Endangered Species Act – Section 7 Biological Opinion and Conference Report

Action Agencies: National Marine Fisheries Service, Pacific Islands Fisheries Science Center, NMFS Office of Protected Resources, Permits and Conservation Division

Activities: Pacific Islands Fisheries Science Center's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean, Office of Protected Resources' Issuance of a Letter of Authorization to Take Marine Mammals Incidental to Fisheries Research Conducted by Pacific Islands Fishery Science Center

Consultation Conducted by: National Marine Fisheries Service, Pacific Islands Region, Protected Resources Division, Intergovernmental Coordination and Conservation Branch

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ACRONYMS

ASARA	American Samoa Archipelago Research Area
ASLL	American Samoa longline fishery
BE	Biological Evaluation
CFR	Code of Federal Regulations
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	Catch per Unit Effort
cm	Centimeter(s)
CO_2	Carbon Dioxide
DAS	Days at Sea
dB	Decibel(s)
DPS	Distinct Population Segment
DSLL	Deep-set longline fishery
DQA	Data Quality Act
EEZ	U.S. Exclusive Economic Zone
ESA	Endangered Species Act
FAD	Fish Aggregating Devices
ft.	Feet
FR	Federal Register
FWS	US Fish and Wildlife Service
GHG	Greenhouse Gas
HARA	Hawaiian Archipelago Research Area
Hz	Hertz
IATTC	Inter-American Tropical Tuna Commission
ICCB	Intergovernmental Coordination and Conservation Branch
in	Inch(es)
ITS	Incidental Take Statement
ITP	Incidental Take Permit
IUU	Illegal, unreported and unregulated fishing
kg	Kilogram(s)
m	Meter(s)
Mara	Mariana Archipelago Research Area
mm	Millimeter(s)
nm	Nautical Mile(s)
NMFS	National Marine Fisheries Service (aka NOAA Fisheries)
NOAA	National Oceanic and Atmospheric Administration
MTBAP	Marine Turtle Biology and Assessment Program
PIFSC	Pacific Islands Fisheries Science Center
PIRO	Pacific Islands Regional Office
PSAT	Pop-off Satellite Archival Transmitting Tag
PTS	Permanent Threshold Shift
SPL	Sound Pressure Level
SSLL	Shallow-set longline fishery
TTS	Temporary Threshold Shift
U.S.	United States

WCPFC	Western and Central Pacific Fisheries Commissions
WCPO	United States Western Central Pacific Ocean
WCORA	Western and Central Pacific including the Pacific Remote Islands Research Area
ºC	Degrees Celsius
ºF	Degrees Fahrenheit

1 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1536(a)(2)) requires each federal agency to insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species. When a federal agency's action "may affect" a listed species or its designated critical habitat, that agency is required to consult formally with the National Marine Fisheries Service (NMFS) or the United States Fish and Wildlife Service (FWS), depending upon the endangered species, threatened species, or designated critical habitat that may be affected by the action (50 CFR 402.14(a)). Federal agencies are exempt from this general requirement if they have concluded that an action "may affect, but is not likely to adversely affect" endangered species, threatened species or their designated critical habitat, and NMFS or the FWS concur with that conclusion (50 CFR 402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, in accordance with the ESA Subsection 7(b)(3)(A), NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes reasonable and prudent measures to minimize such impacts and terms and conditions to implement the reasonable and prudent measures. NMFS, by regulation has determined that an ITS must be prepared when take is "reasonably certain to occur" as a result of the proposed action. 50 C.F.R. 402.14(g)(7).

"Take" is defined by the ESA as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, any threatened or endangered species, or to attempt to engage in any such conduct. NMFS defines "harass" as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (Wieting 2016). NMFS defines "harm" as "an act which actually kills or injures fish or wildlife." Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Take of species listed as endangered is prohibited at the time of listing, while take of threatened species may not be specifically prohibited unless NMFS has issued regulations prohibiting take under section 4(d) of the ESA.

Section 7(a)(4) of the ESA requires that each Federal agency confer with NMFS on any agency action that is likely to jeopardize the continued existence of any proposed species, or likely to result in the destruction or adverse modification of proposed critical habitat as per 50 CFR §402.10(d). NMFS may request to conference if, after a review of available information, it determines that a conference is required for a particular action (50 CFR §402.10(b)). If requested by the Federal agency and deemed appropriate by NMFS, the conference may be conducted in accordance with the same procedures as a formal consultation (50 CFR §402.10(d)). A conference opinion may be adopted as a biological opinion when the species is listed or critical habitat is designated as long as no significant new information is developed and no significant changes to the Federal action are made that would alter the content of the opinion. An ITS provided with a conference opinion does not become effective unless NMFS adopts the conference opinion once the listing is final or proposed critical habitat is designated as final. Federal agencies may also engage in voluntary conferencing for proposed actions that may affect proposed resources. Following an informal conference with the action agency, NMFS may issue a conference report containing recommendations for reducing adverse effects to the proposed resource.

The Pacific Islands Fisheries Science Center (PIFSC) is conducting and funding all research activities, and is the action agency for this project. The PIFSC will conduct research and provide scientific advice to manage fisheries and conserve protected species throughout the Pacific Islands Region, including the State of Hawaii, Territory of American Samoa, Territory of Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and the Pacific Remote Island Areas (PRIA). The consulting agency for this proposal is NMFS' Pacific Islands Regional Office's (PIRO) Protected Resources Division (PRD), Intergovernmental Coordination and Conservation Branch (ICCB). This document represents NMFS' final biological opinion on the effects of the proposed action on species listed in Table 4. This biological opinion has been prepared in accordance with the requirements of Section 7 of the ESA, the implementing regulations (50 CFR 402), agency policy, and guidance. It is based on information contained in PIFSC's Biological Assessment (BA) (PIFSC 2021), NMFS and FWS recovery plans and status reviews for sea turtles (NMFS and FWS 1998a, 1998b, 1998c, 1998d, 2007, 2013a, 2013b, 2014a; Seminoff et al. 2015), marine mammals (NMFS 2007, 2015, 2021b, 2021d, 2022), corals (Brainard et al. 2009), and elasmobranchs (Miller et al. 2014; Miller and Klimovich 2017; Young et al. 2017), and other sources of information as cited herein.

On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order and on November 14, 2022, the District Court for the Northern District of California granted the Services' motion to remand the 2019 Regulations without vacatur. As a result, the 2019 regulations are still in effect pending future agency rulemaking, and we are applying the 2019 regulations here. For purposes of this consultation, we considered whether the substantive analysis and conclusions articulated in the biological opinion and incidental take statement would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

1.1 Consultation History

The PIFSC (formerly the Honolulu Laboratory of the Southwest Fisheries Science Center) has gathered, directed, and coordinated the collection of scientific information needed to inform fisheries management decisions for over 40 years. We completed one formal and eight informal consultations in 2015, ten informal consultations in 2016, and seven informal consultations in 2017. Copies of these consultations are available at the Pacific Island Regional Office, Honolulu, Hawaii, and the Environmental Consultation Organizer located here: https://appscloud.fisheries.noaa.gov/suite/sites/eco.

On November 30, 2015, the NMFS Office of Protected Resources, Permits and Conservation

Division (PR1) received the request from PIFSC for authorization to take marine mammals incidental to fisheries research activities. PR1 published the request for authorization for a 30-day public review on December 7, 2015.

On September 13, 2018, NMFS completed an informal consultation with PIFSC on their research program (PIR-2018-10420; I-PI-18-1653-AG) concluding that PIFSC's research was not likely to adversely affect (NLAA) the following endangered or threatened species or designated critical habitat under NMFS' jurisdiction: threatened Central North Pacific, Central West Pacific and Central South Pacific Distinct Population Segments (DPS) of green sea turtles; endangered hawksbill sea turtles; endangered leatherback sea turtles; endangered North Pacific and South Pacific loggerhead sea turtle DPSs; threatened olive ridley sea turtles; endangered Hawaiian monk seals; endangered Main Hawaiian Islands insular false killer whales; threatened Indo-West Pacific DPS scalloped hammerhead sharks; threatened oceanic whitetip sharks; threatened giant manta rays; seven threatened corals species *Acropora globiceps, Acropora jacquelineae, Acropora retusa, Acropora speciosa, Euphyllia paradivisa, Isopora crateriformis,* and *Seriatopora aculeata;* designated critical habitat for the Hawaiian monk seal and the Hawaiian Islands insular false killer whale.

On March 22, 2021, NMFS OPR PR1 submitted a proposed rule for public comment on the Taking Marine Mammals Incidental to PIFSC Fisheries Research (86 FR 15298).

On March 16, 2022, NMFS PRD completed a formal consultation with PIFSC on the tagging and releasing of oceanic whitetip sharks opportunistically caught in small boat fisheries in the Hawaiian Islands (PIRO-2021-00317; I-PI-21-1897-AG).

On June 21, 2021, PIFSC submitted a draft BA for the proposed action covered in this opinion to PRD for review.

On June 29, 2021, PR1 requested consultation under Section 7 of the ESA with NMFS PIRO PRD for the Proposed Issuance of a LOA to Take Marine Mammals Incidental to Fisheries Research Conducted by PIFSC in the Pacific Ocean.

Between June 21, 2021, and September 1, 2021, PRD and PIFSC held multiple meetings via phone conference. PIFSC provided an updated draft BA on September 1, 2021 for PRD's subsequent review.

On September 8, 2021, the PIFSC submitted an official request for formal consultation to PRD.

On October 6, 2021, PRD provided comments to PIFSC requesting clarification on the likely to adversely affect determination for sperm whales.

On October 12, 2021, PIFSC responded to PRD comments and suggested edits. Given the preliminary information PRD gathered from PIFSC and PR1, PRD noted we may not agree with PIFSC's not likely to adversely affect determination for listed sea turtles, false killer whales, or Hawaiian monk seals. However, as of November 17, 2021, PRD determined we had adequate information to initiate consultation pursuant to 50 CFR 402.14(c).

On November 22, 2021, PRD provided a memorandum to PIFSC acknowledging the receipt of the PIFSC's September 8, 2021 request for consultation and BA pursuant to Section 7(a)(2) of the ESA. This letter also acknowledged PRD's receipt of PR1's request for consultation on issuing a LOA to PIFSC, pursuant to section 101(a)(5)(A) of the MMPA of 1972, as amended (16 U.S.C. 1361 et seq.), for taking marine mammals incidental to fisheries research. Under the

MMPA, PR1 determined the proposed action would cause injury or mortality of sperm whales and Level B harassment of false killer whales and Hawaiian monk seals.

On November 17, 2021, PR1 clarified through email that these takings under MMPA constitute likely to adversely affect determinations under the ESA. PRD disagrees with PR1 and considers false killer whales and Hawaiian monk seals as not likely to be adversely affected for the purpose of this biological opinion.

On May 17, 2022, PRD requested information to determine what proportion of longline sets would replicate the SSLL and DSLL fisheries respectively, to clarify modifications in the species list, and to clarify an effects determination for Hawaiian monk seal critical habitat in the BA. PRD determined that the East Indian-West Pacific green sea turtle, East Pacific green sea turtle, Southwest Pacific green sea turtle, and Mexican breeding populations of Olive Ridley sea turtles may be affected by the proposed action. These species were not included in the BA (NMFS 2019). Genetic evidence collected in both the SSLL (NMFS 2019) and DSLL (unpublished data) fisheries have determined these species are present within the *Action Area* and may be captured by longline operations conducted by PIFSC.

Additionally, PRD described current records of ESA-listed coral species in the U.S. Pacific Islands (NMFS 2021a) for our evaluation of proposed coral critical habitat (85 FR 76262). Based on this evaluation, PRD has confirmed that *Acropora jacquelineae* and *Seriatopora aculeata* did not occur in any U.S. territorial waters (NMFS 2021a). Therefore, we suggested these two species be removed from further analysis of this proposed action. PIFSC confirmed the genetic evidence available for sea turtles in Hawaiian waters and agreed to include the additional four species of sea turtles in the analysis of the proposed action. PIFSC also agreed to remove *Acropora jacquelineae* and *Seriatopora aculeata* from further analysis and provided clarification that research longline sets will replicate the DSLL fishery only. Lastly, PISFC clarified that designated Hawaiian monk seal critical habitat would be NLAA by the proposed action.

On June 6, 2022, PIFSC confirmed that they use the existing commercial fleet to collect deep set longline samples during their regular longline fishing operations.

On October 5, 2022, PIFSC agreed to conference on proposed Pacific coral critical habitat.

On October 20, 2022, PIFSC added their Marine Turtle Biology and Assessment Program activities in this consultation.

On November 30, 2022, we corrected and updated the amount of take anticipated for this action, and re-evaluated the action's effect to listed species and their habitats, and revised the biological opinion to reflect the updated numbers.

1.2 Description of the Proposed Action

The Programmatic Environmental Analysis, the BA, and the proposed rule (86 FR 15298), provide important background information about the proposed research planned over the five year period from 2021-2026 that we considered in this biological opinion. It provided the description of the action and most of the information required to initiate section 7 consultation.

PIFSC proposes to conduct studies which include biological, physical, and chemical sampling, visual observation and other data collection. Sampling methods include using trawl gear used at various levels in the water column, hook-and-line gear (including longlines with multiple hooks, bottomfishing, and trolling), and deployed instruments (including various traps), and diver surveys. All proposed programs are listed in Table 1. All methods are described briefly in the table, and best management practices (BMP) or mitigating measures to avoid or minimize effects to ESA-listed species or designated or proposed critical habitats are listed in Table 2. PIFSC provided details in their BA and in various emails or other written transmissions to PRD. The proposed action includes PR1's issuance of a LOA to PIFSC, pursuant to section 101(a)(5)(A) of the MMPA of 1972, as amended (16 U.S.C. 1361 et seq.), for taking marine mammals incidental to fisheries research.

PIFSC proposes to use samples taken from all fisheries, including the deep set longline fishery. However, this consultation does not cover the effects (accidental hookings, entanglements, or other take associated with the longline fishing) of the deep set longline fishery, which is the subject of a separate consultation. Under 2019 regulations, effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR 402.02).

The deep set longline fishing will occur regardless of the proposed research sampling, and any effects of the deep set longline fishery to ESA-listed resources are part of the proposed action. Therefore, we concluded that the DSLL effects are not covered in this consultation because the fishing effort associated with PIFSC's sampling will not add to the fishing effort nor the take associated with the DSLL action.

We presented all activities that could expose potential stressors to listed species in Table 1. Proposed mitigation and monitoring measures are presented in Table 2. In the next paragraphs, we describe the activities in more detail to highlight their increased potential exposure of ESA-listed species to harmful effects.

Bottomfish Sampling

PIFSC will also use electric or hydraulic reels with sets of hooks to the bottom of the ocean to sample bottomfish populations. PIFSC proposes 175 sets, which amounts to about 2,100 hooks per year in the Hawaiian Islands, and about 1,000 sets with about 8,000 hooks in the Mariana Islands. The sets are jigged manually by personnel up to 30 minutes and retrieved. PIFSC is also proposing to sample by trolling and headlining. The proposed sample size is 28 operations throughout all of the sub-regions; using up to ten hooks per sample for no more than eight hours of troll or soak time. While the probability is low, depredation is possible.

Multi-beam, split-beam, and echosounder surveys can harm animals by emitting sounds that could cause non-auditory injury, hearing loss, or behavioral response. PIFSC also proposes to emit sounds to survey or sample cetaceans. As PR1 determined, the proposed sound effects are expected to cause harmful effects to sperm whales, Hawaiian monk seals, and Main Hawaiian Island insular false killer whales (NMFS 2021b).

Single and Multi-Frequency Narrow Beam Scientific Echosounders

Multi-beam, split-beam, and echosounder surveys can harm animals by emitting sounds that could cause non-auditory injury, hearing loss, or behavioral response. PIFSC also proposes to emit sounds to survey or sample cetaceans. As PR1 determined, the proposed sound effects are

expected to cause harmful effects to sperm whales, Hawaiian monk seals, and Main Hawaiian Island insular false killer whales (NMFS 2021b).

Echosounders and sonars work by transmitting acoustic pulses into the water that travel through the water column, reflect off the seafloor, and return to the receiver. Water depth is measured by multiplying the time elapsed by the speed of sound in water (assuming accurate sound speed measurement for the entire signal path), while the returning signal itself carries information allowing "visualization" of the seafloor. Multi-frequency split-beam echosounders are deployed from PIFSC survey vessels to acoustically map the distributions and estimate the abundances and biomasses of many types of fish; characterize their biotic and abiotic environments; investigate ecological linkages; and gather information about their schooling behavior, migration patterns, and avoidance reactions to the survey vessel. The use of multiple frequencies allows coverage of a broad range of marine acoustic survey activity, ranging from studies of small plankton to large fish schools in a variety of environments from shallow coastal waters to deep ocean basins. Simultaneous use of several discrete echosounder frequencies facilitates accurate estimates of the size of individual fish, and can also be used for species identification based on differences in frequency-dependent acoustic backscattering among species.

Multibeam Echosounder and Sonar

Multibeam echosounders and sonars operate similarly to the devices described above. However, the use of multiple acoustic "beams" allows coverage of a greater area compared to single beam sonar. The sensor arrays for multibeam echosounders and sonars are usually mounted on the keel of the vessel and have the ability to look horizontally in the water column as well as straight down. Multibeam echosounders and sonars are used for mapping seafloor bathymetry, estimating fish biomass, characterizing fish schools, and studying fish behavior.

Acoustic Doppler Current Profiler (ADCP)

An ADCP is a type of sonar used for measuring water current velocities simultaneously at a range of depths. Whereas current depth profile measurements in the past required the use of long strings of current meters, the ADCP enables measurements of current velocities across an entire water column. The ADCP measures water currents with sound, using the Doppler effect. A sound wave has a higher frequency when it moves towards the sensor (blue shift) than when it moves away (red shift). The ADCP works by transmitting "pings" of sound at a constant frequency into the water. As the sound waves travel, they ricochet off particles suspended in the moving water, and reflect back to the instrument. Due to the Doppler effect, sound waves bounced back from a particle moving away from the profiler have a slightly lowered frequency when they return. Particles moving toward the instrument send back higher frequency waves. The difference in frequency between the waves the profiler sends out and the waves it receives is called the Doppler shift. The instrument uses this shift to calculate how fast the particle and the water around it are moving. Moreover, sound waves that hit particles far from the profiler take longer to come back than waves that strike close by. By measuring the time it takes for the waves to return to the sensor, and the Doppler shift, the profiler can measure current speed at many different depths with each series of pings.

An ADCP anchored to the seafloor can measure current speed not just at the bottom, but at equal intervals to the surface. An ADCP instrument may be anchored to the seafloor or can be mounted to a mooring or to the bottom of a boat. ADCPs that are moored need an anchor to keep them on the bottom, batteries, and a data logger. Vessel-mounted instruments need a vessel with power, a shipboard computer to receive the data, and a GPS navigation system so the ship's movements can be subtracted from the current velocity data. ADCPs operate at frequencies between 75 and 300 kHz.

Net Monitoring Systems

During trawling operations, a range of sensors may be used to assist with controlling and monitoring gear. Net sounders give information about the concentration of fish around the opening to the trawl, as well as the clearances around the opening and the bottom of the trawl; catch sensors give information about the rate at which the cod end is filling; symmetry sensors give information about the optimal geometry of the trawls; and tension sensors give information about how much tension is in the warps and sweeps.

On cetacean ecology assessments, deep coral and sponge research, PIFSC will conduct surveys to produce high-resolution bathymetry and acoustic backscatter maps, provide calibrated quantitative acoustic data useful for interpreting marine life in the water column of the ocean, and gas seeps. Most of the sounds are outside of the hearing range for sea turtles and elasmobranchs. Some of the instruments like ship-based multibeam and sub-bottom profilers produce sounds within the hearing range of all marine mammals, while some like the splitbeam EK60 and OES Netmind are outside of low frequency cetaceans' hearing range. NOAA ships generally cruise at no more than 8 knots. Ship-based profilers are intermittently pinged throughout the cruise as they gather data.

PIFSC will tow nets through the water column at various depths to 1,000 feet, which could entangle or accidentally capture listed species. To date, PIFSC has never entangled an ESA-listed species or large animal from their trawls. The details of the dimensions of each net, planned depth and duration of each tow are listed in Table 1. The largest nets are the Cobb and Isaacs-Kidd trawl and have the highest potential for entanglement. Those nets are proposed to be set for 15 to 20 tows per year resulting in 60 trawls. Sets will fish 4 hours per day/night per tow.

Throughout most of the surveys, PIFSC is proposing to drag nets through the surface and mid-water (up to 1,000 feet depth) to sample for a variety of living and non-living specimens. The total number of sets for each type of net are as follows:

- Cobb trawl, surface – 1,060 trawls
- Cobb trawl, mid-water – 60 trawls
- Plankton net, surface – 990 trawls
- Isaac-Kidd trawl, surface – 440 trawls

These nets are dragged through the water column at no more than 3.5 knots, for no more than four hours at a time.

PIFSC will also set up to 400 traps at bottomfish fishing sites to sample juvenile bottomfish data. The traps are cylindrical with dimensions up to 3 m long and 2 m diameter. Frame composed of semi-rigid plastic mesh of up to 5 cm mesh size. Folded plastic of up to 10 cm mesh is stuffed inside as settlement habitat, and cylinder ends are then pinched shut. Traps are clipped throughout the water column onto a vertical line anchored on the bottom up to 400 m, supported by a surface float.

PIFSC is proposing to set up to 400 sets of traps on sandy bottoms in the Mariana Islands to sample Kona crab (*Ranina ranina*). The traps are dropped from 60 to 210 ft. PIFSC is proposing to use two types of trap arrays; nylon open crab nets attached to a wire ring with bait, and "lobster traps" which are single-chambered, coned-entrance mesh pots. The traps use a trap door mechanism to capture the crabs.

Tagging

PIFSC is proposing to tag, photograph, collect tissue samples and/or collect interaction data from giant manta rays and Indo-West Pacific scalloped hammerhead captured incidentally during all fishing operations in the western and central Pacific Ocean. PIFSC will opportunistically tag these elasmobranchs whenever they are caught, in any of the fisheries mentioned in this opinion. Although tagging will most likely occur during longline or purse seine fisheries where the majority of the bycatch occurs and are staffed by NOAA observers. PIFSC attaches tag anchors to poles or pole spears, and if giant manta rays are within reach, they are able to tag them. PIFSC also proposes to collect tissue samples using either scissors or tissue plugs. PIFSC will collect a small sample (1 cc) of tissue using surgical scissors or a tissue plug. The tissue plug can be taken from the dorsal musculature while fin clips using surgical scissors may come from any fin (pectoral, caudal, dorsal, second dorsal, or pelvic). For all gear types, tissue sampling will occur in a very similar fashion, where fishers will be given a specialized pole with a tissue plug. PISFC will take tissue plugs from the dorsal musculature. These interactions are typically less than one minute. PIFSC may also tag and tissue sample scalloped hammerhead sharks if they are incidentally caught in various fisheries within the region. All scalloped hammerhead sharks not caught within the HARA would be within the Indo/West Pacific DPS, which is threatened. PIFSC would collect tissue samples and tag scalloped hammerhead sharks as described above. This consultation includes the effects of sampling and tagging incidentally-caught giant manta rays and Indo-West Pacific scalloped hammerhead sharks. It does not include the effects of these fisheries. An effect is caused by the proposed action if it will not occur but for the proposed action. These fisheries will occur regardless of the proposed research project.

Marine Turtle Biology and Assessment Program

PIFSC conducts research on sea turtles in the Pacific Islands Region. Their action is described in their permit (NMFS ESA 10(a)1A permit number 21260) and corresponding biological and conference opinion (NMFS 2017). All takes and effects that are expected to harm or harass sea turtles under that permit are covered under that permit and will not be evaluated in this biological opinion.

The MTBAP will employ a variety of tasks and methods to observe and collect data on sea turtles throughout the region. These tasks include visual observation, underwater and land-based captures, measurements, tagging, tissue sampling, swabbing, diet sampling, marking, ultrasound sampling, laparoscopy, photo documentation, and mark-recapture.

The MTBAP uses a variety of vessels to support their activities. PIFSC uses primarily 19- to 22-foot inflatable vessels and estimates no more than 100 vessel trips throughout the region to conduct the activities. To avoid and minimize effects such as disturbance, contact with humans or gear, vessel collision, pollutants, and other effects associated with implementation of the program, the MTBAP will adhere to all relevant BMPs identified in Table 2.

Proposed surveys per year:

- NWHI (if typical, 20 week season): 140 night, 200 basking
- MHI: 30 basking, 30 in-water
- Marianas: 20 in-water, 10 nesting
- American Samoa (Rose): 6 night, 4 in-water
- PRIA: 1 in-water

Table 1. Proposed PIFSC Research Activities in four different research areas: 1) Hawaiian Archipelago Research Area (HARA); 2) Mariana Archipelago Research Area (MARA); 3) American Samoa Archipelago Research Area (ASARA); and 4) Western and Central Pacific including the Pacific Remote Islands Research Area (WCPRA).

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
1) Sampling Pelagic Stages of Insular Fish Species	Results of sampling inform life history and stock structure studies for pelagic larval and juvenile stage specimens of insular fish. Additional habitat information is also collected. Target species are snapper, grouper, and coral reef fish species within the 0-175 meter (m) depth range. Pelagic stages sampling is conducted both at midwater depths using a "Stauffer" modified Cobb trawl (Cobb trawl) or a 10-foot (ft) Isaacs-Kidd trawl, and at the surface using a 6-ft Isaacs-Kidd trawl. Surveys may occur every year in the HARA, but approximately once every three years in the MARA, ASARA, and WCPRA.	HARA MARA ASARA WCPRA 3-200 nautical miles (nm) from shore	Year-round HARA: up to 20 DAS MARA, ASARA, WCPRA: up to 30 DAS approximately once in research area every three years Midwater Research trawls are conducted at night, Surface trawls are conducted day and night	Cobb trawl (midwater trawl) with OES Netmind or Isaacs-Kidd 10-ft midwater trawl	Tow speed: 2.5-3.5 knots (kts) Duration: 60-240 minutes (min) Depth: Deployed at various depths during same tow to target fish at different water depths, usually to 250 m	40 tows per survey per year
				Isaacs-Kidd 6-ft trawl (surface trawl) Dip net (surface)	Tow speed: 2.5-3.5 kts Duration: 60 min Depth: Surface	40 tows per survey per year

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
2) Spawning Dynamics of Highly Migratory Species	Early life history studies provide larval stages for population genetic studies and include the characterization of habitat for early life stages of pelagic species. Egg and larval collections are taken in surface waters using a variety of plankton gear, primarily Isaacs-Kidd 6-ft surface trawl, but also sometimes including 1-m ring net and surface neuston net.	HARA MARA ASARA WCPRA 1-25 nm from shore	Year-round HARA: up to 25 DAS MARA, ASARA, WCPRA: up to 25 DAS approximately once in research area every three years Surface trawls are conducted day and night	Isaacs-Kidd 6-ft (surface)	Tow speed: 2.5-3.5 kts Duration: 60 min Depth: Surface	140 tows per survey per year
				Neuston tows (surface) 1-m ring net (surface)	Tow Speed: 2.5-3.5 kts Duration: 30-60 min Depth: 0-3 meters (m)	140 tows per survey per year
3) Cetacean Ecology Assessment	Survey transects conducted in conjunction with cetacean visual and acoustic surveys within the Hawaii Exclusive Economic Zone (EEZ) to develop ecosystem models for cetaceans. Sampling includes active acoustics to determine relative biomass density of sound scattering layers; trawls to sample within the scattering layers; cetacean observations; surface and water column oceanographic measurements and water sample collection.	HARA MARA ASARA WCPRA	Variable, up to 180 DAS depending on area surveyed Midwater trawls are conducted at night, surface trawls are conducted day and night All other gear and instruments are conducted day and night	Cobb midwater trawl	Tow speed: 3 kts Duration: 60-240 min	180 trawls per research area
				Small-mesh towed net (surface trawl)	Tow Speed: 2.5-3.5 kts Duration: 30-60 min	180 tows total per year
				Active acoustics (splitbeam Simrad EK60, OES Netmind)	38-200 kilohertz (kHz)	Intermittent continuous during surveys
				Acoustic Doppler Current Profiler (ADCP) (RD Instruments Ocean Surveyor 75)	75 kHz	Intermittent continuous during surveys
				CTD profiler	90 min Profiles from surface down to 1000 m depth	Up to 180 per survey per year
				Expendable bathythermograph (XBT)	10 min duration. Profiles from surface down to1000 m depth	Maximum 900 per survey per year

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	Passive Acoustics Calibration - Transmit sound (synthetic pings, dolphin whistles or echolocation clicks, etc.) to passive acoustic recording devices for purposes of in-situ calibration, needed to understand detection distances and received level or frequency-dependent variation in the device performance.	HARA MARA ASARA WCPRA		Underwater sound playback system (Lubell LL916 piezoelectric underwater speaker)	Includes underwater projector and amplifier suspended from small boat or ship. Projection depth may vary from near surface to 100 m.	Intermittent
	Stationary Passive Acoustic Recording - Placement of long-term acoustic listening devices for the purposes of recording cetacean occurrence and distribution, ambient and anthropogenic noise levels, and presence of other natural sounds. Recorders are typically deployed and retrieved once or twice per year at each monitoring location.	HARA MARA ASARA WCPRA		High-frequency acoustic recording package (HARP), ecological acoustic recorder (EAR), or similar device	Deployed in seafloor package or mooring configuration consisting of recorder, acoustic releases, anchor and flotation	Up to ten long-term monitoring sites
	Passive Acoustic Monitoring - Deployment of passive acoustic monitoring devices in conjunction with other sampling measures, such as on fishing gear or free-floating.	HARA MARA ASARA WCPRA		Miniature HARPs, sonobuoys, or similar platforms	Autonomous recorder package modified for attachment to longline gear, oceanographic mooring, or free-floating. Various configurations may have surface buoys with recorder up to 1000 feet (ft) below, or may have smaller form factor with entire package not exceeding 1m length.	Continuous

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	Passive Acoustic or Oceanographic Gliders - Autonomous underwater vehicles used for sub-surface profiling and other sampling over broad areas and long time periods. Passive acoustic device integrated into the vehicle provide measure of cetacean occurrence and background noise. CTD, pH, fluorometer, and other sensors provide oceanographic measures over several months duration.	HARA MARA ASARA WCPRA		Seaglider; WaveGlider; or similar platform	AUV.	Continuous
	Collection of Environmental DNA (eDNA) samples – Shipboard eDNA samples would be collected via the ship's CTD to identify cryptic cetaceans.	HARA MARA ASARA WCPRA	Casts would generally occur during night	eDNA water samples collected via Niskin bottles on CTD frame	Water samples collected at depths ranging from 10 – 1000 m. Water would be collected in Niskin bottles and decanted into 10 liter carboys for processing.	200 casts per research area

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
4) Marine Debris Research and Removal	These surveys: (1) identify and assess the types and locations of marine debris (e.g., derelict fishing gear) in the marine environment and along the shoreline; and (2) conduct targeted removals at high-priority sites. Team members systematically survey reefs using shoreline walks, swim surveys, and towed-diver surveys to locate submerged derelict fishing gear in shallow water. Debris type, size, fouling level, water depth, GPS coordinates, and substrate of the adjacent habitat are recorded. Nets are evaluated before removal actions to determine appropriate removal strategies. Attempts to remove marine debris encountered at sea are variable and can be unfeasible because of operational, vessel, or safety constraints. However, by attaching a satellite-tracked marker to debris, it will be possible to locate that debris in the future and to track and analyze its	HARA MARA ASARA WCPRA	HARA: annually or on an as needed basis, up to 30 DAS ASARA: Occurred once in 2009 after a tsunami Surface trawls are conducted day and night Unmanned Aerial systems (UAS) are conducted during the day or night In-water and beach activities are conducted during the day	Knives, lift bags, scissors, shovels, cargo nets Helicopters (Main Hawaiian Islands [MHI] only)	Gear used to a depth of 30 m in around islands and atolls.	HARA: average of 48 metric tons (mt) per survey per year 1996 - 2013 ASARA: 4 mt per survey per year

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	drifting patterns.					
	Surface and midwater plankton tows to quantify floating microplastic in seawater	HARA MARA ASARA WCPRA	Annually, or on an as-needed basis, up to 30 DAS Surface trawls are conducted day and night UAS are conducted during the day or night In-water and beach activities are conducted during the day	Neuston, or similar, plankton nets surface towed alongside ship and/or small boats	Tow Speed: varied Duration: < 1 hour	Up to 250 tows per survey per year
	The use of UAS platforms can aid in efficiency during survey and removal operations by directing efforts to high density areas	HARA		UASs (e.g., NOAA PUMA or NASA Ikhana systems, hexacopter)	Deployed from shore, small boat, or ship. Operate along shoreline or over water around atoll.	Less than 20 operations per island or atoll per year
	Adding more frequent marine debris research and removal activities to other research areas.	MARA WCPRA	Additional 30 DAS	Same as above	Same as above	Same as above

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	Collection and sieving of mesoplastics from beach sand located between the low and high tide lines. Plastics are removed for sampling and further study.	HARA		Sieves	Sieving of mesoplastics (> 500 microns in size) from sand.	100 samples per atoll
	Structure-from-Motion (SfM) surveys consist of marking off plots on the seafloor (1-3 m depth) with cable ties and/or stainless steel pins, collecting photographs of the plots and processing them using PhotoScan software to create dense point clouds, 3D models and spatially accurate photomosaic images.	HARA MARA ASARA WCPRA	Annually, or on an as-needed basis, up to 30 DAS.	Cable ties, stainless steel pins, camera	Temporarily deployed on the seafloor to mark off plots, removed once photos are taken.	
5) Coral Reef Benthic Habitat Mapping	Produces comprehensive digital maps of coral reef ecosystems using multibeam sonar surveys and optical validation data collected using towed vehicles and AUVs.	HARA MARA ASARA WCPRA	Year-round, up to 30 DAS Day and night	Active acoustics (will vary by vessel): Multibeam Simrad EM3002 D and EM300, multibeam Reson 8101 ER, Imagenex 837 DeltaT, split-beam Simrad EK60	38-300 kHz	Continuous

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
6) Deep Coral and Sponge Research	Research includes opportunistic surveys on distribution, life history, ecology, abundance, and size structure of deep corals and sponges using ROV, divers, and submersibles. Besides visual surveys, sampling protocols include collection of coral and sponges for genetic, growth and reproductive work and an array of data loggers (temperature, currents, particulate load) placed on the bottom for recovery in future years.	HARA MARA ASARA WCPRA	Opportunistically, depending on ship availability Year-round, 50 DAS	Remotely operated vessel (ROV), divers, submersibles, AUV, landers, instrument packages, Ship-based multibeam echosounders (SeaBeam 3012 multibeam, EK-60 18kHz, Knudsen 3260 sub-bottom profiler 3.5 kHz)	ROVs include the Super Phantom S2 ROV system operated by the Undersea Vehicles Program at the University of North Carolina at Wilmington. Subs include Pices V and Pices IV and similar Human Occupied Vehicles (HOV) AUV includes Seabed and other unmanned systems Hull-mounted 3.5-30 kHz multibeam	HARA: 200 MARA: 200 ASARA: 200 WCPRA: 200 DNA specimens N=100, mean weight (wt) = 10 grams (g) Voucher specimens N=60 wt = 10-500 g Paleo-specimens N=40, wt=500-2000 g
7) Insular Fish Life History Survey and Studies	Provide size ranges of deepwater eteline snappers, groupers, and large carangids to determine sex-specific length-at-age growth curves, longevity estimates, length and age at 50% reproductive maturity within the Bottomfish Management Unit Species (BMUS) in Hawaii and the other Pacific Islands Regions. Specimens are collected in the field and sampled at markets.	HARA: (0.2 - 5 nm from shore) every year. MARA ASARA WCPRA	HARA: July-September, up to 15 DAS/yr. Other areas: Year-round, up to 30 DAS for each research area once every three years Day and night	Hook-and-line	Hand line, Electric or hydraulic Reel: Each operation involves 1-3 lines with.4-6 hooks per line; soaked 1-30 min. Squid bait on circle hooks (typically 10/0 to 12/0).	HARA: 350 operations per survey per year Other areas: 240 operations per survey per year for each research area
8) Pacific Reef Assessment and Monitoring	Ecosystem surveys that include rapid ecological assessments; towed-	HARA MARA ASARA	Year-round; Annual (each research area is surveyed triennially) 30-120 DAS depending on which area is surveyed	Hand gear used by SCUBA and free divers.	Spear gun, slurp gun (a clear plastic tube designed to catch small fish by sliding a plunger backwards	MARA: Ad hoc fish collections from 2009, less

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
Program (RAMP)	diver surveys; coral disease, invertebrates, fish, and algae surveys; and oceanographic characterization of coral reef ecosystems. Surveys also include training to conduct surveys which occur between 0-3nm from shore, year-round, using small boats, Self-Contained Underwater Breathing Apparatus (SCUBA) or closed circuit rebreathers (CCR) diver surveys, sampling, and deployment of various equipment. Samples and specimens collected in the field would be analyzed in the laboratory.	WCPRA; 0-20 nm from shore	In-water activities with divers are conducted during the day, all other activities are conducted day and night	EARs, Water samplers (programmable Under water Collection Units [PUCs], Remote Access Samplers [RAS], Surface Temperature Recorders [STRs], Water Temperature Recorders [WTRs], and hand collecting devices) Carbonate sensing instruments [SEAFET (pH), SAMI (pH), SAMI (pCO_2)] Calcium Acidification Units (CAUs) Bioerosion Monitoring Units (BMUs)	out of the tube), hand net, including small boat operations with SCUBA Hammer, chisel, bone cutter, shears, scissors, clippers, scraping, syringe, core-punch, hand snipping Temporary transect line, surface marker buoy, 1 m long plastic spacer pole with camera. Sensors are deployed by use of ~ 70 pound (lb.) anchors guided into place by divers. CTD sized instruments are anchored to a dead portion of the reef with coated weights and cable ties typically deployed at 5-30 m depth.	than 20 specimens. Up to 500 samples per year including corals, coral products, algae and algal products, and sessile invertebrates, fragments to entire individuals/colonies 25 EARs per year, typically deployed for 1-3 years 500 water samples per year, deployed 1-7 days 150 deployments per year, deployed for approximately 1-3 years Up to 500 BMUs and CAU per year Collection of 1900 cm^3 of live rock (e.g., dead Porites sp.) to provide clean

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
						coral skeletons to generate new BMUs to measure bio erosion rates, and study bio erosion.
				Pneumatic/hydraulic drill for coral coring	Approx. 4 cm masonry drill bit used to extract a 2.5 x 5-70 centimeter (cm) sample	30 coral cores per survey per year
				Active acoustics: will vary by vessel (Multi-beam: Reson8101 ER; split-beam: Simrad EK60)	38-200 kHz	Continuous
				BMUs	1 x 2 x 5 cm pieces of relic calcium carbonate, placed next to the reef and deployed at 0-40 m	150 deployments per survey per year, deployed for approximately 1-3 years.
				Autonomous reef monitoring structures (ARMS)	36 x 46 x 20 cm structure placed on pavement or rubble (secured to bottom by stainless steel stakes and weights) in proximity to coral reef structures	150 deployments for a duration of typically1-3 yr. each
				Sea Bird Electronics SBE56 temperature recorders	Instrument and mounting brackets are 10 x 5 x 30 cm, anchored to a dead portion of the reef with two coated 3 lb. dive weights and cable ties, typically deployed at 5-25 m, but may reach 30 m	Typically deployed for 1-3 years
				ADCP	Nortek Aquadopp Sideseeing Profiler, 2 megahertz (MHz) down to 30 m	Continuous during transects
				CTD profiler (shallow-water and deep-water)	Shallow-water CTDs will be conducted from small boats to a depth of 30 meters Deep-water CTDs will be conducted from larger vessels to a maximum depth of 500 m.	Hundreds to thousands of casts per survey per year

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
				Baited remote underwater video system (BRUVS)	35 kg system weight with 1 kilogram (kg) of bait Deployed down to100 m to the seafloor	Up to 600 deployments per survey per year Deployed for approx. 1 hour
				CAUs	Each CAU consists of 2 PVC plates (10 x 10 cm) separated by a 1 cm spacer and mounted on a stainless steel rod which is installed by divers into the bottom (avoiding corals) down to 30 m	150 deployments per survey per year Deployed for approximately 1-3 years
	UAS would be used to collect coral reef ecosystem mapping & monitoring data. Initially testing and field trials would be conducted using multispectral, hyperspectral, or IR sensors. Surveys would be conducted around the MHI.	HARA MARA ASARA WCPRA		UASs (e.g., NOAA PUMA or NASA Ikhana systems, hexacopter)	Deployed from shore, small boat, or ship. Operate along shoreline or over water around atoll.	Less than 20 operations per island or atoll per year
	USV – Unmanned Surface Vehicles	HARA MARA ASARA WCPRA Nearshore areas		*Emily* Unmanned Survey Vehicle (USV) will be used to conduct nearshore sampling of surface and bottom variables, as well as ambient atmospheric conditions near the USV.		
	Visual reef fish surveys	HARA MARA ASARA WCPRA	Year-round, additional 21 DAS	SCUBA and free divers	Visual fish identification and abundance surveys, benthic photo-transect	None
	Photomosaics to collect coral community composition data.	HARA MARA ASARA WCPRA	Year-round, 30-120 DAS depending on area surveyed.	SCUBA, digital cameras and video camera	Camera system with two SLR digital cameras and a single video camera mounted to a custom frame.	None

