ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT: HAWAII ARCHIPELAGO FISHERY ECOSYSTEM PLAN 2019

Western Pacific Regional Fishery Management Council
1164 Bishop St., Suite 1400
Honolulu, HI 96813

PHONE: (808) 522-8220
FAX: (808) 522-8226
www.wpcouncil.org

The ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT for the HAWAII ARCHIPELAGO FISHERY ECOSYSTEM 2019 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council (WPRFMC), National Marine Fisheries Service (NMFS)-Pacific Island Fisheries Science Center (PIFSC), Pacific Islands Regional Office (PIRO), Division of Aquatic Resources (HI) Department of Marine and Wildlife Resources (American Samoa), Division of Aquatic and Wildlife Resources (Guam), and Division of Fish and Wildlife (CNMI).

This report attempts to summarize annual fishery performance looking at trends in catch, effort and catch rates as well as provide a source document describing various projects and activities being undertaken on a local and federal level. The report also describes several ecosystem considerations including fish biomass estimates, biological indicators, protected species, habitat, climate change, and human dimensions. Information like marine spatial planning and best scientific information available for each fishery are described. This report provides a summary of annual catches relative to the Annual Catch Limits established by the Council in collaboration with the local fishery management agencies.

Edited By: Thomas Remington, Contractor & Marlowe Sabater and Asuka Ishizaki, WPRFMC.

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Hawaii Division of Aquatic Resources: Reginald Kokubun, Paul Murakawa, Tom Ogawa, and Bryan Ishida.

NMFS Pacific Islands Fisheries Science Center: Ivor Williams, Felipe Carvalho, Joseph O'Malley, Michael Parke, Thomas Oliver, Melanie Abecassis, Frank Parrish, T. Todd Jones, Minling Pan, Justin Hospital, and Kirsten Leong.

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EXECUTIVE SUMMARY

As part of its five-year fishery ecosystem plan (FEP) review, the Western Pacific Regional Fishery Management Council (WPRFMC; the Council) identified its annual reports as a priority for improvement. The former annual reports have been revised to meet National Standard regulatory requirements for Stock Assessment and Fishery Evaluation (SAFE) reports. The purpose of the reports is twofold: to monitor the performance of the fishery and ecosystem to assess the effectiveness of the FEP in meeting its management objectives; and to maintain the structure of the FEP living document. The reports are comprised of three chapters: Fishery Performance, Ecosystem Considerations, and Data Integration. The Council will iteratively improve the annual SAFE report as resources allow.

The Fishery Performance chapter of this report presents descriptions of Hawaiian commercial fisheries harvesting management unit species (MUS), including Deep 7 bottomfish, non-Deep 7 bottomfish (i.e., only uku, *Aprion virescens*), and crustaceans, as well as ecosystem component species (ECS) replacing former MUS including all coral reef ecosystem MUS (CREMUS). An amendment to the Hawaii Archipelago FEP was passed in early 2019 classifying all non-Deep 7 bottomfish except for uku, all former CREMUS, several crustacean MUS, and all mollusk and limu species as ECS (84 FR 2767). Species classified as ecosystem components do not require annual catch limit (ACL) specifications or accountability measures but are still to be monitored regularly in the annual SAFE report through a one-year snapshot of the ten most caught ECS, complete catch time series of nine prioritized ECS as selected by the Hawaii Department of Aquatic Resources (HDAR), as well as trophic and functional group biomass estimates from fishery independent surveys. Existing management measures still apply to ECS. Data on precious coral MUS are not available due data confidentiality associated with the low number of federal permit holders.

In the Fishery Performance chapter, the data collection systems for each fishery are briefly explained. The fishery statistics are organized into summary dashboard tables showcasing the values for the most recent fishing year and the percent change between short-term (10-year) and long-term (20-year) averages. Time series of fishing parameters and species catch by gear type are also provided. Additionally, the number of federal permits, status determination criteria, specified catch limits, the best scientific information available, harvest extent and capacity, and administrative and regulatory actions associated with insular fisheries in the Hawaiian Archipelago are included.

For Hawaii fisheries in 2019, none of the evaluated MUS had three-year average catch that exceeded their specified ACL, allowable biological catch (ABC) values, or overfishing limits (OFL). The closest to do so was Kona crab, with a three-year average catch of 3,436 lbs. relative to its ACL of 3,500 lbs. Recent average catch for the Main Hawaiian Island Deep 7 bottomfish stock complex (217,846 lbs.) accounted for 44.3% of its prescribed ACL (492,000 lbs.). Note that ACLs were not specified for non-Deep 7 bottomfish other than uku and CREMUS because of the recent ecosystem component amendment to the Hawaii FEP that reclassified many previous MUS as ECS.

In 2019, the Main Hawaiian Island Deep 7 bottomfish fishery was characterized by decreasing trends in catch and effort relative to 10- and 20-year averages. This decline can likely be attributed to trends in the portion of the fishery that harvests using deep-sea handline, which is responsible for a majority of Deep 7 bottomfish catch in the main Hawaiian Islands (MHI).

Catches of opakapaka (*Pristipomoides filamentosus*; 67,218 lbs.) declined nearly 45% relative to its 10-year average and 42% compared to its 20-year average. One Deep 7 bottomfish species, gindai (*Pristipomoides zonatu*), did have increases relative to its short- and long-term trends, while ehu (*Etelis carbunculus*) had an increase of over 2% compared to its 20-year trend. Non-deep sea handling methods catching Deep 7 bottomfish species are responsible for a much lower portion of catch but did have increases relative to historical averages for several species.

Due to the ECS amendment to the Hawaii Archipelago FEP in 2019, the non-Deep 7 bottomfish fishery is now solely comprised of uku (*Aprion virescens*). Total catch for uku (89,836 lbs.) was 17% lower than its 10-year average and 1.5% lower than its 20-year average, likely due to reductions in catch from deep-sea handline and trolling. While catch was lower to uku relative to its historic averages, the CPUE was higher than short- and long-term trends for all gears harvesting uku except for trolling; this may potentially be associated with the observed decline in trips for all gears compared to historical averages.

The Hawaii coral reef ecosystem component section in the 2019 report replaced the section on CREMUS finfish from previous report cycles. The most harvested ECS in 2019 were akule (*Selar crumenophthalmus*) and opelu (*Decapterus macarellus*) followed by parrotfish (multi-species), menpachi (*Myripristis* spp.), taape (*Lutjanus kasmira*), and palani (*Acanthurus dussumieri*). In general, harvest for prioritized ECS (as selected by HDAR) exhibited declines in fishing participation, effort, and catch when comparing 2019 statistics to historical trends. All ten prioritized ECS had reductions in the number of licenses fishing and the number of fishing trips taken. All monitored species and groups except for uhu (parrotfish) and taape had 2019 catch values indicating declines from their 20-year averages. Also notable was that 2019 catches of kumu (*Parupeneus porphyus*) were down over 85% from their short- and long-term trends. While the observed catch of opihi (limpet) species declined, the number of individuals harvested greatly increased relative to historical trends.

In 2019, the MHI crustacean fishery, now comprised of only deepwater shrimp and kona crab, had an overall decline in catch relative to available short- and long-term trends. In general, there was a greater number of fishing trips taken for these species than recorded in their historical trends, but total catch (18,296 lbs.) decreased by 17% from its 10-year trend and 30% from its 20-year trend. Effort, participation, and catch values for shrimp species harvested by shrimp trap were not disclosed due to data confidentiality (i.e., less than three licenses reporting). Kona crab harvested by loop net had increases in catch (5,650 lbs.) and CPUE (80.71 lbs./trip) compared to its 10-year average despite having fewer associated licenses (23) and fishing trips (70); catch increased over 7% from its 10-year average while CPUE increased over 39%. Data for other gear types were unavailable to report due to data confidentiality.

An Ecosystem Considerations chapter was added to the annual SAFE report following the Council's review of its FEPs and revised management objectives. Fishery independent ecosystem survey data, socioeconomics, protected species, climate and oceanographic, essential fish habitat, and marine planning information are included in Ecosystem Considerations.

Fishery independent ecosystem data were acquired through visual surveys conducted by the National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) Reef Assessment and Monitoring Program (RAMP) under the Ecosystem Sciences Division (ESD) in CNMI, the Pacific Remote Island Areas (PRIAs), American Samoa, Guam, the MHI, and the Northwestern Hawaiian Islands (NWHI). This report describes mean fish biomass of functional, taxonomic, and trophic groups for coral reefs as well as habitat condition using mean coral coverage per island for each of these locations averaged over the past ten years. Coral coverage in the MHI ranged from nearly 3% around Niihau to over 21% near Lanai, while coral coverage in the NWHI ranged from just over 2% around Midway to over 31% near French Frigate Shoals. Fish biomass was lower for all fishes in the MHI compared to the NWHI by a factor of four, though the MHI did have slightly higher biomass on average for mid-large target surgeonfish, non-planktivorous butterflyfish, corallivores, and species of the family Serranidae.

Life history parameters derived from otolith and gonad sampling for several bottomfish and coral reef ECS from in the MHI are also presented. These parameters include maximum age, asymptotic length, growth coefficient, hypothetical age at length zero, natural mortality, age at 50% maturity, age at sex switching, length at which 50% of a fish species are capable of spawning, and length of sex switching are provided. Available data for 18 coral reef fish species and eight bottomfish species are presented.

The socioeconomic section begins with an overview of the socioeconomic context for the region, presents relevant socioeconomic data trends including commercial pounds sold, revenues, and prices, and lists relevant socioeconomic studies from the past year. For Hawaii MUS, the Deep 7 bottomfish complex comprised 75% of the revenue, uku comprised 23%, and crustaceans comprised just 2%. While the total number of commercial marine licenses (CMLs) has continuously declined since 2016, there were 478 CMLs that reported data to HDAR in 2019 and 84% of these licenses reported selling fish. In the Hawaii Deep 7 bottomfish fishery, there were 163,341 lbs. sold in 2019 at an average adjusted price of $8.19/lb. for a revenue of $1,338,295. In the uku fishery, 82,756 lbs. were sold at an average adjusted price of $5.05/lb. for a revenue of $417,943. There were 4,717 lbs. of crustacean MUS sold at an average adjusted price of $7.42/lb. for a revenue of $39,989. For the top-ten harvested ECS in Hawaii, there were 487,279 lbs. sold for a revenue of $1,658,506, which was slightly less than the revenue and pounds sold for the same species in 2018. Priority ECS in Hawaii had 134,480 lbs. sold for a revenue of $541,250, which was also slightly less than the revenue and pounds sold for the same species in 2018.

