternative A, GFNMS would no longer allow any exceptions for research and education projects that involve the attraction of White Sharks with any attractant (including decoys, bait, chum, or scent) or to approach a White Shark.

This would not prevent researchers or education tour operators from conducting their activities in other locations outside of the GFNMS management area such as Mexico and South Africa or in the waters within a quarter mile of shore within the Point Reyes National Seashore, outside of areas of GFNMS jurisdiction.

White Shark tours for educational purposes could also continue to occur in the Gulf of the Farallones similar to other wildlife tour operators (such as for whales and birds) where no attractants are used and close approach is not allowed.

Outreach programs such as the Sharkmobile, which educates school children about shark biology and conservation, and other similar White Shark educational activities, would be the main programs used to educate the public about White Sharks in the GFNMS management area.

## 3.2 Alternative B: Allow Certain White Shark Attraction and Approach that Meet Management Goals (Preferred Alternative)

GFNMS supports education and research projects that can demonstrate they will meet management goals in the GFNMS management area. This includes enhancing public understanding about the importance of White Sharks in a healthy and balanced ecosystem, understanding the degree of connectivity between subgroups, improving population trend information, and determining the White Shark life cycle, particularly when and where they mate, where different populations give birth, and the duration of gestation. Allowing for education and research activities that meet these management goals is expected to have positive implications on sanctuary management decisions concerning the conservation and protection of White Sharks throughout their range, which would outweigh the short-term negative disturbances from the preferred methods.

Under Alternative B, attracting White Sharks using decoys and/or bait, chum, or scent for research purposes would continue to be allowed on a case-by-case basis provided the applicant can demonstrate that the proposed activity would advance scientific understanding of White Shark life history or enhance White Shark conservation while implementing methods that minimize potential effects to the sharks.

In addition, under Alternative B, attracting White Sharks near the Farallon Islands using only decoys for tourism operators would continue to be allowed on a case-by-case basis provided the applicant can demonstrate their vessel will have trained naturalists on board and that their visitors will receive an educational benefit that dispels misperceptions about White Sharks, provides an understanding of White Shark conservation and protection efforts, and provides an understanding of the role that both White Sharks and the sanctuaries play in creating a healthy, balanced marine ecosystem. Attracting White Sharks using only decoys would also continue to be allowed on a case-by-case basis for educational filming activities.

Approach of White Sharks would be considered on a case-by-case basis for research or educational filming purposes.

The methods that are preferred to be used in the GFNMS management area are described below. The effects analyses that were used to determine which of the proposed methods would be most suitable to meet the management goals are provided in Sections 4.4 through 4.9. Additional methods that may be used, but which are not under GFNMS or MBNMS regulations specific to approach and attraction, can be found in Section 5.

### 3.2.1 Decoy Attractants for White Shark Research and Education

White Sharks are visual hunters and research indicates that they respond to visual cues (Laroche et al., 2007). They are rarely seen swimming at the surface unless attracted by a decoy or a pinniped killed by another shark (Pyle et al., 1999). Applicants requesting permission to attract sharks for research and education purposes have proposed using stationary or trolling decoys. By investigating a decoy, the animal is trying to determine if it is a potential meal. The typical design lure has been made from a soft material with a low profile that is shaped into the silhouette of an elephant seal, sea lion, or other local marine mammal (Figure 7). Decoys have also been constructed of balsa plywood, approximately six feet in length and one-quarter to one-eighth-inch in thickness. The use of balsa plywood has been proposed as decoy material based on anecdotal use since 1992 near Año Nuevo with a variety of different materials including fabric, carpeting and wood.


**Figure 7. Example of white shark decoy made of cloth. (Courtesy of Chris Duba.)**

Decoy use at the Farallon Islands traditionally has been stationary and not trolled through the water. Trolling decoys may create a more energetic response by the shark and in the past researchers have proposed the use of this method at new sites to determine whether sharks are in the area. Video and photographs taken of breaching sharks off South Africa are some of the most iconic images that depict this behavior.

The preferred alternative would allow up to two decoys to be deployed on a strong fishing line from one vessel per permitted research or education permittee. Except for the use of a fishing pole to reel in the decoy, the sanctuary does not support the use of mechanized means such as trolling the decoy(s) behind a moving vessel. The preferred alternative would also include a decoy that is made of soft material in the shape of a pinniped, unless additional evidence is provided to show that plywood or similar hard materials would create a less energetic effect by the shark when investigating this type of decoy. The preferred construction method would consist of materials that could be easily retrieved if a shark bites through a decoy.

### 3.2.2 Bait, Chum or Scent Attractants for White Shark Research and Education

The terms bait, chum and scent are often interchangeably used to describe when a product is placed in the water to attract sharks to appeal to their acute sense of smell or olfaction. In this document, the term "bait" is used to describe when the product could be ingested directly such as when placed on a hook, or when the bait is enclosed around a tag and then fed to the shark. The terms "chum" and "scent" are used to describe when an oil-based chemical could be detected by the shark's olfactory sensors. An olfactory response depends upon a dissolved sample of the chemical compound fitting into a shark's chemoreceptor cells to induce a neural transmission to the brain where the stimulus is interpreted. Demski and Northcutt (1996) dissected a White Shark brain and found that it contains a higher percentage of olfactory bulbs when compared to that of some other shark and ray species, which could mean that it has a higher sense of smell than other elasmobranchs.

**Figure 8. Circle hooks (left and center) compared to J-hook (right). The hook shown on the left is proposed to be used, which is 13 inches long by 7 inches wide, with a 5-inch gap between the point and the shank (Courtesy of Michael Domeier.)**

The preferred alternative would allow the use of marine mammal blubber only to attract White Sharks for fundamental scientific research. The preferred use of scent would involve attaching the blubber to a hook on a wooden rod and placing it in the water to lure the shark close to the boat or by releasing a small amount of seawater from a bucket containing the marine mammal piece. Use of marine mammal blubber requires a "Letter of Authorization" from NOAA Fisheries.

**Figure 9. Pop-up satellite archival tag attached to a titanium barb on a pole spear. Note the metal tube beneath the spear shaft that would collect biopsy samples. (Courtesy of Sal Jorgensen.)**

Additional attraction methods for research purposes would include baiting a custom-made, barbless circle hook with marine mammal blubber that would be used to catch and restrain the sharks for tagging (refer to Section 5 for details) (See Figure 8).

The preferred alternative does not allow for White Shark educational tour operators to use bait, chum or scent attractants to lure either White Sharks or other fish for passive observations.

### *3.2.3 Proposed White Shark Research Activities*

Based on information the sanctuary has received to date, the following describes all of the white shark research activities that are potentially expected to be proposed in the GFNMS management area over the next five years (2014-2019). These estimates are highly dependent on such things as research funding and business management decisions, but they represent the best understanding at the time this document was prepared.

Researchers propose to attach up to 10 pop-up (or mini-pop-up) satellite archival tags each year to adult and sub-adult white sharks (See Figure 9). The total over five years (50) represents approximately 23% of the modeled subgroup of 219 adult and sub-adult white sharks (refer to Chapple et al., 2011) that has been estimated to occur in the GFNMS management area. The pop-up satellite archival tags would be used to compare whether female sharks utilize the same habitats as the males, and to examine how young sub-adult sharks utilize California current habitats. The tags have an expected life span of one year or more once they are deployed according to the manufacturer. The average length of time they have stayed on the sharks tagged in the Gulf of the Farallones is five months. Initial testing by the researcher indicates that the use of a mini-pop-up satellite archival tag could remain on the animal longer, ideally for at least a year. The manufacturer confirms that the estimated life span of the mini-pop-up tags is one year or more once they are deployed. If a shark has a visible tag, it is likely it would not be tagged with a second tag, but if the tag has fallen off, then it is possible that some sharks could be tagged more than once during the five years of this assessment.

**Figure 10. Real-time satellite tag.**

Up to eleven sharks (potentially three males and eight females) are proposed to be attracted and captured near the Farallon Islands over the next five years to attach real-time satellite tags to their dorsal fins (See Figures 10 and 11). This represents almost 4% of the modeled subgroup within the GFNMS management area. The use of these tags is to better understand the full multi-year migratory cycle of White Sharks that seasonally visit the GFNMS management area. Blood samples and other physical attributes, such as their length and reproductive state, are proposed to be collected during the capture process. The manufacturer indicates that several battery configurations are possible for these tags. For position-only deployments, a single AA battery is capable of providing approximately 70,000 transmissions; a single C-cell provides 180,000 transmissions. As a general rule, a budget of 250 transmissions per day is sufficient to provide daily location calculation via ARGOS. Therefore, a single AA cell provides locations for approximately 280 days; a single C-cell provides locations for 700 days. For deployments reporting temperature histograms, the number of expected transmissions should be decreased by one third. These estimates are based on the battery manufacturers' specifications.

**Figure 11. White shark with real-time satellite tag on dorsal fin.**

Actual results are dependent on animal behavior and environmental temperature. Data indicate that signals are received on average for 975 days (2.7 years). The tags are currently expected to remain permanently attached, but they have been known to detach from the fins (refer to Section 5). Given this, it is anticipated that the same shark is not likely to be tagged more than once with real-time satellite tags.

Another 20 to 30 White Sharks in the GFNMS management area are proposed to be tagged each year over the next five years with acoustic monitoring tags. The total number, ranging from 100 to 150, represents 46% to 68% of the modeled subgroup that is estimated to aggregate in the GFNMS management area. The acoustic tags are to be used to help mathematically model the spatial and temporal patterns and rates of returns/departures. This would provide a second data source for estimating abundance, which would be in addition to the photographic record (described later below). The manufacturer estimates the tag's battery life is a minimum of 4.5 years, but they tend to shed from the sharks within 1 to 2 years. If a shark has a visible tag, it is likely it would not be tagged with a second tag, but if the tag has fallen off, then it is possible that some sharks could be tagged more than once with this type of tag during the five years of this assessment.

**Figure 12. Acoustic monitoring tag attached to a titanium barb on a pole spear. Note the metal tube beneath the spear shaft that is used to collect biopsy samples. (Courtesy of Sal Jorgensen.)**

Additional moorings and receivers to detect acoustically-tagged sharks may also be proposed over the next five years to be installed in various locations within the sanctuary. These would likely be VEMCO receivers, a new prototype that is attached with a surface transmitter that would link to an Iridium satellite to allow for real-time connections when a shark is in the vicinity of that particular receiver. As of the 2013 season, there are a total of eight moorings with receivers permitted within the GFNMS management area: three (3) off southeast Farallon Island; two (2) off Año Nuevo Island; two (2) off Tomales Point; and one (1) at Point Reyes Headland.

Stomach tags embedded in whale meat are proposed to be fed to five sharks in the GFNMS management area each year over the next five years, for a total of 25 sharks. This reflects 11% of the modeled White Shark subgroup within the GFNMS management area. These tags would be used to determine when the shark is feeding and how much energy it is expending. These tags are expected to be expelled from the sharks' stomachs within a week or two of deployment.

Photography and video records are proposed to be taken of the sharks to allow for a type of "mark-recapture" modeling system that could be used to enhance the current initial estimate of White Shark abundance within the GFNMS management area. This technique would use sighting data of different sharks to estimate the population size (refer to the methods described in Chapple et al., 2011). The images would be used to identify unique features on a shark's fin. The data would then be used to help validate model assumptions.

Biopsy samples are also proposed to be collected from as many as 200 free-swimming sharks for genetic analysis. These would be the same sharks that have been tagged with acoustic monitoring tags (100-150) and pop-up satellite archival tags (50), as summarized earlier. Samples would be obtained by mounting a stainless steel biopsy punch on the end of a tagging pole (See Figure 12) to obtain a small amount of tissue for genetic and isotopic studies. The tissue samples would analyze mitochondrial deoxyribonucleic acid (mtDNA) and determine nuclear (microsatellite) markers, which could then be compared to results from the Southern California Bight/Baja nursery area (neonates), Guadalupe Island (adults), and South Pacific (Australia/New Zealand adults and neonates).

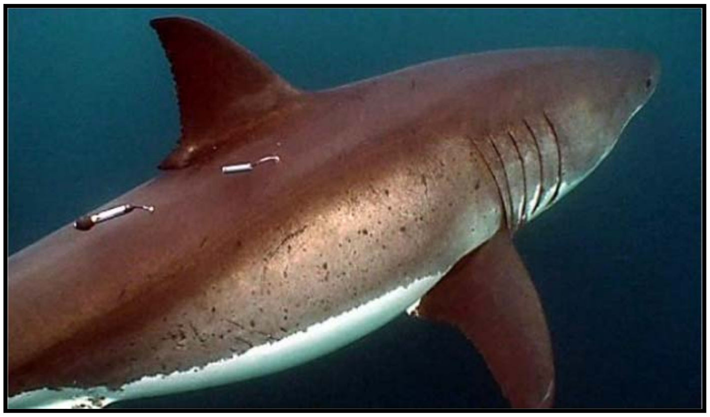


**Figure 13. Two types of tracking devices on a white shark. The acoustic monitoring tag is posterior to the pop-up archival transmitting tag. (Courtesy of Sal Jorgensen.)**

It is anticipated that the likely projects, if approved for the next five years of research, would involve the deployment of as many as 50 pop-up archival transmitting tags, 11 real-time satellite tags, 150 acoustic monitoring tags, and 25 stomach tags. It would also include the deployment of additional moorings and receivers to the seabed to collect information on the acoustic-tagged sharks, and the collection of up to 200 biopsy samples. To conduct the proposed research activities, White Sharks would be initially attracted to a research vessel using a decoy, and then a scent attractant or bait would be used to help bring the sharks closer to the vessel for deploying certain types of tags or to restrain the shark for other tagging methods. All projects associated with deploying tags and collecting biopsy samples require specific authorization by CDFW for a scientific collecting permit.

### 3.2.4 Proposed White Shark Education Activities

Based on information the sanctuary has received to date, the following describes all of the White Shark education activities that may potentially be proposed in the GFNMS management area over the next five years. This would consist of cage diving and top-side wildlife viewing expeditions around the Farallon Islands. Commercial White Shark education expeditions are proposed to be conducted from approximately September 15 through November 30. Up to two operators are expected to use a cage mounted to the back of their boats, which would allow up to four divers to be in the water at the same time to view sharks. The cages float on the surface with a floor depth of around 8 feet (See Figure 14). The air would be supplied to the divers by a “Hookah” system, in which the air delivery system is via hoses that are connected to a compressor located on the boat. The dive masters on these vessels would provide a training session to each customer who plans to enter the cage.

Up to two decoys are proposed to be deployed by each permitted vessel operator for the four to six hours they would be around the Farallon Islands. Requests have also been made in the past to troll the decoys.

Several operators have applied for permits to use scent or chum as an additional attractant, which is proposed to include fish and pork products because these are unrestricted. Otherwise, the use of parts of dead marine mammals requires a "Letter of Authorization" from NOAA Fisheries under the permitting requirements of the Marine Mammal Protection Act (16 U.S.C Chapter 31). The use of a scent or chum attractant has also been proposed by one tour operator for the purpose of conducting a study to assess the knowledge and perceptions of passengers who view White Sharks at close range and the effect these tours have on increasing public participation in White Shark conservation. The preferred alternative does not allow scent, bait or chum to be used as an additional attractant by tour operators.

Filming is another activity that would likely be proposed either in conjunction with research and education projects or as stand-alone projects. Such filming is expected to include both amateur and professional filmmakers on the tourism vessels, as well as professionals filming activities on the research vessels. Tourism operators have proposed that their crews and guests film and photograph White Sharks that are attracted to their boats around the Farallon Islands. The filming would be conducted for personal use as well as commercial use, such as for promotional footage for selling future trips, or to be sold or made available to TV or film production for use in educational and entertainment programs that portray White Sharks in a positive context. Broadcast filming conducted during research is different from the images that would be taken for the purpose of the "mark-recapture" model, which was described above in Section 3.2.1. The filming of White Shark research for public broadcast is proposed to occur when there is a conservation and educational benefit of the film, which would require the issuance of an education permit amended to the research permit. A stand-alone project would mean that the filmmaker proposes to attract or approach White Sharks independent of any specific research or education project.

### 3.2.5 Approach Methods for White Shark Research and Education

**Figure 14. Cage attached to the stern of the white shark tour boat. (Courtesy of Jane Reifert, Incredible Adventures, Inc)**

It is possible that applicants may propose to approach a White Shark for underwater filming with a diver. Applicants may also propose to use mobile, underwater cages, particularly during education tours or for research purposes (See Figure 15). Sanctuary regulations do not specifically prohibit the use of a mobile cage, which could be considered as similar to the passive viewing of White Sharks from a boat, but the preferred alternative is to not allow the approach of White Sharks in a mobile cage. The preferred alternative also does not allow approach for other filming purposes.

**Figure 15. Underwater mobile shark cage. (Courtesy of James Moskito, Great White Adventures, Inc.)**

Researchers have proposed the use of remotely operated underwater and floating vehicles/gliders to follow acoustically-tagged White Sharks. Glider technology can be used to increase the range of data collection capabilities including the ability to collect physical ocean information, census fish populations, improve fisheries management models, and monitor animal responses to climate change. ONMS issued policy guidance in 2009 on interpreting sanctuary discharge prohibitions for certain categories of activities, which specifies that deploying autonomous underwater vehicles (AUVs) is considered a discharge, which is a prohibited activity and requires a permit. ONMS previously issued a permit, in September of 2012, for the use of an unmanned marine robot called the "Wave Glider," to conduct a series of data collection missions throughout the west coast sanctuaries over two years. This glider is a type of AUV that uses small changes in its buoyancy in conjunction with wings to convert vertical motion to horizontal, and thereby propels itself forward with very low power consumption. The glider is equipped with a submersible, single-channel acoustic receiver capable of identifying VEMCO coded transmitters, and has already been successfully employed to assist one White Shark researcher in collecting data on the locations of White Sharks within the sanctuaries. The preferred alternative would allow for the continued use of AUVs provided that they are necessary components associated with fundamental research on White Sharks.

# 4. EFFECTS OF ALTERNATIVES

The purpose of this section is to discuss the effects of both alternatives on physical, biological, and socioeconomic resources within the sanctuaries. An overview of the sanctuaries' physical and sociological setting and biological resources is provided in the Affected Environment section (Section 2).

The analysis in this document takes a programmatic approach and evaluates effects, both as individual projects that could be permitted by the sanctuary and on a larger, cumulative scale that assesses all projects together. In addition to this effects analysis, project-specific proposals and methods would still be assessed on a case-by-case basis when an application is undergoing permit review. There may be other project-specific permit conditions that are identified during a permit review that would further minimize potential effects, which would not have been evaluated in this document. Subsequent reviews would also evaluate whether a project proposed differs substantially from the environmental analysis conducted in this document, and, if so, that project may require additional NEPA analysis.

To determine whether an effect is significant, Council on Environmental Quality (CEQ) regulations (40 CFR 1508.27) and NOAA guidance (NAO 216-6) require the consideration of context and intensity of potential effects. The *context* of a proposed action refers to the affected environment, which could be local, regional, national, or all three, depending upon the circumstances. *Intensity* refers to the severity of the effect. The two alternatives were evaluated for the severity of their effects on sanctuary resources. These effects are classified according to the following categories:

- **Negligible effects** – effects for which virtually no effect to a resource can be detected (whether beneficial or adverse).
- **Less than significant effects** – effects that do not rise to the level of "significant" (as defined below).
- **Significant effects** – effects resulting in an alteration in the health of a physical, biological, historic/cultural or socioeconomic resource. Long-term (see below) or permanent effects with a high intensity of alteration to a resource, whether beneficial or adverse, would be considered significant. Significant effects can be adverse or beneficial, and direct or indirect. Consideration of the accumulation of several individually less than significant effects could result in a determination of significance for cumulative effects.

Effects are characterized as negligible, less than significant or significant, and are also characterized by type (adverse or beneficial), context, intensity, duration (short- or long-term). Effects can be further characterized by whether they affect resources directly or indirectly.

An action can also be made less adverse through appropriate mitigation measures. NEPA defines mitigation as an action that can be taken to avoid, reduce the severity of, or eliminate an adverse effect. Mitigation can include such actions as avoiding adverse effects, minimizing adverse effects by limiting the degree or magnitude of an action, or reducing or eliminating adverse effects over time.

## *4.1 Physical Effects of Implementing Alternative A (No Action)*

Overall, not allowing any exceptions to the attraction and approach prohibition is expected to have less than significant beneficial effects to the physical environment from the reduction of vessels and human activities that have potential adverse effects on air, water, and habitat quality.

### 4.1.1 Air Quality

Not allowing any exceptions to the use of decoys (either stationary or trolled) or scent attractants would result in a decrease in air emissions if the vessels currently anticipated to be used in the proposed research and education projects (including filming) do not continue to operate in the GFNMS management area. This would result in a less than significant beneficial effect on air quality. However, potential beneficial effects on air quality may be reduced if these vessels substitute other research or tourism activities in the GFNMS management area (such as sport fishing, whale watching, etc.)

The prohibition on the use of decoys, the trolling of decoys, or the use of scent/bait/chum attractants would not have a direct effect on air quality. Similarly, continuing the prohibition on the approach of White Sharks would not have an effect on air quality.