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	Carbonate budget assessments to assess reef material production rates	HARA MARA ASARA WCPRA	Year-round, 30-120 DAS depending on area surveyed.	SCUBA divers	Visual benthic, fish, and urchin identification, size, and abundance surveys	None
9) Surface Night-Light Sampling	Conducted opportunistically for decades aboard PIFSC research vessels. Sampling goals: collect larval or juvenile stages of pelagic or reef fish species that accumulate within surface slicks during daylight hours and those attracted to surface and submerged lights from research vessels at night.	HARA; primarily 1-25 nm from shore; adjacent to the Kona coast, but also out to 200 nm and beyond in the WCPRA	Year-round Up to 30 DAS Along with scheduled NOAA research cruises or opportunistically aboard other vessels. Conducted during the night	Net (dip)	Scoop nets (0.5 m diameter sometimes attached to 3-4 m long poles) used while vessel is drifting	30 night-light operations on all vessels combined. Total catch (all species) ≤ 1,500 specimens of larval or juvenile fish per year

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
10) Pelagic Troll and Handline Sampling	Surveys would be conducted to collect life history and molecular samples from pelagic species. Other target species would be tagged-and-released. Different tags would be used depending upon the species and study, but could include: passive, archival, ultrasonic, and satellite tags. Fishery observers or NOAA scientists conduct on-board documentation of catch and survival.	HARA, MARA, ASARA, 0 to 24 nm from shore (excluding any special resource areas)	Variable, up to 14 DAS Day and night	Pelagic troll and handline (hook-and-line) fishing. NOAA research vessels or the equivalent, or contracted fishing vessels.	Troll fishing with up to 4 troll lines each with 1-2 baited hooks or 1-2 hook trolling lures at 4-10 kts. Pelagic handline (hook-and-line) fishing at primarily 10-100 m midwater depths and down to bottomfish depths of 600 m, with hand, electric, or hydraulic reels. Up to 4 lines. Each line is baited with 4 hooks.	A total of up to 2 operations of any of these gear types per DAS, totaling 28 operations (all types combined) for the survey.
11) West Hawaii Integrated Ecosystem Assessment Cruise	Survey transects conducted off the Kona coast and Kohala Shelf area to develop ecosystem models for coral reefs, socioeconomic indicators, circulation patterns, larval fish transport and settlement. Sampling includes active acoustics to determine relative biomass density of sound scattering layers; trawls to sample within the scattering layers; cetacean observations;	HARA; 2-10 nm from shore	Variable timing, depending on ship availability, up to 10 DAS Day and night	Large-mesh midwater Cobb trawl	Tow speed: 3 kts Duration: 60-240 min Depths: Deployed at various depths during same tow to target fish at different water depths, usually to 200 m	15-20 tows per survey per year
				Hook-and-line	Electric or hydraulic reel: Each operation involves 1-3 lines, with squid lures, soaked 10-60 min at depths between 200m to 600m.	No more than 50 hours of effort. Approximately 10 mesopelagic squid caught per year
				Small-mesh surface and midwater trawl nets (Isaacs-Kidd 6-ft and 10-ft, neuston, ring, bongo nets, 1-m plankton drop net)	Tow speed: 3 kts Duration: up to 60 min Depth: 0-200 m	15-20 tows per survey per year (any combination of the nets described)

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	surface and water column oceanographic measurements and water sample collection. This survey is usually performed along with passive acoustic surveys as described under the Cetacean Ecological Surveys			Active acoustics (split-beam: Simrad EK60; trawl mounted OES Netmind; Didson 303)	Hull mounted: 38-200 kHz Surveys typically from surface to 1000 m depth Didson is usually operated between 400 m and 700 m depth. Range is 30 m	Intermittent continuous during surveys Up to 12 Didson casts for up to 120 min per survey.
				ADCP (RD Instruments Ocean Surveyor 75)	75 kHz	Intermittent continuous during surveys
				CTD profiler	90 min/cast	50 tows per survey per year, alternating with Oceanography Cruise
12) Sampling of Juvenile-stage Bottomfish via Settlement Traps	Sampling activity to capture juvenile recruits of eteline snappers and grouper that have recently transitioned from the pelagic to demersal habitat. The specimens will provide estimates of birthdate, pelagic duration, settlement date, and pre- and post-recruitment growth rates derived from the analysis of otoliths. The target species include Deep-7 bottomfish and the settlement habitats these stages are associated with.	MHI; 0.2-5 nm from shore	July-September Up to 25 DAS Day and night	Trap (Settlement)	Cylindrical with dimensions up to 3 m long and 2 m diameter. Frame composed of semi-rigid plastic mesh of up to 5 cm mesh size. Folded plastic of up to 10 cm mesh is stuffed inside as settlement habitat, and cylinder ends are then pinched shut. Traps are clipped throughout the water column onto a vertical line anchored on bottom at up to 400 m, supported by a surface float.	10 traps per line set; up to 4 line sets soaked per day, from overnight up to 3 days. Up to 100 lines of traps set per year. Catch of 2500 juvenile stage bottomfish per year
13) Barbless Hook Donation	Donations of barbless circle hooks are made primarily at shore-based fishing tournaments or	HARA	Year round, no DAS Conducted during the day	Barbless circle hooks	Hooks have the barbs crimped flat (barbs effectively removed)	Up to 35 events (days of donating hooks) per year. Up to 35,000

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	other outreach events to encourage replacement of barbed hooks in normal (legal) use. PIFSC has no control over the use of the hooks after the donation.					hooks donated per yr
14) Insular fish Abundance Estimation Comparison Surveys	Comparison of Fishery-Independent Methods to Survey Bottomfish Assemblages in the MHI: Coordinated research between PIFSC ESD and FRMD, State of Hawaii Department of Land and Natural Resources, University of Hawaii at Manoa, University of Miami. Day and night* surveys are used to develop fishery-independent methods to assess stocks of economically important insular fish. Methods include: active acoustics, stereo baited underwater video camera systems (BotCam, Modular Optical Underwater Survey System [MOUSS], BRUVS), AUV equipped with stereo video cameras, towed optical assessment device (TOAD), and hook-and-line fishing.	HARA MARA ASARA WCPRA	Variable, up to 30 DAS per research area per year, HARA surveyed annually, ASARA, WCPRA surveyed every 3 years	Hook-and-line	Hand, Electric, Hydraulic reels. Each vessel fishes 2 lines. Each line is baited with 4-6 hooks. 1-30 minutes per fishing operation.	HARA: 7,680 operations per year MARA: 1.920 every 3rd year (average 640 operations per year) ASARA: 1,920 every 3rd year (average 640 per year) WCPRA: 1,920 every 3rd year (average 640 per year)
				Active acoustics (split multi-beam: Reson8101 ER; deep water: Simrad EK60; trawl mounted OES Netmind), various fish finder devices	Hull mounted 38-240 kHz	Intermittent continuous during surveys
				Underwater Video Camera (BotCam BRUVS, MOUSS)	Duration: deployed 30-60 min. Depth: 350m	HARA: 7,680 drops per year MARA: 1.920 every 3rd year (average 640 per year) ASARA: 1,920 every 3rd year (average 640 per year) WCPRA: 1,920

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
						every 3rd year (average 640 per year)
				AUV	Speed: 0.5 kts Duration: 3 hours/deployment	HARA: 480 deployments per year MARA: 80 every 3rd year (average 27 per year) ASARA: 80 every 3rd year (average 27 per year) WCPRA: 80 every 3rd year (average 27 per year)
				ROV	Duration: 1 hr	HARA: 480 deployments per year MARA: 80 every 3rd year (average 27 per year) ASARA: 80 every 3rd year (average27 per year) WCPRA: 80 every 3rd year (average 27 per year)
				TOAD	Tow speed: 6 kts Duration: 1 hr	HARA: 480 per year MARA: 80 every 3rd year (average 27 per year) ASARA: 80 every 3rd year (average 27 per year)

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
						WCPRA: 80 every 3rd year (average 27 per year)
				Niskin bottles attached to ship's CTD, MOUSS frame (aboard small boats), or equivalent	Bottles attached to frame would be triggered at different depths (10 – 1000 m). Water would be stored and processed upon conclusion of the cruise.	250 casts / 250 L of water per research area per year
				Ship-based multibeam echosounders (SeaBeam 3012 multibeam, EK-60 18kHz, Knudsen 3260 sub-bottom profiler 3.5 kHz)	Hull mounted	Intermittent continuous during surveys
15) Gear and Instrument Development and Field Trials	Field trials to test the functionality of the gear prior to the field season or to test new gear or instruments described elsewhere in this table, but outside the geographic scope specified for other surveys.	HARA (Primarily in the waters south of Pearl Harbor on the Island of O'ahu)	Year-round, up to 15 DAS Day and night	Nets, lines, instruments Calibration of Simrad EK60	38-200 kHz	Intermittent for 24-48 hours
16) Mariana Resource Survey	Sampling activity to quantify baseline bottomfish and reef fish resources in the MARA. Various artificial habitat designs will be developed, enclosed in mesh to retain captures, and evaluated. Cobb trawl and Isaacs-Kidd trawls will collect pelagic-stage specimens of reef fish and bottomfish species.	MARA 0-25 nm from shore	May - August Up to 102 DAS (once every three years) Midwater trawls are conducted at night, surface trawls are conducted day and night In-water activities are conducted during the day All other activities are day or night	Large-mesh midwater Cobb trawl	Tow speed: 3 kts Duration: 60-240 min trawls; 2 tows per night Depth(s): Deployed at various depths during same tow to target fish at different water depths, usually between 100 m and 200 m	15-20 tows per survey per year
				Small-mesh surface and midwater trawl nets (Isaacs-Kidd, neuston, ring, bongo nets)	Tow speed: 3 kts Duration: up to 60 min Depth: 0-200 m	15-20 tows (any combination of the nets described) per survey per year

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	Large fish traps (1m x 1m x 2m) will be deployed overnight to assess bottomfish composition relative to hook-and-line fishing and the quality of each habitat for recent recruits. Traps will be set along or perpendicular to the bottom contour primarily in mesophotic habitats (50-200 m depths) and in deep-slope bottomfish habitats (200-500 m).			Traps (Kona crab, enclosure)	Nylon nets, meshing 2 1/2 inches attached to a wire ring with bait. Up to ten nets can be tied together with a buoy on the end. Soak for about 20 min. Enclosure traps are Fathoms Plus shellfish "lobster" traps or similar. dome-shaped, single-chambered, two entrance cones with inside mesh dimensions of 45mm x 45mm. Weighted and baited with the remains of life history samples and attached to two surface floats. Two strings of six traps deployed at night on not coral substrate, and retrieved the next morning. Up to 20 traps per string, separated by 20 fathoms of ground line; two depths 10-35 fathoms. Up to 2 strings per DAS. Trap dimensions up to 1m high, 1 m wide, and 2 m long. Traps have outer mesh covering from 0.5-3.0 inch mesh and 1-2 funnel entrances. Trap is baited with fish using an inside baiter. Trap door swings open to retrieve catch and baiter.	25 gear sets per cruise Up to 400 strings set per survey per year
				Simrad split-beam EK60, OES Netmind	38-200 kHz	Intermittent continuous during surveys
				Hook-and-line	Electric or hydraulic reel: Each operation involves 1-3 lines, with squid lures, soaked 10-60 min at depths between 200 m to 600 m.	1000 sets per survey per year
				Divers (spear)	Speargun	1000 reef fish

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
17) Pelagic Oceanographic Cruise	Investigate physical (e.g., fronts) and biological features that define the habitats for important commercial and protected species of the North Pacific Ocean, especially tuna and billfishes, which are targeted by longline fishers. Sampling includes active acoustics to determine relative biomass density of sound scattering layers; trawls to sample within the scattering layers; surface and water column oceanographic measurements and water sample collection.	Pacific Ocean; Western and Central tropical and subtropical Pacific 25-1000 nm from shore in any direction	Annual (season variable) Up to 30 DAS Midwater trawls are conducted at night, surface trawls are conducted day and night All other activities are conducted day and night	Large-mesh midwater Cobb trawl Plankton drop net (stationary surface sampling)	Tow speed: 3 kts Duration: 60-240 min 1-meter diameter plankton drop net would be deployed down to 100 m	20 tows per year, alternating with West Hawai‘i IEA cruise 4 liters of micronekton per tow 20 drops per year (collections would be less than one liter of plankton)
				Small-mesh surface and midwater trawl nets (Isaacs-Kidd, neuston, ring, bongo nets)	Duration: up to 60 min Depth: 0-200 m	15-20 tows (any combination of the nets described) <1 liter of organisms per tow
				Active acoustics (split multi-beam: Reson8101 ER; deep water: Simrad EK60, OES Netmind)	38-200 kHz	Intermittent continuous during surveys
				ADCP (RD Instruments Ocean Surveyor 75)	75 kHz	Intermittent continuous during surveys
				CTD profiler	45-90 min cast duration	60 casts per year, alternating with West Hawai‘i IEA cruise 60 tows/year
18) Lagoon Ecosystem Characterization	Measure the abundance and distribution of reef fish (including juvenile bumphead parrotfish) in any of the lagoons in the WCPRA over a two-week-long period by	Throughout WCPRA	Up to 14 DAS Conducted during the day	Divers with Hand Net or speargun	SCUBA, snorkel, 12-inch diameter small mesh hand net	10 dives per survey 10 fin clips collected for genetic analyses

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	employing standardized transect and photo-quadrant techniques using SCUBA and snorkeling gear. A collection net may also be used to non-lethally sample fish species inhabiting the lagoon to determine genetic identity. Hook-and–line and spear may also be used to lethally collect specimens.					
				Hook-and-line	Standard rod and reel using lures or fish bait from shoreline or small boat	1-30 min casts 60 casts per survey
19) Pelagic Longline, Troll, and Handline Gear Trials	Investigate effectiveness of various types of hooks, hook guards, gear configurations, or other modified fishing practices for reducing the bycatch of non-target species and retaining or increasing target catch. Data collected on catch efficacy, fish size, species selectivity, and survival upon haul-back Investigate the vertical distribution of pelagic species catch and capture time with TDRs and hook-timers. Investigate behavior of catch and bycatch in	25 to 500 nm from shore (excluding any special resource areas).		Trolling and handline (hook-and-line)	Troll fishing with up to 4 troll lines each with 1-2 baited hooks or 1-2 hook troll lures at 4-10 kts Pelagic handline (hook-and-line) fishing at 10-100 m midwater depths, with hand, electric, or hydraulic reels. Up to 4 lines. Each line is baited with 4 hooks. Up to 4 hrs per troll or handline operation	Up to 21 troll or handline (combined) operations per survey per year

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	relation to fishing operations using cameras, hydrophones, or other sensors. Catch may be tagged and released and specimens may be kept for genetic, physiological, and ecological studies. Troll and handline fishing for pelagic species may also be investigated, with tag and release of catch and collection of specimens.					
		HARA MARA ASARA WCPRA	Up to 60 DAS per year	Tags (SPOT, SPAT, miniPAT, dart tags, Coded 69 kHz acoustic transmitters (V16 Vemco).	SPOT = up to 87 x 37 x 23 millimeter (mm) and 57 g fin mounted tags SPAT = 124 x 38 mm and 60 g attached by tether and anchor miniPAT = 124 x 38 mm and 60 g attached by tether and anchor Dart tags = 160 x 1.6 mm attached at base of dorsal fin Acoustic transmitters = 90 x 9 mm, surgically implanted into abdominal wall	50 sharks/year per species (Bigeye thresher, silky, whale, Blue, pelagic thresher, mako spp., mobulid spp.), 3 milliliter (ml) blood samples from the same sharks
20) Fishing Impacts of Non-Target Species	Bycatch reduction research, post release survival and ecological research on sharks commonly encountered in recreational, commercial purse seine and longline fisheries in the Pacific Ocean. Research would include post-release survival studies to identify and develop best handling	HARA MARA ASARA WCPRA	Up to 60 DAS per year	Microwave Telemetry Inc. Pop-off Satellite Archival Transmitting Tags (PSATs,), acoustic tags or conventional identification tags. From small boats used in the tuna fisheryTags (SPOT, SPAT, miniPAT, dart tags, Coded 69 kHz acoustic transmitters (V16 Vemco).	Fishing techniques that might interact with these sharks include: nighttime handline fishing, trolling, jigging, bottom-fishing and spearfishing. SPOT = up to 87 x 37 x 23 millimeter (mm) and 57 g fin mounted tags SPAT = 124 x 38 mm and 60 g attached by tether and anchor miniPAT = 124 x 38 mm and 60 g attached by tether and anchor Dart tags = 160 x 1.6 mm attached at base of dorsal fin	About 27 individuals may be captured and tagged in a given year 50 sharks/year per species (Bigeye thresher, silky, whale, Blue, pelagic thresher, mako spp., mobulid spp.), 3 milliliter (ml)

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
	methods in recreational, purse seine and longline fisheries for improved post-release survival rates and ensuring crew safety. The deployment and analysis of electronic tags would generate robust post-release survival estimates which would improve the rigor of stock assessments and aid in the development of best handling practices for fisheries impacting shark populations.				Acoustic transmitters = 90 x 9 mm, surgically implanted into abdominal wall	blood samples from the same sharks
22) Giant Manta Ray Tagging	Tagging, tracking and biological sampling of giant manta rays incidentally caught in Pacific longline and purse seine fisheries. Research activities would be directed by PIFSC and include training fishery observers to tag, photograph, collect tissue samples and/or collect interaction data from giant manta rays captured incidentally during fishing operations in the western and central Pacific ocean	HARA	Annual (season variable) Up to 20 DAS, daytime operations	Plankton drop net (stationary surface sampling)	1-meter diameter plankton drop net would be deployed down to 100 m	200 drops per year (collection total would be less than five liters of plankton)
23) Coastal Pelagic Ecology,	Investigate physical and			Small-mesh surface nets (neuston, ring, bongo nets)	Duration: up to 60 min Depth: 0-100 m	15-20 tows (any combination of

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
Coastal Fishery Oceanography, Opelu Koas	biological features that define the key habitats for important coastal pelagic species around Hawaiian Islands, especially the mackerel scad locally called opelu, *Decapterus macarellus*, which are targeted by fishers and an important forage fish for the coastal pelagic ecosystem. Sampling includes using 360-degree video cameras in the water column; scientific fishing operations; plankton nets; surface and water column oceanographic measurements; water sample collection for biogeochemical properties, physical properties, and eDNA. These surveys will be conducted in waters within and adjacent to these key habitats.					the nets described) <1 liter of organisms per tow
				CTD profiler (portable unit)	15-30 min cast duration	60 casts per year
				360 degree video camera	Less than 1 hour duration	Up to 20 deployments per year
				Hook-and-line	Standard rod and reel using jigging lures from small boat at ~ 25 meters depth	2 lines used at daytime only. 10-20 small boat trips per year. Less than one hour per trip.

Survey Name	Survey Description	General Area of Operation*	Season, Frequency& Yearly Days at Sea (DAS)	Gear Used	Gear Details (Approx.)	Total Number of Samples (Approx.)
				Water sample collection	Duration: 15-30 min; Depth:0-100m; Water samples collected at depths ranging from 0 – 100 m. Water would be collected in Niskin bottles and decanted into 10 L carboys for processing.	60 casts per year
				Water sample collection	Duration: 15-30 min; Depth:0-100m; Water samples collected at depths ranging from 0 – 100 m. Water would be collected in Niskin bottles and decanted into 10 L carboys for processing.	60 casts per year

Table 2. Proposed Mitigation and Monitoring Measures.

Proposed Activities	Mitigation and Monitoring Measures
Midwater Trawl Surveys	<u>Visual Monitoring Measures</u> • The officer on watch, Chief Scientist (or other designee), and crew standing watch visually scan for marine mammals, sea turtles, and other ESA-listed species (protected species) using binoculars. The monitor should have no other duties while monitoring and should be trained in species identification methods. Because trawling is typically conducted at night, sight distance is generally limited to no more than 20 m beyond the ship. If trawling is conducted during the day, an approximately 1-km radius is scanned. <u>Operational Procedures</u> • "Move-on" Rule: When trawling is conducted during the day, if any marine mammals are sighted by the Chief Scientist or designee within a 1 km radius of the vessel in the 30 minutes before setting the gear, the vessel may be moved away from the animals to a different section of the sampling area if the animals appear to be at risk of interaction with the gear at the discretion of the officer on watch in consultation with the Chief Scientist. When trawling is conducted at night, the visible distance would be limited to 20 m. Small moves within the sampling area can be accomplished without leaving the sample station. After moving on, if marine mammals are still visible from the vessel and appear to be at risk, the officer on watch

Proposed Activities	Mitigation and Monitoring Measures
	may decide, in consultation with the Chief Scientist, to move again or to skip the station. The officer on watch will first consult with the Chief Scientist or other designated scientist and other experienced crew as necessary to determine the best strategy to avoid potential takes of these species based on those encountered, their numbers and behavior, position and vector relative to the vessel, and other factors. For instance, a whale transiting through the area and heading away from the vessel might not require any move or only require a short move from the initial sampling site while a pod of dolphins gathered around the vessel may require a longer move from the initial sampling site or possibly cancellation of the station if they follow the vessel. In most cases, trawl gear is not deployed if marine mammals have been sighted from the ship in the previous 30 minutes unless those animals do not appear to be in danger of interactions with the trawl, as determined by the judgment of the Chief Scientist and officer on watch. The efficacy of the "move-on" rule is limited during nighttime or other periods of limited visibility; although operational lighting from the vessel illuminates the water in the immediate vicinity of the vessel during gear setting and retrieval. • Trawl operations are usually the first activity undertaken upon arrival at a new station in order to reduce the opportunity to attract marine mammals and other protected species to the vessel. However, in some cases, CTD casts may immediately precede trawl deployment. The order of gear deployment is determined on a case-by-case basis by the Chief Scientist based on environmental conditions and other available information at the sampling site. Other activities, such as water sampling or plankton tows, are conducted in conjunction with, or upon completion of, trawl activities. • Once the trawl net is in the water, the officer on watch, the Chief Scientist or other designated scientist, or crew standing watch continue to monitor the waters around the vessel and maintain a lookout for marine mammal presence as far away as environmental conditions allow (as noted previously, visibility is very limited during night trawls). If these species are sighted before the gear is fully retrieved, the most appropriate response to avoid incidental take is determined by the professional judgment of the officer on watch, in consultation with the Chief Scientist or other designated scientist and other experienced crew as necessary. These judgments take into consideration the species, numbers, and behavior of the animals, the status of the trawl net operation (net opening, depth, and distance from the stern), the time it would take to retrieve the net, and safety considerations for changing speed or course. Generally, if a marine mammal is incidentally caught, it would happen during haul-back operations, especially when the trawl doors have been retrieved and the net is near the surface and no longer under tension. The risk of catching an animal may be reduced if the trawling continues and the haul-back is delayed until after the marine mammal has lost interest in gear, or left the area. In other situations, swift retrieval of the net or cutting the cables may be the best course of action. The appropriate course of action to minimize the risk of incidental take of protected species is determined by the professional judgment of the officer on watch and appropriate crew based on all situation variables, even if the choices compromise the value of the data collected at the station.

	Mitigation and Monitoring Measures
	• If trawling operations have been delayed because of the presence of marine mammals, the vessel resumes trawl operations (when practicable) only when these species have not been sighted within 30 minutes or else otherwise determined to no longer be at risk. This decision is at the discretion of the officer on watch and will depend upon the circumstances of the situation. • Care is taken when emptying the trawl, including opening the cod end, as close to the deck as possible in order to avoid damage to protected species that may be caught in the gear but are not visible upon retrieval. The gear is emptied as quickly as possible after retrieval in order to determine whether or not protected species are present. It may be necessary to cut the net to remove the protected species. Tow Duration • Standard tow durations for midwater Cobb trawls are between two and four hours as target species are relatively rare, and longer haul times are necessary to acquire the appropriate scientific samples. However, trawl hauls will be terminated and the trawl retrieved upon the determination and professional judgment of the officer on watch, in consultation with the Chief Scientist or other designated scientist and other experienced crew as necessary, that this action is warranted in order to avoid an incidental take. Marine mammal excluder devices • PIFSC currently uses two types of midwater trawl nets; the Cobb trawl and the Isaacs-Kidd trawl. The Cobb trawl and the Isaacs-Kidd trawl have been used throughout the Pacific Islands Region (PIR) with no interactions with protected species. There are no plans to develop or install marine mammal excluder devices for these types of trawls in this region. Speed limits and course alterations • Vessel speeds are restricted on research cruises in part to reduce the risk of ship strikes with marine mammals. Transit speeds vary from six to ten knots, but average nine knots. The vessel's speed during active Cobb trawl operations and active acoustic surveys is typically two to four knots due to trawl net and sea-state constraints. Thus, these much slower speeds greatly reduce the risk of ship strikes. In addition, PIFSC research vessel captains and crew watch for marine mammals while underway during daylight hours and take necessary actions to avoid them. • At any time during a survey or while in transit, any crew member that sights marine mammals that may intersect with the vessel course immediately communicates their presence to the bridge for appropriate course alteration or speed reduction as possible to avoid incidental collisions, particularly with large whales.

Proposed Activities	Mitigation and Monitoring Measures
	Gear modifications • As applicable, sinking line would be used for approximately the top 1/3 of the line. The other approximately lower 2/3 would still be floating line. This configuration would allow any excess scope in the line to sink to a depth where it would be below where most whales and dolphins commonly occur. Specific line lengths, and ratios of floating line to sinking line, would vary with actual depth and the total line length. This mitigation measure would not preclude the risk of whales or dolphins swimming into the submerged line, but this risk is believed to be lower relative to line floating on the surface.
Longline Gear	Operational Procedures Longline research is currently conducted in conjunction with commercial fisheries, and operational characteristics of the longline gear follows the requirements specified in 50 Code of Federal Regulations (CFR) 229, 300, 404, 600, and 665. PIFSC will generally follow the following procedures when setting and retrieving longline gear: • When shallow-setting anywhere and setting longline gear from the stern: Completely thawed and blue-dyed bait will be used (two 1-lb. containers of blue-dye will be kept on the boat for backup). Fish parts and spent bait with all hooks removed will be kept for strategic offal discard. Retained swordfish will be cut in half at the head; used heads and livers will also be used for strategic offal discard. Setting will only occur at night and begin 1 hour after local sunset and finish 1 hour before next sunrise, with lighting kept to a minimum. • When deep-setting north of 23°N and setting longline gear from the stern: 45 g or heavier weights will be attached within 1 m of each hook. A line shooter will be used to set the mainline. Completely thawed and blue-dyed bait will be used (two 1-lb. containers of blue-dye will be kept on the boat for backup). Fish parts and spent bait with all hooks removed will be kept for strategic offal discard. Retained swordfish will be cut in half at the head; used heads and livers will also be used for strategic offal discard. • When shallow-setting anywhere and setting longline gear from the side: Mainline will be deployed from the port or starboard side at least 1 m forward of the stern corner. If a line shooter is used, it will be mounted at least 1 m forward from the stern corner. A specified bird curtain will be used aft of the setting station during the set. Gear will be deployed so that hooks do not resurface. 45 g or heavier weights will be attached within 1 m of each hook. • When deep-setting north of 23°N and setting longline gear from the side: Mainline will be deployed from the port or starboard side at least 1 m forward of the stern corner. If a line shooter is used, it will be mounted at least 1 m forward from the stern corner. A specified bird curtain will be used

Proposed Activities	Mitigation and Monitoring Measures
	aft of the setting station during the set. Gear will be deployed so that hooks do not resurface. 45 g or heavier weights will be attached within 1 m of each hook. • The "move-on" rule may be implemented if any protected species are present near the vessel and appear to be at risk of interactions with the longline gear; longline sets are not made if marine mammals or sea turtles have been seen within in 1km from the vessel within the past 30 min and represent a potential for interaction with the longline gear, as determined by the professional judgment of the Chief Scientist or officer on watch. Longline gear is always the first equipment or fishing gear to be deployed when the vessel arrives on station. Longline gear is set immediately upon arrival at each station provided the conditions requiring the move-on rule have not been met. • If marine mammals are detected while longline gear is in the water, the officer on watch exercises similar judgments and discretion to avoid incidental take of these species with longline gear as described for trawl gear. The species, number, and behavior of the protected species are considered along with the status of the ship and gear, weather and sea conditions, and crew safety factors. The officer on watch uses professional judgment and discretion to minimize risk of potentially adverse interactions with protected species during all aspects of longline survey activities. • If marine mammals are detected during setting operations and are considered to be at risk, immediate retrieval or halting the setting operations may be warranted. If setting operations have been halted due to the presence of these species, setting does not resume until no marine mammals have been observed for at least 30 min. • If marine mammals are detected while longline gear is in the water and are considered to be at risk, haul-back is postponed until the officer on watch determines that it is safe to proceed. Marine mammals caught during longline fishing are typically only caught during retrieval, so extra caution must be taken during this phase of sampling. Gear Modifications • Use of sinking line as described above for trawl surveys.

Proposed Activities	Mitigation and Monitoring Measures
Plankton Nets, Small-mesh Towed Nets, Oceanographic Sampling Devices, Active Acoustics, Video Cameras, AUV, and Remotely Operated Vessel (ROV) Deployments	• PIFSC deploys a wide variety of gear to sample the marine environment during all of their research cruises, such as plankton nets, oceanographic sampling devices, video cameras, low-power high-frequency active acoustics directed underneath the ship as a beam, AUVs and ROVs. It is not anticipated that these types of gear or equipment would interact with protected species and are therefore not subject to specific mitigation measures. However, the officer on watch and crew visually monitor for any unusual circumstances that may arise at a sampling site and use their professional judgment and discretion to avoid any potential risks to protected species during deployment of all research equipment (e.g., reduced boat speed). Often these types of gear are deployed from small boats, not ships, and therefore visual monitoring is the best measures to avoid interactions with protected species.
Reef Assessment and Monitoring Program and Marine Debris Research and Removal Activities	The following measures are carried out when working in and around shallow water coral reef habitats. These measures are intended to avoid and minimize impacts to protected species and benthic habitats, as well as avoid introducing non-native invasive species. These activities generally include small boat operations and divers in the water. <ins>Small Boat and Diver Operations</ins> • Transit from the open ocean to shallow-reef survey regions (depths of < 35 m) of atolls and islands should be no more than 3 nm, dependent upon prevailing weather conditions and regulations. Each team conducts surveys and in-water operations with at least 2 divers observing for the proximity of protected species sightings, a coxswain driving the small boat, and a topside spotter working in tandem. Topside spotters may also work as coxswains, depending on team assignment and boat layout. Spotters and coxswains will be tasked with specifically looking out for divers, protected species, and environmental hazards. • Divers, spotters, and coxswains undertake consistent due diligence and take every precaution during operations to avoid interactions with any listed species. Scientists, divers, and coxswains follow the Best Management Practices (BMPs) for boat operations and diving activities. These practices include but are not limited to the following precepts: 1. Constant vigilance shall be kept for the presence of protected species 2. When piloting vessels, vessel operators shall alter course to remain at least 100 m from marine mammals and at least 50 m from sea turtles 3. Reduce vessel speed to 10 km or less when piloting vessels in the proximity of marine mammals 4. Reduce vessel speed to 5 km or less when piloting vessels in areas of known or suspected turtle activity

Proposed Activities	Mitigation and Monitoring Measures
	5. Marine mammals and sea turtles should not be encircled or trapped between multiple vessels or between vessels and the shore 6. If approached by a marine mammal or turtle, put the engine in neutral and allow the animal to pass 7. Unless specifically covered under a separate permit that allows activity in proximity to protected species, all in-water work will be postponed until whales are within 100 yards or other protected species are within 50 yards. Activity will commence only after the animal(s) depart the area 8. Should protected species enter the area while in-water work is already in progress, the activity may continue only when that activity has no reasonable expectation to adversely affect the animal(s) 9. Do not attempt to feed, touch, ride, or otherwise intentionally interact with any protected species <u>Protocol for Minimizing Benthic Disturbance (including coral reefs)</u> • Research dives, using scuba, will focus on the goal of data collection for research and monitoring purposes. All care will be taken during anchoring small boats, with sand or rubble substrate targeted for anchorage to minimize benthic disturbance or coral damage. The operational area will be continuously monitored for protected species, with dive surveys being altered, postponed, or canceled and small boats on standby, neutral, or relocating to minimize disturbances or interactions. The anchor will be lowered rather than thrown, and a diver will check the anchor to make sure it does not drag or entangle any benthos or listed species. • ESA coral taxa would be collected as sparingly as possible and would never exceed more than 10 samples per taxon per cruise. Voucher samples would be small (2 cm by 2 cm) and would only be collected from well-established colonies using gloved hands or hammer and chisel with tools bleached between uses. <u>Protocol for Minimizing the Spread of Disease and Invasive Species</u> The following actions are routinely required to minimize the spread of diseases to coral reef organisms and spreading invasive species on equipment and vessels. *Equipment and Gear*

Proposed Activities	Mitigation and Monitoring Measures
	• Equipment (e.g., gloves, forceps, shears, transect lines, photographic spacer poles, surface marker buoys) in direct contact with potential invasive species, diseased coral tissues, or diseased organisms are soaked in a freshwater 1:32 dilution with commercial bleach for at least 10 min and only a disinfected set of equipment is used at each dive site. • All samples of potentially invasive species, diseased coral tissues, or diseased organisms are collected and sealed in at least 2 of a combination of bags or jars underwater on-site and secured into a holding container until processing. • Dive gear (e.g., wetsuit, mask, fins, snorkel, buoyancy compensator, regulator, weight belt, booties) is disinfected by one of the following ways: a 1:52 dilution of commercial bleach in freshwater, a 3 percent free chlorine solution, or a manufacturer's recommended disinfectant-strength dilution of a quaternary ammonium compound in "soft" (low concentration of calcium or magnesium ions) freshwater. Used dive gear is disinfected daily by performing the following steps: (1) physical removal of any organic matter and (2) submersion for a minimum of 10 min in an acceptable disinfection solution, followed by a thorough freshwater rinse and hanging to air dry. All gear in close proximity to the face or skin, such as masks, regulators, and gloves, are additionally rinsed thoroughly with potable water following disinfection. *Small Boats* • Small boats that have been deployed in the field are cleaned and inspected daily for organic material, including any algal fragments or other organisms. Organic material, if found, is physically removed and disposed of according to the ship's solid-waste disposal protocol or in approved secure holding systems. The internal and external surfaces of vessels are rinsed daily with freshwater and always rinsed between islands before transits. Vessels are allowed to dry before redeployment the following day. <u>Sea Turtles and Hawaiian Monk Seals</u> • To avoid interactions with listed species during surveys and operations, team members and small boat coxswains will monitor areas while in transit to and from work sites. If a listed species is sited, the vessel will alter course in the opposite direction. If unable to change course, the vessel will slow or come to a stop awaiting the animal to be clear of the boat as long as passenger safety is not compromised. Currently, there are no known strikes or incidental takes of a listed protected species from a vessel or propeller of a Pacific RAMP vessel in the Northwestern Hawaiian Islands (NWHI), or other surveyed areas around the Pacific. • As part of due diligence, protected species monitoring will continue throughout all dive operations by at least one team member aboard each boat and two divers working underwater. Operations will be altered and modified as previously listed.

Proposed Activities	Mitigation and Monitoring Measures
	• Mechanical equipment will also be monitored to ensure no accidental entanglements occur with protected species (e.g., with Passive Acoustic Monitoring [PAM] float lines, transect lines, and oceanographic equipment stabilization lines). Team members will immediately respond to an entangled animal, halting operations and providing an onsite response assessment (allowing the animal to disentangle itself, assisting with disentanglement, etc.), unless doing so would put divers, coxswains, or other staff at risk of injury or death. • Before approaching any shoreline or exposed reef, all observers will examine the beach, shoreline, reef areas, and any other visible land areas within the line of sight for marine mammals and sea turtles. The Pacific RAMP teams typically do not participate during terrestrial surveys and operations as part of their mandate, and, therefore, minimize the potential for disturbances of resting animals along shorelines. • Land vehicle (trucks) operations will occur in areas of marine debris where vehicle access is possible from highways or rural/dirt roads adjacent to coastal resources. Prior to initiating any marine debris removal operations, marine debris personnel (marine ecosystem specialists) will thoroughly examine the beaches and nearshore environments/waters for Hawaiian monk seals, false killer whales, green sea turtles, and hawksbill sea turtles before approaching marine debris sites and initiating removal activities. Debris will be retrieved by personnel who are knowledgeable of and act in compliance with all federal laws, rules and regulations governing wildlife in the Papahānaumokuākea Marine National Monument and Main Hawaiian Islands (MHI). This includes, but is not limited to: 1. Decontamination of clothing/soft gear taken ashore by prior freezing for 48 hours, or use of new clothing/soft gear as indicated by U.S. Fish and Wildlife Service (USFWS) regulations; 2. Avoidance of seabird colonies; and 3. Avoidance of marine turtles and Hawaiian monk seals, maintaining a minimum distance of 50 yards from all monk seals and turtles, and a minimum of 100 yards from female seals with pups.
Autonomous Underwater Vehicles (AUVs) and Unmanned Aircraft Systems (UAS)	• In order to minimize malfunction of the AUV's during operations, a pre-deployment test of all operating systems will be run to ensure that the AUV is operating correctly and there are no visually apparent physical defects in the AUV. • All AUV deployment missions will have a deployment and retrieval plan to minimize lag time in water and ensure that the AUV is properly retrieved. • In order to minimize the spread of invasive species, all AUV's will be inspected and cleaned of any organic material including algae and other organisms prior to deployment.

Proposed Activities	Mitigation and Monitoring Measures
	• All UAS will undergo a pre-flight test prior to deployment to ensure that the equipment is working properly and weather conditions are conducive to flying a mission. • All UAS operations will be conducted with a pilot and a spotter to ensure that the UAS is monitored at all times. • Should any UAS make an emergency landing in the water, small boats will be deployed immediately to retrieve the equipment to minimize potential for pollution (e.g. loss of gas or batteries into the marine environment). • A submersible dive plan will be in place for each dive that details each mission, locations, and deployment/recovery times to minimize the potential for collision with the substrate or groundings. • Each submersible will be inspected and cleaned of any organic material including algae other organisms, and chemicals, oils or other pollutants prior to deployment, in order to minimize the spread of invasive species and ensure no pollutants are released into the ocean.
Bottom Fishing Hook and Line Research Gear	• Researchers and contracted fishers will use pre-existing mapping data to avoid sensitive areas (areas of high coral cover) when conducting bottomfishing operations Visual monitoring for marine mammals before gear is set and implementation of the "move-on" rule as described for longline gear. • To avoid attracting any marine mammals to a bottom fishing operation, dead fish and bait will not be discarded from the vessel while actively fishing. Dead fish and bait may be discarded after gear is retrieved and immediately before the vessel leaves the sampling location for a new area. • If a monk seal, bottlenose dolphin, or other marine mammal is seen in the vicinity of a bottom fishing operation, then the gear would be retrieved immediately and the vessel would move to another sampling location where marine mammals are not present. • If a hooked fish is retrieved and it appears to the fisher that it has been damaged by a monk seal, then visual monitoring will be enhanced around the vessel for the next ten minutes. Fishing may continue during this time. If a shark is sighted, then visual monitoring would be returned to normal. If a monk seal, bottlenose dolphin, or other marine mammal is seen in the vicinity of a bottom fishing operation, then the gear would be retrieved immediately and the vessel would be moved to another sampling location where marine mammals are not present. Catch loss would be tallied on the data sheet, as would a "move-on" for a marine mammal. • If bottom fishing gear is lost while fishing, then visual monitoring will be enhanced around the vessel for the next ten minutes. Fishing may continue during this time. If a protected shark or ray, monk seal, bottlenose dolphin, or other marine mammal is seen in the vicinity, it would be observed until

Proposed Activities	Mitigation and Monitoring Measures
	a determination can be made of whether gear is sighted attached to the animal, gear is suspected to be on the animal (i.e., it demonstrates uncharacteristic behavior such as thrashing), or gear is not observed on the animal and it behaves normally. If a cetacean or monk seal is sighted with the gear attached or suspected to be attached, then the procedures and actions for incidental takes would be initiated. Gear loss would be tallied on the data sheet, as would a "move-on" because of a marine mammal.
Unknown Future PIFSC Research Activities	In addition to the activities identified above, PIFSC may propose additional surveys or modify existing research activities within the timeframe covered by this BA. Over the next five years advancements in technology may lead to new and better sampling instruments and gear, such as video equipment and UAS. Evaluation of proposed future research activity would: • Determine if the activity would be conducted within the geographic scope of the region evaluated • Evaluate the seasonal distribution of the activity and the gear types proposed to determine if coverage is present.

1.3 Requirements Implemented under the False Killer Whale Take Reduction Plan

Under the proposed action, PIFSC may replicate or test gear configurations for the Hawaii DSLL fishery which is also subject to regulations implemented under the authority of the MMPA to conserve false killer whales (50 CFR 229). NMFS implemented the False Killer Whale Take Reduction Plan (FKWTRP) regulations on December 31, 2012 (77 FR 71260). Because the FFKWTRP includes measures that affect the main Hawaiian Islands (MHI) IFKW, we discuss it here.