The protected species section of this report summarizes information and monitors protected species interactions in fisheries managed under the Hawaii FEP using proxy indicators such as fishing effort and shifts in gear dynamics. Protected species considered include sea turtles, sea birds, marine mammals, sharks, rays, and corals, many of which are protected under the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and/or the Migratory Bird Treaty Act (MBTA). The fisheries included in the Hawaii FEP generally have limited impacts to protected species, and currently do not have any federal observer coverage. Fishing effort and other characteristics are monitored to detect any potential change to the scale of impacts to protected species. Fishery performance data in this report indicate that there have been no notable changes in the fisheries that would affect the potential for interactions with protected species, and there is no other information that indicates that impacts to protected species have changed in recent years. ESA consultation for newly listed elasmobranch species is ongoing. Available information indicates that oceanic whitetip shark interactions in the MHI bottomfish fishery are rare, and there are no records of giant manta ray incidental captures or entanglements in the federally managed bottomfish fisheries. Going forward, the Council intends to better understand potential protected species interactions through improved species identification in both commercial and non-commercial fisheries data, to develop innovative approaches for estimating protected species interactions in insular fishers, and to conduct genetic and telemetry research to improve understanding of population structure and movement patterns of listed elasmobranchs.

The climate and oceanic indicators section of this report includes indicators of current and changing climate and related oceanic conditions in the geographic areas for which the Council has jurisdiction. In developing this section, the Council relied on a number of recent reports conducted in the context of the U.S. National Climate Assessment including, most notably, the 2012 Pacific Islands Regional Climate Assessment and the Ocean and Coasts chapter of the 2014 report on a Pilot Indicator System prepared by the National Climate Assessment and Development Advisory Committee. The primary goal for selecting the indicators used in this report was to provide fishing communities, resource managers, and businesses with climate-related situational awareness. In this context, indicators were selected to be fisheries relevant and informative, build intuition about current conditions considering changing climate, provide historical context, and recognize patterns and trends.

The atmospheric concentration of carbon dioxide (CO_2) has been increasing exponentially with the time series maximum at 411 ppm in 2019. The oceanic pH at Station ALOHA in Hawaii has shown a significant linear decrease of -0.0401 pH units, or roughly a 9.7% increase in acidity ([H+]) since 1989. The Oceanic Niño Index (ONI) transitioned from weak El Niño to neutral condition in 2019. The Pacific Decadal Oscillation (PDO) hovered around zero in 2019, as it was positive (i.e., warm) for five months and negative (i.e., cool) for seven months. The Accumulated Cyclone Energy (ACE) Index ($x10^4$ kt^2) was average in both the Central and Eastern North Pacific. The Eastern North Pacific hurricane season had 17 named storms in 2019, seven of which were hurricanes and three major; the Central North Pacific had four named storms where one became a hurricane and one major. Annual mean sea surface temperature (SST) was 26.24ºC in 2019, and the annual anomaly was 0.72 ºC hotter than average with some intensification along leeward shores. The MHI experienced a coral heat stress event in 2019 that reached its maximum in October. Annual mean chlorophyll-*a* was 0.065 mg/m^3 in 2019, with an annual anomaly that was 0.0053 mg/m^3 lower than average. Precipitation in the MHI had monthly anomalies lower than average in the beginning of the year and positive anomalies in the second half of 2019. The relative trend in sea level rise in the Hawaiian Archipelago is +1.51 mm/year, equal to 0.5 feet in 100 years.

The essential fish habitat (EFH) review section of this report is required by the Hawaii Archipelago FEP and National Standard 2 guidelines, and it includes information on cumulative impacts to essential fish habitat in the U.S. Western Pacific region. The National Standard 2 guidelines also require a report on the condition of the habitat. In the 2017 and 2018 annual SAFE reports, a literature review of the life history and habitat requirements for each life stage of four reef-associated crustacean species regularly landed in U.S. Western Pacific commercial fisheries was presented. This review included information on two species of spiny lobster, (*Panulirus marginatus* and *Scyllarides squammosus*), scaly slipper lobster (*Scyllarides squammosus*), and Kona crab (*Ranina ranina*). For the 2019 report, a review of EFH for reef-associated crustaceans in the MHI and Guam has been included. The EFH section is also meant to address any Council directives toward its Plan Team, however, there were no Plan Team directives for EFH in 2019. At its 174th meeting in October 2018, the Council directed staff to prepare an amendment to the Hawaii FEP to revise EFH for precious corals and selected preliminarily preferred options. The FEP amendment was considered for final action at the

Council's 178th meeting in June 2019 and approved for finalization. There were issues prior to transmittal associated with the designations of the new precious coral EFH, and the Council will recommended further work to ensure transmittal at its 181st meeting in March 2020.

The marine planning section of this report monitors activities with multi-year planning horizons and begins to track the cumulative impact of established facilities. Development of the report in later years will focus on identifying appropriate data streams to report in a standardized manner. In the Hawaii Archipelago, aquaculture, alternative energy development, and military activities are those with the highest potential fisheries impact. The special coral reef ecosystem fishing permit (SCREFP) for the offshore aquaculture facility previously owned by Ocean Era (formerly Kampachi Farms, LLC) was transferred to Forever Oceans, who is in the process renewing the permit cooperatively with NMFS to harvest two cohorts of fish. The Bureau of Ocean Energy Management (BOEM) had previously received four nominations of commercial interest for its Call Areas northwest and south of Oahu, all of which were in the area identification and environmental assessment stage of the leasing process; however, their operations in these areas have since been suspended. The next Rim of the Pacific (RIMPAC) multinational exercise is scheduled for summer 2020. The Long-Range Strike Weapons Systems Evaluation program is currently in effect until August 2022, affecting fishing access while exercises take place.

The Data Integration chapter of this report is under development. The chapter explores the potential association between fishery parameters for uku in the MHI and an index of the El Niño Southern Oscillation (ENSO), a measure of vorticity, and a measure of surface zonal currents. Added to the report for the first time in 2019 was a list of recent relevant abstracts from publications associated with data integration topics.

For the 2017 report, exploratory analyses were performed comparing coral reef fishery species data in the Western Pacific with precipitation, primary productivity, and sea surface temperature. The Archipelagic Fishery Ecosystem Plan Team suggested several improvements to implement to the initial evaluation, which are reflected in the preliminary analysis for uku first presented in the 2018 report. Results of the evaluation for potential fishery ecosystem relationships suggested a strong inverse relationship between uku CPUE in the MHI and the ENSO index used. Uku CPUE had a strong positive relationship with surface zonal flow. While there were some potential relationships between uku fishery parameters and vorticity, they were notably weaker than those for zonal flow. A potential explanation for these results is that increased zonal flow around the MHI could increase retention of pelagic larvae for important fisheries species, such as uku, prior to their recruitment into the fishery. In continuing forward with associated analyses and presentation of results for the Data Integration chapter, work will be expanded to other top species and potentially viable ecological parameters in pursuit of standardization. The implementation of Plan Team suggestions will allow for the preparation of a more finalized version of the Data Integration chapter in future report cycles.

Recommendations from the 2020 Archipelagic Plan Team meeting associated with the annual SAFE reports are as follows:

1. Regarding the annual SAFE report socioeconomics module, the Archipelagic Plan Team recommends the Council direct staff to work with PIFSC Socioeconomic Program, WPacFIN, and Hawaii DAR to investigate the landings of kahala in the top 10 species caught and track the disposition of these incidental catches.

Annual SAFE report work items from the 2020 Archipelagic Plan Team meeting are as follows:

- Provide direction on report structure for next year, particularly for the protected species section (protected species work team in coordination with fishery data section leads);
- Improve bycatch reporting in the annual SAFE reports in coordination with the ongoing standardized bycatch reporting methodology (SBRM) review:
  - Develop a bycatch data sections for the Hawaii fisheries;
  - Improve bycatch data sections for American Samoa and Mariana Archipelago annual SAFE reports where data are available;
- Incorporate discussed changes to the Ecosystem Components section of annual SAFE reports;
- Explore other benthic cover categories in the future reports;
- Review the Habitat Report and identify the data streams that would be useful for the habitat module of the annual SAFE reports;
- Include summaries of the federal logbook data where available (note no data if permittees have not submitted any logbooks due to lack of fishing.

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ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
A_{50}	Age at 50% Maturity
$A\Delta_{50}$	Age at 50% Sex Reversal
ABC	Acceptable Biological Catch
ACE	Accumulated Cyclone Energy
ACL	Annual Catch Limits
ACT	Annual Catch Target
AM	Accountability Measure
AVHRR	Advanced Very High Resolution Radiometer (NOAA)
B	Biomass
B_{FLAG}	Reference point indicating low biomass
BiOp	Biological Opinion
BMUS	Bottomfish Management Unit Species
BOEM	Bureau of Ocean Energy Management
BRFA	Bottomfish Restricted Fishing Areas
BSIA	Best Scientific Information Available
CFEAI	Commercial Fishing Economic Assessment Index
CFR	Code of Federal Regulations
CMAP	CPC Merged Analysis of Precipitation
CML	Commercial Marine License
CMLS	Commercial Marine Licensing System (DLNR-DAR)
CMUS	Crustacean Management Unit Species
CNMI	Commonwealth of the Northern Mariana Islands
CO-OPS	Center for Operational Oceanographic Products and Services (NOAA)
Council	Western Pacific Regional Fishery Management Council
CPC	Climate Prediction Center (NOAA)
CPI	Consumer Price Index
CPUE	Catch per Unit Effort
CRED	Coral Reef Ecosystem Division (PIFSC)
CREP	Coral Reef Ecosystem Program (PIFSC)
CREMUS	Coral Reef Ecosystem Management Unit Species
CRW	Coral Reef Watch (NOAA)
DLNR-DAR/	Dept. of Land and Natural Resources - Division of Aquatic Resources (Hawaii)
DAWR	Division of Aquatic and Wildlife Resources (Guam)
DFW	Division of Fish and Wildlife (CNMI)
DGI	Daily Growth Increments
DHW	Degree Heating Weeks
DIC	Dissolved Inorganic Carbon
DMWR	Department of Marine and Wildlife Resources (American Samoa)
DOD	Department of Defense
DPS	Distinct Population Segment
E	Effort

Acronym	Meaning
EA	Environmental Assessment
ECS	Ecosystem Component Species
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
ENSO	El Niño - Southern Oscillation
EO	Executive Order
ESA	Endangered Species Act
ESRL	Earth Systems Research Laboratory (NOAA)
F	Fishing Mortality
FL	Fork Length
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
FR	Federal Register
FRS	Fishing Report System (DLNR-DAR)
FTP	File Transfer Protocol
GIS	Geographic Information System
GLM	General Linear Modeling
GOES	Geostationary Operational Environmental Satellite (NOAA)
GPS	Global Positioning System
H	Harvest
HAPC	Habitat Area of Particular Concern
HDAR	Hawaii Division of Aquatic Resources
HMFRS	Hawaii Marine Recreational Fishing Survey
HOT	Hawaii Ocean Time Series (UH)
HSTT	Hawaii-Southern California Training and Testing (DOD)
HURL	Hawaii Undersea Research Laboratory (NOAA and UH)
ITS	Incidental Take Statement
k	von Bertalanffy Growth Coefficient
L_{50}	Length at 50% Maturity
$L\Delta_{50}$	Length at 50% Sex Reversal
L_{∞}	Asymptotic Length
L_{bar}	Mean Fish Length
L_{max}	Maximum Fish Length
LAA	Likely to Adversely Affect
LIDAR	Light Detection and Ranging
LOC	Letter of Concurrence
LOF	List of Fisheries
M	Natural Mortality
MBTA	Migratory Bird Treaty Act
MEI	Multivariate ENSO Index
MFMT	Maximum Fishing Mortality Threshold
MHI	Main Hawaiian Islands
MI	Mobile Invertebrates
MLCD	Marine Life Conservation District