### 4.1.2 Water Quality

Not allowing any exceptions to the use of decoys or scent attractants would result in a less than significant beneficial localized effect on water quality, particularly from the removal of scent attractants from use by researchers because no oily discharges from marine mammal blubber or fish/pork parts would be allowed to occur. Eliminating all discharges associated with scent attractants would have a less than significant beneficial effect on water quality near Southeast Farallon Island. The use of chumming materials is already prohibited in this area because it is located within the Southeast Farallon Island State Marine Reserve and fishing is not allowed. Not allowing any exceptions to the prohibition on approaching White Sharks would have a negligible effect on water quality.

Implementing Alternative A could further result in a less than significant beneficial effect on water quality if these vessels no longer operate in the GFNMS management area, thus, reducing the risk of fuel spills, marine debris impacts, or other vessel discharges.

### 4.1.3 Habitat Quality

**Noise**

Not allowing any exceptions to the use of decoys or scent attractants could result in a small decrease in overall noise in the GFNMS management area if White Shark research and tourism vessels no longer operate in the GFNMS management area. This would result in a less than significant beneficial effect on habitat quality by reducing noise impacts.

**Marine Debris**

Because many of the tags that are used by the White Shark researchers are released or shed from the sharks, but are often not recovered, there would be a less than significant beneficial effect to habitat quality from the reduction of plastic debris if attraction associated with White Shark research is no longer permitted. However, it is expected that similar research projects would be conducted just outside of sanctuary boundaries near Point Reyes, or in other regions along the California coast, which means that these tags could become lost within the GFNMS management area, if the sharks are transiting within the area or nearby at the moment their tags detach.

Implementing Alternative A would also result in a less than significant beneficial effect to habitat quality associated with eliminating the possibility that decoy material could become lost in the sanctuaries.

## *4.2 Biological Effects of Implementing Alternative A (No Action)*

### 4.2.1 White Sharks

Implementing this alternative would eliminate the primary disturbances to White Sharks that occur in the GFNMS management area. The use of unbaited decoys around the Farallon Islands has been documented since 1988 (Goldman and Anderson, 1999) mostly as a means to study White Sharks that congregate there. Since 2009, White Shark attraction around the Farallon Islands from all permitted activity (i.e., for both education and research purposes) has occurred an average of 40 days during an approximately 90-day season each year (Office of National Marine Sanctuaries, unpubl. data). Not allowing any exceptions to the prohibition on the use of decoys and scent or bait to attract White Sharks for research and education purposes over the next five years would ensure that the natural behavior of White Sharks is not affected from the presence of attraction devices, including towed or stationary decoys and scent/chum/bait, when they are congregating in the area. This alternative would result in a direct beneficial effect on White Sharks in the GFNMS management area but could result in an indirect significant adverse effect from a decrease in the amount of data being collected by researchers needed to protect and conserve the White Shark population.

Not having long-term monitoring data or being able to understand the fine-scale movements of White Sharks in the GFNMS management area could inhibit the identification of where vulnerable life history stages occur and could affect the ability to identify trends in abundance for this group of White Sharks. Without a complete understanding of life history traits for this group of White Sharks, the extent to which they are vulnerable when they are not within the refuge of the GFNMS management area would remain unknown, impeding future efforts to fully protect the population throughout its range. White Shark conservation is contingent on effective regional, national, and international cooperation. Conservation actions of highly migratory species in one area can be undermined by contrary actions (or lack of action) in another region or by other fishing nations (Camhi et al., 2009). Prohibiting scientific studies in the GFNMS management area would have a significant adverse effect on our understanding of:

- The regions and seasons in which individuals from the north-central California White Shark population could be particularly vulnerable to threats;

- The locations of mature females during the years they are absent from the adult aggregation sites;
- The locations of pregnant females during pupping to identify the connectivity between the pupping and nursery areas and the GFNMS management area;
- The degree and locations of mixing between the Guadalupe Island and north-central California adult group of White Sharks;
- The season and location of mating for White Sharks from the GFNMS management area;
- Environmental factors that might influence White Shark migration patterns or feeding sites;
- Trends in the population of the adult group of White Sharks in north-central California;
- Fine scale movements around the north-central California aggregation sites;
- How White Sharks utilize different areas of the GFNMS management area; and,
- Regional or international threats to White Sharks that visit the GFNMS management area, which is information that could lead to increased effectiveness of international agreements.

Not allowing any exceptions to the prohibition on White Shark attraction for tourism purposes in the GFNMS management area would eliminate another source of disturbances to this group of White Sharks. It could also reduce the chances for people to see White Sharks in the wild on the west coast of the United States (refer also to Section 4.3.1).

Not allowing any exceptions to the prohibition on approach would ensure that this potential source of disturbance is eliminated. This is particularly important during the times that sharks come to the surface, which most often occurs naturally during a feeding event. This would result in a less than significant beneficial effect on White Sharks.

### 4.2.2 Other Fish

No effect on other fishes would occur if the use of decoys to attract White Sharks for research or education tourism is no longer permitted in the GFNMS management area.

Fish resources in the region would not likely be affected by not longer granting exceptions on the use of chum or bait as an attractant because there are sufficient food resources.

### 4.2.3 Other Wildlife

Other wildlife such as seabirds, otters and turtles would not be affected (either beneficially or adversely) if decoys for White Shark research or education are not allowed to be used in the sanctuaries.

Not allowing any exceptions to the prohibition on the approach of White Sharks would have a negligible effect on other wildlife.

## *4.3 Socioeconomic Effects of Implementing Alternative A (No Action)*

### 4.3.1 Educational Tours

Not allowing any further exceptions on attraction of White Sharks for research and educational tours would affect businesses that conduct these activities during the fall months, which would likely cause a decrease in revenues for the vessel owners and tour operators. This alternative also would affect conservation efforts by limiting opportunities to educate the public about threats to White Sharks. The total number of participants that potentially could be affected, if anticipated White Shark educational trips are fully utilized, is estimated to be as much as 6,000 individuals over the next five years. It is possible that some of these White Shark enthusiasts would shift their interest to other wildlife watching tours, which are known to employ naturalists who educate their clients about White Sharks in the sanctuaries, although public awareness about White Sharks specifically could be affected as a result of fewer dedicated trips. This alternative could also affect conservation efforts by limiting opportunities to educate the public about threats to White Sharks. Given the total number of people anticipated to participate in these tours – an estimated 1,200 individuals per year – this is likely to have a less than significant adverse effect on overall White Shark conservation and outreach efforts.

Implementing Alternative A is not expected to result in significant socioeconomic effects because other education activities such as the Sharkmobile for school children, White Shark film projects, aquarium exhibits, and similar outreach efforts are expected to fill this need to educate and inform the public. In addition, wildlife viewing trips in the sanctuaries would continue and White Shark cage diving tours would still occur in other places around the world (and could still continue at the Farallon Islands without the use of attractants). The greater possibility is that people who are unable to visit other countries where White Sharks are actively attracted near tourism vessels, and who wish to see White Sharks in their natural environment in the wild, would be affected.

Implementing Alternative A would result in not allowing any exceptions to the prohibition on approach of White Sharks. One educational tour operator has proposed to use a mobile underwater cage as part of their dive operation. Alternative A would not allow for this activity because it is presumed that divers would move the cage toward a shark if one is seen, which could have an adverse effect on sharks by causing them to deviate from their patrolling patterns due to the presence of the mobile underwater cage. Not allowing approach could also affect filmmakers or others who might request to approach a White Shark for specific reasons.

Overall, Alternative A is likely to have a less than significant adverse effect on changing public perceptions about White Sharks in the sanctuaries. Similarly, there would be a less than significant effect to outreach efforts related to communicating research activities to the public.

### 4.3.2 Research

Implementing Alternative A would have a significant adverse effect on White Shark research within the GFNMS management area since research activities would be limited to passive observation only. Prohibiting researchers from attracting sharks closer to the research vessel would greatly reduce or eliminate the success rates of researchers attempting to deploy tags on White Sharks, obtain biopsy samples, and capture quality, close-up photos of individual sharks for their mark-recapture modeling program. There would be a significant adverse effect on White Shark research in the region that could have a significant adverse effect on White Shark conservation and management efforts.

### 4.3.3 Sport and Commercial Fishing

There could be an increase in chartered fishing activities within the Sanctuary if the White Shark projects are not allowed, because the vessel captains would likely seek other opportunities to continue the highest and best economic use of their vessels during the White Shark season.

### 4.3.4 Recreational and Commercial Vessel Traffic

There would be negligible effects to recreational or commercial traffic expected from this alternative.

## *4.4 Physical Effects of Implementing Alternative B: Allow White Shark Attraction and Approach that Meet Management Goals*

### 4.4.1 Air Quality

Estimates of air quality effects from the alternatives were calculated from the emission factors shown in Table 6 and information provided by the researchers and tourism operators. At the most, shark attraction activities for research would range each season between September 1 and March 1 except around the Farallon Islands where these activities would generally occur from September 1 to no later than November 30. Shark attraction for education is expected to range from approximately the beginning of September through the end of November around the Farallon Islands.

**Table 6. Emission Factors for Diesel Fuel**

| Pollutant Type | Amount of emission (in pounds) per 1,000 gallons of fuel |
|---|---|
| Carbon Monoxide | 110 |
| Nitrogen Oxides | 270 |
| Sulfur Oxides | 27 |

Source: California Department of Fish and Wildlife, 2005.

Under the proposed research activities, a total of 1,385 gallons of diesel is expected to be used annually during the 20 days of research around the Farallon Islands, eight days at Año Nuevo and one day near Point Reyes. A cumulative estimate of 79,200 gallons of diesel is expected to be used over the 165 operator days during each White Shark season for tourism operations near the Farallon Islands. Table 7 shows the expected annual emissions for proposed research projects based on the emission factors listed in Table 6.

The amount of carbon monoxide and nitrogen oxides from the tourism vessels represent less than 1.6% and 1.3%, respectively, of the total emissions estimated in the San Francisco area each year. The amount of carbon monoxide and nitrogen oxides attributed to the research vessels would be substantially less than this. Compared to emissions estimates for all harbor vessels in the San Francisco area (refer to Section 2; Table 3), the slight increase in air emissions from proposed research and education projects would not affect the environment in any lasting or meaningful way. The overall emissions exhaust from these vessels is expected to have a less than significant effect on air quality in the GFNMS management area. The typical prevailing winds would rapidly disperse these pollutants. Additional air quality protection is afforded by CDFW regulations (Title 14 Section 632(b)(33)) extending out one nautical mile seaward around Southeast Farallon Island and North Farallon Island, which require that all commercial diving vessels equipped with an open, deck-mounted air compressor system must have their air compressor's engine exhaust system terminate below the vessel's waterline.

**Table 7. Estimated Annual Emissions (in pounds) for Alternative B**

| Pollutant Type | Research Projects | Education Tourism |
|---|---|---|
| Carbon Monoxide | 152 | 8,712 |
| Nitrogen Oxides | 374 | 21,384 |
| Sulfur Oxides | 37 | 2,138 |

It is possible that an additional vessel may be used specifically for a stand-alone film project. In these few cases, it is expected this would result in a negligible increase in air emissions.

The use of attractants including decoys or bait, chum or scent would have a negligible effect on air quality.

### 4.4.2 Water Quality

The primary discharge anticipated in the GFNMS management area from the proposed activities would occur from using marine mammal blubber to attract sharks for scientific research. Researchers have typically used these scent attractants to overcome a shark's reluctance to approach the vessel in order to deploy tags and obtain biopsy samples and photo identification records. Blubber would leak a small amount of marine mammal lipids (i.e., fatty substance) into the water, which is thought to heighten the shark's hunger motivation, but also causes an oily slick in the water.

**Figure 16. The research vessel *Derek M. Baylis*. (Courtesy of Sal Jorgensen.)**

By limiting the use of bio-attractants to marine mammal blubber for scientific research purposes only, the effects on water quality are expected to be negligible.

Vessel operations have the potential to affect water quality from accidental releases or unlawful discharges of petroleum products or wastes from sewage. The vessels that are proposed to be used during White Shark permitted activities in the GFNMS management area are expected to be in compliance with applicable boating regulations of U.S. Coast Guard, NOAA

Office of National Marine Sanctuaries, Environmental Protection Agency, and State of California. This would ensure that unlawful discharges are prevented and would reduce the potential for accidental releases. Given the state of offshore conditions during the fall and winter months, vessels tend not to operate when small craft warnings have been issued by the National Weather Service. This means that an accidental release is even less likely to occur; therefore, negligible effects on water quality are expected from the proposed vessel operations under Alternative B.

The State of California through its Ocean Plan (State Water Resources Control Board, 2009) regulates the discharge of wastes to State Water Quality Protection Areas, which surround the Farallon Islands, Point Año Nuevo and Año Nuevo Island, and almost the entire boundary of the Point Reyes National Seashore, to minimize water quality degradation. The State of California defines limited-term waste discharges as those activities that are generally related to the replacement or repair of boat facilities, sea walls, stormwater pipes and bridges. These types of projects would not be conducted as part of permitted White Shark activities. Therefore, the effects on water quality that are anticipated to occur in these areas from waste discharges would be less than significant.

The use of decoys as an attractant would have a negligible effect on water quality.

### 4.4.3 Habitat Quality

**Noise**

The sounds of vessel engines, generators, and communications over loud speakers are expected to be heard by wildlife and/or people in the vicinity of permitted research or education vessels around the Farallon Islands, Año Nuevo or Point Reyes. The seasonal special closures around the Farallon Islands, which are in effect from December 1 to September 14, generally do not overlap with the White Shark season. Therefore, the allowance of vessels near portions of the islands that are open to close vessel approach may result in more vessel-related noise. However, all vessels are required to abide by the year-round 5-mile-per-hour speed limit and noise restrictions within 1,000 feet of all the Farallon Islands. Additional noise protection is afforded by CDFW regulations (Title 14 Section 632(b)(33)) extending one nautical mile seaward of Southeast Farallon Island and North Farallon Island by requiring that all commercial diving vessels have their vessel engine exhaust systems terminate either through a muffler for dry exhaust systems, or below the vessel waterline for wet exhaust systems.

The slight increase in ambient sound from research and education activities is expected to have a less than significant effect; it would be the same as other activities that utilize boats near the Farallon Islands, Año Nuevo or Point Reyes. It is anticipated that most of the proposed activities, particularly the education tours, would be concentrated during the weekends in which there could be localized and minor, but less than significant, adverse effects on some seabirds from the noise and on White Sharks who may avoid areas with a high density of boats.

There would be a slight increase in ambient sound from proposed research activities, which would occur each year for approximately 20 days around the Farallon Islands, eight days around Año Nuevo and one day near Point Reyes. This is expected to have a less than significant adverse effect on habitat quality.

Lights from over-nighting boats may illuminate portions of the islands or coastal area, which might affect night-foraging birds by exposing them to predators and/or attracting them toward the lights. The potential for harm can be minimized by requiring the vessel's shades to be drawn, the hatches to be closed, and deck lights to be used sparingly through permitting conditions or other regulatory mechanisms. Therefore, over-nighting activity would have a negligible effect on habitat quality. It is expected that tourism vessels permitted for White Shark attraction will not remain overnight near the Farallon Islands, so likely there would be a negligible effect on habitat quality related to the use of lights.

**Marine Debris**

Between 2000 and 2008, a total of 97 pop-up satellite tags and 78 acoustic tags were deployed on White Sharks near the Farallon Islands, Año Nuevo, Point Reyes and Tomales Point. Of these, only 14 of the 97 pop-up satellite tags were recovered (Jorgensen et al., 2010) and none of the 78 acoustic tags were recovered because these sink when detached. Other animals also have been suspected of ingesting tags by mistaking them as a food source or biting them off a tagged animal (Holland, 2012). Ingested marine debris can kill animals by blocking their esophagus and intestinal tracts. Plastic in the marine environment is also likely to persist for hundreds of years (NOAA Fisheries Service, 2006). Altogether, it is anticipated that 150 acoustic tags, 50 pop-up satellite archival tags and 25 stomach tags would be deployed and then released from the sharks over a 5-year period. All 150 acoustic tags are expected to be lost as marine debris over this five-year period. Assuming past rates of retrieval of approximately 15% based on the findings of Jorgensen et al. (2010), it is expected that approximately 42 of the pop-up satellite archival tags would be lost as marine debris during this time. The 11 real-time satellite tags are also likely to be lost as marine debris, because it is likely they would eventually detach from the shark's fin. Given the short duration of the stomach tags in the sharks (expected to be less than two weeks), it is expected that these tags will be found by the researchers in the vicinity of their deployment. It cannot be determined how many of these lost tags would detach and become lost directly within the sanctuaries. The loss of these tags over the next five years is likely to result in a less than significant adverse effect relative to the amount of debris from other sources in the sanctuaries.

Moored acoustic receivers have also been known to break loose, but these generally can be retrieved or located again (Block, 2011) and are not expected to cause a debris effect. The two acoustic receivers that are planned to be installed on the seabed would have a negligible effect on sandy bottom habitat in the vicinity of the receivers.

Under Alternative B, up to two decoys per vessel would be allowed for attraction purposes up to six hours each day with an estimated number of one to five tour boats anticipated in the area around Southeast Farallon Island on any day of the week. In 2010, a White Shark was observed biting a decoy, which released Styrofoam (that decoy's source of buoyancy) into sanctuary waters. Since the incident, GFNMS has prohibited the use of Styrofoam material in decoys. Occasionally, the tethers to the decoys have become loose, causing the decoys to float away. In the one instance that was reported to the sanctuary the decoy was later recovered by the island biologists. Thus, if sharks bite the decoys or if the decoys are lost, it is possible this could result in a prohibited discharge, which would be anticipated to have a less than significant effect on habitat quality depending on the material used. Trolling a decoy, however, is likely to cause a more energetic response from the sharks, including launching themselves out of the water at a moving decoy. For this reason, the trolling decoys are expected to result in more frequent prohibited discharges in the sanctuary from the decoys being destroyed or detached from its tether. This is not a preferred method under Alternative B.

Education tour operators have proposed to use a container (called a “bait box”) that would hold fish or pork products for the discharge of scent product. If it is not watched constantly, this could result in an attack on the container, which could then be ingested by the shark or lost as debris in the sanctuary. Offshore Guadalupe Island, where dive operators use fish bait attached to a rope and chum with chopped fish mixed with seawater, a survey was conducted in 2009 that found that 30% of shark interactions with the cage diving operators concluded in an attack on the bait, and that the shark successfully obtained the bait 5% of the time (Sosa-Nishizaki, et al., 2010). This is not a preferred method under Alternative B.

## 4.5 Biological Effects of Implementing Alternative B: Allow White Shark Attraction that Meet Management Goals

### 4.5.1 White Sharks

This section assesses the effects of the alternative on a suite of conditions specific to White Shark welfare, including their typical migratory patterns, life history traits (such as mating and reproduction), predator/prey interactions, and their recovery from injury or responses to stress.

**Effects from Attraction with Decoys**

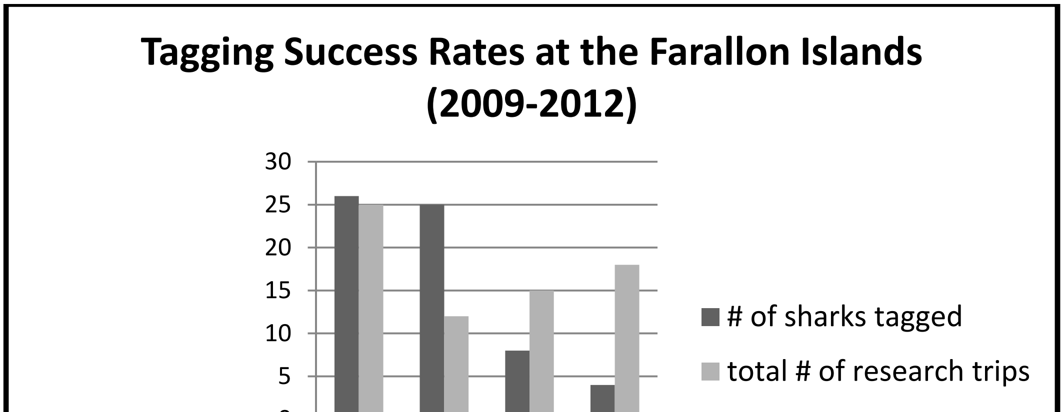
Investigating a decoy attractant has costs to White Sharks and may have an effect on their predation opportunities. It may cause their location to become exposed to prey and to potentially risk losing a meal. Sharks are ambush predators and success depends on the behavior of predator and prey, which imposes costs in terms of energy, time and risks that must be balanced against survival benefits. If the energetic cost of a predation attempt is too high or the likelihood of capture too low, the predator may abandon the attempt (Martin et al., 2005). As noted earlier in Section 2.3.1, once a shark has launched its initial strike on a perceived prey item (including a decoy), the element of surprise is lost (Johnson et al., 2008) and once seals in the vicinity realize the sharks’ whereabouts and intentions, the odds greatly favor the seals (Martin et al., 2005). The decoy may also cause a shark to deviate from patrolling for food, or from mating, which is believed may also affect important energy storage requirements, although this has not been tested.