The FKWTRP implemented the following regulatory measures for the Hawaii DSLL fishery, which would be applicable to deep-set longline sets made by PIFSC during research and testing activities. All were effective on December 31, 2012, with the exception of the gear requirements, which went into effect on February 27, 2013:

- Requires circle hooks with 4.5 mm maximum wire diameter, sufficient round wire in the shank to be measured with a caliper, and 10 degree offset or less.
- Established a minimum 2.0 mm diameter for monofilament used in leaders or branch lines, and a minimum breaking strength of 400 pounds for any line used in the construction of a branch line if any other material is used.
- Established a year-round MHI longline fishing prohibited area in FKWTRP regulations, bounded by the same coordinates as the existing February-September boundary of the MHI longline exclusion zone. The net effect is to prohibit longline fishing year-round in the area north of the MHI that is currently closed to longlining only seasonally. NMFS also revised existing Magnuson-Steven Act regulations defining the MHI longline exclusion zone, to eliminate the seasonal boundary change and make the current February-September boundary permanent year-round, to bring the MSA regulations into accordance with the FKWTRP regulations.
- Requires annual certification in marine mammal interaction mitigation techniques for longline vessel owners and operators.
- Requires posting of a marine mammal handling and release informational placard on longline vessels.
- Requires captains' supervision of marine mammal handling and release.
- Requires posting of a placard instructing crew to notify the captain of marine mammal interactions.
- Established a Southern Exclusion Zone (SEZ) and specific bycatch triggers for closure of this zone to the Hawaii-based deep-set longline fishery (Figure 1).

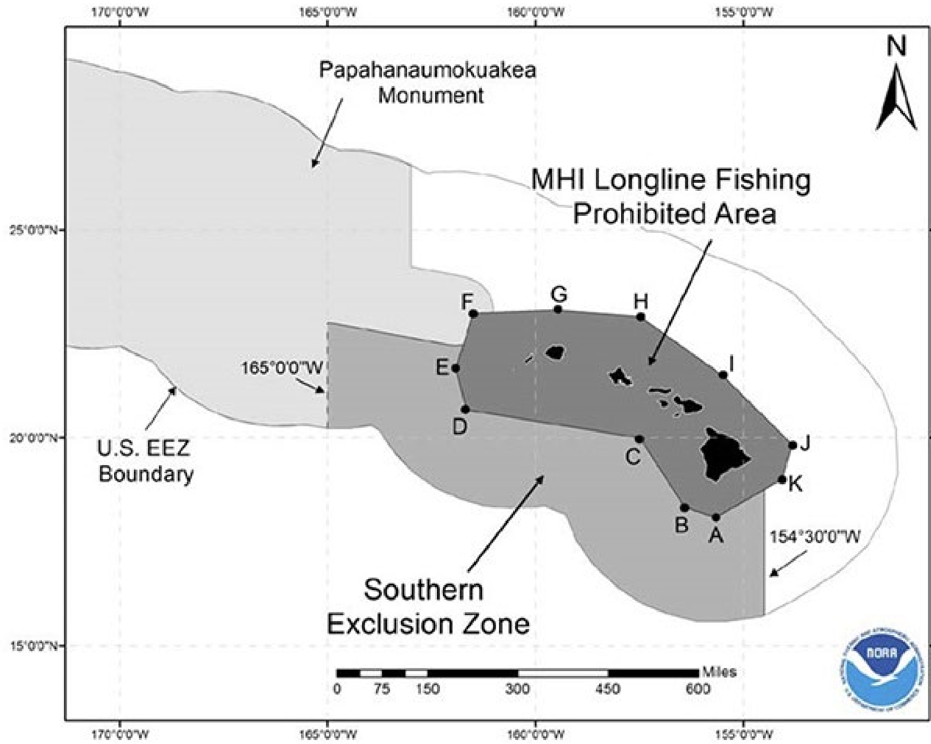

Figure 1. Map of the MHI longline fishing prohibited area, the FKWTRP southern exclusion zone, and the Papahanaumokuakea Monument.

The trigger for closing the SEZ is calculated based on observed false killer whale mortalities or serious injuries in the DSLL fishery that occur in the EEZ around Hawaii. The trigger is calculated as the larger of these two values: (i) Two; or (ii) The smallest number of observed false killer whale mortalities or serious injuries that, when extrapolated based on the percentage observer coverage in the deep-set longline fishery for that year, exceeds the Hawaii Pelagic false killer whale stock's potential biological removal level. The SEZ has been closed twice since implementation of the FKWTRP. The first closure of the SEZ occurred on July 24, 2018, and the SEZ was reopened on January 1, 2019. The SEZ was closed again on February 22, 2019, and reopened on August 25, 2020. In 2020, a new trigger was published to revise the trigger to four observed M/SI of false killer whales (85 FR 81184). In 2021, four observed mortalities or serious injuries of false killer whales occurred incidental to the Hawaii DSLL within the U.S. EEZ around Hawaii on January 18, 2021, March 26, 2021, April 17, 2021, and November 19, 2021. Because the injury determination of the fourth interaction meeting the trigger was not available until January 2022, the timeframe for closing the SEZ in 2021 had passed, and the SEZ was not closed.

1.4 Overview of NMFS Assessment Framework

Biological opinions address two central questions: (1) has a Federal agency insured that an action it proposes to authorize, fund, or carry out is not likely to jeopardize the continued existence of endangered or threatened species; and (2) has a Federal agency insured that an action it proposes to authorize, fund, or carry out is not likely to result in the destruction or adverse modification of critical habitat that has been designated for such species. Every section of a biological opinion from its opening page and its conclusion and all of the information, evidence, reasoning, and analyses presented in between is designed to help answer these two questions. What follows summarizes how NMFS' generally answers these two questions; that is followed by a description of how this biological opinion will apply this general approach to the proposed research activities.

Before we introduce the assessment methodology, we want to define the word "effect." An effect is a change or departure from a prior state or condition of a system caused by an action or exposure (Figure 2). Although Figure 2 depicts a negative effect, the definition itself is neutral: it applies it to activities that benefit endangered and threatened species as well as to activities that harm them. Whether the effect is positive (beneficial) or negative (adverse), an "effect" represents a change or departure from a prior condition (a in Figure 2); in consultations, the prior global condition of species and designated critical habitat is summarized in the *Status of the Listed Resources* narratives while their prior condition in a particular geographic area (the *Action Area*) is summarized in the *Environmental Baseline* section of this opinion. Extending this baseline condition over time to form a future without the project condition (line b in Figure 2); this is alternatively called a counterfactual because it describes the world as it might exist if a particular action did not occur. Although consultations do not address it explicitly, the future without project is implicit in almost every effects analysis.

As Figure 2 illustrates, effects have several attributes: polarity (positive, negative, or both), magnitude (how much a proposed action causes individuals, populations, species, and habitat to depart from their prior state or condition) and duration (how long any departure persists). The last of these attributes—duration—implies the possibility of recovery which has the additional attributes recovery rate (how quickly recovery occurs over time; the slope of line **c** in the figure) and degree of recovery (complete or partial). The recovery rate allows us to estimate how long it would take for a coral reef and associated benthic communities would take to recover.

As described in the following narratives, biological opinions apply this concept of effects to endangered and threatened species and designated critical habitat. Jeopardy analyses are designed to identify probable departures from the prior state or condition of individual members of listed species, populations of those individuals, and the species themselves. Destruction or adverse modification analyses are designed to identify departures in the area, quantity, quality, and availability of the physical and biological features that represent habitat for these species.

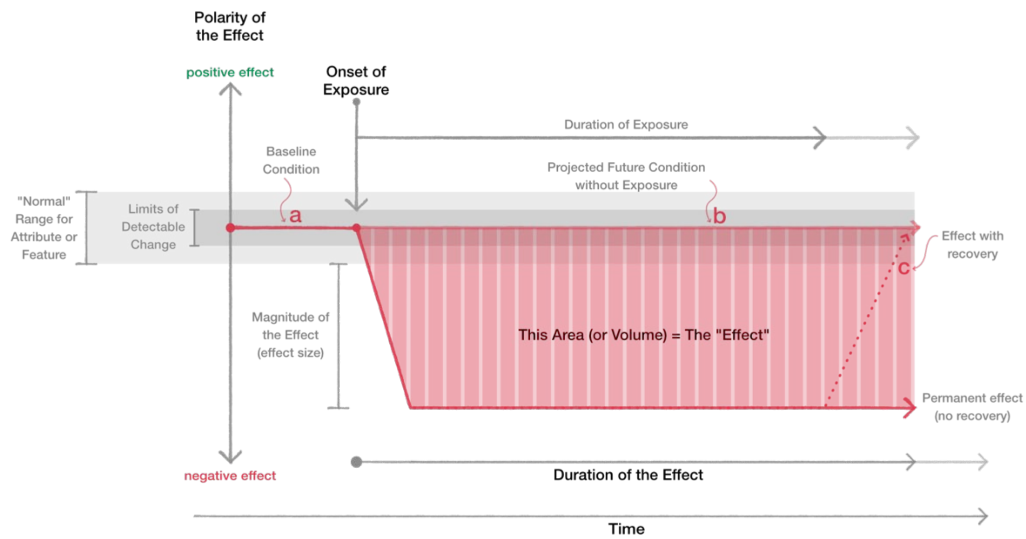

Figure 2. A schematic of the various elements encompassed by the word "effect." The vertical bars in the figure depict a series of annual "effects" (negative changes from a pre-existing or "baseline" condition) that are summed over time to estimate the action's full effect. See text for a more complete explanation of this figure.

1.4.1 Jeopardy Analysis

The Section 7 regulations define "jeopardize the continued existence of " as "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02, emphasis added). The jeopardy standard is focused on the effects of the action when considered together with the species' status and all other threats acting on it. A federal action that adversely affects a declining population does not necessarily jeopardize that species unless the action itself is the cause of some active change of the species' status for the worse. *See National Wildlife Federation v. NMFS*, 524 F.3d 917, 930 (9th Cir. 2008). Minor reductions in the reproduction, numbers, or distribution of a species that are inconsequential at the species level will not be sufficient to jeopardize that species. In other words, a jeopardizing action requires that any reduction in the likelihood of survival or recovery be appreciable; i.e., material or meaningful from a biological perspective. *See Oceana v. Pritzker*, 75 F.Supp. 3d 469, 481-84 (DDC 2014) (holding that NMFS was within the bounds of its discretion to construe the word "appreciably" as entailing more than a bare reduction in the likelihood of survival and recovery, but rather "a considerable or material reduction in the likelihood of survival and recovery"). We note, however, that for a species that has a particularly dire -pre-action condition, an action's even slight impacts may rise to the level of appreciable reduction. This definition requires our assessments to address four primary variables:

1. Reproduction
2. Numbers

3. Distribution
4. The probability of the proposed action will cause one or more of these variables to change in a way that represents an appreciable reduction in a species' likelihood of surviving and recovering in the wild.

Reproduction leads this list because it is "the most important determinant of population dynamics and growth" (Carey and Roach 2020). Reproduction encompasses the reproductive ecology of endangered and threatened species; specifically, the abundance of adults in their populations, the fertility or maternity (the number of live births rather than the number of eggs they produce) of those adults, the number of live young adults produce over their reproductive lifespans, how they rear their young (if they do), and the influence of habitat on their reproductive success, among others. Reducing one or more of these components of a population's reproductive ecology can alter its dynamics so reproduction is a central consideration of jeopardy analyses.

The second of these variables—numbers—receives the most attention in the majority of risk assessments and that is true for jeopardy analyses as well. Numbers or abundance usually represents the total number of individuals that comprise the species, a population, or a sub-population; it can also refer to the number of breeding adults or the number of individuals that become adults. For species faced with extinction or endangerment several numbers matter: the number of populations that comprise the species, the number of individuals in those populations, the proportion of reproductively active adults in those populations, the proportion of sub-adults that can be expected to recruit into the adult population in any time interval, the proportion of younger individuals that can be expected to become sub-adults, the proportion of individuals in the different genders (where applicable) in the different populations, and the number of individuals that move between populations over time (immigration and emigration). Reducing these numbers or proportions can alter the dynamics of wild populations in ways that can reinforce their tendency to decline, their rate of decline, or both. Conversely, increasing these numbers or proportions can help reverse a wild population's tendency to decline or cause the population to increase in abundance.

The third of these variables—distribution— refers to the number and geographic arrangement of the populations that comprise a species. Jeopardy analyses must focus on populations because the fate of species is determined by the fate of the populations that comprise them: species become extinct with the death of the last individual of the last population. For that reason, jeopardy analyses focus on changes in the number of populations, which provides the strongest evidence of a species' extinction risks or its probability of recovery. Jeopardy analyses also focus on changes in the spatial distribution of the populations that comprise a species because such changes provide insight into how a species is responding to long-term changes in its environment (for example, to climate change). The spatial distribution of a species' populations also determines, among other things, whether all of a species' populations are affected by the same natural and anthropogenic stressors and whether some populations occur in protected areas or are at least protected from stressors that afflict other populations.

To assess whether reductions in a species' reproduction, numbers, or distribution that are caused by an action appreciably reduce the species' likelihood of surviving and recovering in the wild, NMFS' first assesses the status of the endangered or threatened species that may be affected by an action. That is the primary purpose of the narratives in the *Status of the Listed Resources* sections of biological opinions. Those sections of biological opinions also present descriptions of the number of populations that comprise the species and their geographic distribution. Then NMFS' assessments focus on the status of those populations in a particular *Action Area* based on how prior activities in the *Action Area* have affected them. The *Environmental Baseline* sections of biological opinions contain these analyses; the baseline condition of the populations and individuals in an *Action Area* determines their probable responses to future actions.

To assess the effects of actions considered in biological opinions, NMFS' consultations use an exposure–response–risk assessment framework. The assessments that result from this framework begin by identifying the physical, chemical, or biotic aspects of proposed actions that are known or are likely to have individual, interactive, or cumulative direct and indirect effects on the environment (we use the term "potential stressors" for these aspects of an action). As part of this step, we identify the spatial extent of any potential stressors and recognize that the spatial extent of those stressors may change with time. The area that results from this step of our analyses is the *Action Area* for a consultation.

After they identify the *Action Area* for a consultation, jeopardy analyses then identify the listed species and designated critical habitat (collectively, "listed resources"); critical habitat is discussed further below) that are likely to occur in that *Action Area*. If we conclude that one or more species is likely to occur in an *Action Area* when the action would occur, jeopardy analyses try to estimate the number of individuals that are likely to be exposed to stressors caused the action: the intensity, duration, and frequency of any exposure (these represent our exposure analyses). In this step of our analyses, we try to identify the number, age (or life stage), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

Once we identify the individuals of listed species that are likely to be exposed to an action's effects and the nature of that exposure, we examine the scientific and commercial data available to determine whether and how those individuals are likely to respond given their exposure (these represent our response analyses). Our individual-level assessments conclude with an estimate of the probable consequences of these responses for the "fitness" of the individuals exposed to the action. Specifically, we estimate the probability that exposed individuals will experience changes in their growth, development, longevity, and the number of living young they produce over their lifetime. These estimates consider life history tradeoffs, which occur because individuals must allocate finite resources to growth, maintenance and surviving or producing offspring; energy that is diverted to recover from disease or injury is not available for reproduction.

If we conclude that an action can be expected to reduce the fitness of at least some individuals of threatened or endangered species, our jeopardy analyses then estimate the consequences of those changes on the viability of the population(s) those individuals represent. This step of our jeopardy analyses considers the abundance of the populations whose individuals are exposed to an action; their prior pattern of growth and decline over time in the face of other stressors; the proportion of individuals in different ages and stages; gender ratios; whether the populations are "open" or "closed" (how much they are influenced by immigration and emigration); and their ecology (for example, whether they mature early or late, whether they produce many young or a small number of them, etc.). Because the fate of species is determined by the fate of the populations that comprise them, this is a critical step in our jeopardy analyses.

Our risk analyses normally conclude by assessing how changes in the viability of populations of threatened or endangered species affect the viability of the species those populations comprise (measured using probability of demographic, ecological, or genetic extinction in 10, 25, 50 or 100 years). This step of our analyses considers data available on the particular populations and species affected by an action. However, this step of our analyses is also informed by empirical information on (1) species that have become extinct—they became endangered but did not "survive" endangerment and, therefore, could not "recover" from it; (2) species whose abundance and distribution has declined and collapsed but whose future—their likelihood of continuing to persist over time (survive) or recovering them from endangerment—remains uncertain; (3) species that have declined and collapsed, but have begun the process of recovering from endangerment although they have not yet "recovered" in the wild; and (4) species that have survived endangered and subsequently recovered from it. The second of these categories includes species that have been extinct in the wild, but "survive" in captivity.

Section 7(a)(2) requires us to insure that threatened or endangered species are not likely to become extinct in the wild and, instead, insure that they are likely to end up in the fourth category (survived and recovered). We fulfill that mandate, by studying data and other information on how and why species ended up in these four categories, identifying common patterns in the data, and using the knowledge, those studies produce to inform our jeopardy determinations.

1.4.2 Destruction or Adverse Modification Analyses

The Section 7 regulations define "destruction or adverse modification" as "a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species." (50 CFR 402.02). This definition focuses on how federal actions affect the quantity, quality, and availability of the physical or biological features of the designated critical habitat.

NMFS uses the same exposure–response–risk assessment framework for designated critical habitat that it uses for jeopardy analyses. Exposure analyses first determine if designated critical habitat occurs in the *Action Area* for a consultation. If it does, those analyses identify the physical or biological features of critical habitat that are likely to be exposed to an action's effects.

Our analyses then consider how those features are likely to respond to that exposure, which requires us to consider the habitat's probable condition when the exposure occurs (that is, the impact of the *Environmental Baseline* on the value of the habitat); the ecology of the habitat at the time of exposure; where the exposure is likely to occur; and when the exposure is likely to occur; and the intensity, duration, and frequency of exposure.

If our analyses lead us to expect the quantity, quality, or availability of the physical or biological features of an area of designated critical habitat to decline because of a proposed action, we ask initially if those reductions are likely to be sufficient to reduce the value of the designated critical habitat for the conservation of listed species in the *Action Area*. By value, we mean the probability that the habitat designated in the *Action Area* will be occupied by and provide utility to individuals of the endangered or threatened species it was designated to help conserve. In this case, occupancy only means that individuals of the species are likely to use the habitat, even if they only use it intermittently; utility means that the individuals that occupy the habitat receive measurable improvement in their fitness (as defined earlier) as a result of using the habitat.

NMFS' destruction or adverse modification analyses are based on whether any reductions in the value of designated critical habitat in an *Action Area* is likely to be sufficient to reduce the value of the entire critical habitat designation. In this final step of our assessment, we combine information about the essential features of critical habitat that are likely to experience changes in quantity, quality, and availability given exposure to an action with information on the physical, chemical, biotic, and ecological processes that produce and maintain those constituent elements in the *Action Area*. We use the conservation value of the entire designated critical habitat (as described in the *Status of the Listed Resources* and *Designated Critical Habitat* subsections of biological opinions) as our point of reference for this comparison.

1.5 Application of this Approach in this Consultation

NMFS has identified several aspects of the PIFSC's Fishery and Ecosystem Research Activities that represent potential stressors to threatened or endangered species or designated or proposed critical habitat. The term stressor means any physical, chemical, or biological entity that can induce a direct or indirect effect on the environment (*Action Area*) or that can induce an adverse response on threatened or endangered species and their critical habitat. Sources of the stressors are primarily vessels and vessel operations, and gear use. The specific stressors addressed in this consultation include:

1. Tagging and genetic sampling
2. Entanglement
3. Direct take of coral specimens
4. Acoustic disturbance
5. Interaction with, including capture of non-target species, such as listed species, or their prey
6. Derelict gear
7. Introduction of oily discharges, cardboard, plastics, and other waste into marine waters
8. Collisions with vessels
9. Vessel groundings
10. Vessel emissions

1.6 Action Area

The *Action Area* is defined by regulation as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR §402.02). The *Action Area* includes all areas affected by the action physically, chemically, or biologically. PIFSC's fisheries research activities take place in the nearshore and offshore areas of the HARA, MARA, ASARA, and the WCPRA; Figure 3. The HARA includes waters surrounding the Hawaiian Islands to a seaward extent of approximately 24 nautical miles (nm). PIFSC conducts research surveys in the HARA, primarily inside the Insular Pacific-Hawaiian Large Marine Ecosystem boundary. The Insular Pacific-Hawaiian Large Marine Ecosystem has a surface area of approximately one million km², extending 1,500 miles from the MHI to the outer northwest islands, including a range of islands, atolls, islets, reefs and banks (WPRFMC 2019). The MARA includes waters surrounding the CNMI and the Territory of Guam to a seaward extent of approximately 24 nm. The ASARA includes waters surrounding the American Samoa archipelago to a seaward extent of approximately 24 nm. The WCPRA includes part of the high seas (i.e., international ocean waters) considered under the jurisdiction of the Western and Central Pacific Fisheries Commissions (WCPFC). The WCPRA also includes the PRIA comprised of Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Wake Atoll, and Palmyra Atoll. This large area essentially captures all future PIFSC high seas research surveys (e.g. oceanography, longline gear research) that occur outside of the HARA, MARA, and ASARA, while also approximately aligning with various other geopolitical boundaries.

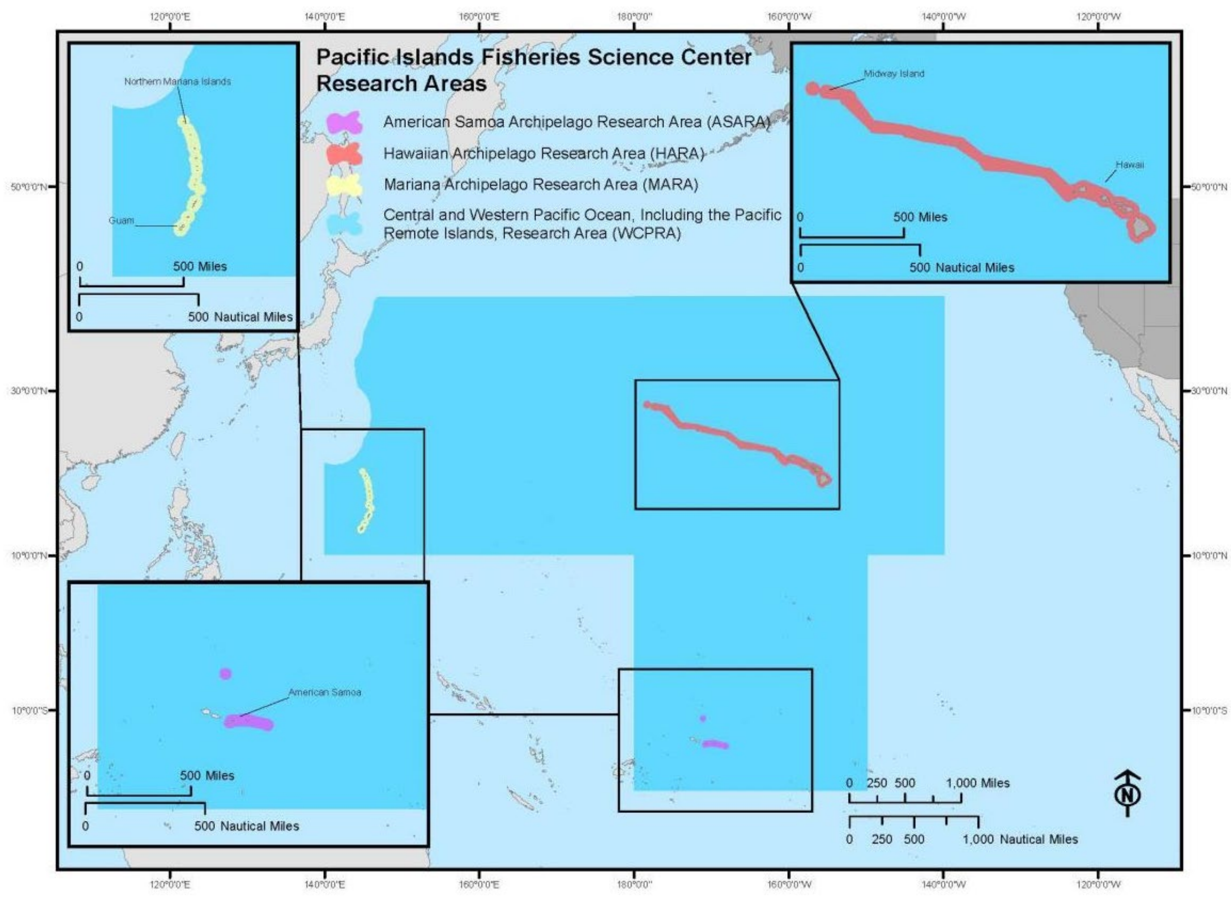

Figure 3. Pacific Islands Fisheries Science Center Research Areas.

1.7 Approach to Evaluating Effects

After identifying the *Action Area* for this consultation, we identified those activities and associated stressors that are likely to co-occur with (a) individuals of endangered or threatened species or areas designated as critical habitat for threatened or endangered species; (b) species that are food for endangered or threatened species; or (c) species that prey on or compete with endangered or threatened species. The latter step represents our exposure analyses, which are designed to identify:

- The exposure pathway (the course the stressor takes from the source to the listed resource or its prey);
- The exposed listed resource (what life history forms or stages of listed species are exposed; the number of individuals that are exposed; which populations the individuals represent); and
- The timing, duration, frequency, and severity of exposure.

We also describe how the exposure might vary depending on the characteristics of the environment (for example, the occurrence of oceanic fronts or eddies) and seasonal differences in those characteristics, behavior of individual animals, etc. Our exposure analyses require knowledge of the action, and a species' population structure and distribution, migratory behaviors, life history strategy, and abundance.

Next, we identified how listed species and their designated critical habitat are likely to respond once exposed to the action's stressors. These analyses evaluated whether the species responses were expected to be immediate or later in time, and considered the severity, frequency, and duration of those responses.

We lay the foundation for our risk assessment and our understanding of the animal's pre-existing physical, physiological, or behavioral state in the Status of Listed Resources and the Environmental Baseline using qualitative and quantitative analytical methods

1.8 Climate Change

Future climate will depend on warming caused by past anthropogenic emissions, future anthropogenic emissions and natural climate variability. NMFS' policy (NMFS 2016) is to use climate indicator values projected under the Intergovernmental Panel on Climate Change (IPCC)'s Representative Concentration Pathway (RCP) 8.5 when data are available or best available science that is as consistent as possible with RCP 8.5. RCP 8.5, like the other RCPs, were produced from integrated assessment models and the published literature; RCP 8.5 is a high pathway for which radiative forcing reaches >8.5 W/m2 by 2100 (relative to pre-industrial values) and continues to rise for some amount of time. A few projected global values under RCP 8.5 are noted in Table 3**.**

Presently, the IPCC predicts that climate-related risks for natural and humans systems are higher for global warming of 1.5 ºC but lower than the 2ºC presented in Table 3 (IPCC 2018). Changes in parameters will not be uniform, and IPCC projects that areas like the equatorial Pacific will likely experience an increase in annual mean precipitation under scenario 8.5, whereas other mid-latitude and subtropical dry regions will likely experience decreases in mean precipitation. Sea level rise is expected to continue to rise well beyond 2100 and while the magnitude and rate depends upon emissions pathways, low-lying coastal areas, deltas, and small islands will be at greater risk (IPCC 2018).

Table 3. Projections for certain climate parameters under Representative Concentration Pathway 8.5 (values from IPCC 2014).

Projections	Scenarios (Mean and likely range)	
	Years 2046-2065	Years 2081-2100
Global mean surface temperature change (ºC)	2.0 (1.4-2.6)	3.7 (2.6-4.8)
Global mean sea level increase (m)	0.30 (0.22-0.38)	0.63 (0.45-0.82)

Given the limited data available on sea turtle populations, and other listed species like whales, sharks, and rays that are adversely affected by the proposed action, and the inherent challenges with creating population models to predict extinction risks of these species, we are not inclined to add more uncertainty into our assessment by creating climate models with little data to parameterize such models. Since trying to apply a climate based model in 2012 to the SSLL, we've learned a few key important lessons: the climate based model incorporating fixed age (lag) is unrealistic given variability ages at sexual maturity for loggerhead and leatherback sea turtles, and fails to consider variation in age of the nesting cohort; studies have shown juvenile loggerhead sea turtles are distributing more widely than thought, and thus are likely impacted in ways not considered under the previous model; a new dispersion model on leatherback sea turtles suggest they too may be dispersing more broadly, and affected differently than previously considered; the model did not account for impacts to more than two life-stages; and arguably, most importantly, the models did not perform as expected because the predictions were wrong for leatherback sea turtles the majority of the time, and predictions for loggerhead sea turtles were wrong half the time (Kobayashi et al. 2008, 2011; Van Houtan 2011; Van Houtan and Halley 2011; Allen et al. 2013; Briscoe 2016a, 2016b; Jones et al. 2018; see also Jones memo 2018).

We address the effects of climate, including changes in climate, in multiple sections of this assessment: *Status of Listed Resources*, *Environmental Baseline*, and *Integration and Synthesis of Effects*. In the *Status of Listed Resources* and the *Environmental Baseline* we present an extensive review of the best scientific and commercial data available to describe how the listed species and its designated critical habitat is affected by climate change—the status of individuals, and its demographically independent units (subpopulations, populations), and critical habitat in the *Action Area* and range wide.

We do this by identifying species sensitivities to climate parameters and variability, and focusing on specific parameters that influence a species health and fitness, and the conservation value of their habitat. We examine habitat variables that are affected by climate change such as sea level rise, temperatures (water and air), and changes in weather patterns (precipitation), and we try to assess how species have coped with these stressors to date, and how they are likely to cope in a changing environment. We look for information to evaluate whether climate changes effects the species' ability to feed, reproduce, and carry out normal life functions, including movements and migrations.

We review existing studies and information on climate change and the local patterns of change to characterize the *Environmental Baseline* and *Action Area* changes to environmental conditions that would likely occur under RCP 8.5, and where available we use changing climatic parameters (magnitude, distribution, and rate of changes) information to inform our assessment. In our exposure analyses, we try to examine whether changes in climate related phenomena will alter the timing, location, or intensity of exposure to the action. In our response analyses we ask, whether and to what degree a species' responses to anthropogenic stressors would change as they are forced to cope with higher background levels of stress cause by climate-related phenomena.

1.9 Evidence Available for this Consultation

Section 7(a)(2) of the ESA and its implementing regulations require NMFS to use the best scientific and commercial data available during consultations. We used the following procedure to ensure that this consultation complies with NMFS' requirement to consider and use the best scientific and commercial data available. We started with the data and other information contained in the NMFS PIFSC 2021 Biological Evaluation, NMFS' proposed rule to designated critical habitat for seven Indo-Pacific corals (85 FR 76262), relevant Letters of Concurrence and biological opinions, and available recovery plans for affected species.

We supplemented these sources with electronic searches of literature published in English or with English abstracts to cross search multiple databases for relevant scientific journals, open access resources, proceedings, web sites, doctoral dissertations and master's theses. Particular databases we searched for this consultation included Google Scholar, Bielefeld Academic Search Engine (BASE), CORE, Bing, Microsoft Academic, Science Direct, Web of Science, Science.gov, and JStor (to identify older studies) with targeted searches of websites for the journals Copeia, Marine Biology, Marine Ecology Progress Series, Marine Pollution Bulletin, Public Library of Science - Biology (PLoS Biology), and Public Library of Science - One (PLoS One).

Electronic searches have important limitations. First, often they only contain articles from a limited time span (e.g., First Search only provides access to master's theses and doctoral dissertations completed since 1980 and Aquatic Sciences and Fisheries Abstracts only provide access to articles published since 1964). Second, electronic databases commonly do not include articles published in small or obscure journals or magazines that contain credible and relevant scientific and commercial data. Third electronic databases do not include unpublished reports from government agencies, consulting firms, and non-governmental organizations that also contain credible and relevant scientific and commercial data. To overcome these limitations, we supplemented our electronic searches by searching the literature cited sections and bibliographies of references we retrieved to identify additional papers that had not been captured in our electronic searches. We acquired references that, based on a reading of their titles and abstracts, appeared to comply with our keywords. If a references' title and abstract did not allow us to eliminate it as irrelevant to this inquiry, we acquired the reference.

To supplement our searches, we examined the literature that was cited in documents and any articles we collected through our electronic searches. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired it. We continued this process until we identified all of the relevant references cited by the introduction and discussion sections of the relevant papers, articles, books, modeling results, and, reports and all of the references cited in the materials and methods, and results sections of those documents. We did not conduct hand searches of published journals for this consultation.

These procedures allowed us to identify relevant data and other information that was available for our analyses. In many cases, the data available were limited to a small number of datasets that either did not overlap or did not conflict. In those cases, none of these sources were "better' than the alternatives and we used all of these data.

2 STATUS OF LISTED RESOURCES

NMFS has determined that the action may affect the threatened and endangered species listed in Table 4, and designated critical habitats in Table 5. These species occur in the *Action Area* and may be affected by the proposed action and they are included in this biological opinion. These listed resources are provided protections under the ESA.

Table 4. Listed resources within the *Action Area* that are likely to be adversely affected by the proposed action.

Species	Scientific Name	ESA Status	Listing Date	Federal Register Reference
Giant Manta Ray	*Manta birostris*	Threatened	02/21/2018	83 FR 2916
Indo-West Pacific Scalloped Hammerhead Shark	*Sphyrna lewini*	Threatened	09/02/2014	79 FR 38213
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Threatened	03/01/2018	83 FR 4153
Coral (no common name)	*Acropora globiceps*	Threatened	10/10/2014	79 FR 53852
Coral (no common name)	*Acropora retusa*	Threatened	10/10/2014	79 FR 53852
Coral (no common name)	*Acropora speciosa*	Threatened	10/10/2014	79 FR 53852
Coral (no common name)	*Euphyllia paradivisa*	Threatened	10/10/2014	79 FR 53852

Species	Scientific Name	ESA Status	Listing Date	Federal Register Reference
Coral (no common name)	*Isopora crateriformis*	Threatened	10/10/2014	79 FR 53852

Table 5. Designated critical habitat within the *Action Area* that may be affected by the proposed action.

Species	Scientific Name	Critical Habitat Effective Date	Federal Register Reference
Hawaiian monk seal	*Neomonachus schauinslandi*	5/26/1988 revised on 8/21/2015	53 FR 18990 80 FR 50925
False killer whale Main Hawaiian Island Insular	*Pseudorca crassidens*	7/24/2018	83 FR 35062
Pacific corals	*Acropora globiceps, Acropora retusa, Acropora speciosa, Euphyllia paradivisa, and Isopora crateriformis*	Proposed on 11/27/2020	85 FR 76262

2.1 Listed Resources Not Considered Further

As described in the *Approach to the Assessment* section of this biological opinion, NMFS uses two criteria to identify endangered or threatened species or critical habitat that are not likely to be adversely affected by PIFSC's research activities. The first criterion is exposure or some reasonable expectation of a co-occurrence between one or more potential stressor associated with the PIFSC's research activities and a particular listed species or designated critical habitat. If we conclude that a listed species or designated critical habitat is not likely to be exposed to PIFSC's research activities, we must also conclude that the species and critical habitat is not likely to be adversely affected by those activities. The second criterion is the probability of a response given exposure, which considers susceptibility: for example, species that may be exposed to vessel noise from fishing vessels operating near them but are not likely to respond to that noise (at noise levels they are likely exposed to) are also not likely to be adversely affected by vessel operations.

Based on the general exposure profiles that we developed during the course of this consultation, and described in Appendix A of this biological opinion, the threatened and endangered species that are not likely to be adversely affected by PIFSC's Fishery and Ecosystem Research

Activities in the Western and Central Pacific Ocean are listed in Table 6. We discuss the basis of these determinations in Appendix A.

Table 6. Listed resources within the *Action Area* that are not likely to be adversely affected by the proposed action.

Species	Scientific Name	ESA Status	Listing Date	Federal Register Reference
Central North Pacific Green Sea Turtles, Central South Pacific, Green Sea Turtle Central West Pacific Green Sea Turtle	*Chelonia mydas*	Threatened	05/06/2016	81 FR 20057
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered	06/03/1970	35 FR 8491
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	06/03/1970	35 FR 8491
North Pacific Loggerhead Sea Turtle	*Caretta caretta*	Endangered	10/24/2011	76 FR 58868
Olive Ridley Sea Turtle (all other populations)	*Lepidochelys olivacea*	Threatened	08/27/1978	43 FR 32800
Hawaiian Monk Seal[1]	*Neomonachus schauinslandi*	Endangered	11/23/1976	41 FR 51612
Blue Whale	*Balaenoptera musculus*	Endangered	12/02/1970	35 FR 18319
Fin Whale	*Balaenoptera physalus*	Endangered	12/02/1970	35 FR 18319
Sei Whale	*Balaenoptera borealis*	Endangered	12/02/1970	35 FR 18319
Sperm Whale	*Physeter macrocephalus*	Endangered	12/02/1970	35 FR 18319

Species	Scientific Name	ESA Status	Listing Date	Federal Register Reference
Main Hawaiian Island Insular[2] False Killer Whale	*Pseudorca crassidens*	Endangered	12/28/2012	77 FR 70915
North Pacific right whale	*Eubalaena japonica*	Endangered	04/07/2008	73 FR 12024
Chambered Nautilus	*Nautilus pompilius*	Threatened	10/29/2018	83 FR 48976

2.2 Introduction to the Status of Listed Species

The rest of this section of NMFS biological opinion consists of a narrative for each of the threatened and endangered species, and designated critical habitat that occur in the *Action Area* and that may be adversely affected by the PIFSC's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean. To fulfill that purpose, the species' narrative presents a summary of: (1) the species' distribution and population structure (which are relevant to the distribution criterion of the jeopardy standard); (2) the status and trend of the abundance of those different populations (which are relevant to the numbers criterion of the jeopardy standard); (3) information on the dynamics of those populations where it is available (which is a representation of the reproduction criterion of the jeopardy standard); and (4) natural and anthropogenic threats to the species, which helps explain our assessment of a species' likelihood of surviving and recovering in the wild. This information is integrated and synthesized in a summary of the status of the species.

Following the narratives that summarize information on these topics, the species' narrative provides information on the diving and social behavior of the different species because that behavior helps assess a species' probability of being captured by fishing gear. A more detailed background information on the general biology and ecology of these species can be found in status reviews and recovery plans for the various species[1] as well as the public scientific literature.

2.2.1 Giant Manta Ray

Distribution and Population Structure

The giant manta ray occurs across the globe in tropical and warm temperate bodies of water from 36°S to 40°N (Mourier 2012). The documented range for this species within the Northern hemisphere includes: Mutsu Bay, Aomori, Japan; the Sinai Peninsula and Arabian Sea, Egypt; the Azores Islands, Portugal; and as far north as southern California (west coast) and New Jersey (east coast), U.S. (Kashiwagi et al. 2010; Moore 2012; CITES 2013). In the southern

[1] Status reviews and recovery plans are generally accessible through NMFS' endangered species conservation website: https://www.fisheries.noaa.gov/topic/endangered-species-conservation#conservation-&-management and NatureServe Explorer: http://explorer.natureserve.org/servlet/NatureServe?init=Species

hemisphere, the giant manta has been documented as far south as Peru, Uruguay, South Africa, French Polynesia, New Zealand, and most recently, photographed in eastern Australia off Montague Island and Tasmania at 40° S (Mourier 2012; CITES 2013; Couturier et al. 2015). Couturier et al. (2015) documented the presence of the species for the first time in waters off eastern Australia and off the northeast coast of Tasmania. In addition, the giant manta ray has been observed in a predictable seasonal pattern in estuarine waters of Florida, Uruguay, and Brazil suggesting that they may use estuaries as nursery areas during summer months (Adams and Amesbury 1998; Milessi and Oddone 2003; Medeiros et al. 2015).

Previously considered to be monospecific, Marshall et al. (2009) presented new data to support the splitting of the *Manta* genus into two species: giant manta ray (*Manta birostris*) and reef manta ray (*M. alfredi*). Prior to 2009, all *Manta* species were categorized as giant manta ray (*Manta birostris*). The reef manta ray inhabits tropical coastal areas while the giant manta ray's habitat is more offshore and extends to sub-tropical regions; however, there is overlap in the habitats of the two species. Furthermore, while there are distinct morphological differences between the two species, they can be difficult to distinguish without adequate training and identification keys (Stevens et al. 2018). Therefore, correct identification to the species level is likely an issue in fisheries observer data.

Area of occupancy for giant manta rays was estimated from observations and expert opinion by Lawson et al. (2017; Figure 4). The environmental variables that drive or are correlated with giant manta ray habitat use in the ocean are largely unknown (Jaine et al. 2014). Giant manta rays are found offshore in oceanic waters near productive coastlines, continental shelves, offshore pinnacles, seamounts, and oceanic islands. In a satellite tracking study off of Mexico, Graham et al. (2012) found that 95% of locations occurred in waters warmer than 21.6° C and that most locations were correlated with high surface chlorophyll concentrations.

Stewart et al. (2016a) also reported that giant manta ray off Mexico tend to occur near the upper limit of the pelagic thermocline where zooplankton aggregate. Burgess (2017) suggested that giant manta ray specifically feed on mesopelagic plankton, which would place them at depths as deep as 1,000 meters (also see Marshall et al. 2018). Giant manta ray are also observed at cleaning sites at offshore reefs where they are cleaned of parasites by smaller organisms.

The population structure of giant manta rays — the number of populations and sub-populations that comprise the species, whether they are linked by immigration and emigration, and the strength of those links — is largely unknown. At a minimum, the evidence suggests that giant manta rays in the Atlantic and giant manta rays in the Indo-Pacific represent separate populations because this species does not appear to migrate to the Pacific through Drake Passage (or vice versa) and they do not appear to migrate around the Cape of Good Hope to the Indian Ocean (Lawson et al. 2017, Marshall et al. 2018; Figure 4).