Acronym	Meaning
MMA	Marine Managed Area
MMPA	Marine Mammal Protection Act
MODIS	Moderate Resolution Imaging Spectroradiometer (NASA)
MPA	Marine Protected Area
MPCC	Marine Planning and Climate Change
MPCCC	MPCC Committee (WPRFMC)
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
MSST	Minimum Stock Size Threshold
MSU	Microwave Sounding Unit
MSY	Maximum Sustainable Yield
MUS	Management Unit Species
n	Sample Size
N_{L-W}	Sample Size for Length-Weigh Regression
N/A	Not Applicable
NAF	No Active Fishery
NASA	National Aeronautics and Space Administration
NCADAC	National Climate Assessment and Development Advisory Committee
NCDC	National Climatic Data Center (NOAA)
NCEI	National Centers for Environmental Information (NOAA)
n.d.	Non-Disclosure
NELHA	Natural Energy Laboratory of Hawaii Authority
NEPA	National Environmental and Policy Act
NLAA	Not Likely to Adversely Affect
NMFS	National Marine Fisheries Service (NOAA)
NOAA	National Oceanic and Atmospheric Administration
NS	National Standard
NULL	No data available
NWHI	Northwestern Hawaiian Islands
OEIS	Overseas Environmental Impact Statement
OFL	Overfishing Limits
OFR	Online Fishing Report system (DLNR-DAR)
ONI	Ocean Niño Index
OPI	OLR Precipitation Index (NOAA)
OLR	Outgoing Longwave Radiation
OTEC	Ocean Thermal Energy Conversion
OY	Optimum Yield
PCMUS	Precious Coral Management Unit Species
PDO	Pacific Decadal Oscillation
Pelagic FEP	Fishery Ecosystem Plan for the Pacific Pelagic Fisheries
PIBHMC	Pacific Islands Benthic Habitat Mapping Center (NOAA and UH)
PIFSC	Pacific Island Fisheries Science Center (NMFS)
PIRCA	Pacific Islands Regional Climate Assessment
PIRO	Pacific Islands Regional Office (NMFS)

Acronym	Meaning
PK	Planktivorous
PMEL	Pacific Marine Environmental Laboratory (NOAA)
PMUS	Pelagic Management Unit Species
POES	Polar Operational Environmental Satellite (NOAA)
PRIA	Pacific Remote Island Areas
RAMP	Reef Assessment and Monitoring Program (CRED)
RIMPAC	Rim of the Pacific
ROD	Record of Decision
ROV	Remotely Operated Underwater Vehicle
RPB	Regional Planning Body
SAFE	Stock Assessment and Fishery Evaluation
SCREFP	Special Coral Reef Ecosystem Fishing Permit
SDC	Status Determination Criteria
SEEM	Social, Economic, Ecological, Management (Uncertainty)
SEIS	Supplemental Environmental Impact Statement
SLP	Sea Level Pressure
SPC	Stationary Point Count
SPR	Spawning Potential Ratio
SSC	Scientific and Statistical Committee (WPRFMC)
SSM/I	Special Sensor Microwave/Imager
SST	Sea Surface Temperature
SSBPR	Spawning Stock Biomass Proxy Ratio
SWAC	Seawater Air Conditioning
t_0	Hypothetical Age at Length Zero
T_{max}	Maximum Age
TA	Total Alkalinity
TAC	Total Allowable Catch
TALFF	Total Allowable Level of Foreign Fishing
TBA	To Be Assigned
TBD	To Be Determined
UFA	United Fishing Agency
UH	University of Hawaii
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
VBGF	von Bertalanffy Growth Function
WETS	Wave Energy Test Site
WPacFIN	Western Pacific Fishery Information Network
WPRFMC	Western Pacific Regional Fishery Management Council
WPSAR	Western Pacific Stock Assessment Review
WSEP	Weapon Systems Evaluation Program

1 FISHERY PERFORMANCE

1.1 DEEP 7 BMUS

1.1.1 Fishery Descriptions

The State of Hawaii Department of Land and Natural Resources, Division of Aquatic Resources (HDAR or DAR) manages the deep-sea bottomfish fishery in the Main Hawaiian Islands (MHI) under a joint management arrangement with the National Marine Fisheries Service (NMFS), Pacific Islands Regional Office (PIRO), and the Western Pacific Regional Fishery Management Council (WPRFMC; the Council). The Deep 7 bottomfish management unit species (BMUS) group is comprised of seven deep water bottomfish: opakapaka (*Pristipomoides filamentosus*; pink snapper), onaga (*Etelis coruscans*; longtail snapper), ehu (*Etelis carbunculus*; ruby snapper), hapuupuu (*Epinephelus quernus*; Hawaiian grouper), kalekale (*Pristipomoides sieboldii*; Von Siebold's snapper), gindai (*Pristipomoides zonatus*; oblique-banded snapper), and lehi (*Aphareus rutilans*; silverjaw snapper).

HDAR collects the fishery information, the NMFS analyzes this information, and the Council, working with HDAR, proposes the management scheme. Lastly, the NMFS implements the scheme into federal regulations before HDAR adopts state regulations. These three agencies coordinate management to simplify regulations for the fishing public, prevent overfishing, and manage the fishery for long-term sustainability. This shared management responsibility is necessary, as the bottomfish complex of species occurs in both State and Federal waters. The information in this report is largely based on HDAR-collected data.

1.1.2 Dashboard Statistics

The collection of commercial main Hawaiian Islands Deep 7 bottomfish fishing reports comes from two sources: paper reports received by mail, fax, or PDF copy via e-mail, and reports filed online through the Online Fishing Report system (OFR) at http://www.dlnr.ehawaii.gov/cmls-fr. Since the federal management of the Deep 7 bottomfish fishery began in 2007, bottomfish landings have been collected on three types of fishing reports. Initially, bottomfishers were required to use the Monthly Fishing Report and Deep-sea Handline Fishing Trip Report to report their Deep 7 landings within 10 days of the end of the month. These reports were replaced by the MHI Deep 7 Bottomfish Fishing Trip Report in September 2011, and bottomfish fishers were required to submit the trip report within five days of the trip end date. HDAR implemented the OFR online website in February 2010.

Paper fishing reports received through mail by HDAR are initially processed by an office assistant that date stamps the report, scans the report image, and enters the report header as index information into an archival database application to store them as database files. The report header index information is downloaded in a batch text file via file transfer protocol (FTP) at 12:00 AM for transmission to the web portal vendor that maintains the Commercial Marine Licensing System (CMLS). This information updates the fisher's license report log in the CMLS to credit submission of the fishing report. The web portal vendor also exports a batch text file extract of the updated license profile and report log data file via FTP daily at 2:00 AM for transmission to HDAR. The office assistant checks reports for missing information, sorts by fishery form type (e.g. Deep 7 or Monthly Fishing Report) and distributes it to the appropriate database assistant by the next business day. Database assistants and the data monitoring associate enter the Deep-sea Handline Fishing Trip Report into the HDAR Fishing Report System (FRS) database and enter the other report types through the OFR within two business days.

The data records from fishing reports submitted online by fishers are automatically extracted and exported as daily batch text files from the OFR and uploaded by HDAR and imported into the FRS database on the following business day.

The FRS processes the data, and a general error report is run daily by the data supervisor. A database assistant will contact the fisher when clarification of the data is needed. Duplicate data checks are run weekly before being researched by a database assistant. Discrepancies between dealer and catch data are checked monthly by a fisheries database assistant, who will call the fisher or dealer to clarify any discrepancies. The data supervisor then transfers both the fisheries and the dealer data to the Western Pacific Fisheries Information Network (WPacFIN) daily where data trends are created and reported weekly to Deep 7 BMUS fishery managers and stake holders. A bottomfish newsletter is published for bottomfishers and fish dealers on a quarterly basis.

1.1.2.1 Historical Summary

Table 1. Annual fishing parameters for the 2019 fishing year in the MHI Deep 7 bottomfish fishery compared with short-term (10-year) and long-term (20-year) averages

Fishery	Parameter	2019 Value	2019 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep 7 BMUS	No. Licenses	318	↓ 22.1%	↓ 20.7%
	Trips	2,019	↓ 26.1%	↓ 28.6%
	No. Caught	47,778	↓ 31.4%	↓ 26.8%
	Lbs. Caught	180,708	↓ 27.1%	↓ 25.2%

1.1.2.2 Species Summary

Table 2. Annual fishing parameters by gear and species for the 2019 fishing year in the MHI Deep 7 bottomfish fishery compared with short-term (10-year) and long-term (20-year) averages

Method	Species/ Fishery Indicator	2019 Value	2019 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep-Sea Handline	Opakapaka	67,218 lbs.	↓ 44.9%	↓ 42.0%
	Onaga	60,168 lbs.	↓ 5.36%	↓ 9.95%
	Ehu	24,891 lbs.	↓ 8.21%	↑ 2.15%
	Hapuupuu	6,328 lbs.	↓ 30.2%	↓ 32.5%
	Kalekale	10,184 lbs.	↓ 17.9%	↓ 8.24%
	Gindai	3,452 lbs.	↑ 16.9%	↑ 23.0%
	Lehi	5,761 lbs.	↓ 30.2%	↓ 33.0%
	No. Lic.	299	↓ 22.9%	↓ 21.3%

	No. Trips	1,895	↓ 27.8%	↓ 30.5%
	Lbs. Caught	178,001 lbs.	↓ 27.4%	↓ 25.5%
	CPUE	93.93 lbs./trip	↓ 1.05%	↑ 5.62%
Non-Deep-Sea Handline Methods	Opakapaka	1,259 lbs.	↓ 11.3%	↓ 2.55%
	Onaga	NULL	-	-
	Ehu	n.d.	-	-
	Hapuupuu	139 lbs.	↑ 47.9%	↑ 5.30%
	Kalekale	54 lbs.	↓ 33.3%	↓ 49.5%
	Gindai	n.d.	-	-
	Lehi	1,175 lbs.	↑ 22.7%	↑ 41.1%
	No. Lic.	39	↓ 5.41%	0.00%
	No. Trips	126	↑ 12.5%	↑ 21.2%
	Lbs. Caught	2,707 lbs.	↓ 3.11%	↓ 0.11%
	CPUE	21.48 lbs./trip	↓ 13.9%	↓ 13.5%

1.1.3 Time Series Statistics

1.1.3.1 Commercial Fishing Parameters

The time series format for the Deep 7 bottomfish fishery begins with an arrangement by the state fiscal year period (July – June) until June 1993. Prior to July 1993, the state issued and renewed the Commercial Marine License (CML) on a fiscal year basis and all licenses expired on June 30, regardless of when it was issued. During that period, each fisher received a different CML number, reducing duplicate licensee counts through June 1993. The State issued and renewed permanent CML numbers effective July 1993. The federal Deep 7 bottomfish fishing year, defined as September through August of the following year, was established in 2007. In order to evaluate Deep 7 bottomfish fishing trends, the time series format was re-arranged to extend from September to August beginning in September 1993 and ending in August 2015. This arrangement provides a 22-year time series trend for the Deep 7 bottomfish fishery. There is a two-month segment spanning from July 1993 through August 1993 that is defined as a separate period.