Studies indicate that individual White Sharks exhibit site fidelity to particular areas around Southeast Farallon Island (Goldman and Anderson, 1999; Klimley and Anderson, 1996). Thus, a small, localized group could be particularly vulnerable to over-exploitation or harassment. Based on conditions seen in the past, the use of decoys to attract White Sharks during the season with potentially up to five educational tour operators and two researchers is not expected to have significant effects on White Shark predatory behavior, although it is conceivable this could cause a minor adverse effect on shark predation success due to the decoys distracting them from a viable meal or exposing them to their prey. However, since the sharks would not be receiving a food reward when exploring the decoy, it is anticipated that using a decoy would have a less than significant effect.

The total number of sharks attracted to research vessels could possibly include every shark known to occur in the GFNMS management area at the end of five years with some expected to be tagged more than once. It is possible this could lead to learned behavior by the sharks to avoid close approach to the research vessels (refer to Figure 17 which shows the number of sharks tagged at the Farallon Islands over a four-year period when using decoys in combination with a scent attractant). However, definitive conclusions cannot be made based on only four years of data. There are potential beneficial effects to the White Shark population from increased data collection that could lead to improved management and conservation efforts.

White Sharks are considered ambush hunters, in which they quickly approach their prey before they can be seen. They are also highly visual hunters; in Laroche et al. (2007), they found that more than 85% of the initial sightings of White Sharks during their study approached from directly below the observer and the majority of these were approaches that were made towards the seal-shaped decoy as opposed to the bait floating nearby. White Sharks often hunt by approaching at depth and attacking from a vertical angle at high speeds. This type of hunting may result in the sharks launching themselves out of the water during an attack. They have also been known to breach the water to strike at decoys, although this behavior has not been observed that often at the Farallon Islands.

**Figure 17. Tagging Success Rates at the Farallon Islands (2009-2012)**




| | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| # of sharks tagged | 26 | 25 | 8 | 4 |
| total # of research trips | 25 | 12 | 15 | 18 |

If a shark bites into a decoy, there could be direct adverse effects from the intake of decoy material. In addition, because sharks will sometimes breach the water to strike at decoys, trolling a decoy is expected to create greater energy expenditures for the shark. This has not been measured in any scientific study, but based on visual observations a trolling decoy may increase the overall effects on the sharks from use of decoys as attractants by inciting more aggressive predatory strikes on the decoys. Thus, it is possible that trolling decoys could result in an adverse effect on White Sharks' natural behavior by causing them to launch themselves out of the water more often than they normally would. However, sufficient data are not available to make conclusive comparisons between shark interactions and decoy use in the GFNMS management area.

**Effects from Attraction with Bait or Scent**

Changes in animal behavior have been documented as a result of people altering natural feeding methods or locations. Often these interactions are being conducted in important habitats that animals use for resting, breeding, calving, nursing, feeding, or shelter. Examples include baiting and feeding bison, bear and deer in parks, and the feeding of fish, dolphins and other animals in the marine environment. Wild animals in national parks and other places are not baited or attracted in other ways for tourism purposes.

The U.S. National Park Service now prohibits feeding or attracting animals for wildlife viewing (36 CFR § 2.2) and the National Marine Fisheries Service prohibits feeding or attempting to feed a wild marine mammal with either food or non-food items (15 CFR § 216.3). In 2002, the State of Florida implemented regulations that banned the baiting or attraction of marine wildlife in all state waters for any purpose other than traditional fishing. Also in 2002, the State of Hawaii prohibited food or other substances to be given to sharks unless it is for traditional Hawaiian cultural or religious practices, provided that the feeding related to these traditional practices is not part of a commercial activity (Chapter 188 § 40.6). CDFW regulations prohibit the feeding of fish and wildlife in California marine protected areas except under a scientific collection permit or if fishing is specifically authorized. Fishing is prohibited in marine reserves, including Southeast Farallon Island State Marine Reserve, North Farallon Islands State Marine Reserve, and Point Reyes State Marine Reserve. Regulations for the Año Nuevo State Marine Conservation Area prohibit the take of all living marine resources except for commercial hand harvesting of giant kelp (*Macrocystis pyrifera*). Marine conservation areas around Point Reyes prohibit the take of all living marine resources except for commercial and recreational harvest of salmon and Dungeness crab. Take is similarly prohibited around the Farallon Islands except for commercial and recreational harvest of salmon in the Southeast Farallon Island State Marine Conservation Area. Sanctuary regulations prohibit the discharge or deposit of any material or other matter, which would include feeding of sharks and other fish or marine life. The one exception is the discharge of fish, fish parts, or chumming materials (bait) that are used in or resulting from lawful fishing activity.

Worldwide, the response to feeding White Sharks in the wild is varied. In Mexico, White Shark regulations prohibit the use of decoys and small boats (i.e., Zodiacs) while allowing the use of scent, provided the product is pathogen-free and consists of local fish such as sardine, ground mackerel or tuna oil (Olivares, 2012). New Zealand does not have regulations for the use of chum or other attractants; however, White Shark cage diving boats have only recently begun operating in the country. Western Australia does not currently have cage diving operations, but news reports state that the Fisheries Minister recently banned the activity out of concern that active chumming could attract more sharks and potentially change their behavior patterns to the detriment of swimmers and surfers (Nicholson, 2012).

The process of attracting sharks to boats also could result in injury if the shark runs into the underwater cages or the boat, which is documented to have occurred in other White Shark aggregation areas that use bait or scent as an attractant (Mackay, 2012; Brody, 2008), although Sosa-Nishizaki et al., (2010) reported no instances of this during their survey. Another article commented that, “It is a fine art to lure the sharks near, but not so near as to allow them to crash into the cage or the boat, thereby accidentally breaking teeth or getting cut” (Frink, 2010). Due to the thrashing that would ensue, this would likely cause a negative effect to any shark that collides into or is caught inside a cage.

White Sharks are sensory hunters using visual, auditory and olfactory cues in their environment, and they can be trained to respond to these stimuli depending on the frequency and level of repetition. A scent attractant can help the shark overcome its innate caution and create an incentive for it to approach a source more closely. White Sharks have been observed swimming in a crisscross pattern several kilometers downstream of a baiting station for periods of up to 12 hours after cessation of chumming (Strong et al., 1996). Bait particles drifting down and concentrating along the bottom over a period of days may also create a “secondary bait source” that sharks would investigate after baiting stops (Strong et al., 1996). Huveneers et al., (2012) found that White Sharks at a known aggregation site at Neptune Island, Australia, also swam at shallower depths and within a smaller spatial range than normal when cage diving vessels using chum were present. The findings of all these studies suggest that the presence of chum may be linked to modification of White Sharks’ normal swimming and/or hunting behaviors.

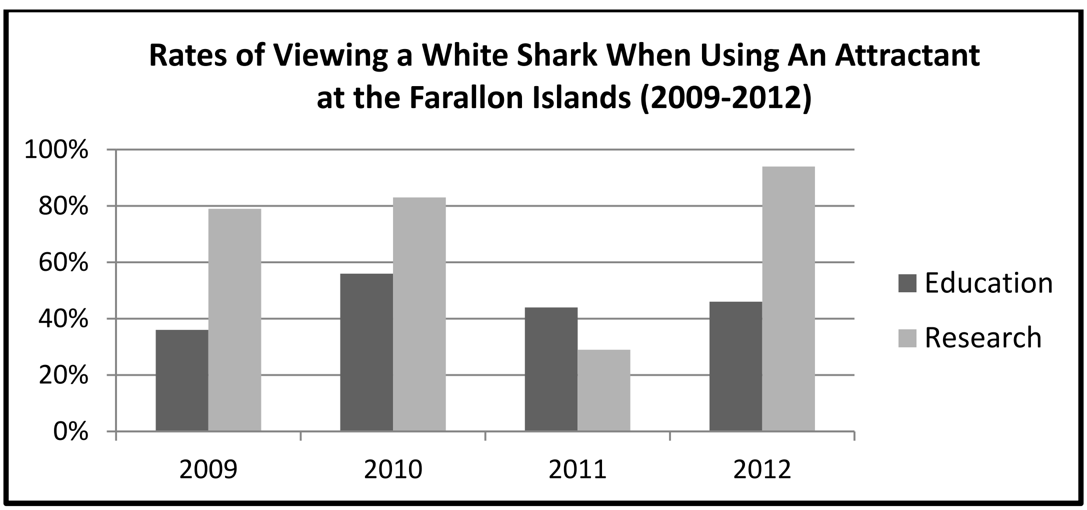
There is limited data available for pelagic species of sharks, but results from behavioral studies show that chemical cues play a role in food detection and search behavior in tuna (a teleost fish), which have similar thermoregulation capabilities and exhibit similar ambush hunting behavior to White Sharks (Bernal et al., 2001). It has been shown that captive yellowfin tuna (*Thunnus albacares*) have strong behavioral responses to the introduction of prey rinses and amino acid extracts into their holding tank (Atema et al., 1980). Presence of prey odors induced such responses as an increase in swimming speed and tight circling in the region where odor was encountered. Although prey odors cause an increase in searching behavior, tunas seldom locate the odor source. These results suggest that chemical cues are important for initiating search behavior in tunas, but other sensory cues, mainly vision, are probably critical for actually locating prey once a search has been initiated (Atema et al., 1980).

In July 2003, the GFNMS advisory council unanimously forwarded recommendations to GFNMS superintendent that had been developed with input from their wildlife disturbance working group and recommendations received during public comment from Lawrence Groth (Great White Adventures) on White Shark attraction. The recommendations by the Sanctuary advisory council were also developed in conjunction with input from Dr. Peter Pyle (a White Shark researcher). The recommendations included guidelines for White Shark observation activity permits and addressed general issues including cage diving safety, dive cages, and attraction methods. The guidelines included recommendations that “no chum or bio-attractant” be used and that only surface decoys or lures be used. At the time the regulations went into effect in 2009, one of the tour operators maintained their company was not using bait or chum based on self-imposed guidelines (Barron, 2009) and another tour company had a voluntary agreement not to use chum (Moskito, 2012). The full set of recommendations that were developed for the GFNMS advisory council by the Wildlife Disturbance Working Group and which the advisory council provided to the sanctuary superintendent in July 2003 can be found at http://sanctuaries.noaa.gov/jointplan/archive/reptoad/gf_pdf/gf_reptoad_p1.pdf.

Data obtained from trip logs from 2009 show that White Sharks were observed either at decoys, from cages, on underwater video systems or otherwise at the surface, some at greater distances from the boat, on approximately 38% of all education trips (Figure 18; Office of National Marine Sanctuaries, unpubl. data). Trip log data in 2010 and 2011 indicate that White Sharks were observed at decoys, from cages, on underwater video systems, or otherwise at the surface on 56% and 44% (respectively) of the education trips conducted in those two years (Office of National Marine Sanctuaries, unpubl. data). Trip log data from 2012 continued to be consistent with statistics from prior seasons in that White Sharks were observed during 46% of the education trips (Office of National Marine Sanctuaries, unpubl. data). These rates represent the true opportunity for passengers on permitted ecotourism boats to see White Sharks in the sanctuary.

Research that is being proposed in the GFNMS management area involves tracking White Shark movements, understanding their migration patterns, and determining critical habitat areas as well as determining relative abundance and genetic connectivity between populations. This would involve deploying tracking devices, taking biopsy samples, and visually identifying individuals by their fins, scars or skin patterns. To do this type of work, researchers need to lure sharks close to the research vessel. In 2009 and 2010, researchers were able to attract a shark close enough to their vessels to conduct their studies approximately 79% and 83% of the time, respectively, while using stationary decoys and marine mammal scent attractants. In 2011, this rate dropped to 29% but rebounded to 94% in 2012 (Figure 18; Office of National Marine Sanctuaries, unpubl. data).

**Figure 18. Rates of Viewing a White Shark Using An Attractant at the Farallon Islands (2009-2012)**




The actions proposed under this alternative would allow the use of scent and bait during short-term research projects. The attractants proposed for research are not expected to cause a significant change in behavior, although it is possible that sharks that ingest bait for deployment of the real-time satellite tags and the stomach tags, and may associate the presence of boats with a potential meal. If this happens, it could cause a less than significant effect to the population given the small number of sharks (up to 36) that would be targeted over five years. It is possible that this positive association could last after the researchers have left the area, which could cause a portion of the adult population of White Shark that congregates in the GFNMS management area to be more responsive in future years to the presence of boats in the vicinity, with or without food. This could lead to increased energy expenditures related to foraging that could have a less than significant effect on approximately 16% of the estimated abundance of White Sharks that congregate in this area. Recent findings from Semmens el al., (2013) suggest that feeding requirements for White Sharks are higher than previously thought. It was previously believed that roughly 30 kilograms of marine mammal blubber could feed a shark for approximately 1.5 months, but the study suggests that White Shark feeding and energy requirements are several times higher than this amount, meaning White Sharks may need to feed more frequently and any disturbances to their normal feeding behavior may result in greater energetic costs.

During a typical season, researchers may spend 10-20 days at the Farallones. GFNMS has determined that the minimal amount of potential disturbance on White Sharks resulting from scent use for research is warranted given the value information of the information being collected for science and management purposes. Between 2009 and 2012, tour operators averaged approximately 48 trips to the islands (ONMS, unpubl. data, 2012). Given the potential for passengers to view White Sharks during an average of almost half (46%) of the trips, in tandem with the recommendations from the GFNMS advisory council working group and the policies of NOAA Fisheries and NPS regarding the attraction of wildlife, the sanctuary has determined that the use of scent by educational tour operators at the Farallon Islands is unwarranted. The use of stationary decoys alone have some measure of effectiveness and the additional use of chum or scent attractants by tour operators could potentially lead to increased disturbances to White Shark natural behaviors. In addition, the use of scent for non-research activities could distract White Sharks from approaching bait, chum or scent used by researchers by exposing the sharks to additional signals and stimuli in the water around the Farallon Islands, thus, having a potential adverse effect on research activities.

**Effects from Approach**

The reason GFNMS implemented regulations that prohibit approaching a White Shark closer than 164 feet (50 meters) within two nautical miles around the Farallon Islands is because White Sharks are stealth hunters and are believed to come to the surface mainly to feed (Johnson et al., 2008). A boat approaching in close proximity can scare away a shark that is feeding or mating. If multiple boats were to regularly approach White Sharks during the short time the sharks are congregating in this area, this could cause them to abandon their prey or mating attempts, resulting in reduced fitness or mating success to the sharks. Approaching White Sharks, therefore, can result in intrusive behavioral effects during this critical period when they are in the GFNMS management area.

### 4.5.2 Other Fish

Salvaged marine mammal flesh and blubber used to bait hooks for research activities may temporarily increase the density of marine fish in the vicinity of the research projects through the same process of attraction. Although some fish species may pick at the bait, most of the life attracted to the bait would not benefit or be harmed by its presence. If small pieces of bait are shed from the hook or scented water, some individual fish would artificially obtain this natural food source, but the total amount would be small and the duration in which this would occur would be short. Thus the effects of using bait, chum or scent on other fish would be negligible.

In a sampling of more than 1,100 fish from six common grouper and snapper species along the north coast of Moorea Island in French Polynesia, it was found that one species of grouper exhibited significantly higher prevalence of a type of larval flatworm that parasitizes sharks and that the intensity of the infestations were significantly higher around shark-feeding localities compared with non-shark-feeding localities. The results suggest that long-term shark feeding has parasitological implications, but adverse effects appeared to be limited and did not seem to affect the overall health of the fish studied (Vignon et al., 2009). The potential to attract other sharks and other fish species during research activities could result in a less than significant adverse effect on fish habitat or fish populations.

If lights are used at night to attract White Sharks, this could also attract small invertebrates and fish around the vessel, which could lead to higher trophic levels of attraction. In some areas, fish attracted to the lights on over-nighting vessels have been observed crashing into the hulls trying to escape predation by mackerels. However, it is expected that vessels participating in White Shark research and educational activities would not overnight at the islands, thus, the effects of lights on fish are expected to be negligible.

### 4.5.3 Other Wildlife

**Seabirds**

For the majority of seabirds during most years (with the exception for the endangered Ashy storm petrel which nests through November), nesting season would be over at the time of proposed White Shark research activities, so it is anticipated that there would be negligible effect on the breeding of the vast majority of species. Some local bird species, however, may remain abundant in the vicinity during the fall and winter months, and wintering waterfowl and coastal birds would also be found. Some research activities would extend to March around Año Nuevo and Point Reyes during the seabird breeding season. Some birds, especially gulls, birds of the order Procellariiformes (e.g. shearwaters, petrels, albatross), and pelicans could be attracted to bait used to attract White Sharks, which could provide an artificial, positive effect from shreds of pinniped or cetacean blubber that may fall from the hook. Given the short time period of all proposed research projects (estimated to be about 29 days total per year), the amount of bait available to gulls or other birds would be negligible in comparison to the rich food supply generally available in the surrounding waters. Oil released from blubber is anticipated to be a thin sheen that would dissipate quickly and unlikely to cause any significant oiling to bird feathers.

White Shark attraction for the purpose of education is expected to take place in the vicinity of Southeast Farallon Island. There are special closure (no-access zone) and speed restrictions in effect to minimize disturbance to seabirds. The seabird nesting season also would be over for most species during the time of the proposed White Shark education tours, so there would be negligible effects on the vast majority of seabird species as a result of proposed tourism operations around the Farallon Islands.

**Marine Mammals**

Elephant seals, sea lions and harbor seals are the primary marine mammals that would be expected to occur in the GFNMS management area during the months between September and November, when decoys are deployed for White Shark attraction. Some northern fur seal adults and pups may be present in the vicinity of the Farallon Islands. Humpback whales and blue whales have been observed in the vicinity of the islands during the fall. The use of decoys to attract White Sharks is expected to have a negligible effect on these or other marine mammal species. In addition, none of these species feed on pinniped or whale blubber, and thus, would not likely show any interest in the scent or bait being used by researchers to attract White Sharks. No disease transmission or other effects to cetacean, delphinid and pinniped populations in the area are anticipated from the use of marine mammal bait. Therefore, the effects of attractants on marine mammals are expected to be negligible.

Some surveys have shown that pinnipeds can be infected with zoonotic enteric bacteria, including *Salmonella* and *Campylobacter* spp. (Stoddard et al., 2005). These bacteria, as well as *Yersinia enterocolitica* and *Listeria monocytogenes*, are high-risk, food-borne zoonotic hazards that occur in pigs (Fredriksson-Ahomaa et al., 2009). Therefore, a potentially significant effect could occur if raw pork products are used as the source of an attractant, which could possibly increase bacterial infections to marine mammals especially in younger, more susceptible animals. For this reason, Alternative B allows for only the use of marine mammal blubber as an attractant and not the use of pork products.

The use of a scent attraction around the Farallon Islands could have an effect, but less than a significant effect on sea lions and seals if the attractant increases the presence of White Sharks in certain areas near these rookeries.

**Sea Otters**

Sea otters are not known to occur near the Farallon Islands and would not be affected by the attraction of White Sharks for research or education activities. Some sea otters may be present in the vicinity of Año Nuevo. The oil released from a blubber attractant, which would be used during proposed research projects, is anticipated to be a thin sheen that would dissipate quickly and probably not cause oiling of sea otter fur. No disease transmission or other effects to sea otters are anticipated from the use of marine mammal bait. A more likely scenario is that the presence of research vessels may frighten away otters that might be in the area. Given the small amount of time when research would be conducted in the area (eight days at Año Nuevo) compared to the presence of boaters and other human activity that generally occurs year-round, only negligible effects between research activities and sea otters are foreseen.

**Sea Turtles**

Sea turtles are known to occur in the GFNMS sanctuary area, but they are not common visitors around the Farallon Islands, Point Reyes or Año Nuevo. Implementing Alternative B would, therefore, result in a negligible effect on sea turtles.

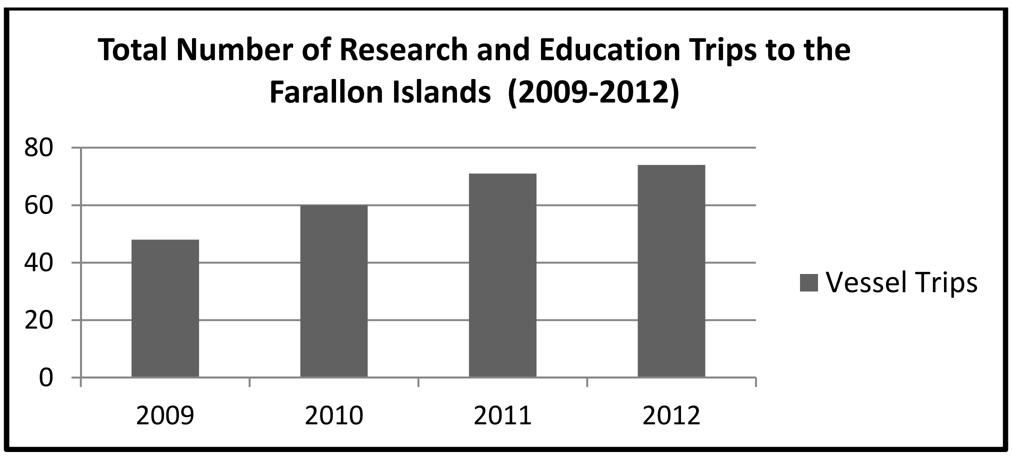
## *4.6 Socioeconomic Effects of Implementing Alternative 2: Allow White Shark Attraction and Approach that Meet Management Goals*

### 4.6.1 Tourism, Education and Research

One of the goals of GFNMS is to support, promote, and coordinate research on, and long-term monitoring of sanctuary resources and natural processes that occur there (National Marine Sanctuaries Act, Title 16 U.S.C. § 1440). White Shark research can lead to a better understanding of White Shark life history and it may contribute to greater public education on the role of this species in the marine ecosystem. White Sharks are considered a charismatic species and the public is interested in learning more about these relatively little-known animals.