Figure 4. Distribution map for the giant manta ray. Extent of occurrence is depicted by light blue and the area of occupancy is noted in darker blue. (Figure 3 from Lawson et al. 2017).

Several authors have reported that giant manta ray likely occur in small regional subpopulations (Lewis et al. 2015; Stewart et al. 2016a; Marshall et al. 2018; Beale et al. 2019) and may have distinct home ranges (Stewart et al. 2016a). The degree to which subpopulations are connected by migration is unclear but is assumed to be low (Stewart et al. 2016a; Marshall et al. 2018) so regional or local populations are not likely to be connected through immigration and emigration (Marshall et al. 2018), making them effectively demographically independent. While NMFS' concluded that the species is likely to become endangered within the foreseeable future throughout a significant portion of its range (the Indo Pacific and eastern Pacific), NMFS did not find the species met the criteria to list as a DPS (83 FR 2916, and 82 FR 3694). This decision is unique to the listing process, and does not mean that NMFS should not or would not consider the potential role that populations play in evaluating whether a proposed action is likely to result in appreciable reduction in numbers, distribution or reproduction, or whether such reductions may affect the viability of the putative populations that comprise the listed species. The preponderance of current evidence, combined with expert opinion suggest the species likely has a complex population structure, and while it may occasionally be observed making long distance movements, it likely occurs in small spatially separated populations, though to be viable the abundance of each subpopulation likely needs to be at least 1,000 individuals. This structure is further supported by studies described by Beale et al. (2019) that have documented fisheries-induced declines in several isolated subpopulations (Lewis et al. 2015; Stewart et al. 2016; Moazzam 2018).

Several studies have tracked individual giant manta rays and provide information on the spatial extent of giant manta ray populations. Stewart et al. (2016a) studied four subpopulations of giant manta ray using genetics, stable isotopes, and satellite tags. They found that these subpopulations appeared to be discrete with no evidence of movement between them. The home ranges for three of these subpopulations (all of which are outside of the *Action Area*), defined as the areas where tagged animals were expected to spend 95% of their time encompassed areas of 79,293 km^2 (Raja Ampat, Indonesia), 70,926 km^2 (Revillagigedo Islands, Mexico), and 66,680 km^2 (Bahia de Banderas, Mexico). They suggest that their findings indicate that giant manta rays form discrete subpopulations that exhibit a high degree of residency. Stewart et al. (2016a) state that this does not preclude occasional long-distance migrations, but that these migrations are likely rare and do not generate substantial gene flow or immigration of individuals into these subpopulations. One instance of a long-distance migration has been noted in the literature. Hearn et al. (2014) tracked nine giant manta rays at Isla de la Plata, Ecuador. Eight of the nine tagged giant manta rays remained in an area of 162,500 km^2, while the ninth traveled a straight-line distance of 1,500 km to the Galapagos Islands, however, Stewart and Hearn later believed it may have been from a floating tag (J. Stewart pers. comm. to J. Rudolph, October 7, 2020).

The Status Review (Miller and Klimovich 2017), notes only four instances of individual tagged giant manta rays making long-distance migrations. Of those, one animal was noted to travel a maximum distance of 1,151 km but that was a cumulative distance made up of shorter movements within a core area (Graham et al. 2012). No giant manta ray in that study moved further than 116 km from its tagging location and the results of Graham et al. (2012) support site fidelity leading to subpopulation structure. The remaining references to long distance migrations include Mozambique to South Africa (1,100 km), Ecuador to Peru (190 km), and the Yucatan into the Gulf of Mexico (448 km). The last two distances are well within core areas of subpopulation habitat use as specified in Stewart et al. (2016a) and may only represent movements between coastal aggregation sites and offshore habitats as discussed in Stewart et al. (2016a). In contrast with these few individuals making long-distance movements, most tracked individuals (Hearn et al. 2014 [8 out of 9 individuals]) or all tracked individuals (Graham et al. 2012 [6 individuals]; Stewart et al. 2016a [18 individuals]) from other studies remained within defined core areas, supporting subpopulation structure. Marshall et al. (2018) summarizes that current satellite tracking studies and international photo-identification matching projects suggest a low degree of interchange between subpopulations.

To date there have been limited genetics studies on giant manta ray; however, Stewart et al. (2016a) found genetic discreteness between giant manta ray populations in Mexico suggesting isolated subpopulations with distinct home ranges within 500 km of each other. In addition to genetics, differentiation was discovered through isotope analysis between those two Mexican populations (nearshore and offshore) and between two others (Indonesia and Sri Lanka). Using satellite tagging, stable isotopes and genetics, Stewart et al. (2016a) concluded that, in combination, the data strongly suggest that giant manta rays in these regions are well-structured subpopulations that exhibit a high degree of residency.

A vulnerability analysis conducted by Dulvy et al. (2014) indicates that mobulid populations can only tolerate very low levels of fishing mortality and have a limited capacity to recover once their numbers have been depleted (Couturier et al. 2012; Lewis et al. 2015). Furthermore, Lewis et al. (2015) suggests local populations in multiple areas in Indonesia have been extirpated due to fishing pressure noting that *Manta birostris* was the most common species previously caught in these areas. Additionally, White et al. (2015) documented an 89% decline in the observed *Manta birostris* population in Cocos Island National Park over a 20-year period and is believed to be from overfishing outside of the park.

A population structure described by small, isolated subpopulations does not conflict with seasonal sightings of giant manta ray as described for a number of the subpopulations studies with photo-identification or acoustic arrays (in contrast with those using satellite tagging; Dewar et al. 2008; Marshall et al. 2009; Rohner et al. 2013). Stewart et al. (2016a) suggest that habitats used by giant manta rays include both nearshore and offshore locations, and that the core spatial distribution of giant manta ray subpopulations encompass both types of habitats, leading to seasonal observations of giant manta rays in the nearshore habitats in many areas. Water temperature and productivity may dictate giant manta ray movements (Freedman and Roy 2012; Beale et al. 2019). In a subpopulation off the coast of North Carolina (U.S.), Freedman and Roy (2012) found that in the cooler winter months, giant manta ray distribution was extremely limited with a tight clustering in an area associated with the Gulf Stream and warmer waters, while in summer giant manta ray were distributed across a larger area, and individuals were more spread out, yet still in a discrete area.

Not all giant manta ray subpopulations are defined by seasonal sightings. Studied subpopulations that have more regular sightings include the Similan Islands (Thailand); Raja Ampat (Indonesia); northeast North Island (New Zealand); Kona, Hawaii (USA); Laje de Santos Marine Park (Brazil); Isla de la Plata (Ecuador); Ogasawara Islands (Japan); Isla Margarita and Puerto la Cruz (Venezuela); Isla Holbox, Revillagigedo Islands, and Bahia de Banderas, Mexico (Notarbartolo-di-Sciara and Hillyer 1989; Homma et al. 1999; Duffy and Abbott 2003; Luiz et al. 2009; Clark 2010; Kashiwagi et al. 2010; Marshall et al. 2011; Stewart et al. 2016a).

Given the current understanding of giant manta ray population structure, for the remainder of this biological opinion, we will use the terms 'giant manta ray' or 'species' to refer to the giant manta ray as they were listed, the term 'population' to refer to the Indo-Pacific population as a whole, and 'subpopulation' to refer to independent subunits considered in this biological opinion. We note that for some of the study areas where only small numbers of individuals have been identified, these may not represent regionally defined subpopulations and we consider them aggregations until further data can be collected.

Status and Trends

NMFS listed giant manta rays globally as threatened in 2018. The IUCN lists them as vulnerable (the category that immediately precedes endangered in the IUCN classification system), with a decreasing population trend. Although the number of regional subpopulations is unknown, the sizes of those identified as regional subpopulations tends to be small, ranging from 600 to 25,250 (CITES 2013; Marshall et al. 2018; Beale et al. 2019; Table 7). CITES (2013) highlights three giant manta ray subpopulations that have been studied and population estimates provided, and counts for more than ten aggregations (Table 7). CITES (2013) also discusses an additional approximately 25 aggregations where species-level information (i.e., *Manta birostris* vs *M. alfredi*) does not exist and, while actual abundance estimates are not available, it is assumed they consist of very small number of individuals. This information was compiled from O'Malley et al. (2013), Heinrichs et al. (2011), Lewis et al. (2015), and Fernando and Stevens (2011). The most comprehensive of these is O'Malley et al. (2013) that presents an overview of the economic value of manta ray watching tourism. They highlight 23 sites globally, and within the *Action Area* of the U.S., these areas include nine sites: Indonesia, Papua New Guinea, Federated States of Micronesia, Palau, Solomon Islands, Kiribati, New Caledonia, Fiji and French Polynesia.

Overall, giant manta ray subpopulations appear to be regionally distinct (Lewis et al. 2015; Stewart et al. 2016a; Moazzam 2018; Beale et al. 2019) and may have distinct home ranges (Stewart et al. 2016a).

Table 7. Numbers of recorded individuals and subpopulation estimates of giant manta ray at identified locations adapted from CITES (2013) and updated with supplementary references as specified.

Location	**Recorded Individuals**	**Subpopulation Estimate**	**Reference**
Mozambique	180 - 254	600	Marshall et al. (2009) and pers. comm. cited in CITES (2013); MantaMatcher (2016)
Egypt	60	-	Marine Megafauna (2011) as cited in CITES (2013)
Republic of Maldives	716	-	J. Stewart pers. comm. to A. Garrett citing S. Hilbourne pers. comm. (2021)
Republic of Maldives	378	-	Nicholson-Jack (2020)
Kona, Hawaii (U.S.)	29	-	Clark (2010)
Thailand	365	-	J. Stewart pers. comm. to A. Garrett citing Manta Trust data (2021)
Raja Ampat, Indonesia	588	1,875	Beale et al. (2019)
Isla de la Plata, Ecuador	~650	1,500	M. Harding, pers. comm. cited in CITES (2013); Sanchez (2016)
Isla de la Plata, Ecuador	2,464	25,250	MantaMatch (2016); Burgess (2017); Marshall and Holmberg 2011as cited in Burgess (2017); Subpopulation estimate from J. Stewart pers. comm. to A. Garrett (2021)

Location	Recorded Individuals	Subpopulation Estimate	Reference
Brazil	60	-	Laje Viva Institute unpubl. cited in CITES (2013), Luiz et al. (2009)
Mexico (Revillagigedos Is.)	916	-	J. Stewart pers. comm. to A. Garrett citing pers. comm to R. Rubin and K. Kumli (2021)
Mexico (Isla Holbox)	> 200	-	R. Graham, pers. comm. cited in CITES (2013)
Jupiter, Florida (U.S.)	59	-	Pate and Marshall (2020)
Flower Garden Banks (U.S. EEZ)	>70	-	Graham and Witt (2008) cited in CITES (2013)
Flower Garden Banks (U.S. EEZ)	95 (52 proposed *M. cf. birostris*)	-	Stewart et al. (2018)
Japan (Ogasawara Islands)	42	-	Kashiwagi et al. (2010)
Azores, Portugal	31	-	J. Stewart pers. comm. to A. Garrett citing A. Sobral pers. comm. (2021).
Myanmar	201	-	J. Stewart pers. comm. to A. Garrett citing Manta Trust data (2021)
Costa Rica	52	-	J. Stewart pers. comm. to A. Garrett citing Manta Trust data (2021)

Population Dynamics

Most documented giant manta ray subpopulations appear to be composed of relatively small population sizes. Photo-identification studies for giant manta ray subpopulations in southern Mozambique (*n*= 180-254; Marshall et al. 2009); southern Brazil (*n*= 60; Luiz et al. 2009); Revillagigedo Islands, Mexico (*n*= 916; J. Stewart pers. comm. to A. Garrett citing pers. comm to R. Rubin and K. Kumli [2021])); the Ogasawara Islands, Japan (*n*= 42; Kashiwagi et al.

2010); the Maldives (*n*= 716; J. Stewart pers. comm. to A. Garrett citing S. Hilbourne pers. comm. 2021)); Isla Holbox, Mexico (*n*= 200; S. Hinojosa-Alvarez unpubl. data 2010 cited in Marshall et al. 2018); with many of these studies having been conducted for the last 10–20 years. A study of Japan-wide photographic records confirmed that the known main aggregation in Ogasawara Islands (42 known individuals during 1995–1998 study) represents a part of a fairly isolated population (Kashiwagi et al. 2010). A mark-recapture population study in southern Mozambique over five years from 2003 to 2008 estimated the local population during that time to be 600 individuals (Marshall et al. 2009). Flight surveys and re-sightings data of individuals at Isla Holbox, Mexico have estimated that roughly 100 manta rays use this area during every season (S. Hinojosa-Alvarez unpubl. data 2010 cited in Marshall et al. 2018). However, 'recorded individuals' may not be indicative of population size.

The number of individually identified giant manta ray for each studied aggregation ranges from less than 50 in regions with low survey effort or infrequent sightings to more than 1,000 in some regions with targeted, long-term studies. However, ongoing research including mark-recapture analyses suggests that typical subpopulation abundances are more likely in the low thousands (e.g., Beale et al. 2019) and in rare cases may exceed 10,000 in areas with extremely high productivity (pers. comm. Joshua Stewart, citing Manta Trust to A. Garrett 2021). Of the 12 studied subpopulations, statistical analyses of sightings/photo-identification data to estimate total population size has only been conducted for three of them. For Raja Ampat, CITES (2013) indicated that there were 72 identified individuals. After additional research and an analysis of resightings data, Beale et al. (2019) estimated the total population size to be approximately 1,875 individuals. Isla de la Plata, Ecuador had approximately 650 identified individuals reported in CITES (2013), in this case, Burgess (2017) conducted further analyses and estimates the total population size to be 2,464 individuals. Similar, for the Republic of Maldives, as of 2013, 63 individuals had been identified (CITES 2013), Nicholson-Jack (2020) reported 378, and further study indicates a more than 10-fold increase over the initial number of identified individuals (n = 716; J. Stewart pers. comm. to A. Garrett citing S. Hilbourne pers. comm. 2021). Thus, while some subpopulations may have been reduced to very small population sizes due to fisheries (direct harvest or bycatch), in general, stable giant manta ray subpopulations are likely to be larger, potentially greater than 1,000 individuals, which would be in keeping with the literature that suggests subpopulations are isolated with limited movement. The current understanding of effective population sizes necessary for the genetic diversity needed to maintain evolutionary fitness in isolated populations is greater than 1,000 (Frankham et al. 2014).

More importantly, the size of some of these subpopulations has declined significantly in regions subject to fishing (Marshall et al. 2018). Fisheries catch and bycatch have caused giant manta rays to decline by at least 30% globally and by up to 80% in significant portions of its range (i.e., Indonesia, Philippines, Sri Lanka, Thailand, Madagascar; Marshall et al. 2018). Lewis et al. 2015 collected data on daily landings of *Manta* and *Mobula* species from 2002 to 2014 for eight locations in Indonesia. For Manta species, *Manta birostris* was the primary target of these fisheries. Total annual landings were estimated by multiplying the number of recorded or observed daily landings by the number of fishing days per year. For the three locations with the most complete data, landings of *Manta* species declined by 71% to 95%. Reports from fishermen suggest that these data are representative of declines in abundance rather than shifts in effort.

Within the *Action Area*, Tremblay-Boyer and Brouwer (2016) present catch per unit effort (CPUE) data for giant manta ray observed captures in the WCPO longline and purse seine fisheries. Giant manta ray were not reliably identified to species by observers in the WCPO purse seine fishery until about 2011 (NMFS 2021c). In their analysis, Tremblay-Boyer and Brouwer (2016) found increasing trends in CPUE from 2005 to 2016 for giant manta rays but they caution that these trends represent increases in compliance with reporting the species and does not represent an index of abundance. CPUE trends in the longline fisheries indicate that giant manta rays are observed less frequently in recent years compared to 2000-2005, suggesting a decline in abundance.

Giant manta rays are a long-lived, late maturing species with productivity that is among the lowest of all elasmobranchs. Rambahiniarison et al. (2018) estimated that giant manta ray off the Philippine Islands matured at about 9 years and had their first pregnancy at about 13 years of age. Overall, age at maturity estimates range from three to more than 15 years. Giant manta rays typically give birth to only one pup every two to three years, but this can range from annual to 5 years (Notarbartolo-Di-Sciara 1989; Marshall and Bennett 2010; Dulvy et al. 2014; Rambahiniarison et al. 2018). Rambahiniarison et al. (2018) reported that the proportion of pregnant females in subpopulations of giant manta ray in the Philippine Islands averaged about 9 out of every 100 females (9%), but they suggested this might depend on the length of the inter-pregnancy period which could depend on the availability of resources. Additionally, sex ratios may differ between populations. Beale et al. (2019) noted a statistically significant female-biased sex ratio of 2.62(f):1 in Raja Ampat. However, Pate and Marshall (2020) did not find a statistical difference in Florida with a sex ratio of 1:1 and Stewart et al. (2018) noted a ratio of 1.3(f):1 in the Flower Garden Banks of the Gulf of Mexico. Differences between locations may be due to unique threats to each population.

Gestation is thought to last around a year. Although manta rays have been reported to live at least 40 years (Dulvy et al. 2014), not much is known about their growth, development, and population dynamics, although generation time is estimated at 25 years. Nevertheless, the combination of long-lives, late-maturation, and low productivity would make this species particularly vulnerable to harvests that target adults (Dulvy et al. 2014; Croll et al. 2016; Miller and Klimovich 2017), which would limit their ability to recover from over-exploitation (Crouse 1999). To illustrate this point, Rambahiniarison et al. (2018) estimated that giant manta ray subpopulations would require about 36.5 to 86.6 years to double in size (the former based on estimated age to maturity; the latter based on estimated age of first pregnancy). A population that requires about 4 to almost 9 decades to double in size has limited ability to recover from exploitation and disturbance, particularly when the exploitation is constant.

In order to determine how changes in survival may affect populations, Smallegange et al. (2016) modeled the demographics of reef manta rays (*M. alfredi*), which have similar life history characteristics to giant manta rays, therefore we chose this species as a proxy and assume their results are relevant to giant manta rays. In their own observations of the population off the southern coast of Mozambique, the authors estimated an adult survival rate of 0.67 (± 0.16 SE). Results from the population modeling showed that, at this adult survival rate and yearling survival rates greater than 0.75, population growth rate was most sensitive to changes in juvenile survival, while if yearling survival rates were less than 0.75, population growth rates were most sensitive to adult survival rates. They contrasted these results to a population model based on an estimated survival rate of 0.95 for a stable reef manta ray population in Japan. Based on the elasticity analysis, population growth rate was most sensitive to changes in the survival rate of adults regardless of yearling and juvenile survival rates (Smallegange et al. 2016). In other words, in order to prevent populations from declining further, Smallegange et al. (2016) found that increases in adult survival rates would have the greatest impact, such as through protection of adult aggregation sites or a reduction in fishing of adult manta rays (Smallegange et al. 2016). However, their results also show that low yearling and juvenile survival can result in declining populations even if adult survival remains high, so increased mortality of those life stages are also important.

Behavior

Although giant manta rays are considered more oceanic and solitary than the reef manta, they have been observed congregating at cleaning sites at offshore reefs and feeding in shallow waters during the day at depths <10 m (O'Shea et al. 2010; Marshall et al. 2011; Rohner et al. 2013). Unlike the reef manta ray, the giant manta ray does not appear in large schools (<30 individuals; Marshall et al. 2018) and despite having a larger distribution when compared to the reef manta, they are encountered with far less frequency.

Giant manta rays appear to exhibit a high degree of plasticity in terms of their use of depths within their habitat. Tagging studies have shown that the species conducts night descents to 200-450 m depths (Rubin et al. 2008 as cited in Miller and Klimovich 2017; Stewart et al. 2016b) but is capable of diving to depths exceeding 1,000 m (A. Marshall et al. unpubl. data 2011 cited in Marshall et al. 2011).

Threats to the Species

Giant manta rays are reportedly targeted in fisheries in Indonesia, Philippines, India, Thailand, Mozambique, Tonga, Micronesia, Peru, Ghana, and previously in Mexico and possibly the Republic of Maldives. Indonesia is reported to be one of the top countries that catch mobulid rays (Heinrichs et al. 2011). Manta and devil ray fisheries span the majority of the Indonesian archipelago, with most landing sites along the Indian Ocean coast of East and West Nusa Tenggara and Java (Lewis et al. 2015). Although fishing for manta rays was banned within the Indonesian exclusive economic zone (EEZ) in February 2014, in May 2014, manta rays were still being caught and processed at Lamakera, with the giant manta the most commonly targeted species (Marshall and Conradie 2014). It is unlikely that fishing effort and associated utilization of the species will significantly decrease in the foreseeable future as interviews with fishermen indicate that many are excited for the new prohibition on manta rays in Indonesian waters because it is expected to drive up the price of manta ray products, significantly increasing the current income of current resident fishermen (Marshall and Conradie 2014).

Giant manta rays are also frequently caught as bycatch in a number of commercial and artisanal fisheries worldwide, particularly commercial longline, trawl, purse-seine and gillnet fisheries off Europe, western Africa, the Atlantic coast of the U.S., Australia, and the Pacific and Indian Oceans.

In regions outside of the *Action Area* considered in this biological opinion (captures in fisheries that overlap the *Action Area* are considered in the *Environmental Baseline* section), giant manta rays are caught in the U.S. WCPO purse seine fishery and the ASLL fishery. The U.S. WCPO purse seine fishery captured 1,523 giant manta rays from 2010-2018 and an estimated 3,676 (95% CI: [3,119, 4,467]) interactions accounting for unidentified *Manta* species and unavailable observer data (NMFS unpublished data). However, it is also considered highly likely that a large portion (~75%) of those individuals identified as giant manta ray were misidentified by observers. In contrast the ASLL fishery captured 12 giant manta rays from 2010-2017 (based on 19 - 25% observer coverage), resulting in an estimated 122 interactions accounting for unobserved sets and individuals not identified to species (NMFS unpublished data).

Conservation

Domestic fishery regulations prohibit the retention of manta rays by persons under U.S. jurisdiction. Additionally, as noted in the final status review report (Miller and Klimovich 2017), established Marine Protected Areas (MPAs) that limit or prohibit fishing also exist that cover areas with observed giant manta ray presence, including the waters off Guam (Tumon Bay Marine Preserve), within the Gulf of Mexico (Flower Garden Banks National Marine Sanctuary), and in the Central Pacific Ocean (Pacific Remote Islands Marine National Monument).

Internationally, the giant manta ray is protected in the Maldives, Philippines, Mexico, Brazil, Ecuador, Yap, Indonesia, Western Australia, and New Zealand (Miller and Klimovich 2017). These protections range from restrictions on knowingly capturing or killing rays, to bans on exportation of ray species and their body parts from established Marine Protection Areas of known giant manta ray aggregations. However, many of these restrictions are difficult and rarely enforced; in Indonesia, restrictions have driven the price of manta ray products up (Marshall and Conradie 2014), which has likely increased demand and had the opposite effect intended.

Manta rays were included on Appendix II of CITES at the 16 Conference of the CITES Parties in March 2013. Export of manta rays and manta ray products, such as gill plates, require CITES permits that ensure the products were legally acquired and that the Scientific Authority of the State of export has advised that such export will not be detrimental to the survival of that species (after taking into account factors such as its population status and trends, distribution, harvest, and other biological and ecological elements). Although this CITES protection was not considered to be an action that decreased the current listing status of the threatened giant manta ray, it may help address the threat of foreign overutilization for the gill plate trade by ensuring that international trade of this threatened species is sustainable (Miller and Klimovich 2017).

In November 2014, the Convention on the Conservation of Migratory Species of Wild Animals listed the giant manta ray on Appendix I and II of the Convention (CMS 2014). Under this designation, Conservation of Migratory Species Parties strive to protect these animals, conserve and restore habitat, mitigate obstacles to migration and engage in international and regional agreements.

There are many conservation efforts presently ongoing to collect research on manta ray life history, ecology, and biology, and to raise awareness of threats to manta rays. Some of these efforts are spearheaded by non-profit organizations specifically dedicated to manta ray conservation, such as the Manta Trust (Stevens et al. 2018), the Marine Megafuna Foundation, the Manta Pacific Research Foundation and MantaWatch. Others are driven by the countries whose economies largely depend on manta ray tourism (Erdmann 2014). In addition, guidelines for best practices for the safe release of manta rays caught in purse seine and longline fisheries have been developed (Hutchinson et al. 2017) and, as discussed in the *Description of the Proposed Action* section, went into effect as a WCPFCIA January 1, 2021. CMM 2019-05 prohibits vessels from targeted fishing or intentional setting on mobulid rays; from retaining on board, transshipping, or landing any part or whole carcass of mobulid rays; fishing vessels must promptly release animals alive and unharmed that will result in the least possible harm to the individuals captured. The U.S. has issued a proposed rule to put the handling practices in CMM 2019-05 into regulation for U.S. fisheries (86 FR 55790).

Summary of the Status

In this section of this biological opinion, we explained that the giant manta ray is highly fragmented and sparsely distributed, which contributes to the lack of information on this species. It is one of the least understood of the marine mega vertebrates. Many of the studied giant manta ray populations' have declined significantly in areas subject to fishing (Marshall et al. 2018). Fisheries catch and bycatch have caused giant manta rays to decline by at least 30% globally and by up to 80% in significant portions of its range (i.e., Indonesia, Philippines, Sri Lanka, Thailand, Madagascar; Marshall et al. 2018). In Indonesia, manta ray landings are estimated to have declined by 71% to 95%, with potential extirpations noted in certain areas (Lewis et al. 2015).

As mentioned above, in the early stages of development as an embryo, the giant manta ray is susceptible to toxins that may be passively transferred from its mother through milk production (Lyons et al. 2013). Species like the giant manta ray with delayed sexual maturity increase their potential to accumulate toxins and therefore, are expected to offload higher levels of contaminants to their offspring. Once the giant manta ray grows beyond a neonate, it is vulnerable to the same threats throughout its juvenile and adult life stages. Targeted capture and bycatch in fisheries is arguably the most significant threat to the giant manta ray (Croll et al. 2016).

Due to their particular life-history characteristics (e.g., slow growth, late maturity, and low fecundity), elasmobranchs, and specifically, the giant manta ray, have little potential to withstand high and sustained levels of fishing exploitation (Hoenig and Gruber 1990; Stevens et al. 2000; Couturier et al. 2012; Dulvy et al. 2014). Despite the best efforts of protections and conservation measures, the overall trend of the giant manta ray continues to decline.

2.2.2 Indo-West Pacific Scalloped Hammerhead Shark

Distribution and Population Structure

In 2014, the scalloped hammerhead shark was determined to consist of six DPSs and of those, four were listed as either threatened or endangered including the Indo-West Pacific scalloped hammerhead shark (Figure 5; 79 FR 38213). The majority of the *Action Area* overlaps with the range of the Central Pacific scalloped hammerhead shark which is not listed under the ESA. While most observed scalloped hammerhead shark captures have occurred within the range of the Central Pacific scalloped hammerhead shark, there have been a smaller number of captures overlapping with the range of the Indo-West Pacific scalloped hammerhead shark. Our assessment is limited to analyzing the effect of the Hawaii DSLL fishery on threatened Indo-West Pacific scalloped hammerhead sharks.

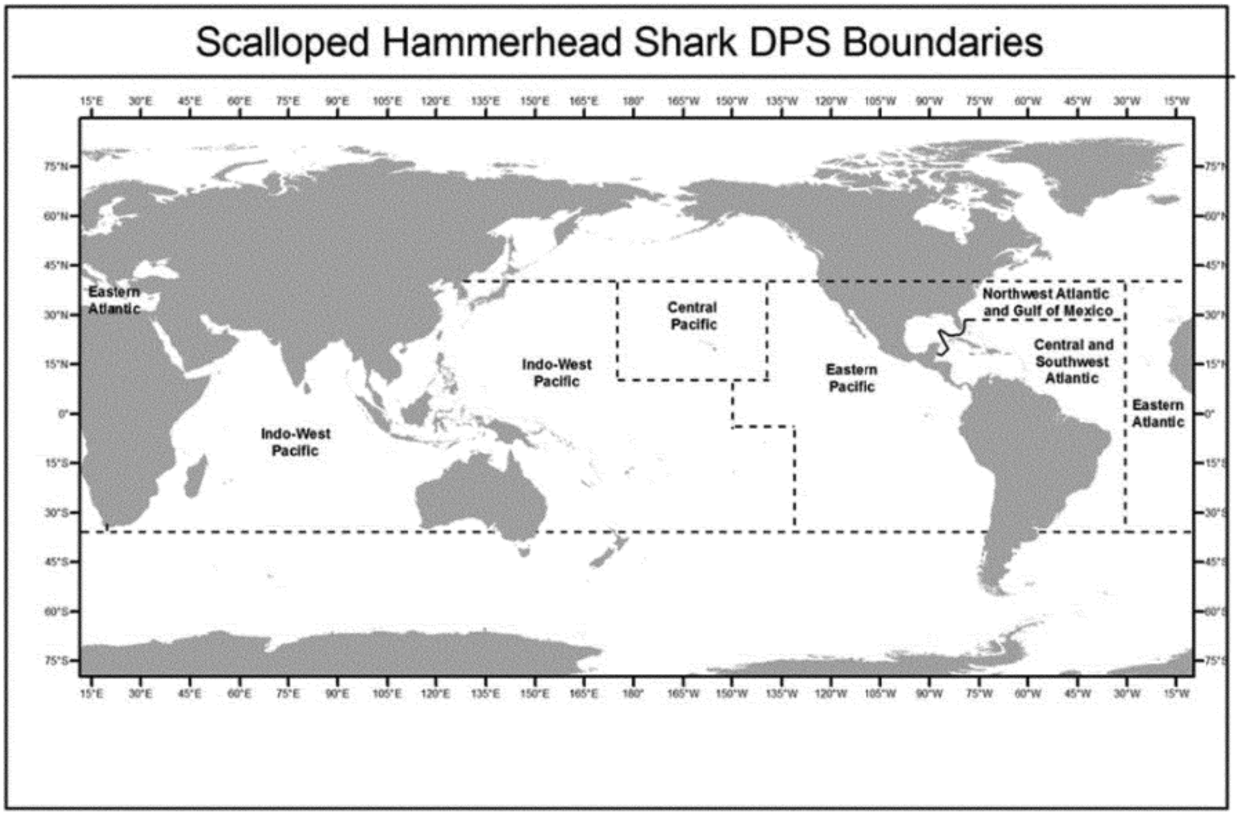

Figure 5. DPS boundaries of the scalloped hammerhead shark (79 FR 38213).

Scalloped hammerhead sharks (*Sphyrna lewini*) can be found in coastal warm temperate and tropical seas worldwide. Indo-west Pacific scalloped hammerhead sharks can be found throughout the entire Indian Ocean and in the western Pacific from Japan and China to New Caledonia, including throughout the Philippines, Indonesia, and off Australia. The scalloped hammerhead shark occurs over continental and insular shelves, as well as adjacent deep waters, but is seldom found in waters cooler than 22°C (Compagno 1984).

These sharks have been observed making migrations along continental margins as well as between oceanic islands in tropical waters (Kohler and Turner 2001; Duncan and Holland 2006; Bessudo et al. 2011; Diemer et al. 2011). Tagging studies reveal the tendency for scalloped hammerhead sharks to aggregate around and travel to and from core areas or "hot spots" within locations (Holland et al. 1993; Duncan and Holland 2006; Hearn et al. 2010; Bessudo et al. 2011), however they are also capable of traveling long distances (1671 km, Kohler and Turner 2001; 1941 km, Bessudo et al. 2011; 629 km, Diemer et al. 2011).

Status and Trends

Indo-west Pacific scalloped hammerhead sharks are listed as threatened because of overharvesting. Although range-wide trends in the abundance of this species are unknown, CPUE data suggest that local populations throughout the range of the species have declined significantly (Miller et al. 2014). For example, the hammerhead population in Australia's northwest marine region has been estimated to have declined between 58-76% between 1996 and 2005 (Miller et al. 2014). Similarly, catch rates of *Sphyrna lewini* in beach mesh programs in South Africa have declined by 99%, 86%, and 64% from 1952-1972, 1961-1972, and 1978-2003, respectively (Dudley and Simpfendorfer 2006; Ferretti et al. 2010). Estimates of the decline in Australian hammerhead abundance range from 58-85% (Heupel and McAuley 2007; CITES 2010). Data from protective shark meshing programs off beaches in New South Wales (NSW) and Queensland also suggest significant declines in hammerhead populations off the east coast of Australia. From 1973 to 2008, the number of hammerheads caught per year in NSW beach nets decreased by more than 90% from over 300 individuals to fewer than 30 (Reid and Krogh 1992; Williamson 2011; Miller et al. 2014). Similarly, data from the Queensland shark control program indicate declines of around 79% in hammerhead shark abundance between the years of 1986 and 2010, with *Sphyrna lewini* abundance fluctuating over the years but showing a recent decline of 63% between 2005 and 2010 (QLD DEEDI 2011 as cited in Miller et al. 2014).

Current effective population sizes are available for the scalloped hammerhead shark, but are considered qualitative indicators rather than precise estimates given their reliance on mutation rates and generation times (Duncan et al. 2006). Using two generation times (5.7 and 16.7 years), Duncan et al. (2006) calculated the effective female population (Nf) size of *Sphyrna lewini* for the major ocean basins. Based on a 1:1 sex-ratio (Clarke 1971; Chen et al. 1988; Stevens and Lyle 1989; Ulrich et al. 2007; White et al. 2008; Noriega et al. 2011), these calculations have been converted into total (both females and males) effective population size (Ne) by using the formula Ne = 2(Nf). Results of Ne greatly varied within and between ocean basins, with the global Ne estimated at 280,000 using a generation time of 5.7 years, and 94,000 using a generation time of 16.7 years (Miller et al. 2014). There are no estimates of abundance for the Indo-West Pacific scalloped hammerhead sharks but we can assume it is less than the global abundance of 280,000.

Pacoureau et al. (2021) indicates a 67% global decline from 1970 to 2018 equating to a 2.31% decline per year. However, Figure 5 of Pacoureau et al. (2021) suggests populations in the South Pacific and Indian Oceans (i.e., Indo West Pacific scalloped hammerheads) have stabilized at a depressed level.

Population Dynamics

Like the other elasmobranchs included in this biological opinion, scalloped hammerhead sharks are long lived, late maturing, and with low productivity (Branstetter 1990). Although their age at maturity varies geographically, scalloped hammerhead sharks are generally considered mature at about 200-250 cm total length (females) while males reach maturity at smaller sizes (range 128 – 200 cm). These lengths correspond to ages from 3.8 to 15.2 years. They are estimated to live for at least 20 to 30 years, have gestation periods of 9 to 12 months (Branstetter 1987; Stevens and Lyle 1989), give birth to live young, and females may rest for about 12 months between births (Liu and Chen 1999).

Behavior

Both juvenile and adult scalloped hammerhead sharks occur as solitary individuals, pairs, or in schools. The schooling behavior has been documented during summer migrations off the coast of South Africa as well as in permanent resident populations, like those in the East China Sea

(Compagno 1984). Adult aggregations are most common offshore over seamounts and near islands, especially near the Galapagos, Malpelo, Cocos and Revillagigedo Islands, and within the Gulf of California (Compagno 1984; CITES 2010; Hearn et al. 2010; Bessudo et al. 2011). Neonate and juvenile aggregations are more common in nearshore nursery habitats, such as Kaneohe Bay in Oahu, Hawaii, coastal waters off Oaxaca, Mexico, and Guam's inner Apra Harbor (Duncan and Holland 2006; Bejarano-Alvarez et al. 2011). It has been suggested that juveniles inhabit these nursery areas for up to or more than a year, as they provide valuable refuges from predation (Duncan and Holland 2006).

Threats to the Species

Overharvest in commercial and artisanal fisheries and illegal fishing are the most serious threats to Indo-west Pacific scalloped hammerhead sharks. Scalloped hammerhead sharks in general are captured in targeted fisheries and captured as bycatch in pelagic longline fisheries and purse seine fisheries. Miller et al. (2014) noted that significant catches of scalloped hammerheads have and continue to go unrecorded or underreported in many countries outside the U.S. Furthermore, Miller et al. (2014), discussed that data on catches of scalloped hammerheads are suspected to underestimate the true catch because many records do not account for discards (example: where the fins are kept but the carcass is discarded) or reflect dressed weights instead of live weights. In addition, many catch records do not differentiate between hammerhead species, or sharks in general, and thus species-specific population trends for scalloped hammerheads are not readily available (Miller et al. 2014). Contributing to the scalloped hammerhead shark's biological vulnerability is the fact that these sharks are obligate ram ventilators and suffer very high at-vessel fishing mortality from fisheries where they are not able to continually swim forward (Morgan and Burgess 2007; Macbeth et al. 2009; Miller et al. 2014; Dapp et al. 2016). For example, between 92 to 94% of the hammerhead sharks captured in bottom longline fisheries die at vessel and this does not include post release mortality (Morgan and Burgress 2007). Considering purse seine fisheries, while Hutchinson's (2015) study focused on silky sharks, the study showed that sharks confined in the sack portion of the net just prior to loading suffered much higher mortality with only a 6.67% chance of survival after brailing. This highlights the consequences of restricting the movement of hammerhead shark species given their respiratory mode (i.e., obligate ram ventilation). Compared to other chondrichthyans, scalloped hammerhead sharks appear to sustain a higher level of fishing mortality (Miller et al. 2014). Miller et al. (2014) further ranked high at-vessel mortality as the most serious threat to the species.

Catches of Indo-West Pacific scalloped hammerhead sharks from foreign fisheries have decreased since reaching a maximum of 798 t in 2002 (see Figure 2 in Miller et al. 2014). According to shark fin traders, hammerheads are one of the sources for the best quality fin needles for consumption and fetch a high commercial value in the Asian shark fin trade (Abercrombie et al. 2005). In Hong Kong, the world's largest fin trade market, scalloped hammerhead, and smooth hammerhead sharks are found under the "Chun chi" market category, the second most traded fin category in the market (Clarke et al. 2006a). Applying a Bayesian statistical method to the Hong Kong shark fin trade data, Clarke et al. (2006) estimated that between 1 and 3 million hammerhead sharks, with an equivalent biomass of 60 – 70 thousand metric tonnes, are traded per year.

U.S. fisheries appear to have less influence on this species status when compared to foreign fisheries. U.S. fisheries in Alaska and California, and the Hawaii SSLL do not overlap with the species range. Thus these fisheries do not interact with Indo-West Pacific scalloped hammerhead sharks. However, the U.S. WCPO purse seine and ASLL fisheries do interact with the Indo-West Pacific scalloped hammerhead.

A total of 14 Indo-West Pacific scalloped hammerhead sharks were caught and positively identified in the U.S. WCPO purse seine fishery between 2008 and 2018. However, NMFS estimates a total of 41 (95% CI: [31, 51]) Indo-West Pacific scalloped hammerhead sharks were captured between 2008 and 2018 using the Bayesian model approach and is expected to interact with 5 individuals a year with 100% mortality (NMFS 2021c).

Lastly, the ASLL fishery is expected to have interacted with approximately 60 Indo-West Pacific scalloped hammerhead sharks over a 9-year period from 2010 to 2019 (2nd quarter; McCracken 2019c). Most confirmed Indo-West Pacific hammerhead sharks were released alive (73%) and no sharks were recorded as retained. Average at-vessel mortality of Indo-West Pacific hammerhead sharks is 27% in the ASLL fishery. However, the publicly available data compiled by Dapp et al. (2016), estimate 37.6% at-vessel mortality based on the gear type (longline) and the respiratory mode of the animals (i.e., obligate ram-ventilation). Thus the greatest influence on the decline of this species is from foreign fisheries throughout the species range in the western Pacific.

Conservation

Within the WCPO, finning bans have been implemented by Australia, Cook Islands, Micronesia New Zealand, Palau, Republic of the Marshall Islands and Tokelau, as well as by the Inter-American Tropical Tuna Commission (IATTC) and the WCPFC. These finning bans range from requiring fins remain attached to the body to allowing fishermen to remove shark fins provided that the weight of the fins does not exceed 5% of the total weight of shark carcasses landed or found onboard. The WCPFC has implemented several conservation and management measures for sharks with the following objectives (Clarke 2013): (1) promote full utilization and reduce waste of sharks by controlling finning (perhaps as a means to indirectly reduce fishing mortality for sharks); (2) increase the number of sharks that are released alive (in order to reduce shark mortality); and (3) increase the amount of scientific data that is collected for use in shark stock assessments. Also, specific to oceanic whitetip sharks, CMM 2011-04 prohibits WCPFC vessels from retaining onboard, transshipping, storing on a fishing vessel, or landing any Indo-West Pacific scalloped hammerhead shark, in whole or in part, in the fisheries covered by the Convention. This CMM was later replaced in 2019 by CMM-2019-04 for all sharks, which retains the retention prohibition for oceanic whitetip sharks, and includes additional measures on minimizing bycatch (including some gear restrictions) and implementing safe release practices.

Also of relevance is the FAO International Plan of Action for the Conservation and Management of Sharks which recommends that RFMOs carry out regular shark population assessments and that member States cooperate on joint and regional shark management plans.

Based on the best scientific and commercial data available the Indo-West Pacific scalloped hammerhead shark appears to be decreasing at significant rates. The species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range

(Miller et al. 2014). Evidence of heavy fishing pressure by industrial/commercial and artisanal fisheries, and reports of significant illegal, unreported and unregulated (IUU) fishing, especially off the coast of Australia, have likely led to overutilization coupled with inadequate regulatory mechanisms are the most concerning threats that may contribute to the extinction risk of the species. As a result of this fishing mortality, the Indo-West Pacific scalloped hammerhead shark population is declining.