Early in the time series, this artisan fishery is dominated by highliners with large landings. Beginning in Fiscal Year 1966, less than 100 fishers made just over 1,000 trips but attained the highest CPUE at 178 pounds per trip. With the expansion of the small vessel fleet during the 1970s and 1980s, effort and landings increased until peaking in the late-80s at 559,293 lbs. in 6,253 trips. In June 1993, the State established bottomfish regulations including: bottomfish restricted fishing areas (BRFAs), vessel registration identification, and non-commercial bag limits. Fishing effort and landings further declined as a result. Since the implementation of federal Deep 7 bottomfish management, landings have been under the jurisdiction of the former total annual catch (TAC) and now annual catch limit (ACL) fishing quotas. In July 2019, four BRFAs including BRFA C (Makahūʻena, Kauaʻi), BRFA F (Penguin Banks), BRFA J (Mokumana-Umalei Pt, Maui), and BRFA L (Leleiwi Pt, Hawaiʻi Island) were re-opened to bottomfishing.

Table 3. Time series of commercial fishing reports for Deep 7 BMUS reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	84	1,149	428	14,611	211,326
1966	92	1,059	414	11,040	181,868
1967	110	1,469	550	16,005	231,315
1968	121	1,194	524	12,943	195,032
1969	132	1,216	532	11,415	177,495
1970	139	1,150	528	8,482	158,195
1971	167	1,254	606	10,203	135,156
1972	218	1,929	831	19,833	228,375
1973	210	1,574	732	16,747	169,273
1974	264	2,163	938	23,976	225,767
1975	247	2,094	903	24,052	221,385
1976	303	2,265	995	23,896	250,270
1977	338	2,728	1,175	26,891	274,843
1978	435	2,660	1,542	41,387	307,740
1979	447	2,255	1,517	32,312	273,846
1980	461	2,853	1,435	35,096	244,219
1981	486	3,770	1,637	45,086	308,306
1982	451	3,917	1,634	46,873	329,436
1983	539	4,880	1,892	61,889	409,453
1984	555	4,483	1,806	55,952	344,441
1985	556	5,812	2,065	93,799	507,639
1986	610	5,812	2,284	101,299	523,194
1987	584	5,586	2,190	132,847	593,050
1988	551	6,050	2,131	137,352	568,661
1989	567	6,308	2,244	120,113	563,967
1990	531	5,257	1,947	90,500	456,932
1991	500	4,242	1,783	69,970	339,147
1992	488	4,511	1,845	84,427	362,517
1993.1	451	3,541	1,494	62,754	262,702
1993.2	120	374	168	7,523	29,574
1994	522	3,909	1,713	85,881	321,701
1995	527	3,925	1,715	77,827	320,220
1996	518	3,980	1,745	81,473	287,324
1997	500	4,189	1,767	82,756	300,645
1998	523	4,124	1,740	83,630	289,338
1999	433	3,019	1,437	57,337	216,600
2000	498	3,931	1,703	84,549	311,694
2001	459	3,585	1,556	71,903	266,175

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2002	388	2,869	1,336	55,855	212,836
2003	364	2,962	1,259	63,615	249,719
2004	333	2,668	1,145	57,715	209,665
2005	352	2,705	1,200	61,406	241,173
2006	352	2,295	1,057	47,918	201,097
2007	357	2,556	1,151	50,203	205,882
2008	351	2,354	1,027	49,397	196,347
2009	478	3,283	1,479	67,065	259,356
2010	460	2,793	1,226	56,542	207,630
2011	474	3,482	1,427	74,449	273,107
2012	480	3,108	1,529	68,024	227,971
2013	459	2,990	1,501	68,441	239,010
2014	423	3,182	1,496	90,296	311,209
2015	411	2,890	1,415	90,816	307,152
2016	373	2,349	1,195	74,492	260,660
2017	340	2,351	1,162	66,396	237,490
2018	341	2,169	1,102	59,215	235,341
2019	318	2,019	1,042	47,778	180,708
10-year avg.	**408**	**2,733**	**1,310**	**69,645**	**248,028**
20-year avg.	**401**	**2,827**	**1,300**	**65,304**	**241,711**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.1.4 Preferred Targets by Gear Type

1.1.4.1 Deep-Sea Handline

The heavy tackle, deep-sea handline gear is the dominant method for this fishery. The opakapaka and onaga are the primary target species, with the latter requiring much more fishing skill. In recent years, bottomfishers have remarked that opakapaka is the preferred target due to less fishing area and because it is easier to land for what is now a one-day fishery. On an annual basis, approximately 99% of all deep-7 landings by weight are caught using the deep-sea handline gear type.

Table 4a. HDAR MHI annual Deep 7 catch summary by species and top gear, deep-sea handline, reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2019

Year	Opakapaka		Onaga		Ehu		Hapuupuu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1965	66	102,901	31	59,521	48	20,093	48	10,965
1966	76	70,651	34	63,965	47	17,607	49	11,863
1967	96	120,888	43	68,442	62	18,350	60	10,624
1968	97	84,164	62	69,504	68	19,864	58	11,304
1969	115	85,663	48	53,839	68	16,088	60	10,881

Year	Opakapaka		Onaga		Ehu		Hapuupuu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1970	114	69,538	44	43,540	62	15,870	64	19,842
1971	130	59,002	53	39,213	78	15,255	81	14,471
1972	184	117,426	71	58,673	105	21,282	112	16,659
1973	175	93,197	68	35,584	94	14,524	117	14,828
1974	220	134,838	86	43,607	113	21,113	117	14,444
1975	199	114,571	94	45,016	113	21,136	108	23,078
1976	224	101,618	118	78,684	105	21,621	140	21,236
1977	255	98,407	100	82,049	144	32,630	130	26,954
1978	345	149,538	135	66,124	191	34,385	198	27,417
1979	306	140,303	133	51,601	190	20,859	184	28,053
1980	344	147,342	161	29,889	183	15,836	182	16,984
1981	386	193,944	153	42,659	207	20,754	188	16,056
1982	370	173,764	177	65,235	233	24,088	189	20,854
1983	422	226,614	240	71,687	277	27,482	209	31,849
1984	396	153,618	240	84,545	282	35,415	208	28,996
1985	442	202,822	297	172,774	310	43,928	253	33,098
1986	481	179,612	346	195,662	371	60,957	245	26,216
1987	457	263,357	289	175,005	321	45,528	177	30,715
1988	446	300,096	273	156,566	297	41,900	195	10,218
1989	438	307,201	303	144,878	320	38,342	185	13,417
1990	419	210,093	307	141,442	312	37,618	176	13,719
1991	385	137,907	277	105,998	301	34,343	169	17,713
1992	374	173,118	253	91,813	310	31,907	167	15,136
1993.1	347	139,801	195	52,760	257	24,027	168	13,880
1993.2	85	14,719	51	5,780	60	3,235	34	2,292
1994	393	176,431	244	72,363	290	23,619	191	12,003
1995	426	178,302	236	66,199	290	26,136	229	15,064
1996	415	147,093	244	67,984	276	28,948	220	10,162
1997	377	157,722	216	59,887	263	27,313	213	13,982
1998	386	145,776	250	68,926	299	25,422	215	12,606
1999	326	101,725	198	60,619	234	20,484	180	10,787
2000	387	165,922	251	71,191	282	28,878	209	13,457
2001	339	126,863	253	63,473	272	27,383	202	15,780
2002	287	101,107	194	59,586	217	18,962	163	9,283
2003	255	127,706	189	70,001	212	16,509	141	10,108
2004	233	87,897	186	76,902	193	20,547	130	8,255
2005	249	102,303	202	87,588	208	21,890	131	10,121
2006	245	77,953	203	75,222	206	21,434	123	9,793

Year	Opakapaka		Onaga		Ehu		Hapuupuu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
2007	272	82,784	202	80,993	224	18,023	118	6,066
2008	268	94,099	197	55,825	207	17,850	130	6,209
2009	362	133,475	245	59,827	296	24,674	168	7,808
2010	324	101,716	251	56,155	297	23,731	164	7,950
2011	369	146,686	258	67,408	306	24,137	175	7,988
2012	345	109,344	261	56,084	323	27,261	157	10,384
2013	327	98,600	246	68,314	308	31,332	156	10,342
2014	324	162,369	234	75,213	276	30,408	161	10,667
2015	309	151,333	228	78,006	271	33,080	138	9,946
2016	285	133,682	203	62,411	234	30,844	122	9,718
2017	266	133,786	173	45,999	223	24,086	126	7,703
2018	258	113,984	183	66,009	220	21,403	129	9,593
2019	210	67,218	157	60,168	218	24,891	107	6,328
10-yr avg.	**302**	**121,872**	**219**	**63,577**	**268**	**27,117**	**144**	**9,062**
20-yr avg.	**296**	**115,941**	**216**	**66,819**	**250**	**24,366**	**148**	**9,375**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 4b. HDAR MHI annual Deep 7 catch summary by species and top gear, deep-sea handline, reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2019

Year	Kalekale		Gindai		Lehi	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1965	25	14,538	19	923	21	1,256
1966	32	13,536	20	829	20	1,953
1967	34	9,584	22	769	32	2,357
1968	31	6,870	28	754	34	2,215
1969	32	4,131	23	462	41	5,924
1970	33	5,079	34	1,437	29	2,547
1971	38	4,316	36	870	34	1,789
1972	65	8,059	50	1,237	58	4,408
1973	66	5,093	47	1,260	57	4,490
1974	64	4,860	49	1,467	67	4,852
1975	79	5,885	59	1,365	78	8,043
1976	100	7,562	59	1,072	84	9,846
1977	96	7,590	67	1,173	81	6,644
1978	150	8,823	103	2,308	116	8,623
1979	126	6,602	89	2,505	114	10,076

Year	Kalekale		Gindai		Lehi	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1980	142	6,295	87	2,083	123	16,824
1981	152	7,377	108	1,654	143	19,282
1982	159	7,735	102	1,473	140	29,500
1983	192	14,080	138	2,321	193	27,766
1984	191	12,427	160	2,798	158	15,892
1985	237	22,171	181	4,598	201	25,484
1986	282	25,053	195	3,752	185	26,548
1987	260	27,936	141	3,231	214	37,503
1988	226	18,040	119	2,057	186	37,970
1989	217	10,910	131	1,680	230	45,170
1990	248	15,477	178	2,785	207	34,944
1991	246	20,305	190	3,762	166	18,992
1992	252	28,002	190	5,120	158	17,254
1993.1	246	17,170	154	3,786	154	11,177
1993.2	48	2,154	28	683	19	658
1994	236	20,624	176	4,328	130	12,029
1995	241	17,313	189	3,813	171	13,087
1996	266	19,629	156	3,169	134	9,523
1997	224	23,661	141	2,931	143	11,897
1998	240	23,122	176	3,273	150	8,701
1999	174	11,518	130	2,388	108	7,643
2000	218	16,736	171	3,819	149	11,024
2001	187	15,947	155	3,899	143	12,325
2002	151	10,909	129	2,535	112	9,838
2003	150	12,708	109	2,241	97	8,272
2004	127	7,614	96	2,081	73	3,779
2005	133	7,846	98	2,028	85	6,800
2006	140	5,719	97	2,016	74	5,643
2007	147	5,709	107	2,017	80	6,851
2008	126	5,320	119	2,424	106	9,748
2009	209	9,382	169	3,557	153	15,159
2010	210	7,886	156	2,666	104	5,141
2011	212	9,821	177	2,956	115	11,147
2012	221	12,185	177	3,853	104	7,109
2013	226	12,026	184	3,423	113	11,503
2014	228	18,861	159	3,715	105	7,239
2015	222	17,623	135	2,885	130	11,350
2016	177	12,832	125	1,843	97	7,591