The total number of education and research trips conducted by permittees over the last four years in the GFNMS management has increased each year since the White Shark Stewardship Program began (See Figure 19; Office of National Marine Sanctuaries, unpubl. data). In 2009, permitted operators made 47 trips to the islands for research and education purposes. In 2010, this number increased to 60 and it increased again to 71 and 74 in 2011 and 2012, respectively. Over these four seasons (from 2009-2012), an average of 63 total vessel trips were made to the islands each year for both education and research (Office of National Marine Sanctuaries, unpubl. data, 2012).

**Figure 19. Total Number of Research and Education Trips to the Farallon Islands (2009-2012)**




Many more trips are scheduled for the education tours each season but are often canceled, primarily due to weather. In 2009, three operators conducted a total of 34 trips out of a possible 77 days in the season. The total number of visitors on these vessels during the 2009 season was estimated at 520. In 2010, two operators conducted a total of 48 trips that season. The total number of visitors on these vessels was estimated around 690 people. During the White Shark season for 2011, three companies made a total of 57 trips. The number of visitors on these vessels was estimated to be 795 passengers. A fourth permit was issued in 2011, but was not validated by the applicant due to reported successful sport fishing activities. In 2012, three tour operators conducted a total of 56 trips. The total number of visitors on these vessels was estimated around 750 people (Office of National Marine Sanctuaries, unpubl. data, 2012).

The amount of time that researchers likely would be conducting research in the GFNMS management area is highly dependent on ship time allocation and weather. For example, in 2009, 21 days of vessel time were chartered to conduct research, but the vessel was able to go offshore only 11 days due to weather (Block, 2011). In 2010, 2011 and 2012, one researcher spent 12, 14, and 18 days, respectively, conducting research around the Farallon Islands. At most each year, it is expected that researchers would spend approximately 20 days conducting research around the Farallon Islands, another eight days at Año Nuevo, and one more day near Point Reyes. Allowing this alternative would have a positive effect on the public through the dissemination of the findings from the proposed research studies.

It is possible that adverse coverage in media outlets could occur both within the local area and nationwide. Responses by the public may be substantial with a wide range of opinions expressed, both positive and negative. Negative public perceptions of proposed projects and potential misunderstanding of scientific knowledge that could be gained would likely cause a minor adverse effect on the sanctuary's image. It is expected that important data resulting from research on White Sharks would enhance knowledge of the White Shark's life history such as where the females go during the two years or more when they are away from the GFNMS management area, which could then lead to greater advances in protection and conservation efforts for the full range of NEP White Sharks, particularly through regional or international efforts. This could help foster increased international coordination opportunities with other White Shark aggregation areas such as Guadalupe Island, as well as the protection of the currently unknown breeding and pupping areas. The dissemination of this information would enhance public knowledge of the full suite of threats faced by White Sharks and could be used to reach a wider audience to allow for a greater appreciation and awareness of the sanctuaries. Therefore, despite the potential negative public perception from these activities, proposed research activities under Alternative B are likely to have a beneficial effect on the population of White Sharks that congregate in the GFNMS management area.

The primary purpose of the National Marine Sanctuaries Act is resource protection. Research permit holders may engage in a greater range of otherwise-prohibited activities because research has provided important information about White Shark migration patterns, genetic isolation, site loyalty, environmental factors affecting abundance and success, and local population estimates. While education activities can increase public understanding and appreciation of White Sharks, using scent to increase sightings of White Sharks does not produce the type of critical scientific and management information resulting from research, and the use of scent for education purposes could potentially lead to undesirable effects on White Sharks in the GFNMS management area.

Another aspect of the use of scent, bait or chum is whether these attractants should be used for White Shark education to determine whether viewing a White Shark in the wild makes one more likely to support marine conservation efforts. A scent attractant has been proposed to increase the number of participants who view White Sharks because the assertion was made that decoys are not effective. Based on data obtained from education permittees, passengers are currently likely to view a shark approximately 46% of the time on these tours (Figure 18; Office of National Marine Sanctuaries, unpubl. data). This includes viewing White Sharks from a distance greater than the decoy or viewed in other directions from the decoy during normal behaviors. These rates represent the true opportunity for passengers on permitted education boats to see White Sharks in the GFNMS management area. The use of stationary decoys without scent attractants appears to satisfy the purposes of educational activities, because it would minimize disturbances to White Shark natural behaviors while maintaining ONMS educational values related to protecting sanctuary resources and qualities.

Concerns have been expressed that commercial filming should not be allowed during permitted White Shark-related research activities, because it could compromise the research or influence the research activities. Applications to conduct filming projects are reviewed on a case-by-case basis to determine whether the project meets the permit criteria. If issued, the filmmaker would receive an education permit that is separate from the research permit, but the filming would be done concurrently with the research field work. Applications for filming White Sharks during permitted scientific tagging studies are evaluated for their educational benefits and the final products are required to convey specific conservation messages in the material presented to the public. If filming is prohibited during proposed research projects, then this could negatively affect the educational benefits that could be realized from presenting White Shark research to the public in a mass media format.

The sanctuary would establish permit conditions to ensure that the filmmakers do not influence how the scientists conduct their work and to ensure that the filmmakers' presence does not compromise the safety or health of the sharks under study. Given these conditions, the presence of the filmmaker should be minimized and should not influence the research activities or create secondary adverse effects on the study animals. Further, if filmmakers need an additional boat to film the research activities, this would involve further analysis during the permitting process to determine whether a cap is needed on the number of boats used for attraction purposes in the GFNMS management area. As currently proposed, the effects of implementing this method would be negligible.

Filming activities conducted during White Shark education tours would likely have a positive educational benefit as long as the conservation messages are included and the activity is not seen as an extreme sport that vilifies the White Shark or dramatizes a "killing" event. Most often the "filmmakers" are individual passengers on the education vessels with their own personal video cameras and the sanctuary has no control regarding what the public posts to a web site. The sanctuary had considered and determined that filming activities cannot be separated from the original education permit issued to tourism operators. The filming of White Sharks from permitted tourism boats should have negligible effects.

### 4.6.2 Sport and Commercial Fishing

Two of the White Shark tour operators that were issued permits in 2011 indicated that their charter fishing operations were still strong going into the winter season. This was the reason that they did not conduct White Shark tours in 2011. One of the charter boats who held a permit for shark tours also canceled a number of tours to pursue fishing activities instead during the 2012 season. Thus, the number of applications for White Shark attraction may depend somewhat on the overall success of charter fishing operations during the season.

It is possible that additional boat operators may seek the opportunity to attract White Sharks in the sanctuary for tourism purposes as an alternative to commercial or recreational fishing. This is considered much more likely if scent is allowed as an attractant.

### 4.6.3 Recreational and Commercial Vessel Traffic

No effects would occur to commercial traffic as a result of the proposed project because the routes taken by commercial vessels entering or exiting the San Francisco Bay area are sufficiently far enough away from the project area that no potential for conflict exists. Also, commercial vessels are not allowed to approach within two nautical miles of the Farallon Islands (CFR 922.82(a)(13)).

If additional recreational and commercial fishing vessels determine that attracting sharks around the Farallon Islands for tourism is a viable alternative to fishing, depending on the number of vessels, this could cause a significant effect related to an increase in commercial and recreational vessels near the island and the potential for increased disturbances of White Sharks. If more than five educational tour permit applications are received, the sanctuary would need to reconsider implementing a cap on these activities.

Participants who embark on a one-day excursion to cage dive near the Farallon Islands to view White Sharks are charged approximately $800 to $900 per person or about half this for top-side viewing. If other recreational and commercial fishing vessels determine that they can create a similar business to attract White Sharks using decoys around the Farallon Islands for tourism as a viable alternative to fishing, which can have fluctuating success, this could cause a beneficial economic effect due to an increase in recreational tourism vessels near the island.

## *4.7 Effects of Past Actions Within the Scope of Analysis*

Although there is no directed fishery for White Sharks, some amount of bycatch of young and juvenile White Sharks still occurs in commercial entangling nets and recreational fisheries in southern California, and this likely affects overall recruitment into the sub-adult and adult group of sharks that occur around the aggregation sites in the GFNMS management area. Large adult White Sharks are generally not known to be caught by commercial or recreational fishing gear in northern California. It is not known if international fishing fleets that occur outside of the U.S. Exclusive Economic Zone are catching White Sharks for fins, jaws or for consumptive purposes.

**Figure 20. Small skiff used for white shark research at the Farallon Islands.**

White Sharks have been tagged continuously since 1999 in the sanctuaries. A total of 220 acoustic and pop-up satellite archival tags have been deployed, representing more than 100 unique individuals over the past 12 years (Figure 20). At least 130 individuals have been identified over a two-year study period (representing three White Shark seasons) through photo identification (Chapple et al., 2011). This means that sharks have been tagged more than once, which is considered necessary by the researcher because of the rate of tag shedding. Another two sharks have been tagged with real-time satellite tags.

Up to eight recreational and commercial boats have been known to try to attract White Sharks with decoys and other attractants near the Farallon Islands before the GFNMS regulations prohibiting this activity were put in place. This did not seem to be occurring as a large, concentrated effort, but it was indicating a trend toward increasing activity levels over a few years' time (Pyle, Anderson and Brown, 2003).

Compared to past actions, especially mortality due to directed fishing, the current research tagging and educational tourism activities are not likely to significantly affect the population numbers of adult and sub-adult White Sharks that visit the aggregation sites in sanctuaries. There have been disturbances of these animals in the sanctuaries, and more so around the Farallon Islands, as a result of decoy and use of bait, chum or scent attractants, but these are considered to result in a less than significant effect at currently permitted levels.

## 4.8 Effects of Present Actions Within the Scope of Analysis

A number of other research projects are currently permitted to occur in the GFNMS management area, but these are mostly conducted close to shore and in the intertidal zone. These projects have not had any identifiable, direct effect on White Sharks. There are no active education permits for White Shark attraction other than the ones currently permitted and previously described. No cumulative effect from the proposed preferred alternative is expected to occur in conjunction with other present actions in the sanctuaries.

## 4.9 Reasonably Foreseeable Actions Within the Scope of the Analysis

For an animal that spends only a few months near the coast and lives in an environment where it is difficult to observe except for brief moments, there is insufficient data for sanctuaries to accurately determine how an incremental increase in future actions may affect the White Shark and whether the actions combined are creating an additive effect. Over the course of the next five years, it is possible that every shark that aggregates in the GFNMS management area may be tagged at least once and some will probably be tagged more than once. This would be more likely if the estimates in Chapple et al., (2011) are correct and the maximum number of adult and sub-adult sharks in the sanctuaries at any one time is between 130 and 275 individuals. This would also likely mean that sharks may be captured that already have an acoustic or pop-up satellite archival tag, resulting in additional stress to that individual. At the same time, up to five tourism operators are likely to have permits to attract White Sharks near the Farallon Islands that could potentially occur every day of the week during the 11-week season.

The status quo represents the level of White Shark research and education activities that are expected to continue into the near future given existing statutory requirements. The effects for the preferred action (i.e., stationary decoys for use during research and education activities, and marine mammal scent for use only during fundamental White Shark research) and for past permitted actions would be minor overall and less than significant. Therefore, the cumulative effects on the White Shark if the proposed activities under Alternative B are allowed to occur over the next five years are expected to be minor overall and less than significant. At the proposed permitted levels, these actions would not likely create a significant cumulative impact to White Sharks that congregate near the Farallon Islands, Año Nuevo and Point Reyes.

The potential for adverse effects could be increased by the number of potential education operators and the number of days they may be operating around the Farallon Islands. There are strong concerns that the cumulative effects of allowing scent attraction for White Shark educational tours could both alter White Sharks' natural behavior and lead to many additional requests for White Shark attraction permits. Depending on the number of additional permit requests, this could lead to secondary adverse effects on the operators as a result of the sanctuary likely needing to implement a cap on the number of White Shark education permits, which may require the sanctuary to implement a lottery system for issuing education permits. In addition, the use of scent for non-research activities could distract White Sharks from approaching bait, chum or scent used by researchers by exposing the sharks to additional signals and stimuli in the water around the Farallon Islands, thus, having a potential adverse effect on research activities.

The tendency for White Sharks to congregate or return to certain sites on a regular basis for feeding, breeding or for other purposes can leave them vulnerable within these localized areas. Terrestrial wild animals in national parks and marine mammals are not attracted with scents or baits for the purposes of tourism. In California sanctuaries, all marine species, except those taken via lawful fishing, are not allowed to be fed or baited for the purpose of tourism.

The effect of additional disturbances beyond the levels currently considered under the preferred alternative is not known, and there is a concern that the cumulative disturbances could adversely affect important energy storage requirements while sharks are in the GFNMS management area to feed. There are still major gaps in scientific understanding related to the cumulative effect of proposed activities on the White Shark. In light of these knowledge gaps, a cautious, precautionary approach is appropriate until more information can be obtained to better assess the cumulative adverse effects of adding additional disturbances to the White Shark in sanctuaries.

# 5. OTHER STUDY METHODS REVIEWED FOR CUMULATIVE EFFECTS ASSESSMENT

## 5.1 Introduction

Research studies have been proposed in the GFNMS management area because of the number of adult White Sharks that aggregate in certain areas, but these studies also include methods that are not directly prohibited by GFNMS and MBNMS regulations, such as putting a tag on a White Shark, capturing a White Shark, collecting biopsy samples or using marine mammal blubber. These methods, while integral components of projects that are regulated by GFNMS and MBNMS, are regulated by other state or federal agencies. The sanctuaries' regulations do not duplicate state or other federal requirements; they were established to complement existing regulations for the protection of White Sharks, and GFNMS coordinates closely with these other agencies in the permitting process.

This section describes and analyzes methods that are expected to be part of the projects associated with the attraction or approach of White Sharks for research purposes in the GFNMS management area. It is provided as additional information that was used to assess the cumulative effects of the proposed action on White Sharks in the GFNMS management area.

## 5.2 Comparison of Tracking Methods

Advances in satellite technology have allowed scientists to better assess behavioral and physiological responses of animals, such as White Sharks, which cannot be easily observed in their natural settings. Traditionally, fish populations have been monitored by measuring recreational and commercial catch effort of exploited species. Due to their rarity and because directed fishing for White Sharks is prohibited offshore the U.S. West Coast (unless a scientific collecting permit authorizes the activity), only a small number of incidental catches of White Sharks have been recorded from the fishery data and these are generally of young and small sharks. Therefore, other methods have to be used to determine such basic factors as when younger sharks recruit into the adult population and where these fish go when they are not in the area.

The following sections provide additional detail on the different methods that have been or are anticipated to be proposed as part of research projects conducted within the GFNMS management area. Several different types of tags would be used, but generally they are not directly comparable to each other, because they each collect various data that are intended to answer distinct ecological questions.

### 5.2.1 Real-time Satellite Tag

For the purposes of this document, the term "real-time satellite tag" has been used instead of other commonly used names such as smart position or temperature (SPOT; Wildlife Computers, http://www.wildlifecomputers.com/spot.aspx) tag or satellite-linked radio transmitting tag. The term real-time satellite tag is meant to differentiate the concept of data being collected by the ARGOS satellite in near real time versus a pop-up archival transmitting tag (see below), which provides position data and other biological data after the device detaches from the animal. The purpose of using real-time satellite tags is to determine the locations of females during their years of absence from the GFNMS management area, as well as to identify the pupping and nursery regions for the group of White Sharks that visit these aggregation sites.

Real-time satellite tags (Figure 10; Census of Marine Life, 2010) are designed to obtain multi-year tracks from adult White Sharks. Tag dimensions are approximately 6 inches long, 1 inch wide and 0.75 inches thick. The weight is approximately 5.9 ounces. The satellite transmitter is activated when the shark is at the surface when both its dorsal fin and the tag are above the water. The satellite transmissions provide location estimates, sometimes within 300 feet. ARGOS calculates these location estimates based on the "location class," which is estimated based on residual error and satellite pass characteristics (ARGOS, 2011). Successive transmissions received by the satellite in short time intervals improve the accuracy of each position. A "Class Z" hit, however, indicates that the location process failed and the position estimates are highly inaccurate (Hammerschlag et al., 2011). If the tag malfunctions, it may not transmit any location data or only limited information such as intermittent data with large time gaps.

Real-time satellite transmitting tags would be affixed to the dorsal fins by drilling one hole through the fin and securing the tag with a plastic bolt. The tag would be mounted so that it does not interfere with the trailing edge of the fin (See Figure 11) because the fin edge is unique to each shark and is used for photo identification purposes. Fin deformation can occur, particularly in smaller sharks (Jewell et al., 2011), and from the previous version of this tag, which was attached with four bolts. This happens because growth of the fin, which is much more energetic in younger sharks, is constrained by the position of the four bolts. Likewise, the four-bolt tag has detached from the fins, which can cause complications for photo identification if the leading edge of the fin is damaged. Because of the potential for these problems, researchers are working to develop a new single-bolt attachment system that should theoretically reduce fin deformation since the single bolt can migrate as the fin grows. The single bolt attachment requires the tag to be mounted to a tag "fin clip" prior to tagging. The fin clip holds the tag and wraps around the leading edge of the fin where it is then fastened with the single bolt. The bolt can be secured via a steel nut, or a cotter pin. Because long term data from tagged females is very valuable, the four-bolt attachment is proposed to be used on adult females until the single bolt method can be tested on captured male sharks to determine whether the single bolt method is safe and effective. As previously mentioned, due to the potential for these types of tags to produce multi-year datasets, NOAA Fisheries recommends the deployment of more satellite tracking SPOT tags on mature female sharks in order to better understand their long-term movements (NOAA Fisheries, 2013) which may provide additional insights for the spatial movements of pregnant females.

The primary purpose of the attachment is to keep the tag on the shark for the duration of the tag's battery life, which is expected to be four to six years. Currently, there are no practical means for the real-time satellite tag to detach from the fin at a set programmable time. Although it is possible to secure the tag with bolts made of a material that would corrode at a certain rate depending on salinity and temperature (Holland, 2012), the plastic bolt will eventually degrade and the tag will fall off. A floatation system could also be installed in the tag to allow it to float, sending out a continuous signal, which could make it possible to recover the tag after it is released from the shark. However, this method is not yet in use and would require additional design and testing before it is known whether it is feasible.

A drawback to the use of this type of tag is the time needed for the shark's dorsal fin to remain out of the water for the satellite to receive a position fix. When the dorsal fin is out of the water, a wet/dry switch activates the transmitter and the tag sends a signal every 45 seconds. If the tag remains out of the water long enough for the satellite to receive at least two consecutive transmissions, the position location is received. If only one message is sent, some information is received such as tag battery level and sea surface temperature, which gives a general indication of where the shark is located (i.e., near shore or pelagic), but no position data is obtained. ARGOS-linked tags have recently incorporated technology that can create a "Fast-GPS" tag. These tags would provide the ability to achieve accurate global positioning system (GPS) locations, while only requiring the tag antenna to be above the surface for less than one second (Wildlife Computers, 2012).

In order to attach the tag to the dorsal fin, the shark would need to be captured by specialized hook-and-line gear. The shark would then be restrained against the vessel while the tag is attached. The gear for capturing an adult White Shark that can weigh in excess of 4,000 pounds must be designed to withstand the pressure exerted against the line and hook. The tackle gear proposed would include a 3/8-inch nylon rope as the mainline and a braided stainless steel cable for the leader to prevent the shark from parting the line with its teeth. A wire leader braided into nylon rope or covered in rubber, which is intended to reduce abrasion to the shark's skin, would then be attached to the hook.

**Figure 21. Line and buoys that would be used to control and tire an adult white shark from the capture boat. (Courtesy of Michael Domeier.)**

Hard plastic buoys would be affixed to the line to tire the shark as it pulls against the resistance it creates, similar to the methods used to tire whales in order to remove marine debris from their bodies. Based on the shark's response to the conditions, the distance between the buoys and the shark would then be shortened to increase the resistance and raise the shark to the surface (Figure 21). When the buoys are immediately adjacent to the shark's head, the shark would be guided alongside a small boat and a line would be wrapped around its tail to keep it from moving.

While the shark is alongside the vessel, the boat would continue to slowly move forward to keep seawater flowing over the shark's gills. This would ensure a steady flow of oxygenated water to the shark during the period when the animal is restrained for tagging and unable to swim. The whole process from time of hooking the shark to releasing it after the tag is attached is estimated to take 40 to 90 minutes. After the tagging and data collection are complete, the barbless hook would be cut to make it easier to pull the two pieces from the jaw, then the rope around the tail would be removed.

### 5.2.2 Pop-up (and Mini Pop-up) Archival Transmitting Tags

Pop-up archival transmitting tags (PAT; Wildlife Computers, 2011) are devices that represent a marriage of traditional archival tags with a satellite-linked transmitter. Traditional archival tags used to be implanted, then the animal had to be caught again to collect the tagging data. Pop-up archival transmitting tags instead store the data, detach at certain programmable time intervals, and then transmit that data to a satellite. Some data can be uploaded to the satellite while the tag is still on the animal; however, most of the information is not available until the tag is released.