2.2.3 Oceanic Whitetip Shark

Distribution and Population Structure

Oceanic whitetip sharks are distributed in circumtropical and subtropical regions across the world, primarily between 30° North and 35° South latitude (Compagno 1984; Baum et al. 2015; Young et al. 2017), although, the species has been reported as far as 45°N and 40°S in the Western Atlantic (Lessa et al. 1999b). These sharks occur throughout the WCPO, including Australia (southern Australian coast), China, New Caledonia, the Philippines, Taiwan, and the Hawaiian Islands south to the Samoan Islands, Tahiti and Tuamotu Archipelago, and west to the Galapagos Islands. In the eastern Pacific, they occur from southern California to Peru, including the Gulf of California and Clipperton Island (Compagno 1984). In the western Atlantic, oceanic whitetips occur from Maine to Argentina, including the Caribbean and Gulf of Mexico. In the central and eastern Atlantic, the species occurs from Madeira, Portugal south to the Gulf of Guinea, and possibly in the Mediterranean Sea. In the western Indian Ocean, the species occurs in waters of South Africa, Madagascar, Mozambique, Mauritius, Seychelles, India, and within the Red Sea.

The geographic distribution of oceanic whitetip shark occurs in a 10° band centered on the equator (Figure 6); their abundance decreases with increasing distance from the equator and increasing proximity to continental shelves (Backus et al. 1956; Strasburg 1958; Compagno 1984; Nakano et al. 1997; Bonfil et al. 2008; Clarke et al. 2011a; Hall and Roman 2013; Tolotti et al. 2013; Young et al. 2017).

Only two studies have been conducted on the genetics and population structure of the oceanic whitetip shark which suggest there may be some genetic differentiation between various populations (Camargo et al. 2016; Ruck 2016). Camargo et al. (2016) compared the mitochondrial control region in 215 individuals from the Atlantic and Indian Oceans. They found evidence of moderate levels of population structure resulting from restricted gene flow between the western and eastern Atlantic Ocean, they also found evidence of connectivity between the eastern Atlantic Ocean and the Indian Ocean (although the sample size from the Indian Ocean was only 9 individuals). It should be noted that this study only used mitochondrial markers, meaning male-mediated gene flow is not reflected in these relationships (Young et al. 2017) although other species in the Carcharhinus genus are known to exhibit male-mediated gene flow between populations (Portnoy et al. 2010). Ruck (2016) compared samples of 171 individual sharks from the western Atlantic, Indian, and Pacific Oceans specifically looking at the mitochondrial control region, a protein-coding mitochondrial region, and nine nuclear microsatellite loci and found no fine-scale matrilineal structure was discovered within ocean basins. Ruck (2016) did detect weak but significant differentiation between the Atlantic and Indo-Pacific Ocean populations. An additional analysis of the sample from both studies

(Camargo et al. 2016; Ruck 2016) did detect matrilineal population structure within the Atlantic Ocean basin with three lineages, the Northwest Atlantic, the rest of the Western Atlantic, and the Eastern Atlantic Ocean (C. Ruck, personal communication, 2016 as cited in Young et al. 2017).

Tagging studies have also provided information on potential population structure (reviewed in Young and Carlson 2020). Two studies have found evidence of site fidelity in the Atlantic Ocean (Howey-Jordon et al. 2013; Tolotti et al. 2015). Howey-Jordon et al. (2013) found that oceanic whitetip sharks tagged in the Bahamas (1 male and 10 females tagged but the tag on the male shark failed) stayed within 500 km of their tagging site for at least 30 days, at which point they dispersed in different directions across a wide area with some sharks travelling more than 1,500 km from their tagging site. The six tagged sharks that retained their tags for longer than 150 days ($n = 6$) were all located within 500 km of their tagging site when their tags popped off. Similarly, Tolotti et al. (2015) tagged 8 oceanic whitetip sharks (sex of sharks was not reported) and found that the tagging and pop-up locations were relatively close to each other, but some individuals traveled long distances (up to 2,500 km) in between these events. Together, these studies suggest that oceanic whitetip sharks can be philopatric (Howey-Jordon et al. 2013; Tolotti et al. 2015; Young and Carlson 2020) however it is not clear if this is a result of females exhibiting site fidelity to pupping areas or if the species has an underlying subpopulation structure (Young and Carlson 2020).

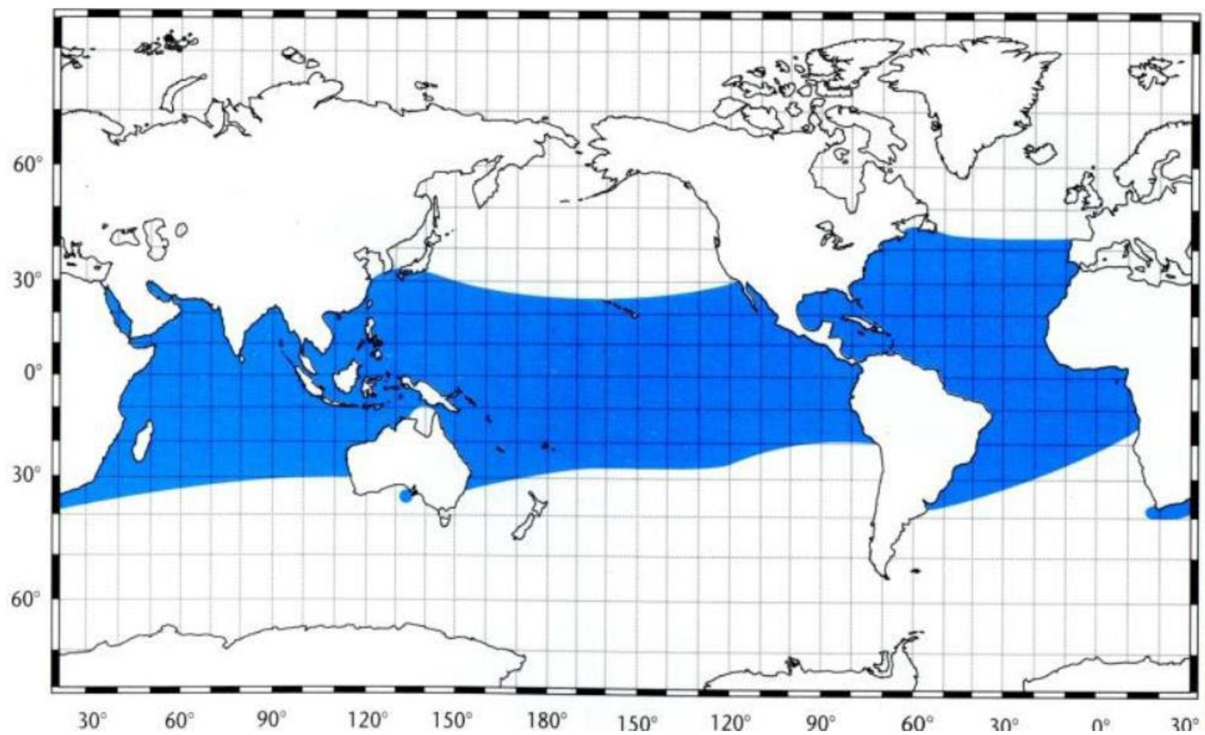

Figure 6. Geographical distribution of the oceanic whitetip shark (Last and Stevens 2009).

Status and Trends

Oceanic whitetip sharks were listed globally as threatened in 2018. Historically, oceanic whitetip sharks were described as one of the most abundant species of shark found in warm tropical and sub-tropical waters of the world (Backus et al. 1956; Strasburg 1958). Oceanic whitetip sharks occur throughout their range with no evidence of range contraction or range erosion (gaps within the species' range that form when populations become extinct locally or regionally; Lomolino and Channell 1995, 1998; Collen et al. 2011). However, recent estimates of their abundance suggest the species has experienced significant historical and continued declines throughout its range. Declines in abundance range from 80-96% across the Pacific Ocean since the late 1990s (Clarke et al. 2012; Rice and Harley 2012; Brodziak et al. 2013; Hall and Roman 2013; Rice et al. 2015; Tremblay-Boyer et al. 2019), 50-88% across the Atlantic Ocean (Baum and Meyers 2004; Santana et al. 2004; Cortes et al. 2007; Driggers et al. 2011); and have been variable across the Indian Ocean, ranging from 25-40% (Anderson et al. 2011; IOTC 2011, 2015; Ramos-Cartelle et al. 2012; Yokawa and Semba 2012).

The only formal stock assessments for the Pacific represent a portion of the total Pacific Ocean population–the West Pacific portion of the population's range (aka. the West Pacific stock). Unfortunately, it remains unclear how much of the total Pacific Ocean oceanic whitetip population this one population assessment covers. As noted above, oceanic whitetip sharks occur primarily between 30° North and 35° South latitude. We used ArcGIS to estimate the area of the Pacific Ocean between these latitudes, as well as, the area of the WCPO between these latitudes. From this assessment, we estimate that the area of oceanic whitetip shark habitat in the WCPO represents about 60% of the total habitat within the Pacific Ocean.

Two stock assessments have been conducted for the oceanic whitetip shark in the WCPO to date and the conclusions have been reinforced by additional studies (Clarke et al. 2011b; Brodziak et al. 2013; Rice et al. 2015; Tremblay-Boyer et al. 2019). Most recently, Tremblay-Boyer et al. (2019) utilized the Stock Synthesis modeling framework (Methot Jr and Wetzel 2013), which is an integrated age-structured population model. The population dynamics model was informed by three sources of data: historical catches, time series of CPUE and length frequencies. The longline fishery was split into bycatch and target fleets, and the purse-seine fishery into fleets of associated and unassociated sets. This assessment also included scenarios of discard mortality assuming 25%, 43.75% and 100% mortality on discards. The stock of oceanic whitetip shark was found to be overfished and undergoing overfishing based on SB/SBMSY and F/FMSY reference points. The current spawning stock biomass (232–-507 metric tonnes) is predicted to be below 5% of the unfished spawning biomass and the population could go extinct over the long-term based on current levels of fishing mortality (Tremblay-Boyer et al. 2019). The most recent assessment concluded that total biomass in 2010 was 19,740 metric tons and that biomass declined to 9,641 metric tons by 2016.

In previous biological opinions, NMFS has estimated that the biomass translates to 200,000 sharks (NMFS 2019) and 264,318 sharks (NMFS 2021a), following an analysis in FAO (2012). The stock assessment conducted by Tremblay-Boyer et al. (2019) included 648 model runs accounting for assumptions about life-history parameters and impact of fishing underpinning the assessment. Using the underlying data from these 648 models in their structural uncertainty grid in Tremblay-Boyer et al. (2019), the authors subsequently estimated the median value of the current total number of individuals in the WCPO at 775,214 (see NMFS 2020). We consider this estimate as the current best available scientific information and use it as our best estimate of the size of the WCPO portion of the Pacific Ocean population of oceanic whitetip sharks. Assuming a similar density of oceanic whitetip shark in the East Pacific to that of the WCPO, and using the proportion described above that the area of the WCPO between the latitudes where oceanic whitetip sharks are found represents 60% of habitat in the entire Pacific Ocean, we estimate a total population size of 1,292,023 ([775,214/60] x100) oceanic whitetip sharks in the Pacific Ocean. However, given that this estimate requires an assumption regarding the density of oceanic whitetip sharks in the East Pacific, we focus our analysis on the minimum population size estimate of 775,214 but acknowledge that the total Pacific population size may exceed one million individuals.

Rice et al. (2021) estimate that WCPO oceanic whitetip sharks will decline by an additional 13.3% (mean; 14.6% median) over 10 years which equates to an annual decrease of 1.4% (mean; 1.6% median) assuming incidental captures and mortalities remain the same as 2016. If longline fishery mortalities are decreased by 10% across the WCPO, Rice et al. (2021) estimate that the WCPO population will only decline by an additional 0.4% (mean; 1.2% median) which equates to annual declines of 0.04% (mean; 0.13% median). If longline fishery mortalities are decreased further, by 20% across the WCPO, Rice et al. (2021) estimate that the WCPO population will increase by 4.2% (mean; 3.3% median) over the next 10 years, which equates to an annual increase of 0.46% (mean; 0.36% median). Rice et al. (2021) indicate that recent catch is likely bounded by the latter two scenarios, or reductions of between 10% and 20% due to adoptions of CMMs and slight decreases in the amount of longline fishing effort. More recently, Bigelow et al. (2022) updated the projections of Rice et al. (2021) with contemporary estimates of at-vessel and post-release mortality rates, and catch reductions facilitated by switching to monofilament leaders. Their results are summarized by projections of the ratio of spawning biomass (projected to 2031) to the equilibrium unfished spawning biomass (i.e. the biomass of an unfished population). This provides a relative measure of the size of the spawning biomass of a population whereby increasing ratios indicate higher biomass. The mean values of these ratios increase from 0.039 estimated for 2016 to 0.118 with updated assumptions regarding at-vessel and post-release mortality reductions and prohibition of wire leaders and shark lines (Figure 7; see Table 3 of Bigelow et al. 2022). These results are based on optimistic post-interaction mortality rates of 3.4 to 8.1% with an at-vessel mortality rate of 19.2% (see Table 1 of Bigelow et al. 2022). It is unclear if these values will apply to all WCPO longline fisheries, however the implementation of CMM-2019-04 is anticipated to improve the survival of released sharks throughout the WCPO.

We believe this new information provided by Bigelow et al. (2022) constitutes the best available. However, Bigelow et al. (2022) do not provide specific population trends, only indicating that the trends in spawning biomass ratios are anticipated to be positive (Figure 7). Additional years of data are needed before we can calculate an estimated population trend. Given the uncertainty in the applicability of the assumption made by Bigelow et al. (2022) to the broader WCPO fisheries, we consider it reasonable to assess the range of population trends presented in Rice et al. (2021) for reductions in fishery mortality between 10 and 20%. Therefore, we focus our analysis on the scenarios presented by Rice et al. (2021) whereby the actual population trend is between a declining rate of 0.13% per year (median value for 10% reduction in fishery mortalities) and an increase rate of 0.36% per year (median value for 20% reduction in fishery mortalities). These numbers include the loss of individuals from the DSLL as currently operated.

Historic declines in abundance of WCPO oceanic whitetip sharks are attributable to impacts from pelagic fisheries, both longline and purse seine fisheries as well as smaller fisheries such as troll, handline and shortline fisheries. As noted above in the *Distribution and Population Structure* section, it is possible that oceanic whitetip sharks are philopatric; therefore, the declines in abundance may have resulted in localized depletions resulting in a loss of genetic diversity, and changes in distribution.

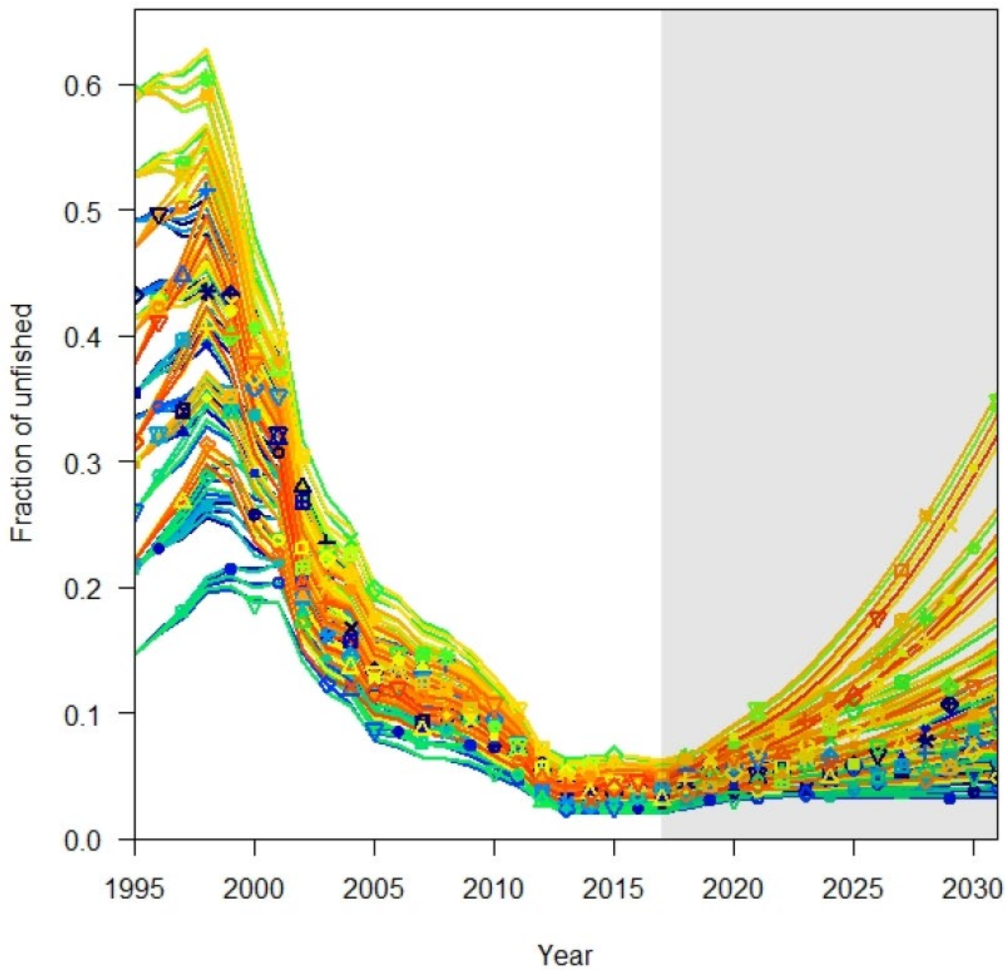

Figure 7. Projected ratios of of spawning biomass (projected to 2031) to the equilibrium unfished spawning biomass for WCPO oceanic whitetip sharks with updated at-vessel and post-release mortality rates and the prohibition of wire branchlines and shark line (Figure 7 in Bigelow et al. 2022).

Population Dynamics

Oceanic whitetip sharks are a relatively long-lived, late maturing species with low-to-moderate productivity. These sharks are estimated to live up to 19 years (Seki et al. 1998; Lessa et al.

1999a; Joung et al. 2016), although their theoretical maximum age has been estimated to be approximately 36 years. Female oceanic whitetip sharks reach maturity between 6 and 9 years of age, although this varies with geography (Seki et al. 1998; Lessa et al. 1999a; Joung et al. 2016) and give birth to live young after a very lengthy gestation period of 9 to 12 months (Bonfil et al. 2008; Coelho et al. 2009). The reproductive cycle is thought to be biennial, with sharks giving birth every one or two years in the Pacific Ocean (Seki et al. 1998; Chen 2006 as cited in Liu and Tsai 2011) and alternate years in other ocean basins. Litters range from 1 to 14 pups with an average of 6 (Seki et al. 1998; Lessa et al. 1999a; Juong et al. 2016). Their generation time has been estimated to range between 7 and 11 years (Cortes 2002; Smith et al. 2008).

Behavior

Oceanic whitetip sharks generally prefer mixed surface layers where temperatures typically remain greater than 20°C to 150 m in depth, with brief deep dives into deeper waters (Howey-Jordan et al. 2013; Howey et al. 2016; Tolotti et al. 2017; Young et al. 2017). The maximum recorded dive of the species was to a depth of 1,082 m (Howey-Jordan et al. 2013). Aggregations of oceanic whitetip sharks have been observed in the Bahamas (Madigan et al. 2015; Young et al. 2017), but there is no evidence of social interactions between individuals or groups of individuals.

Threats to the Species

The primary threat to oceanic whitetip sharks worldwide is intentional targeting and incidental bycatch in commercial fisheries, including both U.S. and foreign fisheries (Young et al. 2017; Young and Carlson 2020). Because of their preferred distribution in warm, tropical waters, and their tendency to remain at the surface, oceanic whitetip sharks have high encounter and mortality rates in fisheries throughout their range. They are frequently caught as bycatch in many global fisheries, including pelagic longline fisheries targeting tuna and swordfish, purse seine, gillnet, and artisanal fisheries. They are also a preferred species for the international fin trade, discussed in more detail below. Impacts to the species from fisheries (U.S. and foreign) that overlap the *Action Area* will be discussed in the *Environmental Baseline*, as appropriate.

Bycatch-related mortality in longline fisheries are considered the primary drivers for these declines (Clarke et al. 2011b; Rice and Harley 2012; Young et al. 2017), with purse seine fisheries being secondary sources of mortality. In addition to bycatch-related mortality, the oceanic whitetip shark is a preferred species for opportunistic retention because its large fins obtain a high price in the Asian fin market, and comprises approximately 2% of the global fin trade (Clarke et al. 2006). Despite finning bans and retention prohibitions both domestically and internationally, this high value and demand for oceanic whitetip fins incentivizes the opportunistic retention and subsequent illegal finning of oceanic whitetip sharks when caught, and thus represents the main economic driver of mortality of this species in commercial fisheries throughout its global range. As a result, oceanic whitetip biomass has declined by 88% since 1995 (Tremblay-Boyer et al. 2019). Currently, the population is overfished and overfishing is still occurring throughout much of the species' range (Rice and Harley 2012; Tremblay-Boyer et al. 2019; 83 CFR 46588). As a result, catch trends of oceanic whitetip shark in both longline and purse seine fisheries have significantly declined, with declining trends also detected in some biological indicators, such as biomass and size indices (Clarke et al. 2011b; Young et al. 2017).

U.S. fisheries in the Pacific that incidentally capture oceanic whitetip sharks include the SSLL, DSLL, and the American Samoa longline fisheries, as well as the U.S. purse seine fishery. The SSLL is estimated to interact with up to 102 oceanic whitetip sharks a year (95th percentile; NMFS 2019). The DSLL is estimated to interact with a mean of 1,708 (95th percentile: 3,185) oceanic whitetip sharks annually (McCracken 2019c; NMFS 2018b), though see the discussion in the *Effects of the Action* section regarding the effect of the fishery switching to monofilament leaders. The American Samoa longline fishery will be discussed in the *Environmental Baseline*, as that fishery overlaps the *Action Area*. No interactions have been noted with oceanic whitetip sharks in any West Coast Highly Migratory Species fishery to date (C. Villafana and C. Fahy pers. comm. to J. Rudolph; March 7, 2019).

Overall, the species has experienced significant historical and ongoing abundance declines in all three ocean basins (Atlantic, Pacific, and Indian Oceans) due to overutilization from fishing pressure and inadequate regulatory mechanisms to protect the species (Hazin et al. 2007; Lawson 2011; Clarke et al. 2012; Hasarangi et al. 2012; Hall and Roman 2013; Young et al. 2017; Tremblay-Boyer et al. 2019). Their population dynamics –long-lived and late maturing with low-to-moderate productivity– makes this species particularly vulnerable to harvests that target adults and limits their ability to recover from over-exploitation.

Conservation

Due to reported population declines driven by the trade of oceanic whitetip shark fins, the oceanic whitetip shark was listed under Appendix II of CITES in 2013. This listing went into effect as of September 2014.

Within the WCPO, finning bans have been implemented by the U.S., Australia, Cook Islands, Micronesia, New Zealand, Palau, Republic of the Marshall Islands and Tokelau, as well as by the IATTC and the WCPFC. These finning bans range from requiring fins remain attached to the body to allowing fishermen to remove shark fins provided that the weight of the fins does not exceed 5% of the total weight of shark carcasses landed or found onboard. The WCPFC has implemented several conservation and management measures for sharks with the following objectives (Clarke 2013): (1) promote full utilization and reduce waste of sharks by controlling finning (perhaps as a means to indirectly reduce fishing mortality for sharks); (2) increase the number of sharks that are released alive (in order to reduce shark mortality); and (3) increase the amount of scientific data that is collected for use in shark stock assessments. Also, specific to oceanic whitetip sharks, CMM 2011-04 prohibits WCPFC vessels from retaining onboard, transshipping, storing on a fishing vessel, or landing any oceanic whitetip shark, in whole or in part, in the fisheries covered by the Convention. This CMM was later replaced in 2019 by CMM-2019-04 for all sharks, which retains the retention prohibition for oceanic whitetip sharks, and includes additional measures on minimizing bycatch (including some gear restrictions) and implementing safe release practices.

Summary of the Status

In this section of this biological opinion, we explained that the oceanic whitetip shark is globally threatened, and that the species' population has suffered substantial historic declines and that, while the rates of declines have been reduced, numbers are continuing to decline. We used our knowledge of the species' demography and population ecology to capture the primary factors that appear to determine the oceanic whitetip shark population dynamics. Primary threats that have contributed to the species' decline and listing include overutilization due to fisheries bycatch and opportunistic trade of the species' fins, as well as inadequate regulatory mechanisms related to commercial fisheries management and the international shark fin trade (Young et al. 2017).

As a result of fishing mortality, oceanic whitetip biomass has declined by 86% in the Western and Central Pacific Ocean, with an estimated decline of 1.6% per year (Young et al. 2017; Rice et al. 2020). The stock is overfished, and overfishing may still be occurring (Rice and Harley 2012; Trembolay-Boyer et al. 2019; Bigelow et al. 2022; 83 CFR 46588). In a recent assessment, Bigelow et al. (2022) suggest the recent initiatives that prohibit retention, improve handling and release conditions, and shifts to monofilament leaders are likely to result in increasing trends for WCPO oceanic whitetip sharks. Historically, catch trends of oceanic whitetip shark in both longline and purse seine fisheries have significantly declined, with declining trends also detected in some biological indicators, such as biomass and size indices (Clarke et al. 2011a; Young et al. 2017). Similar results between analyses of The Pacific Community observer data from the larger Western and Central Pacific and the observer data from the Hawaii-based pelagic longline fishery suggest that the stock decline of oceanic whitetip sharks in this portion of its range is not just a localized trend, but rather a Pacific-wide phenomenon (Brodziak et al. 2013). Based on Bigelow et al. (2022), these trends may turn around, however fishery bycatch, direct harvest and finning continue to be the primary threats to oceanic whitetip sharks.

2.2.4 Corals

Threats Faced by All Pacific ESA-Listed Corals

Corals face numerous natural and anthropogenic threats that shape their status and affect their ability to recover. Because many of the threats are the same or similar in nature for all listed coral species, those identified in this section are discussed in a general sense for all corals. All threats are expected to increase in severity in the future. More detailed information on the threats to listed corals is found in the Final Listing Rule (79 FR 53851; September 10, 2014). Threat information specific to a particular species is then discussed in the corresponding status sections where appropriate.

Several of the most important threats contributing to the extinction risk of corals are related to the continued growth of the human population and associated changes in greenhouse gas (GHG) emissions, water quality, and extractive use of coastal and marine resources.

Ocean Warming

Because of rising atmospheric GHGs, global surface air temperatures have warmed and the rate of warming has increased. The global trend in average temperature is reflected in long-term trends in sea surface temperature. Ocean warming is one of the most important threats posing extinction risks to the listed coral species, but individual susceptibility varies among species. The primary observable coral response to ocean warming is bleaching of adult coral colonies, wherein corals expel their symbiotic algae in response to stress. For many corals, an episodic increase of only 1°C–2°C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching; however, severe, repeated, and/or prolonged bleaching can lead to colony death. Coral bleaching patterns are complex, with several species exhibiting seasonal cycles in symbiotic algae density. Thermal stress has led to bleaching and mass mortality in many coral species during the past 25 years. Mass bleaching events, including at a regional and even global scale, are becoming more common as oceans continue to warm.

In addition to coral bleaching, other effects of ocean warming can harm virtually every life history stage in reef-building corals. Impaired fertilization, developmental abnormalities, mortality, impaired settlement success, and impaired calcification of early life phases have all been documented. Average seawater temperatures in reef-building coral habitat in the wider Caribbean have increased during the past few decades and are predicted to continue to rise between now and 2100. Further, the frequency of warm-season temperature extremes (warming events) in reef-building coral habitat has increased during the past two decades and is predicted to continue to increase between now and 2100.

Ocean Acidification

Ocean acidification is a result of global climate change caused by increased carbon dioxide (CO_2) in the atmosphere that results in greater releases of CO_2 that is then absorbed by seawater. Reef-building corals produce skeletons made of the aragonite form of calcium carbonate. Ocean acidification reduces aragonite concentrations in seawater, making it more difficult for corals to build their skeletons. Ocean acidification has the potential to cause substantial reduction in coral calcification and reef cementation. Further, ocean acidification affects adult growth rates and fecundity, fertilization, pelagic planula settlement, polyp development, and juvenile growth. Ocean acidification can lead to increased colony breakage, fragmentation, and mortality. Based on observations in areas with naturally low pH, the effects of increasing ocean acidification may also include reductions in coral size, cover, diversity, and structural complexity.

As CO_2 concentrations increase in the atmosphere, more CO_2 is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in CO_2 and other GHGs in the atmosphere since the Industrial Revolution, ocean acidification has already occurred throughout the world's oceans, and is predicted to increase considerably between now and 2100. Along with ocean warming and disease, we consider ocean acidification to be one of the most important threats posing extinction risks to coral species between now and the year 2100, although individual susceptibility varies among the listed corals.

Diseases

Disease adversely affects various coral life history events by, among other processes, causing adult mortality, reducing sexual and asexual reproductive success, and impairing colony growth. A diseased state results from a complex interplay of factors including the cause or agent (e.g., pathogen, environmental toxicant), the host, and the environment. All coral disease impacts are presumed to be attributable to infectious diseases or to poorly described genetic defects. Coral disease often produces acute tissue loss. Other forms of "disease" in the broader sense, such as temperature-caused bleaching, are discussed in other threat sections (e.g., ocean warming because of climate change).

Coral diseases are a common and significant threat affecting most or all coral species and regions to some degree, although the scientific understanding of individual disease causes in corals remains very poor. The incidence of coral disease appears to be expanding geographically, though the prevalence of disease is highly variable between sites and species. Increased prevalence and severity of diseases is correlated with increased water temperatures, which may correspond to increased virulence of pathogens, decreased resistance of hosts, or both. Moreover, the expanding coral disease threat may result from opportunistic pathogens that become damaging only in situations where the host integrity is compromised by physiological stress or immune suppression. Overall, there is mounting evidence that warming temperatures and coral bleaching responses are linked (albeit with mixed correlations) with increased coral disease prevalence and mortality.

Monitoring surveys conducted from 2002 to 2006 in the American Samoa archipelago reported total coral disease prevalence rates per island ranging from 0.04% on Swains Island to 0.5% on Tutuila (Brainard 2008). Monitoring surveys conducted from 2003 to 2007 in the Mariana Islands reported total coral disease prevalence rates per island ranging from 0.1% on Rota Island to 1.4% on Guam (Brainard 2012). These studies give us a general idea of coral disease prevalence rates across the region, but do not provide trend information that might indicate temporal patterns.

Effects of Reef Fishing

Fishing, particularly overfishing, can have large-scale, long-term ecosystem-level effects that can change ecosystem structure from coral-dominated reefs to algal-dominated reefs ("phase shifts"). Even fishing pressure that does not rise to the level of overfishing potentially can alter trophic interactions that are important in structuring coral reef ecosystems. These trophic interactions include reducing population abundance of herbivorous fish species that control algal growth, limiting the size structure of fish populations, reducing species richness of herbivorous fish, and releasing corallivores from predator control.

In the Caribbean, parrotfishes can graze at rates of more than 150,000 bites per square meter (m^2) per day (Carpenter 1986), and thereby remove up to 90-100% of the daily primary production (e.g., algae; Hatcher 1997). With substantial populations of herbivorous fishes, as long as the cover of living coral is high and resistant to mortality from environmental changes, it is very unlikely that the algae will take over and dominate the substrate. However, if herbivorous fish populations, particularly large-bodied parrotfish, are heavily fished and a major mortality of coral colonies occurs, then algae can grow rapidly and prevent the recovery of the coral population. The ecosystem can then collapse into an alternative stable state, a persistent phase shift in which algae replace corals as the dominant reef species. Although algae can have negative effects on adult coral colonies (e.g., overgrowth, bleaching from toxic compounds), the ecosystem-level effects of algae are primarily from inhibited coral recruitment. Filamentous algae can prevent the colonization of the substrate by planula larvae by creating sediment traps that obstruct access to a hard substrate for attachment. Additionally, macroalgae can block successful colonization of the bottom by corals because the macroalgae takes up the available space and causes shading, abrasion, chemical poisoning, and infection with bacterial disease. Trophic effects of fishing are a medium importance threat to the extinction risk for listed corals.

Fishing activities also lead to derelict gear that leads to significant habitat degradation. As an example of how much derelict fishing gear can affect coral reefs, Dameron et al. (2007) estimated that at least 52 metric tons of derelict fishing gear annually become entangled in reefs of the NWHI from fisheries thousands of kilometers away. In addition to derelict gear, actively fished gear can damage corals and their habitat depending on the type of gear and where it is deployed.

Land-Based Sources of Pollution

Human activities in coastal and inland watersheds introduce sediment, nutrients, chemicals, and other pollutants into the ocean by a variety of mechanisms including river discharge, surface runoff, groundwater seeps, and atmospheric deposition. Humans also introduce sewage into coastal waters through direct discharge, treatment plants, and septic leakage. Agricultural runoff leads to discharges of nutrients from fertilizers and chemicals from pesticide use. Elevated sediment levels are generated by poor land use practices, including during coastal and nearshore construction. Industry is also a source of chemical contaminants through air emissions and water discharges.

Delivery of terrestrial sediment to areas containing corals results in sediment stress in these animals. The most common direct effect of sedimentation is sediment landing on coral surfaces as it settles out from the water column. Corals with certain morphologies (e.g., mounding) can passively reject settling sediments. Corals with large calices (skeletal component that holds the polyp) tend to be better at actively rejecting sediment. When corals actively remove sediment there is a significant energy cost, meaning respiration increases, photosynthetic efficiency decreases, and the photosynthesis to respiration ratio decreases. Some coral species can tolerate complete burial for several days. Corals that cannot remove sediment will be smothered and die. Sediment can also cause sublethal effects such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. In addition, suspended sediment can reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles. Sediment stress and turbidity can also induce coral bleaching.

Elevated nutrient concentrations in seawater affect corals through two main mechanisms: direct impacts on coral physiology, and indirect effects through stimulation of other community components (e.g., macroalgal turfs and seaweeds, and filter feeders) that compete with corals for space on the reef. Increased nutrients can decrease calcification; however, nutrients may also enhance linear extension while reducing skeletal density. Either condition results in corals that are more prone to breakage or erosion, but individual species do have varying tolerances to increased nutrients. Anthropogenic nutrients mainly come from point-source discharges (such as rivers or sewage outfalls) and surface runoff from modified watersheds. Natural processes, such as *in situ* nitrogen fixation and delivery of nutrient-rich deep water by internal waves and upwelling, also bring nutrients to coral reefs. Elevated nutrient levels have been shown to inhibit gamete development, induce a shift toward more male gametes, reduce fertilization success, and reduce larval settlement. Settlement and growth of recruits may also be affected by elevated nutrient levels. In areas where the populations of herbivores has been depleted, higher nutrient levels lead to increased growth of algae that may overgrow reef substrates.

Toxins and bioactive contaminants may also be delivered to areas containing coral habitats via point and non-point sources. Records of heavy metals in skeletal material are useful for evaluating the effects of long-term chronic exposures to things like contaminated sediments and runoff. Skeletal heavy metals were correlated with reduced coral growth rates near areas with coastal development in Jordan (Al-Rousan et al. 2007), rum refineries in Barbados (Runnals and Coleman 2003), and effects of agriculture and development in marine reserves along the Mesoamerican Reef (Carilli et al. 2010), although heavy metals are most heavily concentrated in zooxanthellae (Reichelt-Brushett and McOrist 2003). Responses to metal concentrations in corals can be species-specific. For example, *Acropora cervicornis* and *Orbicella faveolata* accumulated copper in their tissues when exposed to the metal while *Pocillopora damicornis* did not, but *Acropora cervicornis* and *Pocillopora damicornis* showed reduced photosynthesis and growth while *Orbicella faveolata* did not (Bielmyer et al. 2010). Exposure to pesticides can inhibit coral reproduction, including fertilization, settlement and metamorphosis (Markey et al. 2007). Similarly, endocrine disruptors have been shown to reduce coral growth and fecundity, and increase tissue thickness (Tarrant et al. 2004). The general effects of contaminants on coral communities are reductions in coral growth, coral cover, and species richness, and a shift in community composition to more tolerant species (Brainard et al. 2011).

Conservation and Recovery Goals

No final recovery plans currently exist for any coral species under consideration; however, a recovery outline was developed in 2015 to serve as interim guidance to direct recovery efforts, including recovery planning, until a final recovery plan is developed and approved for the 15 Indo-Pacific coral species listed in September 2014. The following short and long-term recovery goals are listed in the document for all species:

Short-Term Goals:

- Through research, improve understanding of population distribution, abundance, trends, and structure through monitoring and modeling.
- Reduce locally-manageable stress and mortality sources for coral reefs (e.g., acute sedimentation, nutrients, contaminants, and over-fishing on coral reefs).
- Improve understanding of genetic and environmental factors that lead to variability of bleaching response and disease susceptibility.

Long-Term Goals:

- Develop and implement U.S. and international measures to reduce atmospheric carbon dioxide concentrations to curb warming (and its effect on coral disease) and acidification impacts.
- Implement ecosystem-level actions to improve habitat quality and restore keystone species and functional processes to maintain adult colonies and promote successful natural recruitment.

2.2.4.1 Coral Species

Acropora globiceps

Distribution and Population Structure

Acropora globiceps was listed as threatened on September 10, 2014 (79 FR 53852). *Acropora globiceps* is distributed from the oceanic west Pacific to the central Pacific as far east as the Pitcairn Islands. In the U.S., *Acropora globiceps* occurs in American Samoa, the Northern

Mariana Islands, and the minor outlying islands (Figure 8).

Colonies of *Acropora globiceps* are typically about a foot in diameter or less, but can reach approximately 1 m in diameter. Colonies are round, with finger-like branches growing upward. Branches are uniform in size and shape, roughly finger length, diameter, and shape, with almost no side branches. Branch tips are rounded. The axial corallite is small and short. Radial corallites (i.e., corallites on the sides of branches) are uniform and fairly small, and often some are in rows. Branches are usually close together and can have a narrow, uniform crack between them, though not always. Length of branches, how close they are together, and the degree of branch tapering varies some between colonies, but usually not within colonies. Colony color is typically cream to brown, and sometimes fluorescent green in some locations. As explained below, this species is similar to some other *Acropora* species. However, *Acropora globiceps* has distinctive characteristics and can be reliably identified in the field, as noted below and in more detail in Fenner and Burdick (2016) and Fenner (2020b).

Figure 8. Range of *Acropora globiceps*, modified from the map in Veron et al. (2016), based on sources cited in the text. Dark green indicates ecoregions with confirmed observations of *Acropora globiceps* by recognized experts, and light green indicates ecoregions where it is strongly predicted to occur by recognized experts.

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Acropora globiceps* is complicated by many factors, and time-series abundance data is not available for this species. However, overall mean coral cover (i.e., percentage of live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (79 FR 53851-54123; NMFS 2020). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Acropora* species including

Acropora globiceps. For example, between 2013 and 2017 on Guam, reduction in mean *Acropora* cover was much higher than the reduction in overall mean coral cover, and mortality of *Acropora globiceps* colonies from bleaching was higher than overall coral mortality from bleaching (Raymundo et al. 2019). Based on these general trends, it is likely that *Acropora globiceps*' abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

Population Dynamics

Like other *Acropora* species, *Acropora globiceps* reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water. Colonies are hermaphroditic, in that each colony produces both eggs and sperm. Larvae settle on suitable substrates such as rock or dead coral and grow into colonies. Skeletal growth of colonies is relatively rapid compared to other reef-building corals. Prolific reproduction, rapid skeletal growth, and branching colony morphology help *Acropora globiceps* successfully compete for space. However, resilience to disturbance is low, and populations that are frequently disturbed by warming-induced bleaching, storms, and other threats have high levels of mortality, rapid turnover, and high proportions of small colonies (Darling et al. 2012; Adjeroud et al. 2015; Kayal et al. 2015).

Many *Acropora* species have branching morphologies, making them potentially susceptible to fragmentation. Fragment survival can increase coral abundance in the short-term but does not contribute new genotypes (or evolutionary opportunities) to the population.

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. The sites were surveyed from 1994 to 2016, and included all main reef types, including fringing, patch, platform and barrier reefs, atolls, and non-reef coral communities. Non-reef areas are those where environmental conditions prevent reef formation by reef-building corals, but some reef-building coral species are present (Perry and Larcombe 2003). Surveys were generally conducted between the surface and approximately 40 m in depth, although some extended to 40 – 50 m (DeVantier and Turak 2017). The relative abundance of each species in each ecoregion was quantified on a scale of 1 to 5, where 1 = rare, 2 = uncommon, 3 = common, 4 = abundant, and 5 = dominant, then the mean relative abundance of each species was calculated for all of the ecoregions where it was reported. Of the 31 surveyed ecoregions, *Acropora globiceps* was reported from 13 ecoregions, and its mean relative abundance was 1.95 (DeVantier and Turak 2017).

In addition to the 13 ecoregions where the relative abundance of *Acropora globiceps* was estimated by DeVantier and Turak (2017), their rating method has been used to estimate relative abundances of reef-building corals in portions of several other ecoregions in the central Pacific. The relative abundances of *Acropora globiceps* in these surveys ranged from 1.3 (Saipan) to 2.5 (Wallis), and included scores of 1.8 (American Samoa), 1.5 (Tonga), 1.5 (Fiji), 2.1 (New Caledonia), and 1.7 (Marshall Islands; Fenner 2020b). Based on the results of DeVantier and Turak (2017) and Fenner (2020b), the overall relative abundance of *Acropora globiceps* is uncommon, but ranges from rare to common, depending on the location.