Year	Kalekale		Gindai		Lehi	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
2017	169	10,762	121	2,124	111	8,332
2018	174	11,882	118	2,611	102	7,303
2019	169	10,184	129	3,452	79	5,761
10-yr avg.	**201**	**12,406**	**148**	**2,953**	**106**	**8,248**
20-yr avg.	**180**	**11,098**	**137**	**2,807**	**107**	**8,596**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.1.4.2 Non-Deep-Sea Handline Gear Types

The following section denotes Deep 7 species that are harvested using gear types other than the deep-sea handline, including both inshore handline and palu ahi. These gear types do harvest Deep 7 BMUS species though they are typically not their primary targets. The inshore handline gear is supposed to be a lighter tackle than the deep-sea handline. The ehu and onaga landings were probably made with the heavier tackle gear but were reported by fishers as inshore handline. For these cases in recent years, fishers were contacted to verify the gear reported. The fishing report was not amended if the fisher did not respond. The opakapaka and lehi landings were likely fished in shallow-water habitat.

The primary use of palu ahi gear as defined by the HDAR database is as a form of tuna handline. It is a handline gear primarily used during the day with a drop stone or weight and chum. The target species is usually pelagic, including yellowfin and bigeye tuna. The Deep 7 bottomfish landings from palu ahi are common bycatch for Big Island fishers. Some of the landings may have been taken by bottomfishers who used deep-sea handline tackle but reported it as palu ahi because of the gear definition, which involves weights and chum on a handline. For these cases in recent years, fishers were contacted to verify their reported gear. The fishing report was not amended if the fisher did not respond.

Opakapaka is the primary Deep-7 species caught using non-deep-sea handline gear types. On an annual basis, non-deep-sea handline gear catches approximately 1% of all deep-7 species.

Table 5a. HDAR MHI annual Deep 7 catch summary by species for non-deep sea handline methods reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2019

Year	Opakapaka		Onaga		Ehu		Hapuupuu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1965	18	662	n.d.	n.d.	11	222	n.d.	n.d.
1966	7	756	n.d.	n.d.	7	537	NULL	NULL
1967	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.
1968	n.d.	n.d.	NULL	NULL	n.d.	n.d.	n.d.	n.d.
1969	4	281	n.d.	n.d.	4	80	n.d.	n.d.
1970	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.

Year	Opakapaka		Onaga		Ehu		Hapuupuu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1971	7	108	6	57	5	26	n.d.	n.d.
1972	5	428	n.d.	n.d.	n.d.	n.d.	5	72
1973	7	159	n.d.	n.d.	n.d.	n.d.	4	17
1974	8	375	NULL	NULL	n.d.	n.d.	6	181
1975	23	1,613	n.d.	n.d.	n.d.	n.d.	10	123
1976	41	3,771	18	1,550	20	1,180	38	1,163
1977	77	7,927	21	2,704	41	3,267	37	3,507
1978	68	5,104	14	381	42	1,319	30	1,302
1979	106	5,708	21	1,426	63	1,632	61	1,503
1980	54	3,715	32	1,455	36	1,160	28	726
1981	47	3,423	14	210	28	397	27	907
1982	29	3,964	13	710	26	348	18	826
1983	61	3,233	22	1,105	36	506	30	845
1984	65	4,903	44	1,984	36	730	36	721
1985	10	850	7	1,097	8	102	12	121
1986	38	1,770	15	851	25	930	20	325
1987	34	3,947	8	304	11	3,238	15	673
1988	14	818	6	241	6	158	11	193
1989	28	1,044	16	675	11	167	9	170
1990	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	6	454
1991	NULL	NULL	NULL	NULL	NULL	NULL	11	127
1992	n.d.	n.d.	NULL	NULL	NULL	NULL	6	118
1993.1	n.d.	n.d.	NULL	NULL	NULL	NULL	6	88
1993.2	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.
1994	n.d.	n.d.	NULL	NULL	NULL	NULL	8	126
1995	n.d.	n.d.	NULL	NULL	NULL	NULL	8	144
1996	7	262	NULL	NULL	n.d.	n.d.	10	129
1997	12	360	n.d.	n.d.	5	922	7	785
1998	12	799	n.d.	n.d.	n.d.	n.d.	7	68
1999	10	164	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2000	10	148	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2001	10	110	n.d.	n.d.	5	104	4	53
2002	7	200	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2003	27	1,025	4	136	8	220	7	100
2004	30	1,283	7	108	11	129	8	188
2005	22	938	4	444	8	255	5	132
2006	21	1,787	4	344	6	121	4	93
2007	23	1,459	5	169	6	447	n.d.	n.d.

Year	Opakapaka		Onaga		Ehu		Hapuupuu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
2008	20	2,118	n.d.	n.d.	4	412	4	370
2009	29	2,581	8	260	13	270	7	209
2010	35	757	5	201	20	271	10	203
2011	27	1,588	4	125	13	316	7	185
2012	23	540	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2013	26	1,417	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2014	25	1,262	n.d.	n.d.	5	30	n.d.	n.d.
2015	22	1,647	n.d.	n.d.	5	183	n.d.	n.d.
2016	16	968	n.d.	n.d.	5	19	n.d.	n.d.
2017	23	3,288	NULL	NULL	4	126	7	182
2018	14	1,471	n.d.	n.d.	7	111	n.d.	n.d.
2019	24	1,259	NULL	NULL	n.d.	n.d.	4	139
10-yr avg.	**24**	**1,420**	**n.d.**	**n.d.**	**7**	**131**	**4**	**94**
20-yr avg.	**22**	**1,292**	**4**	**149**	**7**	**166**	**4**	**132**

NULL = no available data; n.d. = non-disclosure due to data confidentiality.
1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 5b. HDAR MHI annual Deep 7 catch summary by species and non-deep-sea handline methods, reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2019

Year	Kalekale		Gindai		Lehi	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1965	8	115	n.d.	n.d.	n.d.	n.d.
1966	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1967	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1968	n.d.	n.d.	NULL	NULL	NULL	NULL
1969	n.d.	n.d.	4	8	NULL	NULL
1970	n.d.	n.d.	NULL	NULL	4	129
1971	4	21	n.d.	n.d.	n.d.	n.d.
1972	5	13	4	8	n.d.	n.d.
1973	7	13	n.d.	n.d.	n.d.	n.d.
1974	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1975	7	76	4	38	10	349
1976	14	345	21	133	13	489
1977	21	1,008	16	382	18	601
1978	36	1,003	34	245	43	1,168
1979	71	1,152	33	378	58	2,048

Year	Kalekale		Gindai		Lehi	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1980	25	752	27	306	33	852
1981	22	801	22	200	27	642
1982	21	315	21	142	25	482
1983	35	922	34	332	29	711
1984	25	994	35	767	36	651
1985	12	522	n.d.	n.d.	4	68
1986	27	356	n.d.	n.d.	18	1,158
1987	13	402	n.d.	n.d.	16	1,193
1988	8	129	n.d.	n.d.	15	269
1989	8	181	n.d.	n.d.	9	129
1990	n.d.	n.d.	NULL	NULL	NULL	NULL
1991	NULL	NULL	NULL	NULL	NULL	NULL
1992	n.d.	n.d.	NULL	NULL	NULL	NULL
1993.1	n.d.	n.d.	NULL	NULL	NULL	NULL
1993.2	NULL	NULL	NULL	NULL	NULL	NULL
1994	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1995	n.d.	n.d.	NULL	NULL	6	92
1996	5	32	n.d.	n.d.	13	253
1997	7	727	5	94	22	345
1998	6	236	NULL	NULL	15	351
1999	5	224	n.d.	n.d.	27	843
2000	7	129	n.d.	n.d.	16	357
2001	6	86	4	82	4	34
2002	5	113	n.d.	n.d.	6	159
2003	6	110	4	40	18	545
2004	7	51	n.d.	n.d.	20	765
2005	10	114	6	71	23	644
2006	9	86	n.d.	n.d.	23	874
2007	6	121	5	120	18	657
2008	10	212	n.d.	n.d.	20	1,295
2009	12	316	6	90	32	1,748
2010	15	160	12	64	24	731
2011	10	158	9	132	15	459
2012	7	67	n.d.	n.d.	19	1,050
2013	n.d.	n.d.	n.d.	n.d.	22	1,532
2014	5	53	n.d.	n.d.	27	1,328
2015	7	35	n.d.	n.d.	20	948
2016	n.d.	n.d.	n.d.	n.d.	13	600

Year	Kalekale		Gindai		Lehi	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
2017	9	221	n.d.	n.d.	20	842
2018	5	22	n.d.	n.d.	16	919
2019	6	54	n.d.	n.d.	26	1,175
10-year avg.	**7**	**81**	**n.d.**	**n.d.**	**20**	**958**
20- year avg.	**7**	**107**	**4**	**61**	**19**	**833**

NULL = no available data; n.d. = non-disclosure due to data confidentiality.
1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.1.5 Catch Parameters by Gear Type

The CPUE (lbs. per trip) for deep-sea handline peaked at the beginning of the time series and has leveled off starting in the early 1990s and through 2012. The relatively stable CPUE ranging between 71 and 92 lbs. per trip is attributed to state and federal regulations that removed fishing areas, created an interim closed season, and enforced quotas on landings. A recent increase in CPUE (2014-2018) is thought to be the result of fishers making fewer trips, with catches of larger/heavier fishes. The 2019 drop in CPUE was largely the result of poor opakapaka catch, which fishers have attributed to unfavorable environmental conditions.

Non deep-sea handline CPUE did not peak initially and has instead remained relatively stable throughout the time series. CPUE for the non-deep-sea handline gear type is characteristically lower than that of the deep-sea handline gear type. This can be attributed to the fact that a significant portion of this catch is caught incidentally, rather than a targeted effort for deep-7 species.