One drawback to the pop-up archival transmitting tag is that they have rarely remained attached to the animal for a full year and attachments of one year in duration are considered great successes (Holland, 2012). Of the 97 pop-up archival transmitting tags that were deployed on White Sharks described in the study by Jorgensen et al. (2010), 10 pop-up archival transmitting tags remained on the sharks and were tracked for 300 days or longer; the longest for 362 days (a median of 207 days). Twenty-nine or 30% of the 97 pop-up archival transmitting tags failed to transmit to the satellite after they were attached to the sharks. Approximately 14% of all tags were retrieved after deployment, but the rest have not been recovered (Jorgensen et al., 2010).

Because of this, as well as the cost associated with each tag, limited effort has been spent in the past few years on pop-up satellite archival tagging, although researchers remain interested in using these tags on sub-adult White Sharks to help establish whether there are coastal linkages between the GFNMS management area and southern California populations, or to try to determine whether females migrate into Hawaiian waters during gestation. Recently, a smaller type of tag, called a mini-pop-up archival transmitting tag, has been developed and is believed will have greater success remaining on the sharks. The mini-pop-up archival transmitting tag is designed to archive data for up to a year (Wildlife Computers, 2011), although there is interest in determining whether it might stay on longer due to its smaller size.

This new mini-pop-up archival transmitting tag is proposed to be deployed using the same method as the larger pop-up archival transmitting tag. The shark would be attracted alongside the research vessel, and then a pole would be used to harpoon a metal dart (2.3 inches long) into the musculature, ideally near the dorsal fin. The darts are made from medical grade titanium, which is an inert metal that is often used for surgical applications in vertebrate animals including humans. The dart would be attached to a short monofilament or wire leader (approximately 7 to 8 inches in length) and the other end of the leader would be connected to the tag, which would remain outside the animal (Figure 13).

Once attached to the animal, the mini-pop-up archival transmitting tag would record and store measurements of ambient light levels, depth and temperature at pre-programmed intervals. The tag would then detach from the shark via a corrodible link that has been activated by onboard software at pre-programmed dates set by the operator. The tags would float to the surface where they would transmit summaries of their stored data to ARGOS satellites. If the tag is recovered by the researcher, all raw data can then be obtained (Hammerschlag et al., 2011).

The mini-pop-up archival transmitting tag is approximately 4.5 inches long, not including the antenna, by 1.6 inches wide, and weighs 1.9 ounces (Wildlife Computers, 2012). The position accuracy is expected to range from 0.2 to 0.5 degrees in longitude (approximately 14 to 35 miles) and 0.5 to 2 degrees of latitude (approximately 34 to 137 miles; Block 2011). The advantage of this smaller profile than previously used pop-up archival transmitting tags is that it may create less drag, which could lead to deployment lengths as long as or longer than one year, but the attachment success for this is not known (Holland, 2012). One mini-pop-up archival transmitting tag was deployed on a White Shark in November 2011 at Año Nuevo and recovered by the researchers a year later on December 16, 2012 (Chapple, 2013).

### 5.2.3 Acoustic Monitoring Tag

Passive acoustic monitoring can be used to determine whether a particular animal is present in an area. The system consists of a "listening" device (i.e., the receiver or hydrophone; VR3 from Vemco; www.vemco.com) that can detect signals emitted from an acoustic monitoring tag (Figure 12; Vemco V16; http://www.vemco.com/pdf/v16cont.pdf), which is attached to an animal in the same way as the pop-up archival transmitting tag described above.

Generally, multiple receivers are strategically positioned in a moored array depending on the listening radius of the receivers. Ideally, an array is established so that there is minimal overlap between the reception fields of adjacent hydrophones. This maximizes the coverage area for a given number of hydrophones (Domeier, 2005).

The tags are 6.8 inches long, 0.8 inches wide and 1.6 inches in height, and weigh 2.7 ounces (Wildlife Computers, 2012). Acoustic monitoring tags continually transmit a signal that contains a unique identification code. They are powered by a battery, which allows the tag to send the identifying signals for approximately five to seven years; however, the tags tend to shed from the sharks within one to three years after application (Block, 2011).

With enough replicates and receivers, acoustic monitoring tags could potentially be used to provide information related to individual and group behavior with high spatial accuracy of 35 feet or less (Guttridge et al., 2010; Klimley et al., 2001). With the increasing number of studies in other locales that are employing acoustic-compatible equipment, such as within San Francisco Bay (Jorgensen et al., 2010), the tag information is sometimes picked up by hydrophones in these other areas. Acoustically tagged sharks from the GFNMS management area have reported to receivers located throughout the central coast. For example receivers in San Francisco Bay have picked up the signals of at least five White Sharks that moved into these waters. Receivers at Carmel Bay and Hopkins Marine Station detected White Sharks that had been tagged near the Farallon Islands and Año Nuevo. Acoustic tagged White Sharks from the GFNMS management area have also been detected around Guadalupe Island. Increasing use of acoustic tags and receivers from Oregon to Mexico would help define the spatial extent of movements of White Sharks along the California Coast (Block, 2012).

This ability to detect sharks within the GFNMS management area over multiple years is intended to augment and validate the Bayesian model, which is used to derive an estimate of the number of sharks that are within the GFNMS management area. The tags allow an assessment of the residency of these sharks around the acoustic mooring sites. By monitoring the sharks through photo identification and the acoustic receivers, the intent is to build a robust system for evaluating the population's stability, growth or decline as well as local and regional distribution data.

Acoustic monitoring tags also allow smaller and younger individuals that are located in the California Current to be monitored. For example, animals that have been acoustically-tagged in southern California waters may move into the GFNMS management area as they mature. An increased focus on juvenile and sub-adult White Sharks would help determine when immature sharks recruit into the population. Maintaining acoustic receivers in the GFNMS management area provides important biological information concerning juvenile and sub-adult arrival into adult aggregation sites and residency periods (Block, 2012).

Data from the receivers would be downloaded two times each year by using a remote modem lowered over the side of the boat. The two new acoustic receivers proposed would use an Iridium satellite modem (Iridium Communications, Inc., 2012). The Iridium satellite network is able to transfer large amounts of data in real-time with the ability to monitor various components of the receiver system to detect faults, which reduces the likelihood of losing data. This would allow the data logs to be downloaded remotely (Bradford et al., 2011) and even by a mobile phone, allowing for educational outreach opportunities. Iridium receivers can email notices to researchers as well as to the public regarding the presence of an acoustically-tagged shark near one of the moored receivers (Block, 2011). Each of the receivers has an expected battery life of five years and requires maintenance periodically by a diver, probably no more than one time per year.

### 5.2.4 Intragastric Tag

Intragastric or stomach tags are devices that can be hidden inside a measured piece (to determine caloric value) of marine mammal blubber. The tags help to determine how often sharks eat while they are at the coast and the relative amount of energy expended during their coastal versus offshore phase. The development of an energetic model for White Sharks could determine how much energy they expend during different activities in different locations and how frequently they acquire prey. The theory to be tested is whether energy storage in the shark's liver is replenished during the coastal phase and depleted during the migration offshore, which occurs in many migratory animals but is stored in fat. This is intended to determine which foraging resources are most important for the sharks.

Transmitters are expected to remain inside the sharks for about 10 days to three weeks, during which time the sensors measure stomach temperature to determine what the shark is eating. A lower temperature means that the shark is eating fish, while a higher temperature indicates it has to digest a warm bodied animal like a seal. The probe is ejected naturally when the shark turns its stomach inside out by inverting it through its mouth. Many species of sharks are known to invert their stomachs to remove any indigestible hard parts such as pinniped bones. The transmitter would be ejected during this process and then retrieved.

## *5.3 Biological Sampling Methods*

### 5.3.1 Tissue Collection for Isotopic Analysis

Stable isotope analysis can be used to provide information on diet and habitat (Carlisle et al., 2012) and this technology is proposed to be used to infer where White Sharks spend their time during different life stages (Block, 2011). The stable isotope composition (i.e., the ratios of carbon [$^{13}C/^{12}C$] and nitrogen [$^{15}N/^{14}N$]) of an animal's tissues is directly related to that of its prey. Carbon poor environments include offshore, oligotrophic waters, which are low in plant nutrients but high in dissolved oxygen. High nutrient, trophic environments such as in near shore waters are high in nitrogen. Sharks feeding in oligotrophic waters and sharks feeding in nearshore, trophic waters will reflect that difference in the biogeochemistry of their tissues, blood and bones. This can provide insights into how an individual's diet varies over different time scales. The use of stable isotope analysis would need to include an adequate sample size, especially in species that exhibit a broad feeding niche such as the White Shark. A small sample size could lead to inaccurate conclusions about the foraging ecology of a population (Carrier et al., 2010). However, this method is not likely to be able to determine specific prey because potential prey species may have identical isotopic signatures as the predators (Carrier et al., 2010).

A new technique that is currently being developed is the use of trace element composition of shark vertebrae, which may be able to pinpoint where a shark was born. This is the same technique that has been used for years in bony fish where scientists look at the trace element composition of otoliths to identify natal habitats. This previously was thought to not be possible in shark vertebrae, but new work is showing this may not be the case. Once validated, this approach may be able to identify the region in which sampled white sharks are actually born (Carlisle et al., 2012). Since this would require removal of vertebral bone, this could be accomplished by using young White Sharks that die in commercial fishing gear, which is not known to occur in the GFNMS management area.

### 5.3.2 Tissue Collection for Genetic Analysis

Knowledge of genetic structure of a population, especially one that migrates over many thousands of miles, has important implications for conservation and management. Sharks give birth to a few pups that grow alone in nursery areas, whereas the adults disperse widely to other regions. Where White Sharks give birth, as well as whether or not they show fidelity to specific sites, has important implications for the spatial scale of their management and conservation. DNA samples can be obtained as a means to determine genetic structure and diversity.

A stainless steel biopsy punch mounted on the end of a tagging pole would be used to obtain a small tissue sample for genetic and isotopic studies (refer to Figures 9 and 12), which would take a sample simultaneously with each pop-up archival transmitting and acoustic tagging event. The tissue samples would analyze mtDNA and determine nuclear (microsatellite) markers, which could then be compared to results from the Southern California Bight/Baja nursery area (neonates), Guadalupe Island (adults), and South Pacific (Australia/New Zealand adults and neonates). This is important to determine the genetic population structure and the potential for mixing among other groups.

Small pieces of tissue could also be obtained from the dorsal fins during attachment of the real-time satellite tag and preserved for DNA. The tissue collected would come from the hole that is made to mount the tag on the dorsal fin. The holes would be drilled using a sharpened, hollow coring bit to minimize the amount of tissue affected. The trailing edge of the dorsal fin would not be altered because unique marks on the dorsal fin are used in identifying individual sharks (Anderson et al., 2011).

### 5.3.3 Blood Sampling to Assess Reproductive State

A hypodermic needle would be used to take a blood sample of approximately twenty milliliters (0.68 ounces) from the caudal vein of each shark captured by hook and line. The blood would be evaluated for the presence of reproductive hormones in the female to facilitate the study of the reproductive cycle of this species. Very little is known of the precise timing of ovulation, mating, gestation, and pupping. Such questions are traditionally addressed via lethal means outside of sanctuary waters and throughout the world, but the analysis of blood samples taken through non-lethal methods can address these same questions. It has been suggested that White Sharks mate while they are aggregated at Guadalupe Island and the Farallon Islands and sampling of blood could support or refute this hypothesis. No other viable methods have been found for collecting blood samples or assessing reproductive state from a free-swimming shark.

### 5.3.4 Blood Sampling to Measure Stress Levels

An additional small amount of blood could be collected to measure levels of stress-associated metabolites and other blood parameters on captured White Sharks. For the measured analytes to have some effective meaning, however, the blood draw would need to occur at two separate times during the tagging procedure: 1) immediately after the shark has been hooked, and 2) just prior to release. Even with this information, however, it would not allow for a comparable interpretation of the results to unstressed baseline levels (i.e., prior to hooking), because blood has not been collected from a free-swimming shark.

### 5.3.5 Additional Measurements

Captured sharks would be measured for both length and girth so that the weight of the animal can be estimated. Scientists rarely have direct access to adult White Sharks, so even these simple measurements provide useful, basic biological information.

## *5.4 Other Techniques Reviewed But Not Analyzed Further*

The following additional techniques were reviewed, but for various reasons that are discussed below, they are not likely to be considered as proposed options for White Shark research over the next five years.

### 5.4.1 Towed Real-time Satellite Tag

Towed real-time satellite tags function similarly to real-time satellite tags, but are configured to be towed behind the animal by more than 30 feet of tow line. The use of this tag would not require capturing the shark, but a large metal spearhead (4 inches in one study on whale sharks by Hsu et al., 2007) would be needed to harpoon the tag into the dorsal musculature. Towed real-time satellite tags are designed to plane up and away from the fish so that the tag will surface and transmit when the animal is near the surface. This is accomplished by the long tow line, which is usually made of 1-millimeter-diameter, multi-strand stainless steel. The tow line allows the tag to reach the surface while the animal is swimming. To build such a tag to last more than one year would require it to be very large to provide enough flotation to counteract the weight of the required batteries. Such tags have been used on whale sharks and basking sharks, but only three deployments resulted in tracks that exceeded one year (Hsu et al., 2007; Eckert and Stewart, 2001), possibly because the drag induced by the tag causes the tether to break or the dart to pull out of the flesh.

Towed real-time satellite tags were not considered feasible for the study of White Sharks to pull, because it is believed they could cause deleterious effects and not provide desired information based on their design. In addition to the large metal spearhead that is intended to remain in the shark's active swimming muscle, the long tether could cause entanglement or injury. Furthermore, the tags have been tested on whale and basking sharks, which are filter feeders, not active predators. The visual and/or audible signal that results from the trailing tag could hinder a White Shark's ability to ambush prey. The tag itself, based on limited long-term success on whale sharks, may not provide the level of consistent data that is otherwise expected from other types of tags. Towed satellite tags have had poor tag retention, presumably because the anchor is not holding or the line is getting entangled (Holland, 2011).

### 5.4.2 Spring-loaded Device for Attaching Real-time Satellite Tags

Dr. John Stevens, a shark expert who works for the Australian government, was consulted about a pneumatic device he had designed that was meant to quickly rivet a tag onto the dorsal fin of a free-swimming shark. Considerable funds and time were spent developing this concept, but it did not work because it was not possible to align the device into the desired position on the dorsal fin while the shark was swimming (Domeier, 2011).

**Figure 22. Spring-loaded attachment device for real-time satellite tags. (Courtesy of Michael Domeier.)**

A spring-loaded tag attachment method that could be conducted on free-swimming sharks was also investigated and constructed (Figure 22), but this concept has not yet proven successful, because it did not have enough spring tension to hold the tag onto the fin for a multi-year deployment (Domeier, 2011).

### 5.4.3 Custom Sling for Attaching Real-time Satellite Tags

Researchers in Australia have used slings or cradles when restraining is needed to affix tags to shark dorsal fins (Commonwealth Scientific and Industrial Research Organisation, 2011), but the researchers have a self-imposed size limit of 13.1 feet (Bruce, 2010) to make it easier to handle the shark in the sling.

A custom, rubberized sling was designed (Figure 23) as an alternative to lifting larger sharks from the water. It had been thought that the weight of the shark could be more evenly distributed and firmly restrained with such a sling. Early trials, however, determined that it was so difficult to place the shark in the small sling that the shark had to be tired to the

**Figure 23. Custom rubber-contoured sling. (Photo courtesy of Michael Domeier.)**

point of complete exhaustion. There was also a concern that the shark's rigid pectoral fins could be damaged by the sling.

### 5.4.4 Tonic Immobility for Attaching Real-time Satellite Tags

Tiger sharks have been captured and tagged while restrained in the water (Holland et al., 1999; Holland et al., 2001). In this method, which is better suited to smaller sharks, the shark is brought to the side of the boat after capture and turned on its back to induce a state of tonic immobility (Holland et al., 1999). The largest tiger shark in the Holland et al. (1999, 2001) studies was less than 14 feet and likely weighed less than 3,000 pounds, while the largest White Shark caught in previous real-time satellite tagging was greater than 17 feet, with the largest individuals likely weighing more than 4,000 pounds. The tonic immobility method also is better for surgical implantation of the tracking device. Having the shark upside down would not allow for tags to be attached to the dorsal fins, and it is unlikely that a person could safely conduct this method in the water with a large adult White Shark.

### 5.4.5 Lift Platform with Cushioning Material

Concerns have been expressed that using a platform to lift sharks out of the water during tagging procedures is too hard on the sharks' internal organs, and that if used, then the lift should have a cushioning material during the capture procedures. Although there is no evidence that sharks had been harmed by using a lift platform, the use of a cushion would likely complicate the ability of the platform to drain water and may cause other unforeseen problems if the animal were to get caught in the material. No evidence has been found that would indicate internal organs have been crushed from removing sharks from the water. It is known, however, that if a shark is thrashing about on the deck, this could lead to internal injuries (Campana et al., 2009). Therefore, if a lift platform were to be used then the shark's tail would need to be secured to keep the shark from thrashing.

### 5.4.6 Anesthesia

Anesthesia on captured sharks was also considered. It is likely that anesthesia would not benefit sharks captured by hook and line, because the effects of such drugs have not been tested in large sharks, and the potential to harm them is unknown. Furthermore, use of anesthesia is not considered to be necessary, because sharks lack a neuronal mechanism that is considered essential for the perception of pain (Snow et al., 1993), and direct observations by researchers indicate that sharks do not react when tags are being attached to their dorsal fins (Domeier, 2011). No other large sharks tagged in the wild are anesthetized prior to tagging.

## *5.5 Effects of Tracking Methods*

This section addresses the effects of the different tagging methods on a suite of conditions related to White Shark welfare, including their typical migratory patterns, life history traits (such as mating and reproduction), predator/prey interactions, and their recovery from injury or response to stress. A fundamental tenet of biological studies that attempt to elucidate important life history traits is that the scientific methods should not alter the normal behavior of the animal under study, because it is representing its population as a whole. Conditions such as stress or sub-lethal effects can be subjectively evaluated only on what can be seen about the shark's swimming performance and appearance of injury. Thus, long-term effects can be presumed to be minor or negligible if the shark returns to a state of expected behaviors. These life history traits provide a way to analyze potential effects, particularly of the proposed research methods.

Effects of the proposed tagging methods on individual White Sharks were analyzed based on assessing the animal's "welfare" after the tagging event. Cooke and Sneddon (2007) addressed this concept in a study related to the welfare of fish caught by recreational anglers and defined the term as follows:

> *"Welfare is equated with health and physiological measures (and particularly those involved in coping with stress) and consequently they are used as indicators of the well-being of the animal. Welfare can also be defined from a natural behaviour perspective whereby the animal has an innate suite of behaviours it should be allowed to perform for good welfare."*

Scientific research that involves the installation of equipment to track wild animals for study involves stress, but no direct measurements are possible to determine how an animal is "feeling." Nociception is the term used to describe the process most animals use to detect and respond to *noxious or injurious stimuli*. Pain is a different term than welfare and it is used to describe the *emotional component* associated with noxious or injurious stimuli. The difference in these terms is important because activation of the nociceptors is not pain (St. John Smith and Lewin, 2009), and assessing such factors as discomfort and suffering or consciousness of pain is not possible in fish because it requires a subjective interpretation of how they "feel." Instead, the possibility of pain has to be observed and measured indirectly such as a change in behavior, rather than on subjective states (Sneddon, 2009). Nociceptors have not been found in many species of elasmobranchs (i.e., sharks, skates, and rays; Sneddon, 2009; Snow et al., 1993). Regardless of whether there is an absence of the psychological experience of pain or fear in fish, these animals are still neurologically well designed to react to injurious or threatening stimuli with defensive or physiological responses.

### 5.5.1 Real-time Satellite Tagging

**Hook and Line Capture**

The safe capture, tagging, and release of adult White Sharks involve special tools and capture methods that are intended to minimize the risk of serious injury to the sharks. Although hook-and-line fishing is a source of stress to captured sharks, this tiring of the animal is necessary for the safe handling of the shark.

A potential source of injury is from the wound caused by the hook. It is certain that when a hook penetrates the flesh of a fish that some form of tissue damage or injury occurs, although the extent of this damage would be dependent upon anatomical location, type of gear, and other factors. Sub-lethal injury could occur in the throat, esophagus, or gut from removal of hooks or leaving them in place (Cooke and Sneddon, 2007). The size of the hook proposed to be used (refer to Figure 8) has been used to capture 21 White Sharks of approximately 10.5 to 18 feet in length in California and Mexico. These hooks are 13 inches long by 7 inches wide, with a 5-inch gap between the point and the shank. Smaller commercially-available circle hooks (as shown in the center of Figure 8), would be straightened by large adult White Sharks and the gap is not

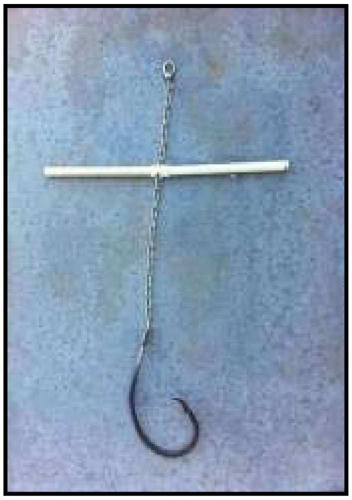


**Figure 24. A blocker-type of device to better assure that white sharks are hooked only in the mouth. (Courtesy of Michael Domeier.)**

large enough to accommodate the thick jaw of an adult shark. In 2011, one hook manufacturer produced a substantially smaller circle hook (size 20/0 vs. the original 27/0), which was tested at Guadalupe Island in 2012; however, White Sharks were able to straighten the hook even when two hooks were wired together (doubling the strength) (Domeier, 2013). Thus, the larger hook size appears to be the most effective for catching larger sharks.