Based on *Acropora globiceps'* distribution and relative abundance, NMFS (2014) estimated the absolute abundance of *Acropora globiceps* to be at least tens of millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 654 million colonies.

Within U.S. waters, *Acropora globiceps* occurs in Guam (a single island), the CNMI (an archipelago of 15 islands), American Samoa (an archipelago of 7 islands), PRIA (an administrative grouping of seven islands, atolls, and reefs widely distributed across the central Pacific), and the NWHI, as described in more detail below.

Guam: *Acropora globiceps* is widely distributed on the reef slopes around Guam. For example, David Burdick reported *Acropora globiceps* from 22 sites around Guam (2015 personal communication reported in NMFS 2021a), and the U.S. Department of Defense reported the species from 24 sites around Guam (Figure 4-14; Navy 2019).

CNMI: *Acropora globiceps* has been recorded throughout southern CNMI, including on Saipan, Tinian, Aguijan, and Rota (Maynard et al. 2015; Fenner 2020b). The islands of northern CNMI are uninhabited and rarely surveyed. However, NMFS (2021a) reports *Acropora globiceps* from Anatahan, Pagan, and Maug. In addition, *Acropora globiceps* has been reported from Farallon de Medinilla (Carilli et al. 2020), an islet between CNMI's southern and northern islands.

American Samoa: *Acropora globiceps* is widely distributed on the reef slopes around Tutuila and Aunu`u, and has also been recorded on South Bank, a seamount south of Tutuila. The species has also been recorded on four of the other five islands of American Samoa, including Ofu, Olosega, Ta`u, and Rose Atoll. Swains Island is the most isolated island of American Samoa. It has occasionally been surveyed for corals, but *Acropora globiceps* has not been recorded there (Montgomery et al. 2019; Fenner 2020a; Fenner 2020b).

PRIA: Portions of each of the seven islands, atolls, and reefs of PRIA have been surveyed over the past several years. Williams et al. (2008) and Kenyon et al. (2011) reported *Acropora globiceps* on Palmyra Atoll, while Kenyon et al. (2011) and Doug Fenner (2017 personal communication reported in NMFS 2021a) reported it from Kingman Reef and Wake Atoll, respectively, and Tony Montgomery reported it from Johnston Atoll (2019 personal communication reported in NMFS 2021a). The species has not been reported on Baker Island, Howland Island, or Jarvis Island.

NWHI: *Acropora humilis* has been recorded in the NWHI multiple times over the last several decades, although only at French Frigate Shoals and Muro Reef. Review of photos from French Frigate Shoals taken in 2014 and 2017 indicate that these colonies are *Acropora globiceps*.

Acropora retusa

Distribution and Population Structure

Acropora retusa was listed as threatened on September 10, 2014 (79 FR 53852). *Acropora retusa* is either confirmed or strongly predicted from the South Africa to French Polynesia (Veron et al. 2016). In addition, *Acropora retusa* has been confirmed in the Chagos Archipelago (NMFS 2021a; Figure 9).

Figure 9. Range of *Acropora retusa*, modified from the map in Veron et al. (2016).

Colonies of *Acropora retusa* are flat plates with short, thick finger-like branches. Branches look spiky because radial corallites are variable in length, giving the species rougher-looking branches than other digitate *Acropora* species. Colonies are typically brown or green in color. Corallites are tubular and thick walled. Similar *Acropora* species and key differences are described in Fenner and Burdick (2016) and Fenner (2020a).

Like other *Acropora* species, *Acropora retusa* reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water. Colonies are hermaphroditic, in that each colony produces both eggs and sperm. Larvae settle on suitable substrates such as rock or dead coral and grow into colonies. Skeletal growth of colonies is relatively rapid compared to other reef-building corals. Prolific reproduction, rapid skeletal growth, and branching colony morphology help *Acropora retusa* successfully compete for space, but susceptibility to threats such as warming-induced bleaching is high (79 FR 53851-54123).

Acropora retusa most commonly occurs on upper reef slopes in less than 5 m in depth. It is also sometimes found on reef flats and in backreef pools, and has been recorded as deep as 10 m on Tutuila, American Samoa (2015 personal communication from Doug Fenner reported in NMFS 2021a).

Status

Acropora retusa is highly susceptible to ocean warming, disease, ocean acidification, trophic effects of fishing, predation, and nutrients. These threats are expected to continue and increase into the future. In addition, existing regulatory mechanisms addressing global threats that contribute to extinction risk for this species are inadequate. *Acropora retusa* is restricted to shallow habitat (0 – 5 m), where many global and local threats may be more severe, especially near populated areas. Shallow reef areas are often subjected to highly variable environmental conditions, extremes, high irradiance, and simultaneous effects from multiple stressors, both local and global in nature. A limited depth range also reduces the absolute area in which the species may occur throughout its geographic range, and indicates that a large proportion of the population is likely to be exposed to threats that are worse in shallow habitats, such as simultaneously elevated irradiance and seawater temperatures, as well as localized impacts.

Acropora retusa's abundance is considered rare overall.

Overall mean coral cover (i.e., percentage live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (79 FR 53851-54123; NMFS 2020). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Acropora* species. Based on these general trends, it is likely that *Acropora retusa*'s abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

This level of abundance, combined with its restricted depth distribution where impacts are more severe, leaves the species vulnerable to becoming of such low abundance within the foreseeable future that it may be at risk from dispensatory processes, environmental stochasticity, or catastrophic events. The combination of these characteristics and future projections of threats indicates that the species is likely to be in danger of extinction within the foreseeable future throughout its range.

Population Dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. Of the 31 surveyed ecoregions, *Acropora retusa* was present within five ecoregions, and its mean relative abundance in the five ecoregions was 1.21 (DeVantier and Turak 2017, Table S2). However, in French Polynesia (outside the area surveyed by DeVantier and Turak (2017)), *Acropora retusa* is one of the most common reef coral species (Lantz et al. 2017), making up one-third of all adult *Acropora* colonies in some locations (Lenihan et al. 2011). Thus, we consider the overall relative abundance of *Acropora retusa* to be rare to common, depending on the location.

Based on *Acropora retusa'*s distribution and relative abundance, NMFS (2014) estimated the absolute abundance of *Acropora retusa* to be at least millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 540 million colonies.

Within U.S. waters, *Acropora retusa* occurs in Guam, CNMI, American Samoa, and PRIA, as described in more detail below.

<u>Guam</u>: Wallace et al. (2012) reported a sample of *Acropora retusa* from Guam in the Museum of Tropical Queensland collection. David Burdick has recorded the species from at least one reef slope site in Guam (2015 personal communication reported in NMFS 2021a). The U.S. Department of Defense reported the species from 2 sites on Guam (Department of Defense 2019).

<u>CNMI</u>: Within CNMI, *Acropora retusa* has only recently been reported on Tinian and Rota. The U.S. Department of Defense reported the species from one site on Tinian (Department of Defense 2019), and Doug Fenner reported it from Rota (2020 personal communication reported in NMFS 2021a).

<u>American Samoa</u>: *Acropora retusa* has been found on Tutuila (Brainard et al. 2011), including at Fagasa Bay, Fagafue Bay, Gataivai, Aoa and Asili on upper reef slopes. Doug Fenner and

Charles Birkeland both reported finding *Acropora retusa* on upper reef slopes of Ofu Island, and Doug Fenner reported the species on upper reef slopes and the reef flat on Ta'u Island (2015 personal communication from Doug Fenner reported in NMFS 2021a), while Kenyon et al. (2011) reported finding *Acropora retusa* on Rose Atoll. The species has not been reported from Swains Island.

PRIA: Kenyon et al. (2011) reported *Acropora retusa* from Johnston Atoll, Howland Island, and Kingman Reef, while Doug Fenner reported it from Wake Atoll (2017 personal communication reported in NMFS 2021a), and Venegas et al. (2019) reported it from Jarvis Island. The species has not been reported from Palmyra Atoll or Baker Island.

Acropora speciosa

Distribution and Population Structure

Acropora speciosa was listed as threatened on September 10, 2014 (79 FR 53852). *Acropora speciosa* has been either confirmed or strongly predicted in the western Indian Ocean to French Polynesia (Veron et al. 2016). In addition, *Acropora speciosa* has been confirmed in the Chagos Archipelago (NMFS 2021a), Pohnpei State of the Federated States of Micronesia (Turak 2005), the Mariana Islands, and American Samoa, and strongly predicted to occur in Yap State of FSM, Kiribati Central, and the Cook Islands (2020 personal communication from Doug Fenner reported in NMFS 2021a; Figure 10) .

Figure 10. Range of *Acropora speciosa*, modified from the map in Veron et al. (2016).

Acropora speciosa most commonly occurs on lower reef slopes. It is found between 12 m and at least 40 m of depth. Fenner (2020a) reports that it is usually found deeper than 18 m, and apparently is more common below 30 m. Montgomery et al. (2019) reported it from 46 m on Tutuila.

Acropora speciosa forms flat-topped colonies with small branches that have long smooth tips. Colonies are usually uniform grey-brown or pinkish in color, and 30 cm or less in diameter. *Acropora speciosa* is very difficult to distinguish from *Acropora globiceps* in the water, but can be distinguished under the microscope based on skeletal characteristics (Fenner and Burdick

2016; Fenner 2020a).

Like other *Acropora* species, *Acropora speciosa* reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water. Colonies are hermaphroditic, in that each colony produces both eggs and sperm. Larvae settle on suitable substrates such as rock or dead coral and grow into colonies (79 FR 53851-54123).

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Acropora speciosa* is complicated by many factors, and we do not yet have time-series abundance data for this species. However, overall mean coral cover (i.e., percentage live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (79 FR 53851-54123; NMFS 2020). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Acropora* species. Based on these general trends, it is likely that *Acropora speciosa*'s abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

Population Dynamics

Relative abundance refers to how common *Acropora speciosa* is relative to other reef-building corals. DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef). Of the 31 surveyed ecoregions, *Acropora speciosa* was present within 17 ecoregions, and its mean relative abundance in the 17 ecoregions was 1.58 (DeVantier and Turak 2017, Table S2), which is between rare and uncommon on DeVantier and Turak's abundance scale.

In addition to the 17 ecoregions where the relative abundance of *Acropora speciosa* was estimated by DeVantier and Turak (2017), their rating method has been used to estimate relative abundances of reef-building corals in portions of several other ecoregions in the central Pacific. The relative abundances of *Acropora speciosa* in these surveys was 1.0 (Tonga), 2.0 (Fiji), and 2.1 – 2.5 (New Caledonia; Fenner 2020b). Based on the results of DeVantier and Turak (2017) and Fenner (2020b), we consider the overall relative abundance of *Acropora speciosa* to be rare to uncommon. Within U.S. waters, *Acropora speciosa* occurs on Guam, American Samoa, and PRIA, as described in more detail below. It has not been reported from CNMI.

<u>Guam</u>: *Acropora speciosa* was not known from the Mariana Islands until recently when a coral skeleton collected from Guam in the University of Guam's Marine Lab was identified as this species (2020 personal communication from Doug Fenner reported in NMFS 2021a) .

<u>American Samoa</u>: *Acropora speciosa* occurs on Tutuila, but has not been reported from any of the other islands of the archipelago (Montgomery et al. 2019; Fenner 2020a).

<u>PRIA</u>: Kenyon et al. (2011) reported *Acropora speciosa* from Kingman Reef. It has not been reported from elsewhere within PRIA.

Based on information from Richards et al. (2008); and Richards et al. (2019), *Acropora speciosa* had a population estimate of 10,942,000 colonies, and an effective population size of 1,204,000 colonies (79 FR 53851-54123). Dietzel et al. (2021) estimated its absolute abundance at 19.2 million colonies.

Euphyllia paradivisa

Distribution and Population Structure

Euphyllia paradivisa was listed as threatened on September 10, 2014 (79 FR 53852). *Euphyllia paradivisa* has been confirmed or strongly predicted in 18 ecoregions from Socotra (Indian Ocean) to Samoa (Veron et al. 2016). In addition, the species has been confirmed in the northern Red Sea (Eyal et al. 2016), Okinawa (Eyal et al. 2016), and Fiji (personal communication from Doug Fenner reported in NMFS 2021a), and is strongly predicted in the southern Red Sea, the Gulf of Aden, the southern Ryukyu Islands, Taiwan, the Solomon Islands, and Vanuatu. Thus, we consider *Euphyllia paradivisa*'s geographic range to consist of at least the 27 ecoregions shown in Figure 11.

Euphyllia paradivisa occurs in environments protected from wave action across a broad depth range, especially in low light habitats, such as turbid areas (Fenner 2020a) and mesophotic depths (Eyal et al. 2016). The species also sometimes occurs on shallow reefs in clear water (Turak and DeVantier 2019). Colonies of *Euphyllia paradivisa* have been reported from a variety of substrates, including fine sediment (Fenner 2020a), sand (Fenner 2001), rubble (Sinniger and Harii 2018), and rock (Loya et al. 2016; Montgomery et al. 2019). Its confirmed depth range is from 6 m (Turak and DeVantier 2019) to 75 m (Muir et al. 2018). At one study site in the northern Red Sea, it was much more common between 30 and 50 m than <30 m (Eyal et al. 2016). Colonies consist of branching, separate corallites. Polyps have branching tentacles, an important characteristic for distinguishing it from other *Euphyllia* species. Color is typically pale greenish-grey with lighter tentacle tips (Fenner and Burdick 2016; Veron et al. 2016; Fenner 2020a).

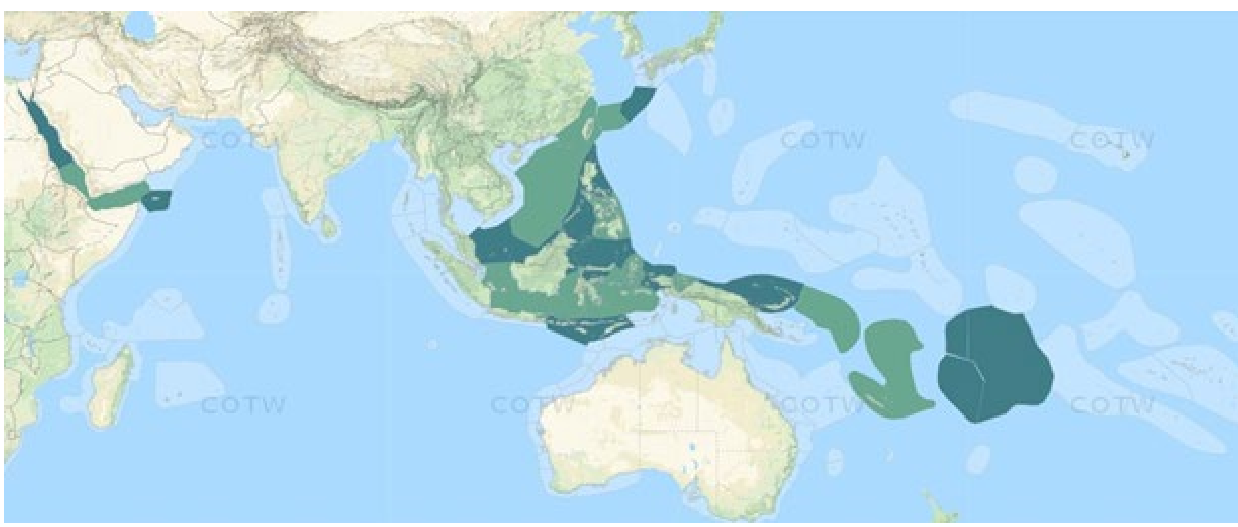

Figure 11. Range of *Euphyllia paradivisa*, modified from the map in Veron et al. (2016), based on sources cited in the text.

While the reproductive life history of *Euphyllia paradivisa* is still unknown, it most likely reproduces by broadcast spawning, whereby colonies release large numbers of eggs and sperm into the water, like other species in the genus (Luzon et al. 2017). Colonies are gonochoric, in that separate colonies produce eggs and sperm. Like all *Euphyllia* species, *Euphyllia paradivisa* has large polyps with tentacles that can be extended 10 – 20 cm resilience (Eyal et al. 2016). Like other *Euphyllia* species, *Euphyllia paradivisa* typically occurs in habitats with high sedimentation, high turbidity, and low light, although it is not limited to such habitats (see Depth section below). In the upper mesophotic zone (30 – 50 m depth) in some parts of the Red Sea, *Euphyllia paradivisa* is the dominant reef-building coral species (Eyal et al. 2016; Loya et al. 2016; Eyal et al. 2019).

Status

Detecting changes in abundance over time of rare or uncommon Indo-Pacific reef-building coral species such as *Euphyllia paradivisa* is complicated by many factors, and we do not have time-series abundance data for this species. However, overall mean coral cover (i.e., % live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (79 FR 53851-54123; NMFS 2020). In 2014, the available information at that time supported the assumption that these trends applied to *Euphyllia paradivisa*.

Population Dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. Of the 31 surveyed ecoregions, *Euphyllia paradivisa* was reported from four ecoregions, and its mean relative abundance was 1.44 (DeVantier and Turak 2017, Table S2), which is between rare and uncommon on DeVantier and Turak's abundance scale. However, as explained below, in some areas *Euphyllia paradivisa* is most abundant at 40 to 50 m in depth, deeper than most of DeVantier and Turak (2017) surveys.

In 2014 when *Euphyllia paradivisa* was listed under the ESA, it was not known to occur in the Red Sea (79 FR 53851-54123), nor was it found at any of the Red Sea sites reported by DeVantier and Turak (2017). However, recent mesophotic research has shown that *Euphyllia paradivisa* is the most common reef coral species in the upper mesophotic zone in the northern Red Sea (Eyal et al. 2016; Loya et al. 2016; Eyal et al. 2019). For example, surveys conducted along a depth gradient from 5 to 150 m in depth in the Gulf of Eilat in the northern Red Sea reported that while *Euphyllia paradivisa* was absent from <30 m depth, it was abundant from 36 to 72 m where it dominated the reef coral community. At some sites between 40 and 50 m, it made up 73% of all live coral cover (Eyal et al. 2016).

Elsewhere in the Indo-Pacific, *Euphyllia paradivisa* has been reported in low abundances from both shallow and mesophotic depths. At 287 sites surveyed from approximately five to ten m to 35 – 50 m of depth in the Coral Triangle and adjacent areas, *Euphyllia paradivisa* was found at two sites, one at six m and one at >30 m (Turak and DeVantier 2019). Single colonies of *Euphyllia paradivisa* have been reported from <30 m in American Samoa and Fiji (personal communication from Doug Fenner reported in NMFS 2021a). Montgomery et al. (2019) reported a group of *Euphyllia paradivisa* colonies from 49 m in American Samoa. Waheed and Hoeksema

(2014) reported *Euphyllia paradivisa* from 3 out of 31 sites (two sites >30 m, one site <30 m) surveyed in Malaysia, and that it was among the least common species in the survey. The species has also been reported at 45 – 53 m (Eyal et al. 2016) and 55 m (Sinniger and Harii 2018) in Okinawa, Japan, although abundance was not mentioned. Thus, we consider the overall relative abundance of *Euphyllia paradivisa* to range from rare to common, depending on the location.

Euphyllia species including *Euphyllia paradivisa* are relatively sediment-tolerant compared to other reef corals (Rachello-Dolmen and Cleary 2007; Morgan et al. 2016), often occurring on shallow, inshore reefs where turbidity and sediment are naturally high (DeVantier and Turak 2017; Morgan et al. 2017), but such turbid sites may not be included in coral reef surveys. For example, in American Samoa, shallow coral reef surveys were conducted for decades without finding *Euphyllia paradivisa*, but the species was observed in turbid water in a bay below the depth of the surveys (personal communication from Doug Fenner reported in NMFS 2021a). On the Great Barrier Reef, fisheries managers working with the coral collection industry report *Euphyllia paradivisa* at "high densities" in "turbid inshore northern waters" (Roelofs 2018), but *Euphyllia paradivisa* is not reported from the Great Barrier Reef in the scientific literature. This may be due to species identification uncertainty by coral collectors, lack of scientific surveys on turbid reefs, or some combination thereof. Regardless, turbid reef species such as *Euphyllia paradivisa* may be under-represented in scientific coral survey results. Within U.S. waters, *Euphyllia paradivisa* occurs on American Samoa, and is described in more detail below. It has not been reported from CNMI or PRIA.

American Samoa: *Euphyllia paradivisa* are found in single colonies or small groups in American Samoa (Fenner, pers. com., Montgomery et al. 2019).

Based on *Euphyllia paradivisa*'s distribution and relative abundance, NMFS (2014) estimated the absolute abundance of *Euphyllia paradivisa* to be at least tens of millions of colonies. However, that estimate was based on the assumptions that *Euphyllia paradivisa*'s distribution was smaller, and its abundance lower, than shown by the recent information cited above.

Isopora crateriformis

Distribution and Population Structure

Isopora crateriformis was listed as threatened on September 10, 2014 (79 FR 53852). *Isopora* remained a subgenus of *Acropora* until Wallace et al. (2007) presented clear evidence that *Isopora* is a separate, valid genus. Since that time, *Isopora* has been treated as a genus, including *Isopora crateriformis* (Wallace et al. 2012; Veron et al. 2016), which is accepted by the World Register of Marine Species (Hoeksma and Cairns 2021).

Isopora crateriformis most commonly occurs in habitats with strong wave action, such as upper reef slopes and reef flats near the reef crest. It may occur on lower reef slopes or backreef pools with strong wave action, but is absent from habitats protected from wave action such as lagoons and harbors. The species is most common in depths of approximately 5 m, but extends to at least 12 m depths (Fenner 2020a). *Isopora crateriformis* has been either confirmed or strongly predicted in 30 ecoregions from the Coral Triangle to Tonga (Figure 12).

Isopora crateriformis forms flattened, solid, encrusting plates, usually with ripples on the surface. Most colonies are tan, but a few have tiny green spots which are the retracted polyps.

Colonies are usually up to about 40 cm in diameter but can be over 1 m in diameter. Corallites are 1-2 millimeters in diameter, rounded projecting tubes, larger on the ridges and smaller between. When a colony occurs on a slope, the lower edge is often lifted as a plate (Veron and Stafford-Smith 2000; Fenner and Burdick 2016). This species is similar to some other *Isopora* species, but *Isopora crateriformis* has distinctive characteristics that can usually be reliably identified in the field. However, it is not distinguishable from juvenile, unbranched *I. cuneata*, as described in Fenner and Burdick (2016).

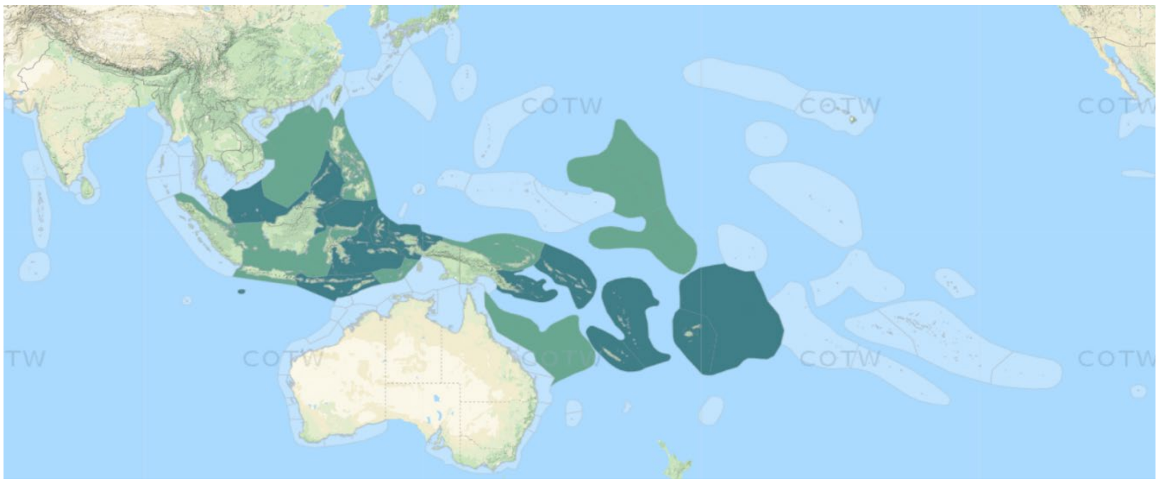

Figure 12. Range of *Isopora crateriformis* (Veron et al. 2016).

Status

Surveys of reef-building corals were conducted at Fagatele Bay, American Samoa, in 1985, 1995, 2002, and 2018. The only ESA-listed coral species to be detected in more than one of the surveys was *Isopora crateriformis*, which showed steadily declining relative abundances of 1.8% of all colonies surveyed in 1985, 1.2% in 1995, 1.1% in 2002, and 0.4% in 2018 (Birkeland 2021). In addition, overall mean coral cover (i.e., percentage live cover of all reef-building coral species combined) has declined across much of the Indo-Pacific since the 1970s, and likely many decades before then in some locations (79 FR 53851-54123; NMFS 2020). Furthermore, from 2014 to 2017, an unprecedented series of bleaching events impacted most of the Indo-Pacific's coral reefs (Eakin et al. 2019), further reducing overall mean coral cover, especially of relatively sensitive species such as many *Isopora* species. For example, between 2013 and 2017 on Guam, the 5 coral genera with the highest percentage of full-colony bleaching-associated mortality included *Isopora* (Raymundo et al. 2019). Based on this information, it is likely that *Isopora crateriformis*'s abundance has been in decline for decades, and that the rate of its decline has accelerated in recent years.

Population Dynamics

DeVantier and Turak (2017) characterized relative abundances of each reef-building coral species present at a total of 3,075 sites distributed throughout 31 Indo-Pacific ecoregions from the Red Sea to the Great Barrier Reef. Of the 31 surveyed ecoregions, *Isopora crateriformis* was present in five ecoregions, and its mean relative abundance in the five ecoregions was 1.40

(DeVantier and Turak 2017, Table S2), which is between rare and uncommon on DeVantier and Turak's abundance scale.

In addition to the five ecoregions where the relative abundance of *Isopora crateriformis* was estimated by DeVantier and Turak (2017), their rating method has been used to estimate relative abundances of reef-building corals in portions of several other ecoregions in the central Pacific. The relative abundances of *Isopora crateriformis* in these surveys was 1.5-1.6 (Fiji), 1.6-1.8 (American Samoa), 1.6-2.0 (New Caledonia), and 1.9 (Wallis; Fenner 2020b), all of which fall between the rare and uncommon categories. However, the species can be common or even dominant in some locations: Wallace (1999) and the Corals of the World website (Veron et al. 2016) note that *Isopora crateriformis* is common in parts of Indonesia. In addition, Fenner (2020a) and Fenner (2020b) notes that the species is dominant on some upper reef slopes on the southwest side of Tutuila, but this is unusual. Based on the information summarized above, we consider the relative abundance of *Isopora crateriformis* to be rare to common, depending on the location. Within U.S. waters, *Isopora crateriformis* has only been observed in American Samoa, and not in the Mariana Islands or any PRIA.

American Samoa: *Isopora crateriformis* is relatively abundant locally throughout American Samoa.

Based on *Isopora crateriformis'*s distribution and relative abundance, NMFS (2014) estimated the absolute abundance of *Isopora crateriformis* to be at least millions of colonies. Dietzel et al. (2021) estimated its absolute abundance at 69.6 million colonies.

3 ENVIRONMENTAL BASELINE

By regulation, the Environmental Baseline refers to the condition of the listed species or its designated critical habitat in the *Action Area*, without the consequences to the listed species or designated critical habitat caused by the *Proposed Action*. The listed resources considered in this biological opinion have been exposed to a wide variety of the past and present state, federal, and private actions in the *Action Area*, which includes of all proposed federal projects in the *Action Area* that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with this consultation. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline. While the impact of those activities on the status, trend or the demographic processes of threatened and endangered species is largely unknown, some are likely to have had and will continue to have lasting effects on the Endangered and threatened species considered in this consultation. The environmental baseline is "an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area" (FWS and NMFS 1998). The purpose of describing the environmental baseline in this manner in a biological opinion is to provide context for effects of the *Proposed Action* on listed species.

The preceding section of this biological opinion addresses global climate change, fisheries and fisheries bycatch, vessel strikes, pollution from chemicals and marine debris, and ocean noise from variety of sources and effects these stressors have on listed resources. Some of these stressors have resulted in mortality or serious injury to individual animals (e.g., fishing, vessel strike), whereas other stressors (e.g., noise) may induce sub-lethal responses like changes in behavior that could impact important biological functions such as feeding or breeding.

The most relevant stressors that affect the two shark species and giant manta ray in the *Action Area* is commercial fishing, and illegal harvest. For coral species, climate change and their associated effects like increasing water temperature have the most significant effect to coral.

Globally averaged annual surface air temperatures have increased by about 1.8 ºF (1.0 ºC) over the last 115 years (1901 to 2016; Wuebbles et al. 2017). The earth's climate is now the warmest in the history of modern civilization. All of the relevant evidence points to human activities, particularly emissions of greenhouse gases since the mid-20th century, as the probable cause of this warming pattern (Wuebbles et al. 2017). Without major reductions in emissions, the increase in annual average global temperature relative to preindustrial times could reach 9 ºF (5 ºC) or more by the end of this century (Wuebbles et al. 2017). With significant reductions in emissions, the increase in annual average global temperature could be limited to 3.6 ºF (2 ºC) or less (Wuebbles et al. 2017). There is broad consensus that the further and the faster the earth warms, the greater the risk of potentially large and irreversible negative impacts (Wuebbles et al. 2017).

Increases in atmospheric carbon and changes in air and sea surface temperatures can affect marine ecosystems in several ways including changes in ocean acidity, altered precipitation patterns, sea level rise, and changes in ocean currents. Global average sea level has risen by about seven to eight inches since 1900, with almost half of that rise occurring since 1993. It is very probable that human-caused climate change has made a substantial contribution to sea level rise, contributing to a rate of rise that is greater than during any preceding century in at least 2,800 years (Wuebbles et al. 2017). Global average sea levels are expected to continue to rise by at least several inches in the next 15 years, and by one to four feet by 2100 (Wuebbles et al. 2017). Climate change can influence ocean circulation for major basin wide currents including intensity and position of western boundary currents (Gennip et al. 2017). These changes have potential for impact to the rest of the biological ecosystem in terms of nutrient availability as well as phytoplankton and zooplankton distribution (Gennip et al. 2017).

Elasmobranch species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). Climate-related shifts in range and distribution have already been observed in some marine mammal populations (Silber et al. 2017). Hazen et al. (2012) predicted up to a 35% change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses.

Significant impacts to elasmobranch species from ocean acidification may be indirectly tied to foraging opportunities resulting from ecosystem changes (Busch et al. 2013; Haigh et al. 2015; Chan et al. 2017). Nearshore waters off California have already shown a persistent drop in pH from the global ocean mean pH of 8.1 to as low as 7.43 (Chan et al. 2017). The distribution, abundance and migration of baleen whales reflects the distribution, abundance and movements of dense prey patches (e.g., copepods, euphausiids or krill, amphipods, and shrimp), which have in turn been linked to oceanographic features affected by climate change (Learmonth et al. 2006). Ocean acidification may cause a shift in phytoplankton community composition and biochemical composition that can impact the transfer of essential nutrients to predators that eat plankton (Bermudez et al. 2016). Increased ocean acidification may also have serious impacts on fish development and behavior (Raven et al. 2005), including sensory functions (Bignami et al. 2013) and fish larvae behavior that could impact fish populations (Munday et al. 2009) and piscivorous ESA-listed species that rely on those populations for food.

Other climatic aspects, such as extreme weather events, precipitation, ocean acidification and sea level rise also have potential to affect elasmobranch species. Changes in global climatic patterns will likely have profound effects on the coastlines of every continent, thus directly impacting marine species that use these habitats (Wilkinson and Souter 2008).

Because habitat for many shark and ray species is comprised of open ocean environments occurring over broad geographic ranges, large-scale impacts such as climate change may impact these species. Chin et al. (2010) conducted an integrated risk assessment to assess the vulnerability of several shark and ray species on the Great Barrier Reef to the effects of climate change. Scalloped hammerheads for instance were ranked as having a low overall vulnerability to climate change, with low vulnerability to each of the assessed climate change factors (i.e., water and air temperature, ocean acidification, freshwater input, ocean circulation, sea level rise, severe weather, light, and ultraviolet radiation). In another study on potential effects of climate change to sharks, Hazen et al. (2012) used data derived from an electronic tagging project and output from a climate change model to predict shifts in habitat and diversity in top marine predators in the Pacific out to the year 2100. Results of the study showed significant differences in habitat change among species groups but sharks as a whole had the greatest risk of pelagic habitat loss.

Environmental changes associated with climate change are occurring within the *Action Area* and are expected to continue into the future. Marine populations that are already at risk due to other threats are particularly vulnerable to the direct and indirect effects of climate change. The oceanic whitetip shark and giant manta ray considered in this opinion have likely already been impacted by this threat through the pathways described above.

The anthropogenic climate change stressors that are affecting marine and coral reef ecosystems across the globe are, as noted above, also occurring in the *Action Area*, and are impacting corals including ESA-listed corals. The Mariana Islands and some islands in the PRIA has experienced extensive and unprecedented thermal stress and coral bleaching events over the last several years. Since 2012, reefs in CNMI have experienced bleaching events in 2013, 2014, 2016 and 2017. The first of these major bleaching events occurred in 2013 when bleaching was observed in 85% of coral taxa on Saipan and Guam (Reynolds et al. 2014). This was followed in 2014 by a second mass bleaching event that impacted the entire archipelago (Heron et al. 2016). These consecutive annual bleaching events resulted in over 90% loss of staghorn *Acropora* spp. corals in Saipan Lagoon (BECQ-DCRM, Long-Term Monitoring Program, unpub. data) and high mortality of shallow water coral communities throughout the island chain (Heron et al. 2016; NOAA Coral Reef Ecosystem Program (CREP) unpub. data). In 2016, mild bleaching occurred throughout the region (Raymundo 2019). In 2017, the most severe mass bleaching event on record occurred across the region: on Saipan, nearly all coral taxa were impacted down to at least 20 m depth (BECQDCRM unpub. data) and preliminary data indicated that 90% of *Acropora* spp. corals and 70% of *Pocillopora* spp. corals died on shallow (<10 m) reefs (NMFS 2020a). Widespread coral bleaching occurred in American Samoa in the early 2000s, and locally bleaching occurred in 2014 and 2015, but is considered to be in “good”[2] condition (Donovan et al. 2020). Some atolls within the PRIA, notably Palmyra experienced mass bleaching in 2016, but are similarly considered in “good” condition.

Corals are also affected by natural disasters and oscillations. In 2015, the Marianas experienced El Niño Southern Oscillation (ENSO)-related extreme low tides that exposed reef flats for prolonged periods during the dry season. This exposed and killed entire colonies or portions of colonies. The Mariana Islands were directly hit by Super Typhoons Soudelor in 2015 and Yutu in 2018. While damage from waves and debris are expected from such events, the coral reefs did not experience widespread damage or irreparable loss.

Local point source and non-point source pollution can have significant effects to colonies where stormwater dumps sediments or chemical pollutants to nearshore waters. Storm runoff often includes sewage and animal feces that run off from residential and rural properties. Coastal development can also disrupt freshwater input regimes, and increase water temperatures through impervious surfaces or lack of coastal shading. While unpopulated or lightly-populated places such as the atolls in PRIA are almost unaffected by man-made development and pollution, some nearshore areas close to urban areas in American Samoa and the Mariana Islands have seen degradation in recent decades (Houk and van Woesik 2008; Houk and Camacho 2010; Kendall et al. 2017). As more development occurs, for example in Saipan, we can expect more degradation of coral reefs and their colonies (NMFS 2020). We have recently completed several section 7 consultations in Guam and American Samoa for adding diffusers or other improvements to sewage outfalls that improve dispersal, which improves water quality.

Commercial fishing in the *Action Area* affects oceanic whitetip shark, Indo-West Pacific scalloped hammerhead shark, and giant manta rays. To summarize the historic impact of the DSLL, between 2004 and 2020, 45 giant manta rays were incidentally captured with an estimated 305 total and 5,149 oceanic whitetip sharks were observed, with an estimated 26,180 sharks incidentally captured (McCracken 2019c; McCracken and Cooper 2020a, 2020b; NMFS 2018). There were four documented Indo-West scalloped hammerhead sharks observed captured with an estimated total of 19 interactions from during this same time frame (McCracken 2019c; McCracken and Cooper 2020a, 2020b; NMFS 2018). Bycatch of these three ESA-listed elasmobranchs is reasonably likely to continue. It is difficult to know if it will continue at similar rates because populations are generally decreasing but fishing effort (number of hooks) are increasing (NMFS 2018).

Giant manta rays face a high probability of extirpation as a result of environmental and demographic stochasticity. Due to their particular life-history characteristics (e.g., slow growth, late maturity, and low fecundity), giant manta rays have little potential to withstand high and sustained levels of fishing exploitation. The information available suggests that giant manta rays have high a probability of becoming extirpated in the Pacific Ocean unless they are protected

[2] NMFS Coral Reef Conservation Program defined scores from very good to critical. The coral reefs in the Mariana Islands were scored as fair, and coral reefs in PRIA and American Samoa were scored as good.
Fair: Some indicators meet reference values. Conditions in these locations are moderately impacted or have declined moderately. Human connections are moderate.
Good: Most indicators meet reference values. Conditions in these locations are lightly impacted or have lightly declined. Human connections are high.

from the combined threats of incidental take in the industrial purse-seine fishery and target take in the artisanal gillnet fisheries that supply the international mobulid gill raker market. The number of individuals that continue to be captured and killed in fisheries in the *Action Area* contributes to the increased extinction risk of the species.

Of the other activities and their associated stressors, the propensity of vessel strikes to go unnoticed or unreported by vessel operators impedes an accurate assessment of the magnitude this threat poses to giant manta ray. However, giant manta ray occur in the pelagic waters within the *Action Area* where their density is sparse in comparison to nearshore aggregation sites where as a result of a higher density of rays, there is an increased risk of a vessel strike. Therefore, we do not expect vessel strikes to contribute to the increased extinction risk of the species.

Because giant manta rays must filter hundreds to thousands of cubic meters of water daily to obtain adequate nutrition (Paig-Tran et al. 2013), they can ingest microplastics directly from the water or indirectly through their contaminated planktonic prey (Setala et al. 2014). Microplastics can prohibit adequate nutrient absorption and physically damage the digestive track (Germanov et al. 2018), they can harbor high levels of toxins and persistent organic pollutants and transfer these toxins to the animal once ingested (Worm et al. 2017). If entangled in marine debris, the giant manta ray is at risk of severing of the cephalic and pectoral fin, severe injuries that can lead to a reduction in feeding efficiency and even death. The number of individuals that continue to ingest and become entangled in marine debris in the *Action Area* contributes to the increased extinction risk of the species.

The stressors discussed in this *Environmental Baseline* are also a threat for the oceanic whitetip shark and Indo-West Pacific scalloped hammerhead shark. Oceanic whitetip sharks are vulnerable to catastrophic population crashes because of both environmental and demographic stochasticity. Due to their life-history characteristics, oceanic whitetip sharks are more susceptible to the effects of high fishing exploitation. The information available suggests that oceanic whitetip sharks have high a probability of being extirpated in the Pacific Ocean unless they are protected from the combined threats of incidental take and commercial utilization from worldwide fisheries.

The Indo-West Pacific scalloped hammerhead shark are less vulnerable because they have a large distribution ranging from east Africa to French Polynesia. Bycatch of Indo-West Pacific scalloped hammerhead sharks through the U.S. fisheries are considerably lower than that of oceanic whitetip sharks. Despite that, the number of individuals that continue to be captured and killed in fisheries in the Action Area contributes to the increased extinction risk of the species.

4 EFFECTS OF THE ACTION

Effects of the action refers to all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action.

As we described in the *Approach to the Assessment* section of this biological opinion, we organize our effects' analyses using a stressor identification - exposure – response – risk assessment framework. The *Integration and Synthesis* section of this opinion follows the *Effects of the Action* and integrates information we presented in the *Status of Listed Resources* and *Environmental Baseline* sections of this biological opinion with the result of our exposure and response analyses to estimate the probable risks the proposed action poses to endangered and threatened species. Species and critical habitat not likely to be adversely affected by the proposed action are discussed in the *Status of Listed Resources Not Considered Further section* 2.1 and in Appendix A.

4.1 Potential Stressors

We determined that the following stressors are not likely to adversely affect any species (See Appendix A for more details):

1. Interactions with sharks during spearfishing activities,
2. Changes in food availability;
3. Anchoring;
4. Potential injuries or behavioral changes from sound sources;
5. Interaction with, including capture of non-target species, such as listed species, or their prey;
6. Interaction with derelict gear;
7. Introduction of oily discharges, cardboard, plastics, and other waste into marine waters;
8. Collisions with vessels;
9. Vessel groundings; and
10. Vessel emissions.