Table 6. HDAR MHI annual Deep 7 CPUE by dominant fishing methods reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2019

Year	Deep-sea handline				Non-Deep-Sea Handline Gears			
	No. Lic.	No. trips	Lbs. Caught	CPUE	No. Lic.	No. trips	Lbs. Caught	CPUE
1965	73	1,067	210,197	197.00	27	89	1,129	12.69
1966	86	1,016	180,404	177.56	15	46	1,464	31.83
1967	107	1,449	231,014	159.43	7	21	301	14.33
1968	118	1,165	194,675	167.10	5	29	357	12.31
1969	128	1,175	176,988	150.63	12	46	507	11.02
1970	135	1,118	157,853	141.19	9	35	342	9.77
1971	163	1,219	134,916	110.68	18	36	240	6.67
1972	214	1,896	227,744	120.12	18	39	631	16.18
1973	201	1,537	168,976	109.94	22	38	297	7.82
1974	258	2,126	225,181	105.92	14	37	586	15.84
1975	238	2,038	219,094	107.50	39	62	2,291	36.95

Year	Deep-sea handline				Non-Deep-Sea Handline Gears			
	No. Lic.	No. trips	Lbs. Caught	CPUE	No. Lic.	No. trips	Lbs. Caught	CPUE
1976	270	2,028	241,639	119.15	86	247	8,631	34.94
1977	290	2,266	255,447	112.73	106	464	19,396	41.80
1978	393	2,366	297,218	125.62	146	353	10,522	29.81
1979	379	1,901	259,999	136.77	187	379	13,847	36.54
1980	412	2,591	235,253	90.80	123	298	8,966	30.09
1981	456	3,459	301,726	87.23	105	342	6,580	19.24
1982	429	3,688	322,649	87.49	97	276	6,787	24.59
1983	501	4,574	401,799	87.84	142	363	7,654	21.09
1984	505	4,176	333,691	79.91	161	383	10,750	28.07
1985	538	5,682	504,875	88.86	44	138	2,764	20.03
1986	587	5,627	517,800	92.02	99	203	5,394	26.57
1987	565	5,426	583,275	107.50	65	164	9,775	59.60
1988	535	5,972	566,847	94.92	50	85	1,814	21.34
1989	539	6,210	561,598	90.43	68	107	2,369	22.14
1990	526	5,238	456,078	87.07	8	19	854	44.95
1991	493	4,224	339,020	80.26	11	21	127	6.05
1992	483	4,488	362,350	80.74	7	23	167	7.26
1993.1	446	3,528	262,601	74.43	8	13	101	7.77
1993.2	119	372	29,521	79.36	n.d.	n.d.	n.d.	n.d.
1994	515	3,887	321,397	82.69	13	25	304	12.16
1995	518	3,901	319,914	82.01	17	24	306	12.75
1996	504	3,930	286,508	72.90	34	55	816	14.84
1997	481	4,118	297,392	72.22	44	85	3,253	38.27
1998	506	4,054	287,826	71.00	36	80	1,513	18.91
1999	416	2,925	215,164	73.56	36	102	1,436	14.08
2000	492	3,882	311,027	80.12	28	50	668	13.36
2001	446	3,543	265,670	74.98	26	46	506	11.00
2002	379	2,835	212,220	74.86	21	37	616	16.65
2003	344	2,858	247,545	86.61	45	107	2,174	20.32
2004	303	2,548	207,075	81.27	49	123	2,590	21.06
2005	319	2,595	238,576	91.94	52	112	2,597	23.19
2006	323	2,184	197,779	90.56	43	111	3,318	29.89
2007	335	2,441	202,442	82.93	40	118	3,440	29.15
2008	329	2,250	191,475	85.10	34	104	4,872	46.85
2009	450	3,133	253,883	81.04	61	153	5,474	35.78
2010	421	2,668	205,244	76.93	67	128	2,386	18.64
2011	450	3,384	270,144	79.83	46	99	2,963	29.93
2012	465	3,007	226,219	75.23	32	102	1,752	17.18

Year	Deep-sea handline				Non-Deep-Sea Handline Gears			
	No. Lic.	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**
2013	439	2,858	235,538	82.41	38	133	3,472	26.11
2014	404	3,069	308,472	100.51	36	114	2,737	24.01
2015	392	2,782	304,223	109.35	33	109	2,929	26.87
2016	360	2,265	258,921	114.31	24	84	1,740	20.71
2017	325	2,226	232,792	104.58	34	126	4,698	37.29
2018	328	2,075	232,784	112.19	25	94	2,557	27.20
2019	299	1,895	178,001	93.93	39	126	2,707	21.48
10-year avg.	**388**	**2,623**	**245,234**	**94.93**	**37**	**112**	**2,794**	**24.94**
20- year avg.	**380**	**2,725**	**239,002**	**88.93**	**39**	**104**	**2,710**	**24.83**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.2 *APRION VIRESCENS* (UKU; FORMERLY NON-DEEP 7 BMUS)

1.2.1 Fishery Descriptions

This species group is characterized by a single snapper: the uku (*Aprion virescens*; green jobfish). Other members of the former non-Deep 7 BMUS complex, the white/giant ulua (*Caranx ignobilis*), gunkan/black ulua (*Caranx lugubris*), butaguchi/pig-lip ulua (*Pseudocaranx dentex*), and yellowtail kalekale (*Pristipomoides auricilla*) were removed from the management unit species (MUS) grouping by the recent ecosystem component species (ECS) amendment to the Hawaii FEP in 2019 (84 FR 2767).

1.2.2 Dashboard Statistics

The collection of commercial uku fishing reports comes from two sources: paper reports received by mail, fax, or PDF copy via e-mail; and reports filed online through the OFR. Uku are reported by commercial fishers on the Monthly Fishing Report, the Net, Trap, Dive Activity Report, or the MHI Deep 7 Bottomfish Fishing Trip Report.

Similar to the Deep 7 bottomfish, the time series format for the uku fishery begins with an arrangement by the state fiscal year period (July – June) until June 1993 before being reported by fishing year. Refer to data processing procedures documented in the Deep 7 BMUS section for paper fishing reports and fishing reports filed online. Database assistants and data monitoring associate will enter the paper Monthly Fishing Report information within four weeks, and the Net, Trap, Dive Activity Report and the MHI Deep 7 Bottomfish Fishing Trip Report within two business days.

1.2.2.1 Historical Summary

Table 7. Annual fishing parameters for 2019 in the MHI uku fishery compared with short-term (10-year) and long-term (20-year) averages

Fishery	Parameter	2019 Value	2019 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Uku	No. License	285	↓ 23.0%	↓ 16.2%
	Trips	1,290	↓ 23.7%	↓ 13.0%
	No. Caught	11,078	↓ 16.5%	↑ 1.12%
	Lbs. Caught	89,836	↓ 17.0%	↓ 1.53%

1.2.2.2 Gear Summary

Table 8. Annual fishing parameters for 2019 in the MHI uku fishery compared with short-term (10-year) and long-term (20-year) averages

Method	Species/ Fishery Indicator	2019 Value	2019 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep-Sea Handline	No. Lic.	143	↓ 21.4%	↓ 20.1%
	No. Trips	524	↓ 32.0%	↓ 30.0%

	Lbs. Caught CPUE	48,103 lbs. 91.80 lbs./trip	↓ 28.7% ↑ 5.24 %	↓ 21.0% ↑ 13.3%
Inshore Handline	No. Lic. No. Trips Lbs. Caught CPUE	38 259 16,460 lbs. 63.55 lbs./trip	↓ 44.1% ↓ 21.3% ↑ 1.98% ↑ 28.1%	↓ 50.7% ↓ 17.3% ↑ 24.8% ↑ 50.8%
Troll with Bait	No. Lic. No. Trips Lbs. Caught CPUE	41 142 5,397 lbs. 38.01 lbs./trip	↑ 10.8% ↓ 11.3% ↓ 30.2% ↓ 21.4%	↑ 51.9% ↑ 14.5% ↓ 21.5% ↓ 32.2%
All Other Gears	No. Lic. No. Trips Lbs. Caught CPUE	130 370 19,876 lbs. 53.72 lbs./trip	↓ 16.1% ↓ 14.8% ↑ 17.6% ↑ 36.6%	↑ 9.24% ↑ 19.0% ↑ 81.9% ↑ 61.9%

1.2.3 Time Series Statistics

1.2.3.1 Commercial Fishing Parameters

Uku is an important species in MHI fisheries. Because of the wide habitat range where this species is found, it is commonly taken by heavy (deep-sea handline) and light (inshore handline) tackles and troll gear. Since the implementation of the federal bottomfish fishing year, uku landings have trended upwards. During the first four federal fishing years, the Deep 7 bottomfish fishery was closed because the TAC or ACL was reached before the end of the fishing year. Bottomfishers shifted target to uku during these closures and doing so recently has been rewarding due good market price.

Table 9. Time series of commercial fishing reports for uku by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	83	627	312	1,732	68,231
1966	84	571	278	1,297	46,816
1967	108	733	366	1,911	64,215
1968	110	571	318	1,224	52,362
1969	116	716	377	1,554	54,139
1970	125	731	394	1,576	49,794
1971	137	608	356	1,712	48,418
1972	161	761	441	1,369	54,139
1973	169	767	472	1,897	46,578
1974	235	1,040	632	3,769	72,955
1975	213	1,041	580	2,709	75,490
1976	213	934	518	2,388	69,009
1977	247	1,097	615	2,652	47,239
1978	377	1,573	1,042	4,475	95,074
1979	381	1,346	1,037	4,832	82,747

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1980	361	1,484	902	5,140	64,016
1981	392	2,117	1,107	7,950	95,027
1982	385	1,994	1,108	7,664	92,871
1983	411	2,649	1,319	10,326	113,772
1984	424	2,389	1,202	12,471	141,586
1985	387	1,878	1,017	8,867	96,014
1986	306	1,345	740	4,766	67,680
1987	325	1,351	775	7,255	87,432
1988	422	2,452	1,155	14,090	185,524
1989	476	3,027	1,519	27,017	313,552
1990	454	2,203	1,266	11,342	134,539
1991	404	1,830	1,086	9,723	118,632
1992	384	1,702	1,003	8,640	93,561
1993.1	337	1,329	800	6,085	65,981
1993.2	230	696	420	2,816	34,463
1994	355	1,488	878	7,089	87,587
1995	339	1,304	789	6,131	60,128
1996	362	1,323	888	6,256	53,617
1997	421	1,714	1,013	8,117	68,241
1998	366	1,462	894	7,359	65,602
1999	378	1,491	908	11,140	91,384
2000	383	1,558	927	11,129	86,554
2001	303	1,209	776	7,047	62,859
2002	274	1,027	661	7,899	71,995
2003	282	1,036	676	6,305	55,692
2004	319	1,291	772	8,756	77,044
2005	302	1,175	744	8,061	67,848
2006	259	1,191	677	7,362	68,642
2007	280	1,265	717	8,390	69,105
2008	318	1,486	812	11,298	92,576
2009	371	1,481	907	10,193	89,830
2010	407	1,928	1,076	13,679	121,181
2011	384	1,699	987	13,011	109,278
2012	407	1,757	1,077	13,651	116,854
2013	394	1,794	1,045	14,027	121,220
2014	379	1,675	1,002	11,668	96,828
2015	418	1,848	1,087	12,892	101,954
2016	380	1,927	1,058	15,188	118,958
2017	362	1,765	1,014	17,372	131,479
2018	285	1,230	741	10,092	74,995

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2019	285	1,290	790	11,078	89,836
10-year avg.	**370**	**1,691**	**988**	**13,266**	**108,258**
20-year avg.	**340**	**1,482**	**877**	**10,955**	**91,236**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.2.4 Catch Parameters by Gear

Uku is the only species in the non-Deep 7 bottomfish group, and it is commonly caught by the following dominant gears: deep-sea handline, inshore handline, trolling with bait, and miscellaneous trolling. Landings of uku along with the Deep 7 bottomfish species peaked in 1989 for the deep-sea handline gear. A second peak for this gear type occurred in 2013 due to deep-7 bottomfishers shifting their fishing target to uku during the summer months.