A mouth hook wound would cause a loss of blood in the short term, with the wound expected to heal within a year or less based on field observations (Domeier and Nasby-Lucas, 2007). The proposed type of hook in the study, called a circle hook, is known to cause lower incidences of internal injury than a conventional J-hook (Domeier et al., 2003; Prince et al., 2007; Graves and Horodysky, 2008), but comparative studies using hooks of the size proposed have not been conducted. Jim Abernathy, who conducts recreational dives with sharks in the Bahamas, reports on hand-removing a large J-hook from a lemon shark (*Negaprion brevirostris*) in which the wound was "hardly detectable" in little more than a week later (Abernathy, 2011).

**Figure 25. Shark photographed one year after tagging in which hook had remained in left corner of the mouth but is now gone with no visible sign of injury or scarring. The real-time satellite tag is on the right side of the dorsal fin, but the bolt pattern is slightly visible on the left side. (Courtesy of Michael Domeier.)**

Of the cumulative 21 adult sharks captured for real-time satellite-tagging near Guadalupe Island and the Farallon Islands between 2007 and 2012, 17 were hooked in the corner of the mouth, three were hooked in the upper jaw, and one was hooked in the esophagus. The entire hook was removed from all but two sharks. Only a portion of the hook was removed from the shark that was hooked in the esophagus in the GFNMS (refer to Appendix A for more details). An entire hook was left in the left corner of the mouth of one shark in 2007 near Guadalupe Island, which was re-sighted in 2008 and 2009 with the hook missing and the wound healed one year later (Figure 25).

A hook embedded in the esophagus could cause additional stress such as a chronic infection that could lead to a debilitating condition if the shark was unable to expel the hook. Sharks have the ability to invert their stomachs to expel bones and other indigestible matter (Carwardine, 2004), which is one way a hook could be expelled. Both of the hooks that were left in the sharks discussed above were cut to expose the galvanized metal to saltwater, which hastens corrosion. The first shark tagged in the sanctuary in 2009 was observed one year later with semi-circular wounds above the gills and at the jaw. Experts consulted generally believe that the retained hook was not the cause of the injuries observed and that the wounds were more likely to have been caused by another shark; however, possible effects from retention of the hook cannot be discounted (refer to Appendix A for an in-depth discussion of potential effects from the tagging of this shark).

A method being considered to reduce the chance of hooking a White Shark in the stomach or throat is the use of a "deep hook preventer" or blocker device. The device would be incorporated in the fishing gear, very close to the hook, to prevent the shark from ingesting the hook beyond the mouth cavity. The device is a straight length of PVC pipe that is longer than the width of the mouth (Figure 24). The device was successfully tested on three White Sharks caught near Guadalupe Island in 2012, on two large tiger sharks caught for research purposes offshore Hawaii in 2011 (Domeier, 2011; Domeier, 2012b), and by a professional shark fisherman from Maryland (http://bigsharks.com/blocker-rig-study). The concept has generated interest from biologists and marine managers, which has led to a study to determine the ability of the blocker device to eliminate gut-hooking without sacrificing capture rate (Shahalemi, 2011).

One potentially negative effect from the use of this type of blocker device is that it could break during the hooking and capturing of the shark thereby allowing the shark to swallow a piece of the plastic or it could cause a discharge to the sanctuary. In the former situation, it is expected that the shark would regurgitate the PVC without any lasting harm to the animal similar to how sharks swallow stomach tags and regurgitate them days to weeks later (Kerstetter et al., 2004). Preliminary studies using a blocker device on the tiger sharks in Hawaii showed that the PVC was unmarked after these sharks were captured (Domeier, 2011). This appears to be a viable method to mitigate the potential for deep-hooking.

Applying pressure immediately on the line when the shark takes the hook would also prevent the shark from swallowing the hook, because the shark would turn away from the line as soon as the hook is taken into the mouth and there is pressure on it. Another method to reduce the possibility of a shark swallowing a hook would be to place the baited hook in the upper four feet of the water's surface and constantly watch it. Visibility through the water column around the Farallon Islands is generally at least 20 feet. This method of placing the bait near the surface has been successfully demonstrated by other White Shark researchers (Bruce, 2010).

An Independent Review (Appendix B) of the real-time satellite tagging in 2009 in the GFNMS management area recommended that hooks used to capture White Sharks should not be barbed. While this could result in a fish slipping loose from the hook after the line has been set, it is expected to result in less overall adverse effect to the shark than leaving a hook in the shark. Concerns had been expressed about the size of the hook, but smaller hooks may cause other adverse effects if the hook is straightened during the capture process, which could result in more sharks being hooked, but not landed.

While these changes outlined above are expected to result in the hook being removed each time, the hooks also would be galvanized, not stainless steel, which would facilitate their deterioration and dropping from a shark in case the hook cannot be removed.

Long capture times have been known to kill bony fish and other sharks. As noted earlier, the estimated average time from hooking to releasing the shark is between 40 and 90 minutes. Heberer et al. (2010) reported on a study of thresher sharks caught in a popular southern California fishery in which the sharks are generally hooked by the tail and towed backwards to the boat. The study found that all of the mortalities reported occurred in large individuals of almost six feet or greater and when capture times were longer than 85 minutes. The 20 thresher sharks in the study were tracked over 10 days with pop-up satellite archival tags. The post-release mortality was 26%. For the 19 White Sharks tagged near Guadalupe Island, the shortest tracking duration was five months. None of the sharks died as a direct result of the capture methods, which is generally considered to be within weeks or perhaps a couple of months, according to experts consulted (refer to Table 8 and to Appendix A). Of the 21 adult White Sharks that have been caught to date using the proposed methods, it appears that they are resilient to the induced capture stresses.

The capture of sharks would involve a braided steel cable for a leader, which cannot be severed by their sharp teeth. While steel cable can be abrasive to shark skin during the capture process, at times causing raw wounds, the braided cable leader would be embedded into the center of nylon rope, which is soft and flexible and prevents the cable from coming into contact with the skin. Thus, the hybrid cable/nylon rope leader is a reasonable method to use on captured adult White Sharks while preventing the occurrence of raw abrasive wounds. The cable/rope hybrid is also easier and safer for researchers to handle while controlling the shark near the catch boat.

Independent reviewers have recommended that all buoys should be sized large enough to prevent the sharks from swallowing them (Appendix B). The red buoys shown in Figure 8 are considered to be of sufficient size (12 inches or larger in diameter). The Independent Review also recommended that hard ridged buoys should be avoided because of possible effects that could be caused by the ridges if a shark does swallow a buoy (Appendix B).

**Post Tagging Survival and Migration Behavior**

The most effective measure of the responses to and the physiological changes associated with the proposed capture process to attach real-time satellite tags is whether the animal resumes a known behavioral regime based on the best available scientific knowledge of the species. The researcher has similarly tagged two White Sharks near the Farallon Islands and 19 near Guadalupe Island. In regards to post-tagging survival, all 21 of the adult White Sharks survived the capture methods, as indicated by their satellite transmissions and re-sightings (Table 8, Domeier, unpubl. data). The shark that was captured near the Farallon Islands in 2009 (tag # 12; Table 8), was poorly hooked resulting in a portion of the hook having to be left inside its esophagus when it was released. After its migration offshore, the shark was then seen one year later around the Farallon Islands with injuries around its jaw and above its gills. It was not observed the following year after another migration, but it is known to have returned to the area around the Farallon Islands based on the satellite signals received. Appendix A provides an in-depth chronology of this tagging event and assessments from outside shark experts of the potential effects on this particular shark. The two sharks tagged near the Farallon Islands in 2009 (tags #12 and #13) were tracked for at least 851 and 881 days, respectively.

All 21 of the tagged sharks were found to have resumed "normal" behavior, as determined by the migration patterns, which has been established from previous satellite tagging (Boustany et al., 2002; Weng et al., 2007; Domeier and Nasby-Lucas, 2007; Jorgensen et al., 2010). At the time of the writing of this document, the longest signal duration has been 1,692 days (more than 4.5 years) on a male shark that was tagged in December 2007. A message was received from that tag as recently as July 23, 2012. With the exception of the two female sharks tagged only 5-6 months ago at Guadalupe Island (tag #20 and tag #21), the shortest span of time for a signal duration has been 223 days from a female shark tagged in January 2010 and whose latest message was received on June 29, 2010 (tag #14). Another mature female from Guadalupe Island was tagged in December 2007 and tracked offshore for 15 months before traveling into the Sea of Cortez in early spring 2010, which is believed to be a pupping area (tag #4). Her tag stopped transmitting two months later. The remaining 16 tagged sharks have sent signals for at least 755 days (2.1 years).

**Table 8. Status of real-time satellite tagged White Sharks (at the time of the writing of this document).**

| Tag No. | Tagging date | Location | Sex | Total Length (meters) | First Message | Latest Message | Re-sighted at Original Aggregation Site |
|---|---|---|---|---|---|---|---|
| 1 | 12/6/2007 | Guadalupe Island | M | 3.15 | 12/25/2007 | 3/10/2014 | 2012 |
| 2 | 12/6/2007 | Guadalupe Island | M | 3.68 | 1/5/2008 | 11/20/2009 | 2008, 2009, 2010, 2011, 2012 |
| 3 | 12/8/2007 | Guadalupe Island | M | 3.68 | 12/10/2007 | 12/30/2010 | 2008, 2009, 2010, 2011, 2012 |
| 4 | 12/8/2007 | Guadalupe Island | F | 3.96 | 12/21/2007 | 7/19/2010 | 2008, 2009, 2012 |
| 5 | 12/3/2008 | Guadalupe Island | F | 5.08 | 12/4/2008 | 3/19/2014 | 2009, 2011 |
| 6 | 12/4/2008 | Guadalupe Island | M | 4.57 | 1/20/2009 | 3/23/2013 | 2009, 2011 |
| 7 | 12/4/2008 | Guadalupe Island | M | 4.42 | 12/7/2008 | 12/9/2011 | 2009, 2010, 2011 |
| 8 | 12/4/2008 | Guadalupe Island | F | 4.82 | 12/8/2008 | 4/28/2012 | |
| 9 | 12/6/2008 | Guadalupe Island | M | 4.47 | 12/8/2008 | 3/19/2011 | 2011, 2012, 2013 |
| 10 | 12/7/2008 | Guadalupe Island | M | 4.57 | 12/9/2008 | 7/30/2012 | 2009, 2010, 2011, 2012[1] |
| 11 | 12/9/2008 | Guadalupe Island | F | 4.98 | 12/13/2008 | 6/27/2011 | |
| **12** | **10/29/2009** | **Farallon Islands** | **M** | **4.27** | **11/2/2009** | **3/3/2014** | **2010, 2013, 2014** |
| **13** | **11/2/2009** | **Farallon Islands** | **M** | **4.52** | **11/3/2009** | **4/2/2012** | **2011, 2012** |
| 14 | 11/18/2009 | Guadalupe Island | F | 4.85 | 1/12/2010 | 6/29/2010 | |
| 15 | 11/19/2009 | Guadalupe Island | M | 4.39 | 11/19/2009 | 4/19/2012 | 2010, 2011, 2012[1], 2013 |
| 16 | 11/19/2009 | Guadalupe Island | F | 4.62 | 11/30/2009 | 1/28/2012 | 2011 |
| 17 | 11/20/2009 | Guadalupe Island | F | 4.62 | 11/21/2009 | 3/13/2014 | |
| 18 | 11/20/2009 | Guadalupe Island | M | 4.72 | 11/29/2009 | 2/19/2014 | |
| 19 | 11/20/2009 | Guadalupe Island | M | 5.41 | 11/23/2009 | 1/13/2014 | |
| 20 | 11/30/2012 | Guadalupe Island | F | 4.88 | 11/30/2012 | 5/26/2013 | |
| 21 | 12/2/2012 | Guadalupe Island | F | 5.20 | 12/4/2012 | 3/18/2014 | |

[1]These sharks were re-sighted in 2012 and were no longer carrying their tags.

There have been nearly 23,459 days of tracking data from all 21 sharks with an average duration of 1,117 days or more than 3 years. In June 2011, the two-year migration cycle for three additional sexually mature females from Guadalupe Island was documented revealing two separate potential pupping/nursery regions for this population of White Sharks. These results have been published (Domeier and Nasby-Lucas, 2013), and since the publication, two of the females (tag #5 and tag #17) travelled to the potential pupping regions again in spring/summer of 2013, with each shark returning to the same general region as they had two years prior. Both of these tags have revealed two complete two 2-year migrations for mature females. Two additional females (tag #20 and tag #21), which were tagged in the winter of 2012, traveled as far north as Oregon and Point Conception, CA, respectively, which suggests that there may be some direct connectivity of mature females between Guadalupe Island and the central California coast (Domeier, 2013). One of these sharks is still transmitting regular data from offshore, where she has been for the last nine months, and is expected to head to the coast for pupping this spring or summer.

Following their tagging, both of the Farallon-tagged sharks (tag #12 and tag #13) left the GFNMS management area earlier than other sharks observed by Jorgensen et al. (2010) and Weng et al. (2007), although departure times in these two studies were highly variable (Table 9). In the Jorgensen et al. (2010) study, most of the departures began after December 1, with the majority of departures occurring from January through mid-February. In the Weng et al. (2007) study, departures occurred between November 19 and March 24 with an average departure date of January 2. The first Farallon shark (tag #12), which was the one hooked in the esophagus, left the area more than a month after its tagging. The second Farallon shark (tag #13), in which tagging proceeded as expected, left less than a week after the tagging event. Based on data received from three seasons, their departures and subsequent returns are consistent and appear to be within the range of expectations.

**Table 9. Tagging, Departure and Return Dates of 2009 Farallon Sharks.**

| | Tagging date | Departure dates | Return dates | Expected Departure Range |
|---|---|---|---|---|
| Farallon Shark (tag #12) | October 29, 2009 | ~ December 13, 2009<br>~ December 2, 2010<br>> November 23, 2011 | ~ July 26, 2010<br>~August 2, 2011 | Mid-November through March |
| Farallon Shark (tag #13) | November 2, 2009 | ~ November 8, 2009<br>~ November 10, 2010<br>~ November 4, 2011 | ~ August 4, 2010<br>~ August 1, 2011 | |

Almost 2.4 years of tracking data have been obtained from the two tagged Farallon sharks (Figures 26 and 27). The separate color coding in these figures shows the three offshore migration periods (2009/2010, 2010/2011 and 2011/2012) since the tagging occurred. The arrows indicate the direction of travel. Satellite transmitters on both sharks have been sending data to ARGOS since 2009, which shows that as of Spring 2012, both sharks were alive and have been exhibiting typical, long-distance migratory patterns.

The latest signal from the first shark captured near the Farallon Islands (tag #12) was on March 2, 2012, but with only a single message indicating that he was in warmer water and had likely moved offshore (Nasby-Lucas, 2012). The date when the tag remained out of the water long enough for the satellite to receive a transmission fix on its location occurred on November 23, 2011, when he was in the vicinity of the Farallon Islands (See Figure 26).

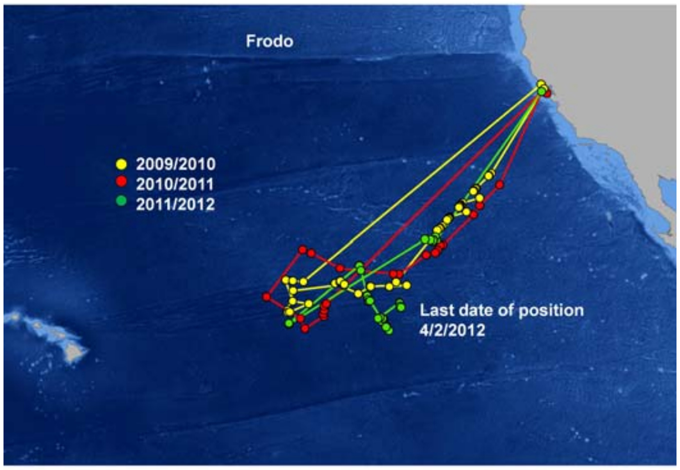



**Figure 27. Satellite tracks of Farallon Shark Tag #13 (refer to Table 8) that was SPOT-tagged in 2009 at the Farallon Islands. Arrows indicate direction of travel (Domeier, unpubl. data).**

The second shark (tag #13) was tagged on November 2, 2009 and was observed feeding on an elephant seal at Southeast Farallon Island by researchers and a tourism boat on September 14, 2011. The latest transmission received was on April 2, 2012, when he was in the offshore region. He was observed in October 2012 by a tour operator around the Farallon Islands, but the tag and a portion of his fin were missing (Moskito 2012a). He was re-sighted by island biologists at the Farallon Islands in October 2013 (Unpubl. Data, ONMS, 2013).

Additional information on general migratory behavior after capture and release was provided during the 2010 public comment period for the original draft of this document. Dr. Barry Bruce of the Commonwealth Scientific and Industrial Research Organisation submitted comments about his findings from similar research activities that show tagged sharks are re-sighted with no obvious adverse effects although they do appear to undergo a six to 48-hour recovery period after capture and tagging based on changes in expected behavior patterns (Bruce, 2010). However, Dr. Bruce used an in-water stretcher to restrain the sharks, which is substantially different than the lift platform that had been used in 2009. The in-water stretcher has not been proposed for future tagging work within the GFNMS management area. Heberer et al. (2010) also found a six-hour period following release of captured thresher sharks in which the sharks' vertical movements were highly variable. However, these sharks were caught by tail-hooking them and pulling them backwards to the boat, so this information also is not directly comparable.

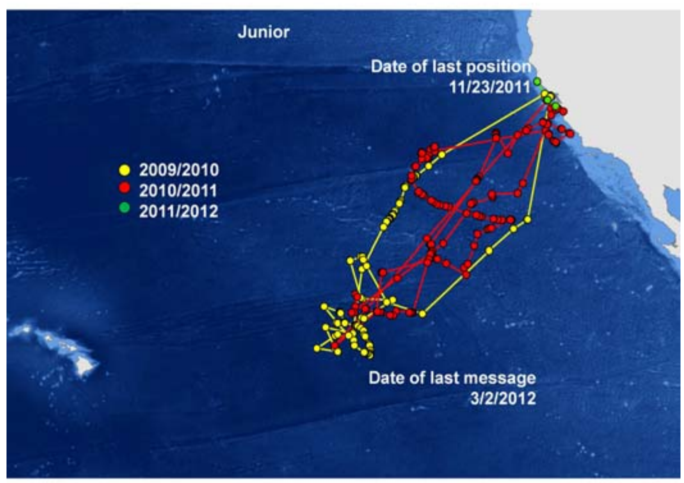



**Figure 26. Satellite tracks of white shark #12 (refer to Table 8) that was real-time satellite tagged in 2009 at the Farallon Islands. Arrows indicate direction of travel (Domeier, unpubl. data).**

Results presented to GFNMS staff to date do not show evidence that sub-lethal effects have occurred. However, an internal injury or its potential effects would be difficult to assess unless the animal can be captured and a necropsy conducted, or the animal confined for more direct observations. The only possible indicator of sub-lethal stress is the post-tagging behavior of the sharks and whether they resumed normal seasonal migrations. Practically nothing is known about White Shark mating behavior; therefore, it cannot be determined whether this type of tagging could cause an effect on mating, nor are there any means of studying whether such an adverse effect has occurred.

Due to these concerns about the additional stress experienced by the shark as a result of being lifted from the water, a new method was developed to restrain the White Sharks alongside a small catch-boat so that the tagging could take place while the shark is completely submerged. Two adult female White Sharks, which were caught and successfully tagged with real-time satellite (SPOT) tags near Guadalupe Island in 2012 (tag #20 and tag #21), were restrained using this method (Domeier, 2012b) (Figure 28). During the entire tagging procedure the boat was slowly moving forward, ensuring maximum flow of water over the surface of the gills. The sharks swam away vigorously upon release. Based on this and the maintenance of normal seasonal migratory patterns in males and females that have been tagged to date, this suggests that sub-lethal effects are neither debilitating nor causing a significant change in behavior.

In considering the effects to a population as a whole, it is known that the deaths of adults, particularly breeding-age females, will cause a greater negative effect to a population than the deaths of younger-aged animals. Therefore, any substantial increase in adult mortality could have important consequences to a population whereas a substantial increase in newborn mortality is anticipated to have relatively minor negative effects because they are generally considered to be less likely to survive to reproductive age. Data on northeastern Pacific White Shark population numbers are insufficient to determine the effect of such a loss; however, certain inferences can be made based on existing information.