As a result, in this section, we focus primarily on the stressors created by active fishing, which results in hooking and entanglement; tagging and genetic sampling, and directed take of coral specimens, as these stressors are likely to adversely affect listed species under consideration. The potential stressors associated with the proposed action are:

1. Entanglement in troll and bottomfishing gear;
2. Hooking
3. Tagging and genetic sampling;
4. Direct take of coral specimens;

4.1.1 Entanglement in Troll and Bottomfishing Gear

Marine mammals, sea turtles, and elasmobranchs can get entangled in any troll and bottomfishing gear that PIFSC places in the water to collect resources. This includes tow nets, tow traps, crab and juvenile fish traps, bottomfish and troll line, and instruments. The probability of entanglement increases with the amount of material in the water, the duration of potential exposure, the position in the water column, and the rigidity and strength of the material. Most instruments that are left at the benthos are rigid and have low risk of entanglement. Bottom traps are set for about no more than four hours. Trolling, bottomfishing, net tows of all kinds are "day trip" activities, which are actively monitored. Bottomfish reel fishing are generally in deeper areas where giant manta rays generally do not feed which makes entanglement during those activities even more uncommon.

Considering the methods of fishing proposed in this action, trolling or bottom fishing would likely be the main source of entangling lines due to trailing fishing lines. Sharks, turtles, or seals could become entangled in trailing fishing line as a byproduct of becoming hooked. Depending on the length of the line or where on the body the hook attaches, the line may trail until the hook is released, or entangle the animal, wrapping flippers, or around fins, necks, tails or other parts of the animals which could hinder movement. This can lead to wounds or in severe cases, dismemberment or cause starvation. We are reasonably certain that entanglement interactions from trolling or bottomfishing will be uncommon for giant manta rays, and occur at most once per each shark species considered during the five-year period.

4.1.2 Hooking

Sharks are incidentally captured when they bite baited hooks or depredate on catch. Injuries to sharks from hooks can be external-generally in the mouth, jaw, gills, roof of mouth, tail and fin or ingested internally, considered deeply hooked or gut-hooked. Oceanic white tip sharks and scalloped hammerhead sharks can be accidentally hooked if they depredate fish caught in troll or bottomfish fisheries. These events are rare and considering the limited number of samples proposed for this action, the probability of hooking an ESA-listed animal is low.

The effect of being hooked can vary in severity, from simple piercing of flesh, to internal ingestion that can pierce internal organs which can cause life-threatening injuries. The effects associated with hookings are not limited to the piercing itself, but also the stress that sharks endure while fighting on the line. Hooked sharks can expend maximum energy which can lead to eventual death.

As with other marine species, even if the hook is removed, which is often possible with a lightly hooked shark, the hooking interaction can be a significant event. During capture, the amount of water flow over the gills is limited and biochemical recovery can take up to 2 to 7 days, and even longer for injured sharks (Campana et al. 2009). In addition, sharks are vulnerable to predation while being captured due to their restricted mobility, and after their release due to exhaustion and injury. Furthermore, handling procedures can cause additional damage (e.g., cutting the jaw, tail, gaffing, etc.), stress, or death.

A gut-hooked shark is at risk of severe damage to vital organs and excessive bleeding. Campana et al. (2009) found in a post-release mortality study that 33% of tagged blue sharks with extensive trauma such as a gut-hooking perished. Campana et al. (2009) attribute rapid post-release mortality of sharks to occur because of the trauma from the hooking rather than any interference with digestion or starvation.

Unlike sharks, manta rays do not actively prey on distressed fish and unlike longline fishing, the fishing methods used in this action do not send out miles of fishing line in which to get entangled. Considering the locations and the method of fishing, the probability of interactions from fishing gear during this action and giant manta rays are extremely unlikely, and therefore discountable.

If it were to occur, hooking and entanglement in gear would be the most significant hazard to ESA-listed Indo-West Pacific scalloped hammerhead and oceanic whitetip sharks. In addition, if air-breathing species are hooked or entangled, they could drown after being prevented from surfacing for air. All listed species that are hooked or entangled, but do not immediately die from their wounds can suffer impaired swimming or foraging abilities, altered migratory behavior, and altered breeding or reproductive patterns, and latent mortality from their interactions.

Despite several efforts to assess the significance of unobserved or slipped catch, the number of unobserved interactions (for example, Moyes et al. 2006; Murray 2011; and Warden and Murray 2011; Gilman et al. 2013), and the difference between the number of observed interactions and the actual number of interactions remains unknown. Some species have a better opportunity to escape capture before being observed by the vessel by breaking the line either through sheer force or by biting the line.

Interactions such as shark depredation on trolling lines are generally rare. Considering the status of the species in the *Action Area*, the probability of the interactions being oceanic whitetip sharks or the ESA-listed populations of scalloped hammerhead sharks would be even rarer. Bottomfishing sets are not soaked long, which limits the opportunity for sharks to depredate bait or distressed fish. The life stages (adult) of ESA-listed sharks that are expected to be exposed during this action are generally pelagic and surficial, which limits exposure to the benthic nature of bottomfishing.

The state of Hawaii has recorded “whitetip sharks” caught as bottomfish bycatch which could include both oceanic whitetip sharks and reef whitetip sharks (*Triaenodon obesus*). Despite the benthic nature of whitetip reef sharks, at least some of the bycatch were believed to be oceanic whitetip sharks. We do not have similar data on scalloped hammerhead sharks, nor in regions outside of Hawaii. Bycatch of both oceanic whitetip sharks and scalloped hammerhead sharks in the bottomfish fishery are generally rare but not discountable.

Considering the scarcity of ESA-listed individual sharks, low densities in random fishing areas, small effort, number of hooks used, and short durations of the fishing effort, we are reasonably certain that bycatch of oceanic whitetip sharks and Indo-West Pacific sharks would be limited to one individual each for the duration of this action. We cannot predict the nature of the hooking or associated injury so we evaluated death for both individual sharks as the worst case scenario.

4.1.3 Tagging and Genetic Sampling Activities

As noted in the Description of the Proposed Action section, it is anticipated that up to 30 giant manta rays will be exposed to tagging or sampling activities per year (150 individuals over the course of the project [five years]). Additionally, up to 250 scalloped hammerheads would be affixed with satellite tags and/or undergo tissue sampling (50 individuals per year). These research activities will be conducted opportunistically when individual giant manta rays or Indo-West Pacific scalloped hammerhead sharks are captured incidentally under normal, otherwise lawful fishing operations in the DSLL, U.S. WCPO purse seine fisheries, and any other fishery or operation associated with this consultation if the tags are available at the time of accidental capture. Attachment of the external tags will typically involve placement of a single-barb dart into the animal. PSAT tags are programmed for a year. Tissue samples obtained will involve a fin clip and/or small dermal tissue sample for population genetic analyses.

Based on observations in this program previously, only one in more than 100 tagged oceanic whitetip sharks experienced immediate mortality following tagging due to poor tag placement (NMFS 2021a). We do not know the details of why that individual died and it could have been because of several other factors other than the wound itself. It is possible that sharks and rays could experience stress and infection from tagging or sampling activities. Elasmobranchs regenerate tissue and heal incredibly fast (Heupel and Bennett 1997; Chin et al. 2015; McGregor et al. 2019), so minor injury associated with tagging is expected to heal quickly. The condition of the individual prior to tagging, and handling of the individual are more important factors in their survival. In summary, it would be rare that tagging would result in any long-term injury or adverse effects to the long-term health or fitness of any tagged individuals.

Most flesh wounds will heal within a few days without serious injury. In rare cases, wounds can increase the probability of getting infected from bacteria, viruses, or disease which could lead to more severe injury. While tagging or tissue collection is expected to be collected quickly, the additional handling may increase stress to individuals that would otherwise be cut free immediately.

The proposed tagging and tissue sampling procedures are common and accepted practice in elasmobranch research. The effects of collection of tissue are expected to be similar to those experienced from tagging. Tissue sample sites are known to heal quickly and completely when used on a variety of vertebrates such as sharks, rays, teleosts, and marine mammals (Weller et al. 1997; Krutzen et al. 2002). While the shark or ray will also experience some level of stress, it is unlikely that genetic sampling will result in any long-term injury or adverse effects to the long-term health or fitness of any sampled individuals. There is the small possibility that the biopsy site could become infected, but this would be an incredibly rare occurrence.

While the mere task of stabbing a tagging device or carving of flesh will cause minor injuries, the act of handling a large animal under duress could have more serious effects. PIFSC will monitor captured ESA-listed sharks and rays to determine whether it is in a healthy enough condition to withstand the additional handling necessary to place tags or take samples. PIFSC will also determine if it is safe for both animal and crew to tag or take samples of animals to avoid increasing stress to animals. During tagging or tissue sampling PIFSC will implement best management practices (BMPs) listed in the BA and in CMM 2019-05, such as only tagging healthy individuals that are likely to survive additional handling, limiting the duration of their captured state during tagging, and releasing by using dehookers or line clippers to minimize further stress from handling.

4.1.4 Direct Take of Coral Specimens

The proposed action would include the directed take of voucher specimens of *Acropora globiceps*, *Acropora retusa*, *Acropora speciosa*, *Euphyllia paradivisa*, and *Isopora crateriformis*. The RAMP Surveys collect up to 500 samples per year of corals, including ten voucher samples for each of the five ESA-listed coral species annually over five years (250 samples total). The fewest samples needed are collected for characterization of disease and confirmation of identity. The total number cited (i.e., 500) is the maximum of all disease/invasion/ID/ESA collections.

PIFSC is not specifically targeting ESA-listed corals for specimen collection so the actual number of specimens from ESA-listed corals will be a fraction of the total number. Large numbers of ESA-taxa are not proposed to be sampled, but are required to confirm a suspected ESA-listed coral sighting. The smallest possible fragments of corals are collected by gloved hands or by using small tools that are cleaned between each use. Each sample is intended to act as a skeletal and genomic voucher, and typically consist of 2 cm by 2 cm pieces. This size is large enough to determine and record skeletal features. As noted in the *Description of the Proposed Action* section of this opinion, coral tissue samples will be carefully collected from threatened corals using bone cutters or hammer and chisel (as necessary). None of the individual specimens will constitute a complete colony. In the case of *Euphyllia paradivisa*, the biopsy metrics considered for these harvests are based on the skeletal features and not the extended soft tissue of the polyp. Due to the growth pattern of *Euphyllia paradivisa* and maximum allowable extent of harvest, the resultant individual specimen is expected to be a singular branched polyp with or without buds. Two polyps per *Euphyllia paradivisa* specimen would be the maximum expected harvest per 7 cm sample.

For all species of threatened corals, the removal and loss of tissue and subsequent regrowth of tissues has energetic costs that could slow other growth and reproduction, exposed areas of coral skeleton are prone to bioerosion and overgrowth by algae and certain sponges, and damaged and stressed tissue may be more susceptible to infection by coral diseases that may hinder or prevent healing to the point that the colony dies. Even so, coral colonies will continue to exist even if numerous polyps die, or if the colony is broken apart or otherwise damaged. The sampling described in this opinion would potentially injure and negatively affect colony polyps, but given the small sample size (and associated sampling protocol), and the colonial nature of corals, we would not expect significant injury would occur to any colony of any species. As such, the proposed specimen samples would not likely represent a serious threat to the health or survival of the colony sampled of any species. Breakage of coral fragments are common naturally as surf breaks on coral colonies move objects that break corals, and fish such as parrotfish graze on coral or in the bumphead parrotfish's case break and ingest pieces of branching corals. Most coral colonies will heal their wounds and live after samples are taken.

Lesions often heal naturally, may do so quickly with little to no effect on the colonies (Jayewardene 2010), but can result in the affected coral colony being subject to reduced fitness in three ways. First, coral tissue regeneration requires energy so that resources may be diverted from growth and reproduction (e.g., Kobayashi 1984; Rinkevich and Loya 1989; Meesters et al 1994; Van Veghel and Bak 1994; Lirman 2000). Secondly, colony health and survival may be compromised because open lesions provide sites for the entry of pathogens and bioeroders and space for the settlement of other organisms such as algae, sponges, and other corals (Bak et al 1977). Third, injuries reduce the coral's surface area available for feeding, photosynthesis and reproduction (e.g. Jackson and Palumbi 1979; Wahle 1983; Hughes and Jackson 1985), which may alter colony survivorship (e.g. Hughes and Jackson 1985; Babcock 1991; Hall and Hughes 1996). Severe injuries to colonies can lead to death, especially if the colony is simultaneously exposed to other stressors such as warm sea temperatures, and bleaching (e.g. Meesters and Bak 1993).

The ability for lesions to heal ultimately depends on the species of coral, colony growth form, the surrounding environment, colony interactions with other organisms on the reef, and the size and shape of the lesion (Meesters et al 1994). *Acropora globiceps colonies* are typically small (about 12 cm in diameter) round, with finger-like branches growing upward. Branches are uniform in size and shape, roughly finger length, diameter, and shape, with almost no side branches. The size and appearance of branches depends on degree of exposure to wave action, but are always short, closely compacted, with dome-shaped ends (NMFS 2020). *Acropora globiceps* lives on reef flats, but also upper reef slopes often exposed to surf. A coral with these characteristics likely experiences natural breakage. To survive in such conditions, *Acropora globiceps* like many of the *Acropora spp*. that are digitate, branching, or table- or plate-like, have likely adapted to breakage and are more likely to heal readily.

A study by Hall (1997) on 18 branching *Acropora* spp. colonies noted that all lesions in the study healed within 74 days, while some began vertical branch extension from the lesion. In Saipan, ten out of 11 lesions on *Acropora globiceps* parent colonies from which fragments were taken in 2019 as part of the Saipan coral nursery pilot project healed successfully within 2-4 months post collection. Regenerated tissue across lesions included symbionts, and formed new apical polyps. The lesion on the one parent colony that did not heal successfully is believed to have been adversely affected by boring sponges that were documented on the colony when the initial fragmentation occurred (Steve McKagan, NMFS HCD, personal communication 2020). Monitoring of a lesion on a single fragment of *Acropora globiceps* in the coral nursery in the summer of 2020 indicated that tissue regenerated across the lesion within a single week.

NMFS believes that the magnitude and intensity of the impact from the directed take of voucher specimens for all species considered herein will be mitigated by the following factors: 1) the small number of colonies from which specimen material would be collected compared to the estimated abundance of the species; 2) the infrequent surveys; 3) the use of random sample design; and 4) the strict adherence to BMPs for sampling coral species which includes: sampling no more than one specimen of the target taxa present at any of the survey sites and not sampling if it is judged that collection may inhibit the capacity of the colony to replenish itself.

However, it is possible that parent colonies may become stressed from the damage, in particular if simultaneously exposed to other environmental stressors, which may reduce their fitness and possible lead to death. PIFSC will collect up to 500 samples, including up to 250 voucher samples from colonies of ESA-listed corals. Considering how diverse the coral communities are and the random nature of selecting corals for sampling, only a few ESA-listed corals will be sampled. Of those sampled, most will survive as lesions heal. However, in a worst case scenario, some colonies will die or be severely hampered while recovering. We cannot predict how many of those would be ESA-listed corals but it would likely be no more than ten (2% of the total).

Some of these species are locally common (*Acropora. globiceps*, *Isopora crateriformis*, *Euphyllia paradivisa*), and others are widespread (*Acropora globiceps*, *Acropora retusa*). Total global population for these species range from the 10,000s to millions. The loss of ten colonies throughout their range would have a negligible effect on the species as a whole. The loss of those colonies represents negligible risk to any sampled populations for all species considered. We therefore conclude that the proposed action presents negligible risk to the overall species. NMFS considers the risk negligible that project-related effects from sampling the coral colonies would appreciably reduce reproduction rates, numbers, or distribution of these five species in the *Action Area*, and across their global range.

5 CUMULATIVE EFFECTS

"Cumulative effects", as defined in the ESA implementing regulations, are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). For an action to be considered reasonably certain to occur, it must be based on clear and substantial information, using the best scientific and commercial data available. Factors to consider when evaluating whether activities caused by the proposed action (but not part of the proposed action) or activities reviewed under cumulative effects are reasonably certain to occur include, but are not limited to: 1) past experiences with activities that have resulted from actions that are similar in scope, nature, and magnitude to the proposed action; 2) existing plans for the activity; and 3) any remaining economic, administrative, and legal requirements necessary for the activity to go forward. (50 CFR 402.17). Future federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

NMFS searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the *Action Area*. Most of the *Action Area* is outside of territorial waters of the U.S., which would preclude the possibility of future state, tribal, or local action that would not require some form of federal funding or authorization. NMFS conducted electronic searches of business journals, trade journals, and newspapers using Google scholar, WorldCat, and other electronic search engines. Those searches produced no evidence of future private action and their effects in the *Action Area* that would not require federal authorization or funding and is reasonably certain to occur.

While we considered various state managed vessel-based fisheries that exist in Hawaiian waters, we do not believe they will overlap in geographical space for fishing activities and would only overlap when vessels from this fishery transit to Hawaiian ports. The same could be said for recreational boating around the MHI as well. The primary effects we would expect from State fisheries and recreational boating, would include injury and mortality from ship strikes and fishing, as well possibly changes in local prey numbers and distribution. NMFS is not aware of any actions that are likely to occur in the *Action Area* during the foreseeable future.

6 INTEGRATION AND SYNTHESIS OF EFFECTS

The *Status of the Listed Resources*, *Environmental Baseline*, and *Cumulative Effects* described the pre-existing condition of the listed species globally and within the *Action Area* given the effects of activities such as commercial fisheries, direct harvests and modification or degradation of habitat caused by marine debris and climate change. The pre-existing condition of these species serves as the point of reference for our conclusions. The *Effects of the Action* section of this biological opinion describes the direct and indirect effects of the PIFSC's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean.

This section of this biological opinion recapitulates, integrates, and synthesizes the information that has been presented thus far to evaluate the risks that PIFSC's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean poses to giant manta rays, Indo-West Pacific scalloped hammerhead sharks, oceanic whitetip sharks, *Acropora globiceps*, *Acropora retusa*, *Acropora speciosa*, *Euphyllia paradivisa*, and *Isopora crateriformis* in the Pacific Ocean.

The "risks" this section of the opinion considers are (1) increases in the extirpation/extinction probability of particular populations and of the species as they have been listed; and (2) reductions in their probability of being conserved (that is, of reaching the point where they no longer warrant the protections of the ESA). These two probabilities correspond to the species' likelihood of surviving in the wild (that is, avoiding extinction) and their likelihood of recovering in the wild (that is, being conserved). Our analyses give equal consideration to both probabilities; however, to satisfy the explicit purposes of the ESA and NMFS' obligation to use its programs to further those purposes (16 U.S.C. 1536(a)(1)), a species' probability of being conserved has greater influence on our conclusions and jeopardy determinations. As part of these analyses, we consider the action's effects on the reproduction, numbers, and distribution of each species.

Our analyses find that the proposed action, while it results in sublethal injuries or stress due to handling of individual threatened oceanic whitetip shark, threatened Indo-West Pacific scalloped hammerhead shark, and threatened giant manta, it has very small effects on the dynamics of the populations those individuals represent or the species those populations comprise. As a result, we believe it does not appreciably reduce these species' likelihood of survival and recovery in the wild. Similarly, we anticipate up to ten ESA-listed coral colonies to have fragments or core samples taken from them, which could lead to lesions or increased stress. We cannot predict the exact distribution of the number of colonies by each species but at least some colonies of *Acropora globiceps*, *Acropora retusa*, *Acropora speciosa*, *Euphyllia paradivisa*, and *Isopora crateriformis* could experience cores being drilled into them or fragments removed. In very rare occasions, sampled colonies could die. Some of these species are locally common (*Acropora globiceps*, *Euphyllia paradivisa*, *Isopora crateriformis*), and others are widespread (*Acropora globiceps*, *Acropora retusa*). Total global population for these species range from the 10,000s to millions. The loss of ten colonies throughout their range would have a negligible effect on the species as a whole.

We explain the basis for this conclusion in the following sections. These summaries integrate the results of the exposure, response, and risk analyses we presented earlier in this biological opinion with background information from the *Status of the Listed Species* and *Environmental Baseline* sections of this biological opinion to assess the effect that PIFSC's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean is likely to pose to endangered and threatened individuals, the population or populations those individuals represent, and the "species" as it was listed pursuant to the ESA of 1973, as amended.

6.1 Fisheries Interactions with Elasmobranchs

As described in the *Effects of the Action* section, there is a potential for bycatch during fishing activities proposed in this action. As discussed in the effects section, unlike sharks, manta rays do not actively prey on distressed fish and unlike longline fishing, the fishing methods used in this action do not send out miles of fishing line in which to get entangled. Considering the locations and the method of fishing, the probability of interactions from fishing gear during this action and giant manta rays are extremely unlikely, and therefore discountable.

Due to the limited amount of fishing effort and the relatively short durations of effort while fishing, we consider accidental hooking, depredation, or entanglement of gear to be rare. Nonetheless, we conservatively predict one oceanic whitetip shark and one Indo-West Pacific scalloped hammerhead shark to be hooked, entangled, or otherwise injured from depredating baited hooks or hooked fish. Injuries from these interactions could range from minor hookings in the mouth or outer flesh to swallowed hooks that lodge into internal organs or full entanglements or ingestion of fishing line. We cannot predict the nature of the hooking or associated injury so we evaluated death for both individual sharks as the worst case scenario.

Oceanic whitetip sharks are listed as threatened throughout their range. Outside the scope of this project, they are exposed to fishing activities throughout the *Action Area* for many different fisheries. As discussed in the *Status of Listed Species*, two stock assessment has been completed to date, estimating the population at 264,318 and only pertains to the Western Pacific. Stock assessments have not been conducted for either the Eastern Pacific or for the global population. Overall, the species has experienced significant historical and ongoing abundance declines in all three ocean basins due to overutilization from fishing pressure and inadequate regulatory mechanisms to protect the species (based on CPUE). However, Young et al. (2017) believe CPUE may have stabilized at a depressed state in the Pacific.

The Indo-West Pacific scalloped hammerhead shark population is estimated at approximately 5.4 million adults. As displayed in the *Status of the Listed Resources* section, this estimate is from a combination of population estimates from six known geographic populations throughout the species' range. All geographical populations are thought to be stabilized (Miller et al. 2014).

We predict future interaction levels of one individual in the *Action Area* in five years. We are also evaluating the worst case scenario that the individual dies. The action is not expected to reduce the abundance of individuals in the population (less than .01% of the estimated population in the western Pacific), which may consequently affect the population's viability. Hooking will only kill 0.004% of the WCPO oceanic whitetip shark stock and less than 0.0002% of the Indo-West Pacific scalloped hammerhead shark population. We find no analyses or models that demonstrate death of these low percentages of a population will meaningfully effect its reproduction rates, numbers, or distribution. Thus, we are reasonably certain it will not measurably reduce the population's abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures.

PRD has considered the action's effects with the other threats occurring to the species, and even with the worst case scenario (loss of individuals due to this action) added to other losses discussed in the *Environmental Baseline* and *Cumulative Effects* sections, these actions reasonably would not be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of these species in the wild by reducing the reproduction, numbers, or distribution.

6.2 Opportunistic Tagging and Sampling of Giant Manta Rays and Scalloped Hammerhead Shark

As described in the *Effects of the Action* section, up to 150 giant manta rays and 250 scalloped hammerhead sharks could be tagged or sampled during the action. These tagged or sampled animals are limited to those accidentally caught in various fisheries throughout the region. PIFSC will pierce the skin of individuals for tagging or cut small pieces of flesh for samples. If individuals are either in poor condition, or if it is either too dangerous for the crew or captured individual to cut tissue samples or tag, PIFSC will avoid the procedure and release the animal immediately.

Giant manta rays are listed as threatened throughout their range, while scalloped hammerhead sharks are listed in some of their global range. Any scalloped hammerhead shark born within the HARA is not an ESA-listed shark. Outside the scope of this project, each species is exposed to fishing activities throughout the *Action Area* for many different fisheries. Both species are caught as bycatch throughout their range and within the *Action Area*. All species are also exposed to purposeful harvest throughout their range. Purposeful harvest is illegal in the *Action Area*, but occurs at unknown levels. Other threats to the ESA-listed elasmobranchs include bioaccumulative pollutants, marine debris, and common natural threats such as predators, and changing and variable ocean conditions.

The potential impacts from climate change on open water habitat are highly uncertain, but given their broad distribution in various habitat types, these species can move to areas that suit their biological and ecological needs. Therefore, while effects from climate change have the potential to pose a threat to sharks in general, including habitat changes such as changes in currents and ocean circulation and potential impacts to prey species, species-specific impacts to oceanic whitetip sharks and their habitat are currently unknown, but are considered a low level threat (Miller et al. 2014; Miller and Klimovich et al. 2017).

PRD has considered the action's effects with the other threats occurring to the species. In most cases, tagged or sampled individuals will swim away largely unaffected by the flesh wound that will heal in a few days. Some may experience stress from the wound or handling, and in an unusual event, severe injury or death. We do not expect lethal take, however one tagged oceanic whitetip shark died after tagging in Hawaii (one of 100). Considering those odds, at least two giant manta rays could die from the activities.

Given the limited number of tags and tissue samples as described in the *Effects Analysis*, NMFS predicts future interaction of 250 Indo-West Pacific scalloped hammerhead sharks and 150 giant manta rays in the *Action Area* on an annual basis. Every interaction that includes data collection (tagging and genetic sampling) is harm. Of those sampled, most will recover without long-term effects, and at most, we are reasonably certain that no more than two giant manta rays and three Indo-West Pacific scalloped hammerhead sharks may die as a result of the wounds or handling stress associated with tagging. Therefore, the action is not expected to reduce the abundance of individuals in the population (less than 0.01% of the estimated population), and will not appreciably affect the population's viability.

Fewer tags and samples are proposed for scalloped hammerhead sharks which reduces the probability of death. Not all sharks or rays that die after tagging would have necessarily died from the tagging or tissue sampling, as sharks or rays hooked on a fishing line or caught in a net will have already experienced stress that can kill them. Various experts have predicted local populations of scalloped hammerhead sharks and we have combined those numbers to estimate that there are over 1.2 million oceanic whitetip sharks of all relevant DPS' in the Pacific Ocean, and around 280,000 of the Indo-West Pacific DPS. With the worst case scenario (loss of up to three scalloped hammerhead individuals due to this action) added to other losses discussed in the

Environmental Baseline and *Cumulative Effects* sections, we do not expect these actions to result in appreciable reduction of the species.

We are more uncertain about the total population of giant manta rays throughout the world. There are 23 known populations ranging from 100-1,500 individuals in each population. With the worst case scenario (loss of two individuals due to this action) added to other losses discussed in the *Environmental Baseline* and *Cumulative Effects* sections, we do not expect these actions to result in appreciable reduction of the species. Therefore, when taken in context with the *Status of the Listed Resources*, the *Environmental Baseline*, *Cumulative Impacts and Effects*, the proposed action is not likely to appreciably reduce the number of Indo-West Pacific scalloped hammerhead sharks and giant manta rays in the *Action Area*, or appreciably reduce the likelihood of their survival and recovery globally.

6.3 Direct Take of Coral Specimens

As described in the *Effects of the Action* section, we estimate that PIFSC will collect up to 250 voucher samples from ESA-listed coral colonies. These fragments or core samples will be removed from the colony and all polyps that are associated with the collected fragments or samples will die. However, coral colonies are resilient and lesions left behind are expected to heal. In rare cases, the colonies will die and we evaluated risk of the worst case scenario (death of the colony) to each species. While we cannot predict how many of each species would be sampled and therefore harmed, due to the random selection of colonies to be sampled and the diversity of coral species at sample sites, we are reasonably certain that all of the five predicted colony deaths would not be from one species. Furthermore, we are also reasonably certain that all samples would not be from the same location. This reduces the possibility of extirpating or severely reducing the number of colonies within an area, thereby affecting distribution.

As discussed in *the Status of the Listed Resources* section, these five species are widely distributed (at least four eco-regions ranging thousands of miles and several archipelagos), and numbers range from the millions to hundreds of millions of colonies. American Samoa represents the eastern edge of distribution for both *Euphyllia paradivisa* and *Isopora crateriformis*. Both species are locally abundant in areas within American Samoa.

PIFSC will harm ESA-listed colonies by collecting fragments or coring samples, which will leave lesions which could make the colony more prone to disease, boring sponges, or other agents that could increase stress to the colony. Colonies would expend energy to heal lesions which could cause more stress. In extreme cases, colonies could die. We are reasonably certain losing ten colonies from species that have millions of colonies spread throughout multiple oceans and large distribution areas will not measurably reduce the abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures. Thus, the proposed action will not lead to an appreciable reduction in the likelihood of survival or recovery of any of the five ESA-listed coral species.

7 CONCLUSION

After reviewing the *Status of Listed Resources*, the *Environmental Baseline* for the *Action Area*, the *Effects of the Proposed Action*, and the *Cumulative Effects*, it is NMFS' biological opinion that the PIFSC's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean is not likely to jeopardize the continued existence of the following species:

Threatened giant manta ray, threatened Indo-West Pacific scalloped hammerhead shark, threatened oceanic whitetip shark, threatened *Acropora globiceps*, *Acropora retusa*, *Acropora speciosa*, *Euphyllia paradivisa*, and *Isopora crateriformis*.

8 INCIDENTAL TAKE STATEMENT

The proposed action results in the incidental take of threatened giant manta ray, threatened Indo-West Pacific scalloped hammerhead shark, and threatened oceanic whitetip shark. Currently there are no take prohibitions for oceanic whitetip sharks, giant manta ray, and Indo-West Pacific scalloped hammerhead shark, so an exemption from the take prohibitions of Section 9 of the ESA is neither necessary nor appropriate. However, consistent with the decision in *Center for Biological Diversity v. Salazar*, 695 F.3d 893 (9th Cir. 2012), we have included an ITS to serve as a check on the no-jeopardy conclusion by providing a reinitiation trigger so the action does not jeopardize the species if the level of take analyzed in the biological opinion is exceeded. In addition, 50 CFR 402.14(i)(3) provides that in order to monitor the impacts of incidental take, "the Federal agency or any applicant must report the progress of the action and its impact on the species to the Service as specified in the [ITS]." For these reasons, PIFSC is required to monitor and report its compliance with the ITS, and if the ITS is exceeded, shall promptly reinitiate consultation to ensure that it does not jeopardize any species.

Tagging and sampling during the proposed action results in the directed take of 150 threatened giant manta rays, 250 threatened Indo-West Pacific scalloped hammerhead sharks, and 250 colonies of listed corals in the form of voucher specimen collections. This take is not incidental, as tagging and sampling for scientific research is the purpose of the activity. An incidental take statement is not required for take that is direct, and not incidental to the otherwise lawful activity. However, if any of the take amounts exceed the directed take anticipated in this Biological Opinion (150 threatened giant manta rays, 250 threatened Indo-West Pacific scalloped hammerhead sharks, and 250 colonies of listed corals), reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out 50 CFR 402.16(2) & (3) will have been met.

8.1 Amount or Extent of Take

The following levels of incidental take may be expected to result from the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. NMFS uses causal inference to determine if individual threatened and endangered species, or their designated critical habitat, would likely be taken by harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting or attempting to engage in any such conduct. If take is anticipated to occur then the Services must describe the amount or extent of such anticipated take and the reasonable and prudent measures, and terms and conditions necessary to minimize the impacts of incidental take (FWS and NMFS 1998). If, during the course of the action, this level of incidental take is exceeded for any of the species as listed, NMFS PIFSC must immediately reinitiate formal consultation with NMFS PRD pursuant to the Section 7 regulations (50 CFR 402.16). NMFS PRD anticipates the following incidental take as a result of the proposed action:

1. No more than one oceanic whitetip shark harmed by hooking or entanglement in the five year period,
2. No more than one Indo-West Pacific scalloped hammerhead shark harmed by hooking or entanglement in the five year period.
3. No more than two giant manta rays and three Indo-West Pacific scalloped hammerhead sharks to die.

8.2 Reasonable and Prudent Measures

NMFS PRD has determined that the following reasonable and prudent measures, as implemented by the terms and conditions that follow, are necessary and appropriate to minimize the impacts of PIFSC's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean as described in the proposed action, on threatened species and to monitor the level and nature of any incidental takes. These measures are non-discretionary.

1. NMFS PIFSC shall prioritize the health and safety of living elasmobranchs that are accidentally caught, while tagging or gathering tissue samples.
2. PIFSC shall establish record keeping and reporting standards for these data collections and provide an annual summary to NMFS PRD to track the take of the ESA-listed species.

8.3 Terms and Conditions

NMFS PIFSC shall undertake and comply with the following terms and conditions to implement the reasonable and prudent measures identified in Section 10.2 above. These terms and conditions are non-discretionary.

1. The following terms and conditions implement Reasonable and Prudent Measure No. 1:
    a. NMFS PIFSC shall collect tag or collect tissue samples from only healthy individuals who are captured to ensure supporting the highest probability of survival and rapid healing of wounds, or collecting tissue samples from dead individuals.
    b. NMFS PIFSC shall release lethargic individuals, or ones who look stressed or violently thrashing which would make tagging or sample collecting dangerous for either animal or crew.

3. The following terms and conditions implement Reasonable and Prudent Measure No. 2.
    a. PIFSC shall immediately begin monitoring the actual take from the research activities against the anticipated take in this opinion. This report should be provided to NMFS PRD annually, by the end of each calendar year.

8.4 Reinitiation Notice

This concludes formal consultation on PIFSC's Fishery and Ecosystem Research Activities in the Western and Central Pacific Ocean. Reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law, and if:

1. The amount or extent of anticipated incidental take is exceeded;
2. New information reveals that the action may affect ESA-protected marine species or critical habitat in a manner or to an extent not considered in this Opinion;
3. The action is subsequently modified in a manner that may affect ESA-protected marine species or critical habitat to an extent, or in a manner not considered in this Opinion; or
4. A new species is listed or critical habitat designated that may be affected by the action.

Additionally, if any of the take amounts exceed the directed take anticipated in this Biological Opinion (150 giant manta rays, 250 Indo-West Pacific scalloped hammerhead sharks, 250 listed coral colonies), reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (2) & (3) above will have been met.

9 APPENDIX A: LISTED RESOURCES NOT CONSIDERED FURTHER

The proposed action is not likely to adversely affect Central North Pacific, Central South Pacific, and Central West Pacific green sea turtle, hawksbill sea turtle, Leatherback sea turtle, North Pacific loggerhead sea turtle, olive ridley sea turtle, blue whale, fin whale, sei whale, sperm whale, Hawaiian monk seal, MHI insular false killer whale, North Pacific right whale, and chambered nautilus. We also conclude that the action is not likely to adversely affect critical habitats of the Hawaiian monk seal and MHI insular false killer whale, and not likely to adversely modify or destroy proposed critical habitat of Pacific Ocean corals.

9.1 Stressors Not Likely to Adversely Affect Listed Resources

9.1.1 Sound Exposure

Man-made sounds can affect animals exposed to them in several ways such as: non-auditory damage to gas-filled organs, hearing loss expressed in permanent threshold shift (PTS) or temporary threshold shift (TTS) hearing loss, and behavioral responses. They may also experience reduced hearing by masking (i.e., the presence of one sound affecting the perception of another sound).

Subsequently, NMFS (2018) described generalized hearing ranges for these marine mammal hearing groups. Generalized hearing ranges were determined based on the approximately 65 dB threshold from the normalized composite audiograms, with an exception for lower limits for low-frequency cetaceans where the result was deemed to be biologically implausible and the lower bound of the low-frequency cetacean hearing range from Southall et al. (2007) retained. Marine mammal hearing groups and their associated hearing ranges are provided in Table 8. Sea turtles hearing was characterized in (Finneran 2016) and thresholds were identified in NMFS' Multi-species Pile Driving Calculator (NMFS 2022, unpublished spreadsheet).

To develop some of the hearing thresholds of received sound sources for sea turtles, expected to produce TTS and PTS, the Navy compiled all sea turtle audiograms available in the literature in an effort to create a composite audiogram for sea turtles as a hearing group. Measured or predicted auditory threshold data, as well as measured equal latency contours, were used to influence the weighting function shape for sea turtles. For sea turtles, the weighting function parameters were adjusted to provide the best fit to the experimental data. The same methods were then applied to other species for which TTS data did not exist.

Table 8. Marine Mammal Hearing Groups (NMFS 2018).

Hearing Group	**Generalized Hearing Range***
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz

Hearing Group	**Generalized Hearing Range***
High-frequency (HF) cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz
***** Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007) and PW pinniped (approximation).	

However, because these data were insufficient to successfully model a composite audiogram via a fitted curve as was done for marine mammals, median audiogram values were used in forming the sea turtle hearing group's composite audiogram. Based on this composite audiogram and data on the onset of TTS in fishes, an auditory weighting function was created to estimate the susceptibility of sea turtles to hearing loss or damage. Sea turtles generally have a limited hearing range that appears to end near 1 kHz. It is described in detail in the technical report Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III) (Navy 2017). The frequencies around the top portion of the function, where the amplitude is closest to zero, are emphasized, while the frequencies below and above this range (where amplitude declines) are de-emphasized, when summing acoustic energy received by a sea turtle (Navy 2017). Furthermore, sea turtle' hearing appears to be affected more by particle velocity rather than sound pressure, which is what we generally use for management of sound effects for all animals.

Current data indicate that not all marine mammal species have equal hearing capabilities (e.g., Richardson et al. 1995; Wartzok and Ketten 1999; Au and Hastings 2008). To reflect this, Southall et al. (2007) recommended that marine mammals be divided into functional hearing groups based on directly measured or estimated hearing ranges based on available behavioral response data, audiograms derived using auditory evoked potential techniques, anatomical modeling, and other data. No direct measurements of hearing ability have been successfully completed for mysticetes (i.e., low-frequency cetaceans). Similarly, sea turtles and elasmobranchs have different ear structures and have different ranges of frequencies than marine mammals. We used a modified version of the publicly available NMFS marine mammal sound calculator (https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-acoustic-technical-guidance, accessed June 2022), to calculate the distances for all sound sources. Thresholds for all sound types, exposure types, and hearing groups are presented in the calculator. The thresholds identified in the calculator is established by NMFS (2018). We used thresholds established by the Navy (2017) for sea turtles in their projects. We grouped all species of sea turtles as one because they are similar in body type, ear structure, and hearing range. Barotrauma is predicted for all animals at 237 dB (re 1 μPa). Sea turtles exposed to peak pressures as loud as 232 dB and 204 dB for SEL could experience permanent threshold shifts (PTS) or hearing loss. We also predict that all animals may experience temporary threshold shifts (TTS) at levels 15 dB less than the PTS thresholds. For continuous underwater sound, we use a threshold for behavioral response of 160 decibels (dB) re 1 μPa (micro-Pascals) rms for sea turtles, 120 dB re 1 μPa rms for whales, including MHI insular false killer whales, and pinnipeds, and 150 dB re 1 μPa rms for sharks and rays.

Given the number of vessels PIFSC uses (and the small number of vessels in the fishery and the wide area they cover), the fact that the sound field produced by the vessels is relatively small and would move with the vessel, the animals would be moving as well, vessel transit vectors would be predictable, and sudden or loud noises would be unlikely or infrequent, we are reasonably certain any exposure to noises generated by this fishery would be short-term and transient. These will generally be ignored by animals that are temporarily exposed to sounds emanating from the vessels in this fishery. Numerous studies demonstrate that marine animals are unlikely to change their behavior when confronted with stimuli with these attributes, and we would also expect masking would be highly unlikely to occur, if not improbable. Although hydraulics may have the potential to create loud noises; due to the expected above water operations, frequency and duration of time these species spend at the surface, dissipation of sound from the source, and the poor transference of airborne generated sounds from the vessel to ocean water through the hull, it is highly unlikely noises generated from vessel operations would elicit behavioral reactions from ESA-listed species considered in this consultation. NMFS is reasonably certain some individuals of ESA-listed resources will hear noise, but the resulting response will not rise to the level of harm or harassment. Thus, will have insignificant effects.

PIFSC will expose listed species to other man-made sound through various sources including, active acoustics, echo locators, vocal playbacks, and sound generated from divers installing instruments or other activities. It is not likely to have a measurable increase in sound intensity, frequency of exposure, or duration of effect from the current baseline. PIFSC proposes to use recorded sounds to locate whales. By design, these sounds will cause a behavioral response. Individuals of the species targeted for study who can hear the sounds might call back to them, ignore the sounds, halt their activities, approach or retreat from the sounds. The sounds will not be loud enough or sustained long enough to cause temporary or permanent hearing loss, or non-auditory injury. While the sounds could temporarily change the behavior of exposed animals, PIFSC plans to emit the minimal amount and duration of sound necessary to collect their data. Exposed animals are not expected to change their behavior in a measurable manner, and return to their normal behavior as soon as PIFSC halts emission.

All individuals within those respective thresholds could experience the disturbance described. A wide range of active acoustic sources are used in PIFSC fisheries surveys for remotely sensing bathymetric, oceanographic, and biological features of the environment. Most of these sources involve relatively high frequency, directional, and brief repeated signals tuned to provide sufficient focus and resolution on specific objects. PIFSC also uses passive listening sensors (i.e., remotely and passively detecting sound rather than producing it), which do not have the potential to affect marine mammals. PIFSC active acoustic sources include various echosounders (e.g., multibeam systems), scientific sonar systems, positional sonars (e.g., net sounders for determining trawl position), and environmental sensors (e.g., current profilers).

Mid- and high-frequency underwater acoustic sources typically used for scientific purposes operate by creating an oscillatory overpressure through rapid vibration of a surface, using either electromagnetic forces or the piezoelectric effect of some materials. A vibratory source based on the piezoelectric effect is commonly referred to as a transducer. Transducers are usually designed to excite an acoustic wave of a specific frequency, often in a highly directive beam, with the directional capability increasing with operating frequency. The main parameter characterizing directivity is the beam width, defined as the angle subtended by diametrically opposite "half power" (-3 dB) points of the main lobe. For different transducers at a single operating frequency the beam width can vary from 180° (almost omnidirectional) to only a few degrees. Transducers are usually produced with either circular or rectangular active surfaces. For circular transducers, the beam width in the horizontal plane (assuming a downward pointing main beam) is equal in all directions, whereas rectangular transducers produce more complex beam patterns with variable beam width in the horizontal plane.