Since 1975, the proportional catch of uku using deep-sea handline has steadily decreased as alternative gear types are reported more frequently. Whereas nearly all uku at the beginning of the timeseries were caught using deep-sea handline, in 2019 over 46% of the total annual catch could be attributed to other gear types.

Table 10. Time series of uku CPUE (lbs./trip) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	Deep-sea handline				Inshore handline				Troll with bait				All Other Gear Types			
	No. Lic.	No. trips	Lbs. Caught	CPUE	No. Lic.	No. trips	Lbs. Caught	CPUE	No. Lic.	No. trips	Lbs. Caught	CPUE	No. Lic.	No. trips	Lbs. Caught	CPUE
1965	74	560	66,926	119.51	10	17	822	48.35	NULL	NULL	NULL	NULL	7	51	483	9.47
1966	78	514	46,358	90.19	4	4	50	12.50	NULL	NULL	NULL	NULL	6	53	408	7.70
1967	101	683	63,303	92.68	4	5	554	110.80	NULL	NULL	NULL	NULL	9	46	358	7.78
1968	104	510	51,715	101.40	8	13	345	26.54	NULL	NULL	NULL	NULL	8	48	302	6.29
1969	107	615	52,824	85.89	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	NULL	11	98	1,291	13.17
1970	115	633	48,645	76.85	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	NULL	10	94	1,129	12.01
1971	133	548	48,038	87.66	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	NULL	5	56	355	6.34
1972	154	663	53,336	80.45	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	NULL	12	95	791	8.33
1973	161	675	45,817	67.88	8	9	47	5.22	NULL	NULL	NULL	NULL	12	83	714	8.60
1974	216	969	72,132	74.44	7	10	158	15.80	NULL	NULL	NULL	NULL	21	61	665	10.90
1975	191	947	74,325	78.48	16	23	331	14.39	NULL	NULL	NULL	NULL	24	71	834	11.75
1976	166	732	63,048	86.13	42	97	2,453	25.29	NULL	NULL	NULL	NULL	33	106	3,508	33.09
1977	188	717	36,187	50.47	61	212	7,837	36.97	NULL	NULL	NULL	NULL	50	168	3,215	19.14
1978	304	1,099	75,738	68.92	134	298	14,348	48.15	NULL	NULL	NULL	NULL	50	183	4,988	27.26
1979	248	857	67,218	78.43	211	431	12,673	29.40	NULL	NULL	NULL	NULL	26	70	2,856	40.80

Year	Deep-sea handline				Inshore handline				Troll with bait				All Other Gear Types			
	No. Lic.	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**
1980	290	1,197	57,761	48.25	71	110	1,825	16.59	NULL	NULL	NULL	NULL	77	179	4,430	24.75
1981	338	1,763	90,177	51.15	67	110	1,198	10.89	NULL	NULL	NULL	NULL	59	247	3,652	14.79
1982	355	1,752	88,334	50.42	43	64	582	9.09	NULL	NULL	NULL	NULL	40	180	3,955	21.97
1983	369	2,448	109,650	44.79	46	67	581	8.67	NULL	NULL	NULL	NULL	56	138	3,541	25.66
1984	381	2,152	134,986	62.73	53	76	1,169	15.38	NULL	NULL	NULL	NULL	69	166	5,431	32.72
1985	361	1,785	94,464	52.92	4	4	207	51.75	NULL	NULL	NULL	NULL	33	89	1,343	15.09
1986	269	1,219	63,773	52.32	22	52	2,323	44.67	NULL	NULL	NULL	NULL	47	75	1,584	21.12
1987	246	986	61,087	61.95	91	245	11,695	47.73	NULL	NULL	NULL	NULL	53	120	14,650	122.08
1988	349	2,089	167,794	80.32	91	186	10,401	55.92	NULL	NULL	NULL	NULL	59	177	7,329	41.41
1989	423	2,662	297,702	111.83	75	162	4,532	27.98	NULL	NULL	NULL	NULL	77	209	11,318	54.15
1990	375	1,799	122,703	68.21	78	218	2,653	12.17	NULL	NULL	NULL	NULL	91	187	9,183	49.11
1991	323	1,433	104,859	73.17	106	236	4,719	20.00	NULL	NULL	NULL	NULL	75	165	9,054	54.87
1992	281	1,119	68,813	61.50	127	441	18,850	42.74	NULL	NULL	NULL	NULL	73	144	5,898	40.96
1993.1	223	810	54,563	67.36	114	354	8,286	23.41	NULL	NULL	NULL	NULL	60	166	3,132	18.87
1993.2	172	508	30,667	60.37	45	90	1,740	19.33	NULL	NULL	NULL	NULL	40	99	2,056	20.77
1994	259	1,057	73,717	69.74	93	275	11,415	41.51	NULL	NULL	NULL	NULL	74	158	2,455	15.54
1995	249	931	52,322	56.20	76	222	4,836	21.78	NULL	NULL	NULL	NULL	78	152	2,970	19.54
1996	224	746	41,295	55.36	140	400	8,612	21.53	NULL	NULL	NULL	NULL	87	179	3,710	20.73
1997	232	921	47,915	52.02	189	634	17,575	27.72	NULL	NULL	NULL	NULL	87	161	2,752	17.09
1998	224	778	48,583	62.45	146	550	14,049	25.54	NULL	NULL	NULL	NULL	69	134	2,970	22.16
1999	235	834	76,431	91.64	153	508	11,700	23.03	NULL	NULL	NULL	NULL	61	150	3,253	21.69
2000	246	926	70,493	76.13	143	485	12,948	26.70	NULL	NULL	NULL	NULL	71	148	3,113	21.03
2001	185	712	42,311	59.43	115	356	15,369	43.17	NULL	NULL	NULL	NULL	62	143	5,179	36.22
2002	176	619	57,863	93.48	79	275	9,614	34.96	9	17	404	23.74	68	117	4,115	35.17
2003	141	585	41,480	70.91	78	209	6,454	30.88	17	66	4,376	66.30	86	177	3,382	19.11
2004	155	721	57,647	79.95	94	307	7,871	25.64	23	93	7,395	79.52	86	170	4,130	24.30

Year	Deep-sea handline				Inshore handline				Troll with bait				All Other Gear Types			
	No. Lic.	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**
2005	164	660	48,976	74.21	71	217	5,378	24.78	18	90	6,768	75.20	89	209	6,726	32.18
2006	147	670	47,487	70.88	51	230	9,554	41.54	12	76	6,171	81.20	80	216	5,430	25.14
2007	153	684	45,566	66.62	66	276	11,488	41.62	12	112	7,500	66.96	78	193	4,552	23.58
2008	177	826	63,152	76.46	84	319	12,983	40.70	17	123	10,962	89.12	95	220	5,480	24.91
2009	205	847	68,252	80.58	90	291	10,677	36.69	16	61	2,789	45.72	118	284	8,112	28.56
2010	221	1,068	83,633	78.31	100	371	17,287	46.60	31	118	5,890	49.92	135	373	14,370	38.53
2011	206	866	76,622	88.48	97	402	18,282	45.48	28	114	4,076	35.75	140	319	10,298	32.28
2012	206	770	75,758	98.39	90	409	19,789	48.38	32	146	5,778	39.57	144	435	15,529	35.70
2013	184	799	76,271	95.46	80	332	18,964	57.12	44	205	7,762	37.86	167	463	18,224	39.36
2014	163	715	56,801	79.44	67	276	12,156	44.04	45	196	8,259	42.14	167	488	19,612	40.19
2015	178	779	65,083	83.55	64	346	12,591	36.39	49	172	6,344	36.88	200	552	17,936	32.49
2016	181	823	73,383	89.17	60	309	11,523	37.29	34	223	12,728	57.08	176	575	21,324	37.09
2017	201	894	85,060	95.15	45	317	16,989	53.59	35	152	13,724	90.29	151	404	15,705	38.87
2018	138	469	34,014	72.52	34	273	17,363	63.60	27	132	7,404	56.09	140	359	16,213	45.16
2019	143	524	48,103	91.80	38	259	16,460	63.55	41	142	5,397	38.01	130	370	19,876	53.72
10-yr avg.	**182**	**771**	**67,473**	**87.23**	**68**	**329**	**16,140**	**49.60**	**37**	**160**	**7,736**	**48.36**	**155**	**434**	**16,909**	**39.34**
20-yr avg.	**179**	**748**	**60,898**	**81.05**	**77**	**313**	**13,187**	**42.14**	**27**	**124**	**6,874**	**56.19**	**119**	**311**	**10,965**	**33.18**

NULL = no available data; n.d. = non-disclosure due to data confidentiality.
1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.3 CORAL REEF ECOSYSTEM COMPONENTS

1.3.1 Fishery Descriptions

In 2018, the Council drafted an Amendment 5 to the Hawaii Archipelago FEP that reclassified a large number MUS as Ecosystem Component Species (ECS; WPRFMC, 2018). The final rule was posted in the Federal Register in early 2019 (84 FR 2767). This amendment reduces the number of MUS from 173 species/families to 20 in the Hawaii FEP. All former coral reef ecosystem management unit species (CREMUS) were reclassified as ECS that do not require ACL specifications or accountability measures but are still to be monitored regularly to prioritize conservation and management efforts and to improve efficiency of fishery management in the region. All existing management measures, including reporting and record keeping, prohibitions, and experimental fishing regulations apply to the associated ECS. If an ECS stock becomes a target of a Federal fishery in the future, NMFS and the Council may consider including that stock as a MUS to actively manage that stock.

Representing continued effort to monitor ECS, a one-year reflection of the top ten harvested ECS (by weight) is included. Additionally, HDAR selected ten species reclassified as ECS that are still of priority to the State for regular monitoring. These prioritized ECS species are opihi (*Cellana* spp.; limpet), lobster (*Panulirus* spp.), kumu (*Parupeneus porphyreus*; whitesaddle goatfish), omilu (*Caranx melampygus;* bluefin trevally), uhu (family Scaridae; parrotfish), he'e (*Octopus cyanea*; day tako), kala (*Naso* spp.), nenue (*Kyphosus* spp.; brown chub), manini (*Acanthurus triostegus*; convict tang), and taape (*Lutjanus kasmira*; bluestripe snapper) Time series for these species are included in the report as well. These ten species are important not only commercially but recreationally and culturally as well. There is no current data gathering system for recreational or subsistence catch of these ten species other than the Hawaii Marine Recreational Fishers Survey (HMRFS). HMRFS conducts creel surveys around the state to collect catch data from recreational and subsistence fishers. This data, along with the commercial data, can be used to determine the overall catch for these ten species. HDAR can also use fisheries independent data (in-water surveys) to obtain abundance numbers for these ten species. With this data, HDAR can propose regulations in order for these ten species to be harvested in the future.