**Figure 28. Successful in-water satellite tagging of a white shark in 2012 at Guadalupe Island (photo courtesy of Michael Domeier).**

There are many conditions that affect population growth, but the accidental removal of an adult male from a population is not expected to significantly impact the rate of annual population increases since other males can copulate with receptive females. Assuming that the sex ratio of northeastern Pacific White Sharks is near parity, the removal of an adult female is calculated to result in a loss of 1% of the estimated abundance of sub-adult and adult females in the GFNMS management area, which is assumed to be 219, with a modeled range between 130 to 275 (Chapple et al., 2011). Assuming an intrinsic rate of population increase of 4 to 5% annually (Table 2; CITES, 2004), the loss of one adult individual (which was estimated to be 1%) could theoretically reduce this sub-group's growth rate to a 3 or 4% increase during the study period. Because the Chapple estimate does not provide population estimates for each age class of the total northeastern Pacific White Shark population and not all sub-adults visit the aggregation sites in the GFNMS management area, a significant portion of the total White Shark population was not included in this model (Sosa-Nishizaki et al., 2012). Therefore, the loss of one female White Shark would constitute less than 1% of the total northeastern Pacific White Shark population and the actual intrinsic growth rate likely would be more than 3 or 4%. This does not mean to say that White Sharks are not at risk. Vulnerability to excessive mortality is inversely proportional to the annual rates of increase with groups that have rates less than 10% being particularly at risk. The annual intrinsic rate of population increase for shark species calculated from a variety of sources generally ranges from 1-10%, which indicates that elasmobranchs are particularly vulnerable to over-exploitation (Mace et al., 2002).

Another way to consider how deaths may affect a population is by calculating Potential Biological Removal (PBR), which is a term that is defined for marine mammals under the Marine Mammal Protection Act as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal unit (called stocks) while allowing that stock to reach or maintain its optimum sustainable population. PBR could be a useful approach for calculating allowable incidental take levels in other marine animal species although it is specifically designed for marine mammals. It is conservative in that it uses minimum population estimates and a recovery factor based on the population status, it addresses data uncertainty in a straightforward way, and it follows the precautionary principle with more conservative management when data are less precise (Young, 2006). The PBR level is the product of the following factors:

- The minimum population estimate of the stock ($N_{min}$);
- One-half the maximum theoretical or estimated net productivity rate or recruitment of the stock at a small population size ($R_{max}$); and
- A recovery factor of between 0.1 and 1.0 ($F_R$).

The formula to calculate potential biological removal is $N_{min}$ x ½ $R_{max}$ x $F_R$. For adult and sub-adult White Sharks that aggregate in the GFNMS management area, the initial minimum population estimate is 130 (Chapple et al., 2011). $R_{max}$ is known as the intrinsic rate of recovery and this is believed to be between 4 and 5% (refer to Table 2). The recovery factory would be .5, which is the default value for populations of indeterminate status. Using the more conservative intrinsic rate of recovery value of 4% in this calculation, then the potential biological removal equation [130 x ½ (.04) x .5] indicates that one White Shark could be removed by death each year and this sub-population would continue to reach or maintain sustainable population levels at these aggregation sites. As noted earlier, the proposed research has been tested and the tagging methods have not caused the death of a White Shark.

New recruits also appear to be coming into the sanctuary on a regular basis (Jorgensen, 2012). Each year, 3 to 4-year-old, new recruits are seen in central California that are reproductively immature sharks, approximately 8 to 10 feet in length, and are trying to become established into this adult habitat. This may be a critical link in the population such that their recruitment may be

**Figure 29. Tagged shark on platform. Note size of the fin-mounted tag relative to the dorsal fin. A second acoustic tag is attached to the base of the dorsal fin, which is not being proposed (photo courtesy of Michael Domeier).**

limited during this transition phase, which may explain why there seems to be so few adults in the GFNMS management area (Jorgensen, 2012).

Concerns have been expressed to the sanctuary that the weight of the tags (between 3-6 ounces each) along with their placement on the dorsal fins could result in: fin deformation; the fin tissue dying (i.e., cellular necrosis) due to the bolt attachment; the tags becoming encrusted with organic debris or biofouling; or the tags themselves could rust. One way to assess this is by a report from Jewell et al. (2011) on the effects of real-time satellite tags on 15 sub-adult White Sharks in South Africa. In that study, the tagged sharks were approximately 11 feet in length at the time of their capture and the largest was 12.8 feet (Jewell et al., 2011). One shark that was 9.5 feet in length when tagged was later re-sighted with excessive biofouling on the tag and then later seen with a hole and degradation of the fin after the tag had detached. In a second shark (9.8 feet in length), the tag was no longer attached, but the bolt holes were visibly raw. Four of the 15 tagged sharks were not re-sighted; the other nine were found with "pigmentation scaring" after the tag had detached from the dorsal fin (Jewell et al., 2011).

In another analysis by the Monterey Bay Aquarium, real-time satellite tags on juvenile White Sharks were determined to affect the growth of the dorsal fin by growing around the tag or causing a deflection to the tip of the fin (O'Sullivan, 2011). Shark cartilage itself is a highly energetic material and there may be an exaggerated reaction from the cartilage and connective tissue in the presence of the bolts and the tag, especially in growing tissue. Because of the significant growth that occurs with juvenile White Sharks, these tags are no longer being used on young fish by the Monterey Bay Aquarium (O'Sullivan, 2011). Jewell et al. (2011) also recommended that a review of the tag design be considered for long-term deployments on smaller sharks.

The development of a real-time satellite tag that attaches at a single point is believed will eliminate effects on fin growth or deformation. This single point attachment provides the ability for the tag to be shed. The immunological responses or physical changes that may occur to the shape of the dorsal fin do not appear to be causing any direct detrimental effects to adult shark behavior, hunting or swimming ability, although it cannot be ruled out. Fifteen of the 19 sharks tagged during similar research were 14 feet or larger (refer to Table 8). Of the four that were less than 14 feet, one was smaller than 12 feet. The two sharks captured and tagged near the Farallon Islands in 2009 were 14.01 and 14.88 feet. Because of the generally larger size of shark around the Farallon Islands, the tag is not expected to cause a significant visible deformation to an adult-sized shark's fin, but there could be a more pronounced effect on sharks that are smaller than 13 feet or if the tag is torn off from the fin. One way to minimize potential effects is to only target sharks that are larger than 13 feet, which can be estimated visually and to use a single bolt attachment or a tag in which the bolt corrodes after a certain amount of time.

The size of the tag compared to the size of the shark (about 2,000 pounds or more; see Figure 30) is likely to cause a negligible degree of drag as a result of biofouling organisms that become attached to the tag. Photographic data of real-time satellite-tagged sharks taken years after tagging show that some biofouling occurs, but this is limited to macro algae, which may look “rust-colored.” Photographs of tagged sharks two years after tagging indicate that biofouling of the tags is minimal due to the anti-fouling paint that is used on the surface of the tags, which does not come into contact with the skin. A re-sighting of one of the Farallon sharks (tag #13) showed biofouling of the tag two years after its attachment (Figure 29) and observations from the tour operator said the fin was deflected when it was out of the water (Moskito, 2012). To minimize biofouling, the tags proposed to be used in the study would be covered in anti-fouling paint and then wrapped in tape. It is expected this would also reduce effects due to drag or abrasions.

There could be damage to the fin margins because of the placement of the tag and this could affect the unique patterns that are used to identify individual sharks (Chapple et al., 2011). The tags cover a relatively small portion of the fin, which by themselves could be used as identifying markers. However, alterations of the dorsal fin from the tag placement, fin deformation, or other fin injuries could affect future identification success on the eleven sharks that are proposed to be tagged by this method.

### 5.5.2 Pop-Up Archival Transmitting and Acoustic Monitoring Tagging

Pop-up archival transmitting tags and acoustic monitoring tags would be attached to the sharks using the same deployment method. Both tags involve harpooning a dart into the active swimming muscle, which has the potential to cause drag that could lead to irritation of the area. Tissue damage and possible infection have been reported in a lemon shark tagged with a pop-up archival transmitting tag (Hammerschlag et al., 2011). Exposed injuries and lesions at the site of insertion can increase an individual shark’s susceptibility to bacterial infection. The anchor and tether, which often remain embedded in the musculature of sharks long after the tag has detached, can provide attachment sites for parasites (Hammerschlag et al., 2011). In most cases, the leaders and darts are expected to work themselves out similar to a splinter over time (Block, 2011).

**Figure 30. Farallone shark #13 resighted two years after tagging (Photo courtesy of Sal Jorgensen.).**

No evidence or data has been made available that either pop-up satellite archival tags or acoustic monitoring tags have caused injuries or infections on sharks in the GFNMS management area. The darts are made from medical grade titanium, which is an inert metal that is often used for surgical applications in vertebrate animals including humans. A special shrink-wrap around the monofilament leader has been developed and has been found to result in little impact or injury at the exit site. Syntactic foam would also be used to lift the tag so it does not rub on the animal (Block, 2012).

No data or additional information is available to assess whether effects on migration or behavior have occurred from these tagging methods.

### 5.5.3 Intragastric Tagging

Stomach tags are expected to be expelled from the sharks' stomachs within a week or two of deployment. It is not known what effect stomach tags would have on behavior or other life history conditions. Because of the short duration, these tags are not expected to adversely affect migration patterns or other important life history patterns. Hooks are not being proposed to embed the tags in the meat and there appears to be no known differences in retention times from using stomach tags that have been attached to whale meat with small hooks versus tags that are only placed inside the meat (Brunnschweiler, 2009). Because the stomach tags would be fed to the sharks inside whale blubber, this could cause a positive association to the boats around the Farallon Islands as a result of this research. The effect of feeding five sharks each year may cause short-term minor negative effects due to extra energy expended to hunt and possible habituation, but this would not likely lead to long-term, significant changes in White Shark life history traits such as mating and reproductive fitness since this is anticipated to be a short-term research activity.

Stomach tags have never been previously deployed on White Sharks in the GFNMS management area, but there is no evidence to suggest that this tagging method would cause significant effects.

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- John O’Sullivan, Curator of Field Operations, Monterey Bay Aquarium.
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# Appendix A

## Assessment of Tagging Effects on One Shark

# APPENDIX A. ASSESSMENT OF TAGGING EFFECTS ON ONE WHITE SHARK

Section 4 assessed the effects of proposed research and education projects and methods generally at the population level to determine whether impacts would be significant. The purpose of this section is to assess the effects on one shark (hereafter referred to as "Farallon Shark Tag #12"; refer to Table 8) that was tagged in the sanctuary and was observed in an injured state approximately one year later near the Farallon Islands. This section provides a chronology of events, a description of the shark's condition, and a discussion about possible contributors to the injuries that were seen on the shark.

## *A.1 Background*

On October 29 and November 2, 2009, two adult (14.0 and 14.8 feet) male White Sharks were captured in GFNMS and fitted with real-time satellite tags. As of March 2012, the tags from both sharks had transmitted data, indicating the tags are working and the sharks are alive more than 28 months after these tagging events occurred (refer to Figures 26 and 27).

When Farallon Shark Tag #12 was caught in October 2009, it swallowed both the hook and a small (7-inch) rigid buoy that was attached to the hook. This can be seen in Figure 30, which depicts the shark on the platform deck with the buoy lodged in its mouth. Crew members had to pry the shark's mouth open to remove the buoy (Figure 32). Approximately 10 minutes after landing Farallon Shark Tag #12, the buoy was removed from its mouth.

The baited hook had also become lodged in the pharyngeal region (between the mouth cavity and the stomach). A member of the research team was able to reach through the gill slits to grab the end of the hook and the leader (Figure 33), then used bolt cutters to cut as much of the hook free as possible (Figure 34). Most of the hook below the hook eye was left in Farallon Shark Tag #12. The top portion of the hook, consisting of the eye and the leader, were removed.

Nineteen minutes and 34 seconds elapsed from the time the shark was completely removed from the water to the time it was lowered and seawater was again covering its gills. Farallon Shark Tag #12 can be seen on the deck just after the tagging was completed and prior to its release (Figure 35).

As required by his permit, the researcher, Dr. Michael Domeier, immediately notified GFNMS officials that Farallon Shark Tag #12 had been hooked in the throat. The GFNMS permit was suspended. The research team met with the sanctuary superintendent and other sanctuary staff to review video footage and photographs of that first tagging event. As a result of this consultation, the baiting techniques were modified to ensure that sharks could not swallow the hook, as well as to ensure easier removal of the hook from the mouth. The modifications included removing the barb and keeping the baited hook in the upper four feet of the water's surface so that observers could maintain visual contact on the shark just prior to it taking the hook in its mouth.

Larger buoys were required to prevent the sharks from swallowing them. With these modifications, GFNMS reinstated the permit with additional conditions to prevent deep hooking, and a second shark was captured, tagged, and released without incident in the sanctuary.

The first tagging and potential injury to Farallon Shark Tag #12 from the retained hook raised concerns among the public and the GFNMS advisory council about the methodologies that were being used, whether there was an actual need for the research, and the overall welfare of the sharks subjected to the tagging procedures. Following the 2009 tagging season, the sanctuary decided in 2010 to prepare an environmental assessment (EA) to evaluate whether the proposed project would result in significant effects. On September 30, 2010, a draft EA was published in the *Federal Register* and disseminated for public review and comment. No permit was issued to Dr. Domeier in 2010 or 2011, and he has not conducted research activities in GFNMS since 2009.

**Figure 36. Close-up image of the jaw injury, as seen in the video.**

On October 12, 2010, another team of researchers studying White Sharks at the Farallon Islands captured video of Farallon Shark Tag #12 nearly one year after the tagging event. A GFNMS observer was with the researchers at the time and requested that the video be released to the sanctuary for further review. During the 26 seconds that the shark can be seen in the 2010 video, open wounds are apparent above the shark's right gill slits and along the right side of its jaw. For the duration of time seen in the video, the shark's lower jaw also seems to remain open wider than is typically seen in other sharks, which caused concern that this indicated a possible jaw injury (Figure 36).

When the sanctuary received this video about mid-October 2010, it initially consulted with staff from NOAA Fisheries Service Southwest Region Fisheries Science Center and the Southwest Region Sustainable Fisheries Division, who had conducted the independent review (Appendix B), and with staff from the California Department of Fish and Game, the agency that issued the scientific collection permit for the research. Additional consultations were then conducted with experts in the fields of electronic tagging of sharks, as well as shark pathology, stress physiology, bioenergetics, and husbandry. This was done via webcasts and conference calls to enable the video and photographs to be shared, and then questions were asked of the experts as they viewed this material. The results of this analysis rely on the opinions of all the experts consulted. This does not mean, however, that these experts approve of the methods used or implicitly support the research. The experts consulted for this section are listed in Table 10.

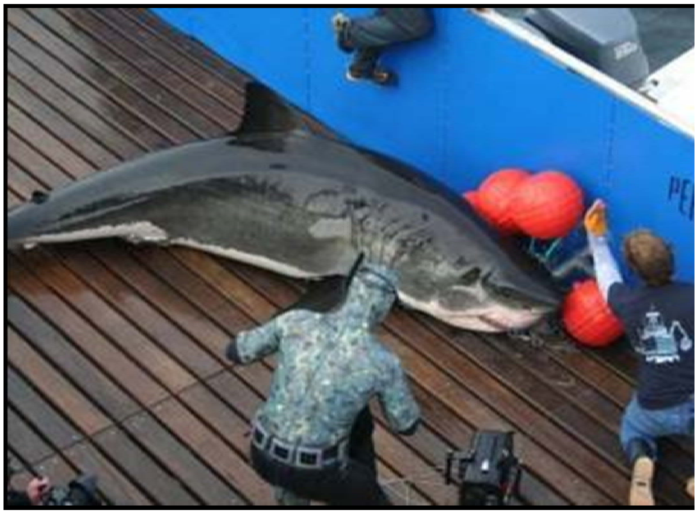


**Figure 31. Farallon Shark Tag #12 on deck with buoy stuck**


**Figure 32. Prying device used on the shark's mouth.**


**Figure 33. Reaching in to the gill slits to grab the hook.**


**Figure 34. Using bolt cutters to remove the eye and leader from the hook.**


**Figure 35. Shark #1 just prior to release with tagged dorsal fin and buoy removed from mouth.**

**Table 10. Experts Consulted for the Analysis in Appendix A and their Professional Affiliations.**

| Name | Title/Affiliation |
|---|---|
| Joanna Borucinska, D.V.M., Ph.D | Associate Professor, Department of Biology, University of Hartford |
| Heidi Dewar, Ph.D | Fisheries Research Biologist, Large Pelagics Lab, NOAA Southwest Fisheries Science Center |
| Kenneth Goldman, Ph.D | Biologist, Alaska Department of Fish and Game, Division of Commercial Fisheries |
| Samuel H. Gruber, Ph.D | Professor and researcher, Division of Marine Biology and Fisheries Rosenstiel School of Marine and Atmospheric Sciences and Bimini Biological Field Station |
| Craig Heberer | Fisheries Biologist, NOAA National Marine Fisheries Service, Southwest Region Sustainable Fisheries Division |
| Suzanne Kohin, Ph.D | Fisheries Biologist, Large Pelagics Lab, NOAA Southwest Fisheries Science Center |
| Nancy Kohler, Ph.D | Director of Apex Predators Program, NOAA Northeast Fisheries Science Center, Narragansett Lab, Rhode Island |
| John Mandelman, Ph.D | Research Scientist, New England Aquarium |
| Mike Murray, D.V.M., Ph.D | Staff Veterinarian, Monterey Bay Aquarium |
| Lisa Natanson, Ph.D | Fisheries Biologist, NOAA Northeast Fisheries Science Center, Narragansett Lab, Rhode Island |
| John O'Sullivan | Curator of Field Operations and Manager of the Monterey Bay Aquarium White Shark Project |
| Greg Skomal, Ph.D | Senior Fisheries Biologist, Massachusetts Division of Marine Fisheries |
| Dale Sweetnam | Senior Marine Biologist, California Department of Fish and Game |
| E. Scott Weber III, V.M.D., M.Sc | Associate Professor of Clinical Aquatic Animal Health, University of California, Davis |

## *A.2 Condition and Assessment of the Shark*

Images from the video and other photographs from the tagging event, raised concerns among GFNMS staff that the shark's jaw may have been injured as a result of the methods used to remove the buoy or that leaving part of the hook in the esophagus may have limited its ability to feed or leave it susceptible to attacks from other sharks. The following assessment is based on opinions of outside experts who were consulted and could view photographs of the tagging event and the video showing the shark both weeks before and a year after the tagging event. Information that might allow for a more definitive assessment (such as could be possible with a necropsy or additional sightings) is not available.

**Figure 37. Still images from video taken of Shark #12 in 2009 prior to tagging (left image) and approximately one year after the tagging (right image).**

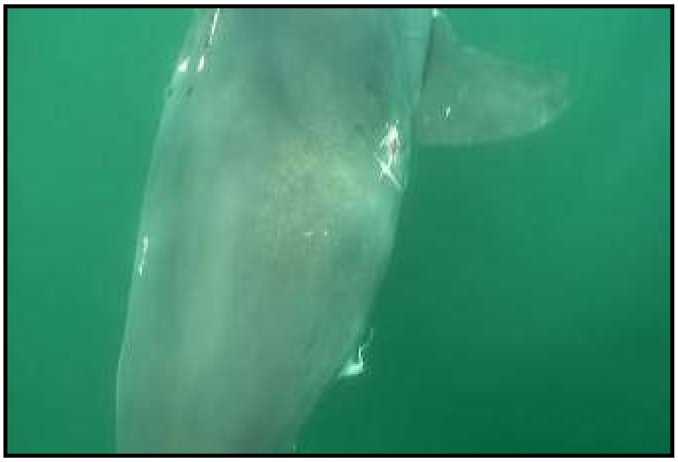


Figure 38. Injuries seen on the left side of Shark #12 (head is pointing toward the bottom of the pictures).

On September 17, 2009, Farallon Shark Tag #12 was seen 42 days prior to tagging (Figure 37; left-hand image), and on September 12, 2010, 318 days after tagging (Figure 37; right-hand image).

Based on reviews of the video, the experts were of the opinion that the shark had been bitten by another predator in two places on the right anterior dorsal side just above the gills. The semi-circular patterns are similar to those seen on other White Sharks, as well as other species of sharks. There are also injuries to the left side of the shark (Figure 38). These appear to be of recent origin and would not likely have been caused by the tagging event from one year earlier.

The injury at the jaw appears to be more severe than the side injuries with the trauma focused in the region that hinges the upper and lower jaws (refer to Figure 37; right image). Consultation has determined that the injury was likely caused by traumatic force, possibly from an attack by another shark or an orca. It is not believed that the injury was caused by a systemic infection as a result of retention of the hook, but that theory cannot be discarded as a possibility. It also cannot be determined when these injuries were inflicted, but the experts consulted suggested that they appear to be of "recent" origin. Similar semi-circular patterns around the jaw have been seen in other sharks (Figure 39).