The types of active sources employed in fisheries acoustic research and monitoring, based largely on their relatively high operating frequencies and other output characteristics (*e.g.*, signal duration, directivity), should be considered to have very low potential to cause effects to marine mammals that would cause behavior responses from marine mammals. Sea turtles and elasmobranchs will not hear these sounds. Acoustic sources operating at high output frequencies (>180 kHz) that are outside the known functional hearing capability of any marine mammal are unlikely to be detected by marine mammals. Although it is possible that these systems may produce subharmonics at lower frequencies, this component of acoustic output would also be at significantly lower SPLs. While the production of subharmonics can occur during actual operations, the phenomenon may be the result of issues with the system or its installation on a vessel rather than an issue that is inherent to the output of the system. Many of these sources also generally have short duration signals and directional beam patterns, meaning that any individual marine mammal would be unlikely to even receive a signal that would likely be inaudible.

Acoustic sources present on most PIFSC research vessels include a variety of single, dual, and multi-beam echosounders (many with a variety of modes), sources used to determine the orientation of trawl nets, and several current profilers with lower output frequencies that overlap with hearing ranges of certain marine mammals (*e.g.*, 30-180 kHz). However, while likely potentially audible to certain species, these sources also have generally short ping durations and are typically focused (highly directional) to serve their intended purpose of mapping specific objects, depths, or environmental features. These characteristics reduce the likelihood of an animal receiving or perceiving the signal. Furthermore, for cumulative sound exposure levels to build, the individual would have to experience repeated exposures over a long period of time. This is even more unlikely.

PIFSC also proposes to use several types of echo sounders throughout the region for oceanographic mapping and other data collection. PIFSC will operate the echo sounders intermittently throughout the surveys. The vessel generally travels at 8 knots with intermittent pings. The pings range from 0.001 to 0.4 microseconds, at a ping rate that ranges from 0.33 to 10 Hz.

Acoustic sources used by PIFSC vary in frequency, intensity, duration, rate of input, and other factors. The acoustic system used during a particular survey is optimized for surveying under specific environmental conditions (e.g., depth and bottom type). Lower frequencies of sound travel further in the water (i.e., longer range) but provide lower resolution (i.e., less precision). Pulse width and power may also be adjusted in the field to accommodate a variety of environmental conditions. Signals with a relatively long pulse width travel further and are received more clearly by the transducer (i.e., good signal-to-noise ratio) but have a lower range resolution. Shorter pulses provide higher range resolution and can detect smaller and more closely spaced objects in the water. Similarly, higher power settings may decrease the utility of collected data. For example, power level is adjusted according to bottom type, as some bottom types have a stronger return and require less power to produce data of sufficient quality. Accordingly, power is typically set to the lowest level possible in order to receive a clear return with the best data. Survey vessels may be equipped with multiple acoustic systems; each system has different advantages that may be utilized depending on the specific survey area or purpose. In addition, many systems may be operated at one of two frequencies or at a range of frequencies. Primary source categories are described below, and characteristics of representative predominant sources are summarized in Table 9. Predominant sources are those that, when operated, would be louder than and/or have a larger acoustic footprint than other concurrently operated sources, at relevant frequencies.

Table 9. Operating Characteristics of Representative Predominant PIFSC Active Acoustic Sources.

Active acoustic system	**Operating frequencies**	**Maximum source level**	**Single ping duration (ms) and repetition rate (Hz)**	**Orientation/ Directionality**	**Nominal beamwidth**
Simrad EK60 narrow beam echosounder	38, 70, 120, 200 kHz	224 dB	1 ms at 1 Hz	Downward looking	7°
Simrad EM300 multibeam echosounder	30 kHz	237 dB	0.7-15 ms at 5 Hz	Downward looking	1°
ADCP Ocean Surveyor	75 kHz	223.6 dB	1 ms at 4 Hz	Downward looking (30° tilt)	4°
Netmind	30, 200 kHz	190 dB	up to 0.3 ms at 7-9 Hz	Trawl-mounted	50°

Predominant active acoustic sources used by PIFSC are the Simrad EM300 echosounder, operated at an assumed primary frequency of 30 kilohertz (kHz), Simrad EK60 (30-200 kHz), and Acoustic Doppler Current Profiler (ADCP) Ocean Surveyor (75 kHz). Assuming a generalized hearing range (GHR) extending to 35 kHz, we assume that mysticete cetaceans may be able to detect sound from the Simrad EM300 and the Simrad EK60 when it operates at the lower frequency. However, the beam pattern is extremely narrow (1 degree) at that frequency. The ADCP Ocean Surveyor operates at 75 kHz, which is outside of baleen whale hearing capabilities. Therefore, we are reasonably certain the probability of exposures to signals above the behavioral threshold in mysticete cetaceans, sea turtles, or elasmobranchs is extremely unlikely and therefore discountable. While whales in the mid-frequency group like the MHI Insular false killer whales, and phocid pinnipeds like Hawaiian monk seals may be able to hear some of the frequencies of the sounds emitted by various equipment used by PIFSC, the probabilities of extended exposure are not likely to occur to the level of harassment or harm. Thus, for these species, the response is insignificant.

9.1.2 Vessel Collision

The proposed action would expose all ESA-listed marine species under NMFS' jurisdiction found in both the coastal and pelagic exposure categories (both potential and observed) to the risk of collision with vessels. Vessel sizes range up to nearly the maximum 100-ft limit, but the average size is 65 to 70 ft. PIFSC vessels have displacement hulls and travel at speeds less than 10 kts. Vessel speed is an important component of the risk for a collision between a vessel and an individual from a listed species.

PIFSC is proposing to have 300 days at sea with NOAA vessels. The current NOAA vessels that could be used during this action are the NOAA vessels Oscar Elton Sette, Rainier, Reuben Lasker, and Okeanos Explorer. All vessels are no larger than 231 feet long and cruises at no more than 12 knots. From the main ships, PIFSC will travel an estimated 650-900 vessel trips from smaller vessels. These vessels are no greater than 36 feet long and travel no higher than 25 knots. Small vessels are generally more commonly deployed nearshore, which biases exposure to nearshore species more often. Sea turtles in their neritic phase can occur in high densities in some places, especially in the Hawaiian Islands. PIFSC will minimize exposure by operating vessels with professional and certified vessel operators who are trained to operate safely and avoid all visible objects and wildlife at the surface. Observers will alert operators of wildlife at the surface to help avoid collisions.

Turtles and monk seals

Kelly (2020) documented vessel collisions with sea turtles resulting in lethal and sub-lethal injuries. Sea turtles may be in the *Action Area*, and could potentially be struck by the transiting vessel during the proposed activities. NMFS (2008) estimated 37.5 vessel strikes of sea turtles per year from an estimated 577,872 trips per year from vessels of all sizes in Hawaii. More recently, we estimated as many as 200 green sea turtle strikes annually in Hawaii (Kelly 2020). If these turtle strikes are evenly distributed around the islands, the probability of a green sea turtle strike from any one vessel trip is extremely low (on average 0.035%, calculated by dividing the most recent strike estimate of 200 per year by the best estimate of all vessel transits of 577,872 per year). However, green sea turtle strikes are not evenly distributed throughout the islands. They are concentrated in areas where small vessel activity is highest (e.g., near small boat harbors and boat launches), such as Kaneohe Bay and Pearl Harbor on Oahu (Kelly 2020).

Green sea turtles are most vulnerable to small vessels (< 15 m), travelling at fast rates (>10 kts) (Kelly 2020). Increased vessel speed decreases the ability of sea turtles to recognize a moving vessel in time to dive and escape being hit, as well as the vessel operator's ability to recognize the turtle in time to avoid it. The vessels used in the proposed action will be under a speed restriction in areas of known turtle activity. The *Action Area* includes all areas within the Pacific Island Region and Kelly (2020) only identified hot spots for green sea turtle strikes in the Hawaiian Islands. Green sea turtle densities are much higher in the Hawaiian Islands than other places within the region. Generally, the other research areas, especially the Mariana Islands, have lower densities of sea turtles which make collisions less likely to occur. Therefore, the probability of a green sea turtle strike is likely less than the overall rate calculated above. Thus, we are reasonably certain the likelihood of exposure of any green sea turtle to vessel strikes from this action is extremely unlikely, and therefore discountable.

Vessel activities may also occur in American Samoa, which has a considerably smaller density of sea turtles in their surrounding waters compared to the density of green sea turtles around the Hawaiian Islands. We expect that the chances of a PIFSC vessels strike a turtle is even less due to the lower density of turtles around the islands compared to the density of turtles around Hawaii.

The other sea turtle species have a lower rate of striking than green sea turtles. This is likely mostly due to their low abundance numbers and preference for deeper offshore waters (Kelly 2020). There were only four documented vessel strikes of hawksbill sea turtles between 1984 and 2020 and two olive ridley sea turtles in Hawaii (Kelly 2020). We have no documentation of vessel strikes on leatherback or loggerhead sea turtles in Hawaii. Because the probability of a vessel striking any other sea turtles is even lower than that of a green sea turtle, and because of the transit speeds into port are slow, we are reasonably certain the likelihood of exposure of any individual is extremely unlikely, and therefore discountable.

According to PIFSC's database there have been only four verified vessel strikes of Hawaiian monk seals between 1981 and 2016 (John Henderson, pers. comm., PIFSC 5/4/17). Other wounds and blunt force trauma have been documented but wounds, especially those that have healed, are difficult to distinguish between vessel strikes and other blunt force trauma such as intentional killing.

Considering that vessels involved these research activities do not move at speeds that typically pose collision risks when transiting, the rarity of document vessel strikes, that vessels would only be expected to transit through areas where monk seals may occur, and the low abundance and widely scattered nature of monk seals in the *Action Area*; we are reasonably certain the likelihood of exposure of any monk seal to vessel strikes from this proposed action is extremely unlikely, and therefore discountable.

Whales

Whales surface to breathe, with calves surfacing more regularly than adults. While at the surface, a whale is at risk of being struck by a vessel. Vanderlann and Taggart (2007) found that the severity of injury to large whales is directly related to speed, the probability of lethal injury from large ships increased from 21% for vessels traveling at 8.6 kts, to over 79% for vessels moving at 15 kts or more. In a study by Lammers et al. (2003), 22 whale/vessel incidents were recorded from 1975 – 2003, with 14 of those occurring during the years from 1994 – 2003. Using the ten-year period of highest vessel strikes, and the same number vessel transits mentioned above, that calculates to a probably of a collision between a whale and a transiting vessel to be 0.0000024%. According to the study by Lammers et al. (2003), the vast majority (17) of the vessel strikes were from vessels traveling at speeds in excess of 15 kts, and nearly all of them occurred in close proximity to the coastline of the main four Hawaiian Islands.

Based on the expected transit speeds for vessels in this fishery, the collision risks from the references cited above, and the low abundance and widely scattered nature of the whale species in the *Action Area*; we are reasonably certain the likelihood of an individual from the whale being struck is extremely unlikely, and therefore discountable.

Invertebrates

Chambered nautiluses are closely associated with steeply-sloped forereefs and muddy bottoms and are found in depths typically between 200 and 500 m and are not known to swim in the open water column nor found in shallow water depths except for rare occasions when the water is cold enough (Miller 2018). Open ocean environments and specific temperature gradients are considered geographic barriers to movement as the species does not swim through the mid-water (Miller 2018). Therefore, it is extremely unlikely a chambered nautilus would be exposed to vessels at the surface within this fishery and would only pertain to vessel trips that transit to American Samoa.

While it has properly been assumed for listed coral species that physical contact of equipment or humans with an individual constitutes an adverse effect due to high potential for harm or harassment, the same assumption does not hold for ESA-listed corals due to two key biological characteristics:

1. All corals are simple, sessile invertebrate animals that rely on their stinging nematocysts for defense, rather than predator avoidance via flight response. So whereas it is logical to assume that physical contact with a vertebrate individual results in stress that constitutes harm and/or harassment, the same does not apply to corals because they have no flight response.
2. Most reef-building corals, including all the listed species, are colonial organisms, such that a single larva settles and develops into the primary polyp, which then multiplies into a colony of hundreds to thousands of genetically-identical polyps that are seamlessly connected through tissue and skeleton. Colony growth is achieved mainly through the addition of more polyps, and colony growth is indeterminate. The colony can continue to exist even if numerous polyps die, or if the colony is broken apart or otherwise damaged. The individual of these listed species is defined as the colony, not the polyp, in the final coral listing rule (79 FR 53852). Thus, affecting some polyps of a colony does not necessarily constitute harm to the individual.

Corals are sessile invertebrates which do not move locations except for extenuating circumstances such as when progeny are broadcasted into ocean currents or breakage and recolonization of substrate from severe weather events. Vessels are expected to use established transportation channels or be deep enough water to avoid contact with corals and would only pertain to transits in MARA, ASARA, WCPRA, and the small portions of the HARA where *Acropora globiceps* has been documented (i.e. NWHI; NMFS 2021a).

In conclusion, given the small number of vessels participating in these research activities, the small number of anticipated vessel trips, the slow vessel speeds during fishing operations and vessel transiting, the expectation that ESA-listed marine species would be widely scattered throughout the proposed *Action Area*, the potential for an incidental vessel strike is extremely unlikely to occur. Thus, NMFS is reasonably certain this the probability of vessel collision with a listed coral is extremely unlikely, and therefore discountable.

9.1.3 Introduction of Vessel Wastes and Discharges, Gear Loss, and Vessel Emissions

The diffuse stressors associated with the vessel operations: vessel waste discharge, gear loss, and carbon emissions and greenhouse gasses, can affect both pelagic and coastal areas. ESA-listed resources could be exposed to discharges, and run-off from vessels that contain chemicals such as fuel oils, gasoline, lubricants, hydraulic fluids and other toxicants. PIFSC research and fishery vessels burn fuel and emit carbon into the atmosphere during fishing operations and transiting. Parker et al. (2018), estimates that in 2011, the world's fishing fleets burned 40 billion liters of fuel and emitted 179 million tons of carbon dioxide greenhouse gasses into the atmosphere. Between 1990 and 2011, emissions grew by 28% primarily due to increased harvests of crustaceans, a fuel intensive fishery (Parker et al. 2018). While we don't have an accurate estimate of the carbon footprint of the PIFSC research activities, we expect the contribution to global greenhouse gases to be relatively inconsequential based on the low number of participants in the fishery.

PIFSC will implement BMPs to prevent the introduction of plastics and spills. If any accidental spill were to occur, it is anticipated to be small in size, contained, and quickly cleaned up prior to entering the aquatic environment. Based on the low likelihood of an ESA-listed species in the vicinity in the unlikely event of a spill occurring, and the adherence to the BMPs that will prevent or minimize potential exposure from spills, we are reasonably certain the probability of exposure of ESA-listed species to wastes and discharges is extremely unlikely and, therefore be discountable.

Although leakage, wastes, gear loss and vessel emissions could occur as a result of PIFSC research activities, given the small number of vessels, use of BMPs, large *Action Area*, low density of listed species,, the probability that ESA-listed resources will be exposed to measurable or detectable amounts of wastes, gear, or emissions from this fishery, is extremely unlikely, and therefore discountable on the ESA-listed resources in Table 4.

9.1.4 Changes in Food Availability

While researchers may harvest fish species that ESA-listed species under NMFS' jurisdiction identified in Table 4, forage on, it is not expected that the amount of proposed harvest would reduce the opportunity for an ESA-listed species to successfully capture prey, or affect the available prey density as described in the BA. Thus, any reduction in food availability is extremely unlikely, and therefore discountable. Listed coral within the *Action Area* obtain food through two processes, photosynthesis and filter feeding (Soo and Todd 2014; Veron 2014). We do not expect any research operations for this survey to affect water quality or phytoplankton communities in a manner that would affect a listed coral. CTD casts will collect small quantities of seawater and would not create an appreciable reduction in the plankton community. Thus, any reduction in food availability is extremely unlikely, and therefore discountable.

9.1.5 Demersal and handline fishing

Demersal and handline fishing will occur throughout the HARA, MARA, and ASARA. Recreational fishing methods pose hooking and entanglement risks to green, hawksbills, loggerhead, leatherback and olive Ridley sea turtles; oceanic whitetip shark, scalloped hammerhead shark, and the giant manta ray. These fishing activities will not occur within the Hawaiian monk seal or Main Hawaiian Insular false killer whale's range. While various cetacean species may depredate bait or catch, we do not expect the ESA-listed cetacean species noted in Table 4 to do so as most are large baleen whales. Cetacean depredation of either bait or catch by toothed whale species could occur, but typically results in only the fish being removed from the hook. However, cetaceans could possibly be entangled in the fishing lines.

Hooking can result in physical damage to the animal, increase the opportunity for a depredation event by a higher level predator while the animal is on the line, interfere with reproduction, reduce foraging efficiency, require extra energy for movement, and in the case of sea turtles and marine mammals, may result in drowning.

Hawaiian monk seals are commonly caught in shoreline fisheries in Hawaii. Hawaiian monk seals appear to favor live bait, or fish attached to a hook, but have been known to feed on squid bait as well. A captured bottomfish could also be depredated as well. Bottomfish set ups are similar to shore fishing (squid-baited circle hooks), and occur in areas where Hawaiian monk seals have been known to feed. We investigated the potential of exposure but found no data or reports from commercial bottomfish fisheries. Interactions could occur but was not considered a major threat. Hawaiian monk seal presence in deep offshore areas are sparse, and as bottomfish rigs are only soaked for 30 minutes, the co-occurrence is considered extremely rare. Hawaiian monk seals and turtles generally do not chase bait in troll fisheries. PIFSC has never reported a Hawaiian monk seal hooking or depredation during similar sampling activities. We are reasonably certain the probability of exposure of any individual Hawaiian monk seal is extremely unlikely, and therefore discountable.

In addition to being entangled, sea turtles are also injured and killed by being hooked. Sea turtles are commonly caught in shore fishing in Hawaii where there are high densities of green sea turtles and shore fishing. Shore fishing is not proposed in this action. However, bottomfish fishing uses the same method (i.e. squid-baited circle hooks) that is commonly used in shore fishing. Sea turtles generally do not forage in deep locations where bottomfish sampling occurs, and PIFSC and federally permitted commercial bottomfish fisheries has never reported a hooked a sea turtle during bottomfish activities as described in the proposed action. Interactions could occur but was not considered a major threat. Hawaiian monk seal presence in deep offshore areas are sparse, and as bottomfish rigs are only soaked for 30 minutes, the co-occurrence is considered extremely rare. Hawaiian monk seals generally do not chase bait in troll fisheries. We also predict that the primarily nearshore nature of the fishing proposed in this action would have a low probability of hooking whales. We are reasonably certain the probability of exposure of any individual sea turtle, Hawaiian monk seal, or cetacean is extremely unlikely, and therefore discountable.

Entanglements can also create physical damage to the animal by constriction of the line which can partially sever limbs or flippers, create penetrating injuries, increase the opportunity for necrosis or death of tissues to occur, and can potentially immobilize an animal (Andersen et al. 2007; Parga 2012). Entanglements also interfere with reproduction, reduce foraging efficiency, and require extra energy for movement, and in the case of sea turtles and marine mammals, may also result in drowning. Ingestion of fishing line by sea turtles causes delayed mortality by blocking intestinal tracts leading to starvation as summarized by Parga (2012).

Cetaceans would not be expected to be boarded in the highly unlikely event they were hooked. Based on their size, strength, and the fishing gear to be used, it would be expected that the line would part. Entanglement would be the primary stressor for these species. Passive entanglement could occur if large baleen whales were transiting through the area and happened to contact the deployed fishing line. However, based on the species distribution, abundance, and expected food sources, we do not expect the bait or catch to be depredated by species listed in Table 4 and Table 4 and the likelihood that a large baleen whale would contact a small number of lines would be extremely unlikely. Along with established BMPs to survey the area, maintaining a watch for listed species around the vessel, and termination of operations if animals are spotted, we consider the interaction of a cetacean becoming entangled in a demersal fishing line to be extremely unlikely and therefore discountable.

9.1.6 Anchoring

The PIFSC prefers not to anchor vessels in coral reef ecosystems where their work routinely takes place. An anchor could potentially have severe consequences for listed coral depending on the severity of damage it inflicts, ranging from tissue damage, fragmentation, or complete destruction of the colony or bivalve (Dinsdale and Harriott 2004). Ocean conditions are dynamic and unforeseen issues with vessels can potentially occur as well. While operations are not expected to take place in harsh ocean conditions, if one of the auxiliary boat Captains needs to set an anchor for safety reasons, anchoring would permissible as long the BMPs are properly implemented and would be removed at the conclusion of the days operation. This includes a diver assisting the deployment and setting of the anchor, anchorage will only occur in sand with periodic visual observation to monitor dragging and to identify if proper tension is being maintained on the line thereby reducing opportunities for entanglements by listed species, and monitoring of ocean conditions that might affect the anchors functionality.

The PIFSC does not expect this operation will require anchoring and operations will only occur during favorable sea state conditions. For these reasons, along with the established BMPs, and the fact that the vessels can deploy the divers and move to deeper waters if need be, we believe anchoring that could potentially affect listed species is extremely unlikely to occur and therefore discountable.

The mooring design for this action, in the unlikely event that it is even deployed, consists of single anchor line that would use the minimum line length necessary to account for expected fluctuations in water depth due to tides and waves from the vessel(s) to the ocean floor. While intact, the anchor line is expected to be held tight by the combination of buoyancy of the vessel, the pressure exerted on the line by currents and waves, and the anchors holding power. Thus the potential for loops to form in the line is extremely remote.

Most ESA-listed species under consideration, like sea turtles, the scalloped hammerhead shark, giant manta ray, etc., are highly mobile species which can avoid anchor lines. ESA-listed corals are sessile animals and anchor lines would pose no threat of entanglement. We do not expect anchoring to occur in Hawaiian waters during the transit phase, thus the Hawaiian monk seal and MHI insular false killer whale are not considered. For the remaining vertebrate ESA-listed species under NMFS' jurisdiction that could potentially interact with anchor lines, the combined weight of the anchor and the pressure exerted on the line by currents make the potential for entanglement extremely unlikely. A taut anchor line would pass harmlessly along the body of a marine animal should an animal encounter one. Further, failed anchors would sink to the seafloor such that any loose line would be short, and the risk of an encounter during the descent of the line with an ESA-listed marine animal is extremely unlikely. Anchor lines could then be manually recovered by the dive team.

Because of the unlikely probability that an anchor would actually be deployed, and the established BMPs, including active monitoring of the anchor system in the unlikely event that it is, we are reasonably certain the probability of exposure of species in Table 4 and Table 5 **is** extremely unlikely, and therefore discountable.

9.1.7 Entanglement

PIFSC is using various sizes of trawl nets at various depths and durations for their research. The breakdown of each trawl method and their details are presented in Table 1. For our evaluation, we consider the total duration of nets in the water, compare it to the likelihood of encountering a listed species, and the probability of a listed species being caught and entangled in these nets. Most sampling occurs in pelagic areas where large animal density is low and co-occurrence of nets and listed species are minimal.

Over the course of a year, PIFSC will deploy over 5,000 nets, ranging from 1-4 hours per tow. PIFSC is also proposing to set up to 175 traps at the bottom of the ocean at bottomfish fishing sites to gather data on juvenile fish communities. These traps are either 8-ft long by 5-ft wide by 3-ft high, with 1.5 inch mesh; or 2-ft long by 1-ft wide by 1-ft high with 0.5-inch mesh. The traps will be left in place for 6-24 hours per set. PIFSC will set traps as deep as 400 m, where sea turtles generally do not forage, but Hawaiian monk seals might forage. The traps are designed with plastic mesh at the entries, which turtles, seals or other large animals can break and escape.

PIFSC will implement BMPs such as observing areas for listed species prior to setting equipment out into the water column, which will reduce the probability of interactions. PIFSC has never captured a sea turtle, monk seal, cetacean, or elasmobranch during any of the tow or trawls, nor has ever entangled them in any other sampling efforts. Other bait trap activities such as the trapping for *Ranina ranina* in the Mariana Islands are actively managed while trapping is occurring, which reduces the likelihood of accidental capture or entanglement. Bottomfish set ups have rigid mainlines that do not entangle easily, while other trap lines like the *Ranina ranina* traps are located in relatively shallow areas where the pelagic-based cetaceans and elasmobranchs rarely occur and are managed during the set.

We are not reasonably certain entanglements with ESA-listed cetaceans will occur. Tows and trawls will be conducted and actively monitored during the tow, and PIFSC will minimize interactions by implementing BMPs. Interactions are limited due to a low number of tows, and low densities of cetaceans in open ocean areas. Most fishing and trapping occur relatively close to shore where cetaceans generally do not occur and either reel lines are rigid and difficult to entangle or monitored closely during operation.

The Navy gathered data and developed a species densities database for their consultations on training exercises in the Pacific Ocean (Navy 2017). The database includes estimates of animals per square km, which is useful to estimate the probability of interacting with gear used in this action. The densities range from 0.0005 (blue whales) to 0.4 animals (green sea turtles – coastal Hawaii) per square km. These densities project that interactions between activities and ESA-listed species would be extremely unlikely, and therefore discountable.

9.1.8 Nearshore and Land-based Surveys

The Pacific RAMP, Marine Debris Research and Removal Surveys, and Marine Turtle Biology and Assessment Program involve circumnavigating islands and atolls using small vessels that may approach the shoreline. Additionally, the Marine Turtle Biology and Assessment Program activities include visual observations, and underwater and land-based captures and sampling of sea turtles, and the Marine Debris Research and Removal Surveys may involve land vehicle (trucks) operations in areas of marine debris where vehicle access is possible from highways or rural/dirt roads adjacent to coastal resources. These activities have the potential to disturb monk seals hauled out during research activities either from approaches of nearshore small vessel based research or land based debris research and clean-up activities.

PIFSC will be deploying numerous instruments that may directly contact species (ROVs, cameras, BRUVs, and other various equipment etc.). Considering the large *Action Area* and disperse distribution of most of the listed species in Table 1, it would be extremely rare for concurrent existence. Furthermore, PIFSC's will implement BMPs which include avoiding working in areas where listed species are observed, and halting work when they are in the work area and can potentially be harmed by activities. Instruments will either be moving as they are towed, or left in place for a period of time to collect data. Exposure to objects in water increase with duration. Because of PIFSC BMPs to avoid listed species, we are reasonably certain direct contact or associated disturbance is extremely unlikely, and therefore discountable.

9.2 Critical Habitat

Critical habitat exists within the *Action Area* for three of the species analyzed in this document (see Table 5).

9.2.1 Main Hawaiian Islands Insular False Killer Whale

Critical Habitat for MHI insular false killer whale includes waters from the 45-meter (m) depth contour to the 3,200-m depth contour around the main Hawaiian Islands from Niihau east to Hawaii Island. We defined the essential features for MHI insular false killer whales as island-associated marine habitat with four characteristics that support this feature. The four characteristics include: 1) adequate space for movement and use within shelf and slope habitat; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; (3) waters free of pollutants of a type and amount harmful to MHI insular false killer whales; and (4) sound levels that will not significantly impair false killer whales' use or occupancy.

PIFSC will conduct activities within MHI insular false killer whale critical habitat in some of the HARA. While traps, fishing sets, and other equipment could potentially be hazardous to MHI insular false killer whales as entanglement, hooking, or other risks, they are temporary in nature and will have no long-term effects on the habitat or the essential features of the habitat once they are removed from the research areas. PIFSC will remove all equipment after research activities are complete. With the implementation of BMPs, PIFSC will avoid or minimize the effects of sound, vessel traffic, and hazardous chemicals to expose MHI insular false killer whales to levels that would prevent them from occupying the area, supporting prey species, or providing areas where they can forage, rest, reproduce, or transit through.

9.2.2 Hawaiian monk seal

The proposed action will occur in monk seal critical habitat. Specific areas for designated critical habitat include 16 occupied areas within the range of the species: ten areas in the NWHI and six in the MHI. These areas contain one or a combination of habitat types: Preferred pupping and nursing areas, significant haul-out areas, and/or marine foraging areas, that will support conservation for the species. Specific areas in the NWHI include all beach areas, sand spits and inlets, including all beach crest vegetation to its deepest extent inland, lagoon waters, inner reef waters, and including marine habitat through the water's edge, including the seafloor and all subsurface waters and marine habitat within 10 m of the seafloor, out to the 200-m depth contour line around the ten areas: Kure Atoll, Midway Islands, Pearl and Hermes Reef, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island, and Nihoa Island. Specific areas in the MHI include marine habitat from the 200-m depth contour line, including the seafloor and all subsurface waters and marine habitat within 10 m of the seafloor, through the water's edge 5 m into the terrestrial environment from the shoreline between identified boundary points on the islands of: Kaula, Niihau, Kauai, Oahu, Maui Nui (including Kahoolawe, Lanai, Maui, and Molokai), and Hawaii.

PIFSC will conduct activities within Hawaiian monk seal critical habitat in some of the HARA. While traps, fishing sets, and other equipment could potentially be hazardous to monk seals as entanglement, hooking, or other risks, they are temporary in nature and will have no long-term effects on the habitat or the essential features of the habitat once they are removed from the research areas. PIFSC will remove all equipment after research activities are complete. With the implementation of BMPs, PIFSC will avoid or minimize the effects of sound, vessel traffic, and hazardous chemicals to expose monk seals to levels that would prevent important activities such as foraging, pupping, or resting.

9.2.3 Proposed Pacific Coral Critical Habitat

On November 27, 2020, NMFS announced a proposed rule in the Federal Register (85 FR 76262) to designate critical habitat for seven of the fifteen threatened Indo-Pacific corals, A. globiceps, Acropora retusa, A. jacquelineae, Acropora speciosa, Seriatopora aculeata, Euphyllia paradivisa, and Isopora crateriformis. Critical habitat is proposed for most of the geographic area occupied by these seven listed corals in U.S. Pacific Islands waters and includes a total of 17 specific occupied units, or areas, containing physical features essential to the conservation of the coral species.

Proposed critical habitat is defined as all waters 0-40 meters depth around each occupied unit, except for the areas specified below. The proposed coral critical habitat consists of substrate and water column habitat characteristics essential for the reproduction, recruitment, growth, and maturation of the listed corals. Sites that support the normal function of all life stages of the corals are natural, consolidated hard substrate or dead coral skeleton free of algae and sediment at the appropriate scale at the point of larval settlement or fragment reattachment, and the associated water column. Several attributes of these sites determine the quality of the area and influence the value of the associated feature to the conservation of the species:

(1) Substrate with presence of crevices and holes that provide cryptic habitat, the presence of microbial biofilms, or presence of crustose coralline algae; (2) Reefscape (all the visible features of an area of reef) with no more than a thin veneer of sediment and low occupancy by fleshy and turf macroalgae; (3) Marine water with levels of temperature, aragonite saturation, nutrients, and water clarity that have been observed to support any demographic function; and (4) Marine water with levels of anthropogenically-introduced (from humans) chemical contaminants that do not preclude or inhibit any demographic function.

Proposed critical habitat does not include the following particular areas where they overlap with the 0-40 meter depth in:

1) All areas that were excluded for national security, economic impact, or on military lands managed by Integrated Natural Resources Management Plans that provide sufficient conservation value. Those excluded areas are listed in the proposed listing (86 FR 16325). Critical habitat also does not include areas where the essential feature does not occur (e.g., where hard substrate does not occur);

2) All managed areas that may contain natural hard substrate but do not provide the quality of substrate essential for the conservation of threatened corals. Managed areas that do not provide the quality of substrate essential for the conservation of the seven Indo-Pacific corals are defined as particular areas whose consistently disturbed nature renders them poor habitat for coral growth and survival over time. These managed areas include specific areas where the substrate has been disturbed by planned management authorized by local, territorial, state, or Federal governmental entities at the time of critical habitat designation, and will continue to be periodically disturbed by such management. Examples include, but are not necessarily limited to, dredged navigation channels, shipping basins, vessel berths, and active anchorages;

3) Artificial substrates including but not limited to: Fixed and floating structures, such as aids-to-navigation (AToNs), seawalls, wharves, boat ramps, fishpond walls, pipes, submarine cables, wrecks, mooring balls, docks, aquaculture cages;

4) The Commonwealth Ports Authority harbors, basins, and navigation channels, their seawall breakwaters; all other channels, turning basins, berthing areas that are periodically dredged or maintained, and a 25 m radius of substrate around each of the AToN bases;

Given that the duration of the proposed action (5-years) may overlap with a final designation of the proposed coral critical habitat, NMFS PIRO PRD is with this consultation conferencing with PIFSC on the effects of the proposed action on the proposed critical habitat in the *Action Area* to gain efficiencies in the process, and avoid disruption of the proposed action if the critical habitat is designated.

We evaluated the effect of removing fragments or core samples from not only ESA-listed corals but all corals to proposed coral critical habitat. Potential effects to non-listed corals can affect the critical habitat proposed for ESA-listed corals. We also evaluated the effects of other activities such as temporary placement of instruments near coral reefs, trapping, spearfishing, and other activities in critical habitat. PIFSC will avoid or minimize injuring coral, breaking or altering hard substrate by implementing BMPs to avoid contact with existing corals, and measures to ensure hard structure is kept intact. We discussed the effect of removing coral fragments and samples on the individual colonies. In rare cases, sampling could lead to death of the colony. Most colonies will heal and survive but considering up to 500 are being sampled, we anticipate that few may die. PIFSC will select corals are selected at random distributions and will avoid oversampling in one area. This avoids creating a large void in small areas, which could affect the overall health of the coral community.

We evaluated the effect of taking up to 500 coral samples from coral colonies throughout the region, over five years. Proposed Pacific coral critical habitat exists in the MARA, ASARA, and WCPRA, but not in the HARA. Not all sampling locations within the MARA, ASARA, and WCPRA will be in critical habitat, however, we expect most places where PIFSC proposes to collect samples will be. Corals would be collected as sparingly as possible from each location to avoid affecting large numbers of colonies in one area. This will minimize the risk of killing multiple colonies in a small area, which could have a large scale effect to the local coral community, and minimize the magnitude of the effect to essential features of coral critical habitat. We expect most coral colonies to heal lesions and continue to live after PIFSC's sampling. This further reduces the long-term effect to the coral community and critical habitat. The death of a few colonies could occur but considering the implementation of BMPs, we do not expect a loss of a few colonies in communities that have thousands of colonies to have long-term and lasting effects to the local coral community and the essential features of critical habitat in the *Action Area*.

Direct physical contact with proposed coral critical habitat's hard substrate, including essential features (1) and (2) as listed above, may occur from the same set of activities as described in Section 5.3 of this document. Depending on the nature of contact, direct physical contact can reduce the quality and quantity of hard substrate needed for listed corals to settle and grow.

However, the BMPs to be employed to avoid contact with listed corals and their habitat (BMPs 1-4 and 8-10), will minimize direct contact with critical habitat's hard substrate including essential features (1) and (2). Given the nature of the stressor, direct physical contact will have no effect on proposed critical habitat's water column, including essential features (3) and (4).

PIFSC will only place traps or set anchors in sandy areas to avoid damage to hard substrate or coral. Placement of instruments and traps are temporary and the habitat will return to its ambient state once the instruments are removed. PIFSC will remove some fish from coral reef communities but will only take what they need for sampling. This will ensure important functions provided by fish to coral colonies and the reef are not significantly reduced. With the BMPs in place, we do not expect activities with the exception of coral sampling to alter the essential features of critical habitat in the long term.

Based on this information, the likelihood of proposed coral critical habitat being exposed to direct physical contact is considered extremely unlikely, and therefore discountable.

Entanglement with the proposed coral critical habitat's hard substrate, including essential features (1) and (2), may occur if traps, anchors, or other equipment are poorly placed, or drifts into or drapes and eventually becomes lodged around live or dead corals or other hard substrate structures. Depending on the nature of the entanglement, this can reduce the quantity or quality of the hard substrate by damaging, altering and/or removing attributes such as crevices and holes, which can negatively impact the reef frameworks upon which listed corals depend on. Given the nature of the stressor, entanglement will not affect proposed critical habitat's water column, including essential features (3) and (4). Based on the above and PIFSC proposed implementation of BMPs, the likelihood of the proposed coral critical habitat being exposed to entanglement is considered extremely unlikely, and therefore discountable.

There is a potential for the introduction of invasive species from vessels, equipment, and divers associated with proposed activities to have an effect on proposed coral critical habitat's hard substrate, including essential features (1) and (2), during all phases of the project. Introduced invasive species, such as fleshy algae or sponges, have the potential to reduce the quantity or quality of the hard substrate, through occupation and dominance of the hard substrate, which can negatively impact the reef frameworks upon which listed corals depend on. However, PIFSC will implement BMPs which will ensure no organisms are being introduced or transported amongst project sites. PIFSC will use gear and equipment washed in fresh water after every work day and will ensure that organisms are not being transported from different sites. Given the nature of the stressor, introduction of invasive species will not have any effects on proposed critical habitat's water column, including essential features (3) and (4). Based on this information, the likelihood of the proposed coral critical habitat being exposed to the introduction of invasive species is considered extremely unlikely, and therefore discountable.

As mentioned above for sea turtles and corals, waste, discharge and other pollutants may be introduced to the marine environment from vessels, equipment and divers during all phases of project activities in the form of hydrocarbon-based chemicals, debris/trash, and toxins from materials used for settlement units and/or sunscreen. Similar to the analysis provided for *Acropora retusa* and *Seriatopora aculeata* corals, depending on the nature of the discharge/s, these may affect proposed critical habitat hard substrate, including essential features (1) and (2), and critical habitat's water column, including essential features (3) and (4). The quantity and quality of hard substrate needed for corals to settle and grow may be reduced through for example contaminants harming live coral tissue, nutrients promoting fleshy algal growth, and trash abrading and breaking coral skeletons. In addition, discharge may reduce water quality. However, as mentioned above for listed corals, various measures including BMPs will be implemented to limit discharges and their effects on organisms, hard substrate and water quality. Therefore, the likelihood of proposed coral critical habitat being exposed to waste, discharge and other pollutants is considered extremely unlikely, and therefore discountable.

Vessel collisions with proposed coral critical habitat hard substrate, including essential features (1) and (2), will not occur due to the lack of spatial overlap between hard substrate and vessel movement in the water column. In addition, given the nature of the stressor, vessel collisions will have no effect on proposed critical habitat's water column, including essential features (3) and (4).

Noise exposure of proposed coral critical habitat's hard substrate, including essential features (1) and (2), will not occur as there is no evidence, as mentioned for corals above, that coral colonies, or hard substrate, can "hear" sound. The temporary and minor levels of sound generated from project activities as mentioned above, are not expected to be associated with pressure waves. In addition, given the nature of the stressor, noise will have no effect on proposed critical habitat's water column, including essential features (3) and (4). Increased turbidity Increased turbidity exposure of proposed coral critical habitat's hard substrate, including essential features (1) and (2), and critical habitat's water column, including essential features (3) and (4), is extremely unlikely to occur due to the lack of spatial overlap between hard substrate (and the overlaying water column) and any turbidity plume/s generated by the sediment disturbance activities associated with the proposed action. Turbidity would be associated only with activities causing disturbance of sand, which is expected to be limited to a few occurrences for a matter of minutes at a time once per the 5-year project duration per location at most, and infrequently for vessel anchoring across the *Action Area* during all phases of activities. Any turbidity generated is expected to be temporary and confined to the immediate vicinity (> 3 m) of the source of disturbance. Based on this analysis, the likelihood of proposed coral critical habitat being exposed to increased turbidity is considered extremely unlikely, and therefore discountable.

Benthic disturbance and change in proposed coral critical habitat's hard substrate, including essential features (1) and (2) will be exposed to the benthic disturbance and change in habitat stressor as a result of the placement of settlement units and installation of plot markers on hard substrate at reef sites, and placement of data-gathering equipment. Benthic disturbance and change in habitat can reduce the quality and quantity of the essential features listed above, and the hard substrate needed for the listed corals to settle and grow. Given the nature of the stressor, benthic disturbance and change in habitat will have no effect on proposed critical habitat's water column, including essential features (3) and (4). The level of exposure of proposed coral critical habitat to the disturbance and change in habitat stressor is expected to be minor.

Proposed coral critical habitat's hard substrate and associated water column, including essential features (1), (2), (3) and (4) are extremely unlikely to be exposed to direct physical contact; entanglement; introduction of invasive species; introduction of wastes and other pollutants; and vessel collisions. PIFSC will not increase levels of noise; and turbidity to levels that will diminish water quality that prevents or reduces survival of existing coral colonies or settlement of coral.

9.3 Conclusion

Considering the information and assessments presented in the consultation request and available reports and information, and in the best scientific information available about the biology and expected behaviors of Central North Pacific, Central South Pacific, and Central West Pacific green sea turtle, hawksbill sea turtle, Leatherback sea turtle, North Pacific loggerhead sea turtle, olive ridley sea turtle, blue whale, fin whale, sei whale, sperm whale, Hawaiian monk seal, MHI insular false killer whale, North Pacific right whale, and chambered nautilus, all effects of the proposed action are either discountable or insignificant. We also conclude that the action is not likely to adversely modify or destroy critical habitats of Hawaiian monk seal and MHI insular false killer whale, and not likely to adversely modify or destroy proposed critical habitat of Pacific Ocean corals. Accordingly, we concur with your determination that the proposed action is not likely to adversely affect them.

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