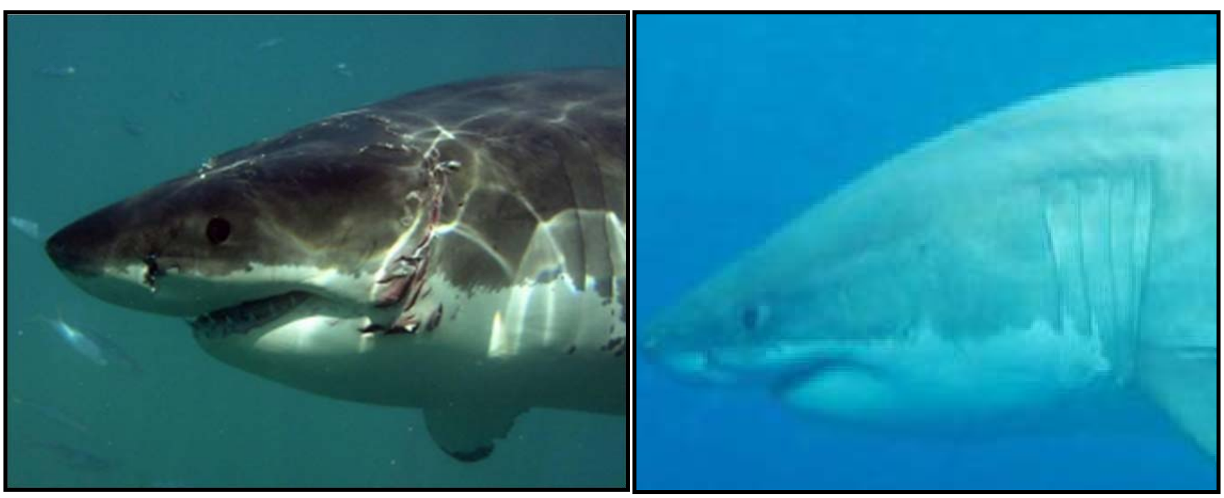


Figure 39. Guadalupe Island white shark with a semi-circular injury near its jaw in 2003; right image shows same shark in 2005 with injuries healed.

It is possible, and of greater concern, that the shark has a broken jaw. During the 26 seconds when the shark can be observed in the video, the jaws remain in an open position and do not appear to articulate. The jaws in this open position may be a response by the shark to its stressed state to allow more oxygenated water to flow over its gills or it may indicate that the shark is having difficulty closing its jaws, possibly at the location of the mandibular joint. The use of the prying devices is an implicating factor that could have affected the jaw; however, experts told sanctuary staff that these types of tools are routinely used during similar research activities with large animals. Except for animals that are thrashing when such devices have been used, which was not the case for Farallon Shark Tag #12, these consultations indicate that it is unlikely that prying the shark's mouth open caused the impact to the jaw that is seen in the video. Images of the shark on the deck of the boat after the tagging (Figure 35) do not show signs of such damage to the jaw.

With the shark on deck just before its release, there also is no indication of gill damage after team members reached into the gill slits and used bolt cutters to remove the end of the hook. One purpose for cutting the hook was to expose the galvanized metal to saltwater and hasten its corrosion. Blood loss from the tagging appeared to be minimal and is considered typical under similar handling conditions. Sharks that have had injury to their gills are known to die quickly soon after their release.

White Shark aggression is fairly common. Many sharks, both male and female, carry wounds that were inflicted by conspecifics. It has been suggested that White Sharks refrain from escalating aggression to the point where life threatening wounds are inflicted (Barlow, 1996); however, many bite marks that have been observed on White Sharks at Guadalupe Island were on or near the gill flaps, which could be particularly debilitating. One large female was observed with gill flaps torn off and the gill arches exposed. Attacks on the gill region are evidence of more serious aggression, which could lead to death. It has also been suggested that bite marks on the flanks of females are a result of mating when the male grips the side of the female, often near the gills (Francis, 1996). These types of bite marks were observed on both sexes suggesting that although mating may produce such marks on females, the presence of these marks does not necessarily indicate mating (Domeier and Nasby-Lucas, 2007).

Sharks have demonstrated a tremendous capacity to heal from injury, which can be seen in Figure 40 depicting five individual sharks at different times to show the recovery of similar types of injuries. These images as well as video by Towner et al. (2010) are some of the only data available to indicate the ability of this species to recover from stress and injury. Although bite marks were prevalent among sharks observed at Guadalupe Island, it was determined that the marks made poor characters for photo-identification because of the ability of the White Shark to regenerate tissue (Domeier and Nasby-Lucas, 2007). With the information available from field observations regarding the rate of external injury recovery in White Sharks (considered to take place within a year or less), it is expected that Farallon Shark Tag #12 has largely healed from the open wounds in the 14 months since the video images were taken.

Based on the professional opinion of the experts consulted and the information reviewed as well as evidence provided to date, it is likely that the hook that was left in Farallon Shark Tag #12 has been expelled, but it cannot be ruled out whether the hook remains embedded in the esophagus. If this occurred, then the research has possibly caused an adverse effect in this individual out of a total of 21 tagging events utilizing similar methods as proposed in the GFNMS study. Information obtained from the satellite data, however, showed that the shark continued to exhibit normal migratory behavior more than two years after the tagging occurred (refer to Section 4, Table 6). If the hook had remained embedded in the shark, it is possible this caused secondary adverse effects that could have resulted in the shark becoming more susceptible to attacks by other sharks.

In the video from 2010, it appears that the shark may have lost body mass because the experts indicated that it appeared thin. These conditions could have been the result of secondary effects from a hook left in the esophagus and an inability to properly feed. However, White Sharks are often seen in the GFNMS management area after their offshore migrations in a “lean” condition (Chapple et al., 2011).

White Sharks have elevated metabolic rates (Weng et al., 2007) and likely need to feed at least once a month (Klimley et al., 2001). The injuries were first noticed on October 12, 2010, and the latest recorded location of Farallon Shark Tag #12 was obtained on March 2, 2012. It is not believed that a White Shark could survive if it went without feeding for more than six months, much less for 17 months. This length of time since it was tagged in 2009 is one indication that the shark’s visible injuries were not caused by the capture and tagging process.

A return to normal migratory patterns and swimming speed are also two indicators to suggest that the shark is behaving normally. Following tagging, the shark migrated to the mid-Pacific region. In 2009, the speed of Farallon Shark Tag #12 on his travel to this area was 68 to 73 miles per day (mpd). There were not enough satellite transmissions to track the shark’s speed to the area in 2010, but during the time he was in this pelagic region in 2011, he traveled approximately 64 mpd. Other researchers have reported White Sharks traveling at speeds of 44 mpd (Boustany et al., 2002) and up to 56 mpd (Weng et al., 2007).

Analysis of the evidence and consultation with experts concludes that the wounds seen near the gills, along the jaw line, and on the left side of the shark (Figures 36, 37 and 38) were likely caused by the bites of another animal and not from a systemic injury from the hook, even if the hook had remained in the body. The loss of body mass could be an effect of hook retention; however, it is also just as likely to be normal loss of body mass resulting from the migration back from the mid-Pacific region. Based on evidence from Jewell (2011), the tag could cause the dorsal fin to slightly droop, but this would not have a debilitating effect on the shark. Despite the wounds seen in 2010, Farallon Shark Tag #12 survived the capture process in 2009 and is feeding and conducting normal activities based on its ability to migrate thousands of miles across the ocean. This suggests that the animal will continue to survive and heal itself.

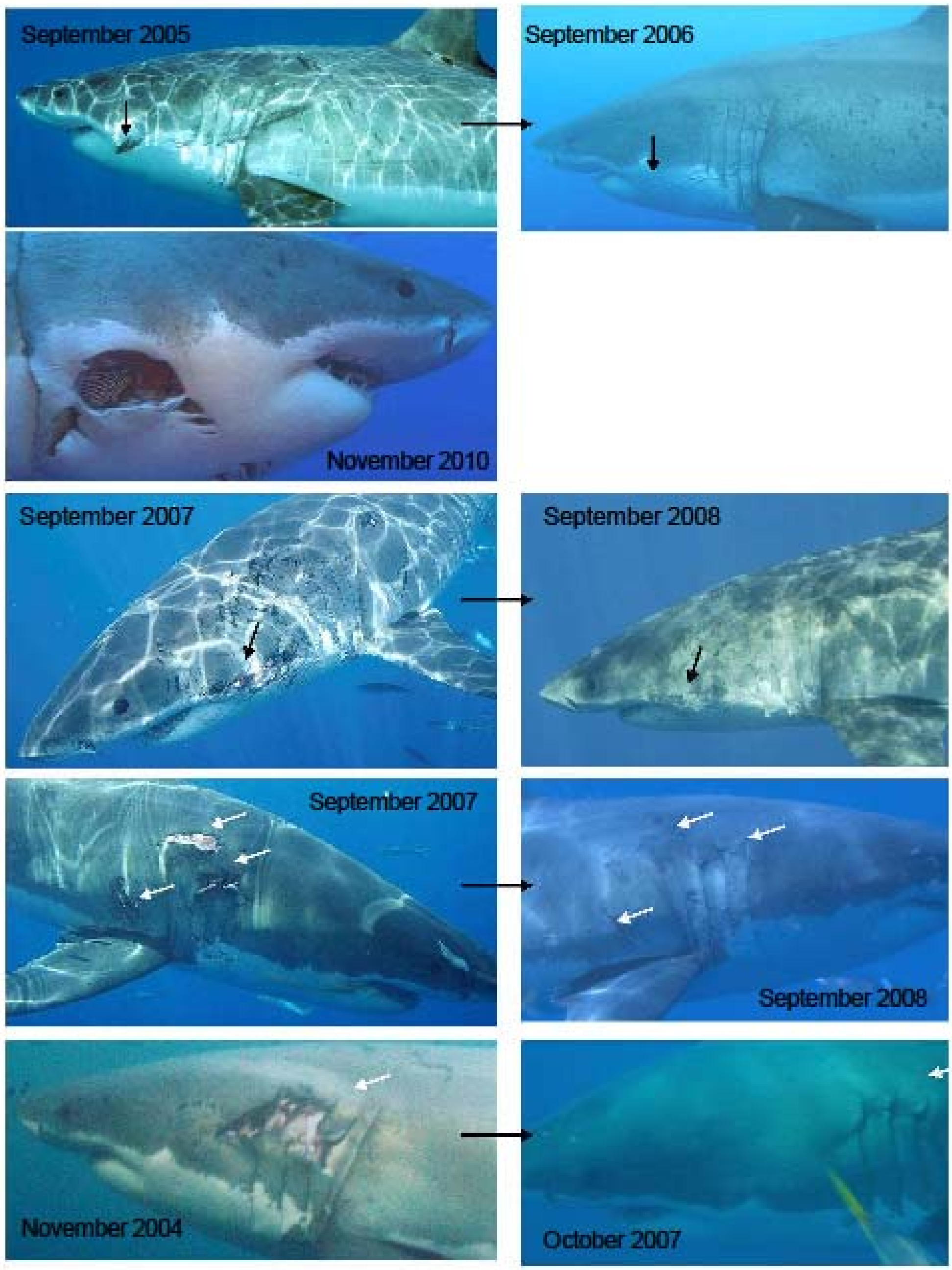
## *A.3 Risk/Benefit Analysis*

Many complicating factors can arise when researchers study large animals and these problems could lead to damage of the animal, as well as its death. Lethal sampling (i.e., the killing of animals for the purpose of obtaining life history data) has been conducted on sharks to further scientific knowledge that can lead to their protection, such as by reducing their accidental capture in certain commercial or recreational fishing activities. Lethal sampling is not being proposed for sanctuary White Sharks, and results to date indicate that White Sharks have not been killed as a result of the methods used.

Information that can be gained from tracking the long-term movements of female White Sharks can lead to better management efforts for the population that returns to the GFNMS management area. The sanctuaries provide one of only a few locations known in the world where adult and sub-adult White Sharks congregate on a regular basis and where tracking studies can be undertaken. Increasingly sophisticated techniques have been developed to reveal the behavior and ecology of these large, highly migratory sharks. If one wishes to attempt to understand movements, migrations and behavior of large aquatic vertebrates, especially White Sharks, it is necessary at this time to use indirect methods such as telemetry-tracking including acoustic monitoring, accelerometer and archival as well as satellite tags. Direct observations of highly dispersive aquatic species would not be possible without this technology. The use of these types of electronic tracking systems; however, can be both intrusive and potentially invasive.

To conduct real-time satellite tagging research on sharks larger than about 10 feet, the only feasible method is to use hook and line. There will be stress and damage due to both struggle (fatigue and lactate buildup) and lacerations from the hook; but any other reasonable option is potentially far too costly in terms of the success or even for the shark to survive the capture. Other highly migratory species such as billfish and tuna have been tagged and released using hook and line in experimental studies. Real-time satellite tags have been deployed on salmon sharks, juvenile and adult White Sharks, mako sharks, blue sharks, and striped marlin (Weng et al., 2005, 2007; Block et al., 2011; Hammerschlag et al., 2011; Domeier, 2012). In a study by Block et al. (2005) up to 90 bluefin tuna were captured using circle hooks and line, brought aboard the vessel, and then attached with pop-up archival transmitting tags. These large tuna were successfully released and the results published in the journal *Nature*. Thus, the techniques were not only approved by the editorial board of Nature but they were found to be safe and highly successful as well.

**Figure 40. White Shark injuries near gills and subsequent wound healing.**



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**Appendix B**

## Independent Review

UNITED STATES DEPARTMENT OF COMMERCE
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September 17, 2010

# Independent Review of the Status of the White Sharks Tagged Under the Domeier Permit

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In response to public concern, Gulf of the Farallones National Marine Sanctuary initiated an Independent Review to assess the status of two white sharks tagged in October and November 2009 under a permit issued to Dr. Michael Domeier of the Marine Conservation Science Institute (GFNMS-2009-004).

Materials reviewed included:

1) Excerpts from video of male white shark tagging at Farallon Islands, Oct 29, 2009.
2) Photos and timeline of tagging event, Oct. 29, 2009.
3) Draft Environmental Assessment for the application to amend permit GFNMS-2009-004).
4) Separate plots showing the tracks of Farallon tagged sharks and Guadalupe tagged sharks.
5) Plots showing the tracks of longitude by date for Farallon tagged sharks and PSAT and SPOT tagged sharks from Guadalupe Island.
6) Information on fight time, sizes and departure dates of sharks tagged at the Farallones and Guadalupe Island.
7) Previously published information on the movement of white sharks tagged at the Farallon Islands – Jorgensen et al. 2009, Weng et al. 2007.
8) Information on the presence and departure of white sharks from the Farallones as observed by the Vessel Monitoring Project[1], PRBO Shark Watch[2] and/or GFNMS permittee log reports.

This review addresses four specific sets of questions regarding the status of the tagged sharks and recommendations to improve capture, handling and tagging methods.

## *Are the sharks alive?*

As of the end of August, 2010, we believe both sharks tagged at the Farallones in 2009 are alive. The tag from the first shark tagged is transmitting good quality locations on a regular basis and the movements of

[1] The Vessel Monitoring Project, lead by Gulf of Farallones National Marine Sanctuary in collaboration with PRBO Conservation Science and U.S. Fish and Wildlife Service, assesses whether vessel operators are complying with sanctuary regulations and provides baseline information on vessel use patterns near southeast Farallon Island. This study is conducted in conjunction with PRBO Conservation Science Shark Watch.

[2] For the past 22 years, biologists have been conducting standardized surveys from the lighthouse on southeast Farallon Island. White shark predation events are recorded between 1-September and 30-November, during daylight hours; however, the total number of shark survey hours per day depends on the number of biologists on the island. Surveys are cancelled if weather limits the visibility of the observer to less than 1 km of water around the island. Shark surveys as well as the Vessel Monitoring Project resume as weather permits.

the tag are consistent with what is known of movements of white sharks in the northeast Pacific. Transmissions in early August were from the coast north of the Farallon Islands. For the second tag, only poor quality transmissions (type Z hits) that do not provide location information were received between January 31, 2010 and July 26, 2010. Starting on July 26, 2010 the tag has reported a few locations from the coast north of the Farallon Islands. The persistence of transmissions and the transmitted temperature data are consistent with the survival of both sharks. Similarly, all white sharks tagged using these tags and methods at Guadalupe Island also survived, based on either resightings or tag transmissions, although some of the earlier tags did not report.

Table 1. Dates concerning the two sharks tagged under the Domeier permit.

| | Tagging date | Departure date | Return date |
|---|---|---|---|
| Shark #1 | October 29, 2009 | ~ December 13, 2009 | ~ July 26, 2010 |
| Shark #2 | November 2, 2009 | ~ November 8, 2009 | ~ August 4, 2010 |

*Has the behavior of the shark(s) been significantly altered since tagging? How is the behavior of the shark(s) similar or different to other sharks tagged near the Farallon Islands? Did the shark(s) leave at the same time as other sharks, compared across years?*

Both sharks left the GFNMS earlier than usual post tagging, based on the Jorgensen et al. 2009 and Weng et al. 2007 studies. Departure time does appear to be quite variable. In the Jorgensen study, most tagged shark departures began after December 1 and by March 15, with the majority of departures occurring in January through mid February. In the Weng study, departures occurred between November 19 and March 24 with an average departure date of January 2. In the GFNMS, shark sightings have been recorded in GFNMS permittee logs, by the PRBO Shark Watch and through a Vessel Monitoring Project until November 30 or December 15 nearly every year. Exceptions were in 1997 and 2009 when Orcas were present near the Farallon Islands. The sharks Dr. Domeier tagged in 2009 departed around November 8 and December 13. Dr. Domeier suggested early departures may have been due to the presence of Orcas which were first sighted in the GFNMS on November 2; the available sightings data have no records of sharks past November 8, 2009. While these departure dates, especially the November 8 departure, may be earlier than most based on the other tagging studies, it is impossible to assign a cause to the early departures.

A longer-term component of behavior is the seasonal migration. For the Farallon tagged sharks, both animals have returned to the Central California coast near the Farallones suggesting that a migration pattern typical of other tagged male white sharks has resumed.

*Given your knowledge of sharks and shark behavior, based on the shark's known injuries, what long-term injuries, if any, may persist? Repercussions of these injuries?*

In reviewing the materials provided and the methods employed, there is definitely the potential for physical injury from hooking and handling the sharks. The first shark was hooked in the esophagus and the researchers attempted to remove the hook by reaching into the bucal cavity through the gill slits. In addition to a wound where the hook was lodged, there was likely some damage to the gills as efforts were made to free the hook through the gill slit. In the end, the hook was cut near the eye of the hook with most of the hook left in. Our experience is that sharks appear to be quite robust and capable of recovering from superficial hook wounds, as we have caught sharks with healed wounds. The hook was tin-coated steel and because the eye was cut, the tin was compromised and the hook should have started to rust immediately. But the hook was also very large and how long it may have remained lodged in the esophagus, and to what degree it may have interfered with feeding is unknown. Additionally, there could be injury to internal organs due to the pressure of lying unsupported on the deck. Unfortunately, this type of injury is difficult to assess, confirm or predict the impacts of.

The sharks are intentionally tired out prior to pulling them on the deck. While white sharks may be pre-adapted to tolerate low oxygen conditions, voluntary excursions into oxygen poor waters are likely very different physiologically from an hour-long fight at the end of a line. The survival of these sharks demonstrates that they were able to recover from any potential anaerobic debt. But there is a growing body of literature on stress associated with capture in large pelagic fish, and there may be a threshold stress level beyond which recovery is less likely (e.g. Moyes et al. 2006). It may be worthwhile to measure levels of stress-associated metabolites and blood parameters in order to help evaluate impacts of the capture and handling methods and make recommendations for future safe handling techniques.

The fact that both tags have been transmitting for over 10 months suggests that short-term lethal injury did not occur. However, stress or sub-lethal injuries associated with the capture may still affect the shark's well-being. The long term effects of the methods employed are difficult to assess.

*Are there any changes (in addition to those already made by the permittee) to the hooking/tagging techniques that you would recommend the Sanctuary consider?*

Many of the other tagging studies on sharks have been done in the water or in a cradle or sling and thus are not directly comparable to this one. The large size of these sharks and the hard flat platform may create excessive pressure on tissues and organs that usually do not bear weight. All efforts should be made to minimize the handling time once the shark is on the platform. It would be valuable to work with the permitee to determine if there are other options to reduce the time on the deck and to provide additional support to the animal. Insufficient information was available in the materials provided to assess the timeline of individual components involved in the handling process in order to suggest specific improvements to handling time.

We recommend trying a smaller hook, and the hook should be barbless. Discussions with other researchers and fishermen who have caught large white sharks on hooks suggest that a hook 2/3 or half the size of the one Dr. Domeier uses may be adequate. A smaller barbless hook, no matter where it is lodged, is likely to leave a smaller hole, tear less tissue when removed and corrode more quickly if left in. It is unclear how their revised methods for hooking (using bait near the surface in cloudy waters) help reduce the potential for swallowed hooks. An observer should be on board to record details of the capture and handling. If the revised methods prove inadequate and another white shark is foul hooked, i.e. swallows the hook, then we suggest the GFNMS consider terminating the project.

We recommend using floats that don't have hard ridges and are large enough so that they don't fit in the shark's mouth. The video and photos provided showed that the shark had taken a buoy into its mouth. It took 10 minutes to free the buoy from the shark's mouth.

It may be worth considering limiting the sharks to be tagged to adult females no larger than the maximum size successfully tagged at Guadalupe Island (roughly 18 feet). The effects of being elevated out of the water may be greater as shark size increases and we have no information to indicate that survival rates will be as high for larger sharks. Furthermore, the applicant states that enough information is known about the migrations of adult males. While any potential injury or mortality of a reproductive female would clearly have a greater negative impact on the population reproductive potential than the loss of an adult male, because males are already well studied, there is no need to subject them to the tagging protocols. Given the murky conditions at the Farallones, allowances should be made for accidentally taking males or larger females, both of which should have the hook removed and be released as quickly as possible.

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