1.3.2 Dashboard Statistics

The collection of commercial ECS finfish and invertebrate fishing reports comes from two sources: paper reports received by mail, fax, or PDF copy via e-mail, and reports filed online through the OFR. The ECS are reported by commercial fishers in the Monthly Fishing Report, the Net, Trap, Dive Activity Report, or the MHI Deep 7 Bottomfish Fishing Trip Report.

Similar to the Deep 7 Bottomfish, the time series format for the ECS fishery begins with an arrangement by the state fiscal year period (July – June) until June 1993 before being reported by fishing year. Refer to data processing procedures documented in the Deep 7 BMUS section for paper fishing reports and fishing reports filed online (see Section 1.1.2). Database assistants and the data monitoring associate will enter the paper Monthly Fishing Report information within four weeks, and the Net, Trap, Dive Activity Report and the MHI Deep 7 Bottomfish Fishing Trip Report within two business days.

1.3.2.1 2019 Most Harvested ECS

Table 11. Top ten landed species (lbs.) in Hawaii ECS fisheries in 2019

Species	No. Licenses	No. Trips	Catch (lbs.)
Selar crumenophthalmus (akule)	205	1,605	241,161
Decapterus macarellus (opelu)	120	1,337	120,917
Parrotfish species (uhu)	62	611	47,361
Myripristis spp. (menpachi)	173	844	45,425
Lutjanus kasmira (taape)	177	823	29,663
Acanthurus dussumieri (palani)	47	460	25,037
Mulloidichthys vanicolensis (red weke)	55	179	18,258
Portunus sanguinolentus (kuahonu crab)	n.d.	n.d.	n.d.
Seriola dumerili (kahala)	153	587	14,158
Octopus cyanea (he'e; day tako)	49	366	11,045

1.3.2.2 Prioritized Species Summary

Table 12. Annual fishing parameters for 2019 for prioritized MHI ECS designated by DAR compared with short-term (10-year) and long-term (20-year) averages

Species	Fishery Indicator	2019 Value	2019 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Opihi	No. Lic.	19	↓ 13.6%	↓ 13.6%
	No. Trips	180	↓ 30.2%	↓ 32.3%
	No. Caught	50,631	↑ 53.3%	↑ 161%
	Lbs. Caught	10,976 lbs.	↓ 34.7%	↓ 22.2%
Lobster	No. Lic.	9	↓ 47.1%	↓ 55.0%
	No. Trips	127	↓ 38.1%	↓ 42.8%
	No. Caught	2,118	↓ 44.7%	↓ 47.8%
	Lbs. Caught	4,206 lbs.	↓ 46.7%	↓ 49.6%
Kumu	No. Lic.	44	↓ 43.6%	↓ 46.3%
	No. Trips	103	↓ 75.5%	↓ 75.0%
	No. Caught	378	↓ 87.4%	↓ 82.4%
	Lbs. Caught	581 lbs.	↓ 87.6%	↓ 85.2%
Omilu	No. Lic.	96	↓ 21.3%	↓ 16.5%
	No. Trips	287	↓ 26.6%	↓ 18.5%
	No. Caught	726	↓ 39.9%	↓ 32.7%
	Lbs. Caught	4,782 lbs.	↓ 30.2%	↓ 25.7%
Uhu	No. Lic.	62	↓ 26.2%	↓ 31.9%
	No. Trips	611	↓ 34.5%	↓ 31.4%
	No. Caught	10,194	↓ 20.6%	↓ 0.80%
	Lbs. Caught	47,361 lbs.	↓ 15.3%	↑ 4.11%
He'e (Day tako)	No. Lic.	49	↓ 36.4%	↓ 33.8%
	No. Trips	366	↓ 54.5%	↓ 53.3%
	No. Caught	4,061	↓ 56.0%	↓ 49.7%

	Lbs. Caught	11,045 lbs.	↓ 59.2%	↓ 53.2%
Kala	No. Lic.	32	↓ 38.5%	↓ 45.8%
	No. Trips	154	↓ 62.5%	↓ 62.2%
	No. Caught	2,331	↓ 59.6%	↓ 52.5%
	Lbs. Caught	8,863 lbs.	↓ 64.1%	↓ 61.1%
Nenue	No. Lic.	37	↓ 43.9%	↓ 47.1%
	No. Trips	217	↓ 39.9%	↓ 37.1%
	No. Caught	4,285	↓ 29.5%	↓ 30.7%
	Lbs. Caught	10,240 lbs.	↓ 45.7%	↓ 47.4%
Manini	No. Lic.	40	↓ 33.3%	↓ 39.4%
	No. Trips	362	↓ 38.9%	↓ 39.0%
	No. Caught	18,734	↓ 22.0%	↓ 18.8%
	Lbs. Caught	8,821 lbs.	↓ 30.5%	↓ 30.6%
Taape	No. Lic.	177	↓ 26.9%	↓ 23.7%
	No. Trips	823	↓ 31.8%	↓ 33.5%
	No. Caught	44,925	↓ 1.80%	↑ 11.1%
	Lbs. Caught	29,663 lbs.	↓ 12.0%	↓ 20.2%

1.3.3 Prioritized Species Statistics

Table 13. Time series of commercial fishing reports for all opihi (limpet) species reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	14	239	66	0	16,651
1966	13	171	61	0	13,989
1967	40	779	176	0	36,000
1968	26	450	112	0	23,185
1969	36	413	127	0	23,818
1970	41	392	133	1,810	20,446
1971	46	368	148	1,929	17,229
1972	44	268	117	5	16,739
1973	46	257	121	600	17,169
1974	51	351	147	66,163	19,558
1975	46	333	140	115	14,396
1976	52	327	151	13,560	19,052
1977	60	306	157	750	13,969
1978	54	231	155	15,622	15,119
1979	51	182	158	0	14,146
1980	49	230	119	28	10,617
1981	36	218	87	30	7,889
1982	36	190	82	1	7,725
1983	38	191	81	0	6,675
1984	40	181	95	61	8,547

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1985	36	285	95	151	13,512
1986	64	289	141	1,066	12,426
1987	91	563	222	200	17,949
1988	71	334	145	618	12,277
1989	68	319	143	40	12,675
1990	56	179	110	0	7,848
1991	58	212	114	0	7,680
1992	55	315	130	0	9,271
1993.1	39	194	87	0	5,672
1993.2	26	138	55	0	4,628
1994	42	435	137	0	11,444
1995	56	461	151	0	13,098
1996	41	371	115	0	12,079
1997	51	299	125	1,106	10,979
1998	50	289	128	110	13,936
1999	43	406	112	0	10,774
2000	31	415	103	0	9,950
2001	24	356	96	710	12,938
2002	32	426	104	11,300	13,430
2003	23	341	106	9,975	11,714
2004	15	196	57	2,234	8,255
2005	12	181	42	372	7,380
2006	19	143	51	7,919	10,264
2007	20	182	63	5,508	6,911
2008	27	202	67	3,692	10,530
2009	25	294	81	16,716	22,773
2010	34	340	97	16,570	26,747
2011	25	261	78	41,370	16,053
2012	28	287	95	8,750	18,268
2013	17	361	85	6,893	25,761
2014	27	333	91	10,419	22,417
2015	17	248	82	14,126	14,211
2016	16	156	77	39,166	9,125
2017	16	189	79	65,806	11,057
2018	17	229	93	76,541	13,336
2019	19	180	89	50,631	10,976
10-year avg.	**22**	**258**	**87**	**33,027**	**16,795**
20-year avg.	**22**	**266**	**82**	**19,435**	**14,105**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 14. Time series of commercial fishing reports for all lobster species from reported by Calendar Year from 2002-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2002	16	58	25	968	1,982
2003	38	205	90	3,645	7,404
2004	24	278	75	4,382	8,451
2005	27	321	73	5,844	11,633
2006	18	247	62	3,770	7,669
2007	18	224	64	4,028	8,246
2008	19	261	60	5,242	11,510
2009	28	353	80	6,832	14,512
2010	28	300	77	5,727	12,094
2011	26	257	73	5,190	10,646
2012	25	257	72	4,841	9,808
2013	14	237	56	4,690	10,153
2014	19	228	54	4,887	10,526
2015	13	140	40	2,939	5,916
2016	14	161	44	2,480	5,003
2017	15	184	49	2,811	5,565
2018	8	157	36	2,585	5,015
2019	9	127	31	2,118	4,206
10-year avg.	**17**	**205**	**53**	**3,827**	**7,893**
20-year avg.	**20**	**222**	**59**	**4,054**	**8,352**

Table 15. Time series of commercial fishing reports for kumu (*Parupeneus porphyus*; white saddle goatfish) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	62	700	234	1,874	12,060
1966	51	546	201	2,900	8,515
1967	62	575	216	3,826	9,599
1968	51	482	179	3,570	8,599
1969	72	649	240	3,215	8,616
1970	78	635	248	2,883	8,408
1971	96	598	270	1,649	7,205
1972	98	583	274	2,674	6,394
1973	99	617	296	2,731	8,813
1974	109	629	290	3,521	7,894
1975	88	630	255	2,585	7,033
1976	104	639	285	3,037	7,367
1977	117	887	380	2,629	10,373

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1978	168	879	519	3,731	15,427
1979	163	613	488	3,133	15,430
1980	146	750	436	2,536	13,697
1981	143	1,192	465	4,891	15,235
1982	119	980	411	3,024	10,164
1983	119	771	361	2,145	8,728
1984	143	814	386	2,074	7,118
1985	134	941	396	2,015	10,937
1986	117	719	331	1,194	6,760
1987	129	782	368	2,290	7,919
1988	121	739	316	2,164	8,288
1989	137	763	373	1,788	7,959
1990	122	616	327	1,564	5,903
1991	149	650	374	1,193	5,335
1992	118	799	343	1,746	6,943
1993.1	117	760	334	935	6,841
1993.2	79	335	159	595	2,811
1994	132	575	336	1,151	4,037
1995	151	784	391	1,174	6,246
1996	139	665	386	839	5,284
1997	132	638	368	1,128	5,120
1998	127	642	347	2,103	5,357
1999	108	560	319	1,436	4,117
2000	110	535	305	1,646	5,133
2001	104	532	276	1,648	4,539
2002	98	536	278	1,143	3,675
2003	91	364	223	1,218	2,585
2004	82	380	231	1,255	2,233
2005	72	296	182	959	2,590
2006	56	228	148	673	1,471
2007	61	315	174	971	1,759
2008	71	297	192	918	2,335
2009	111	555	305	2,612	5,483
2010	101	841	359	5,535	9,874
2011	96	665	305	6,144	9,564
2012	106	679	333	6,220	8,461
2013	102	565	285	4,453	7,090
2014	91	437	235	2,939	4,412
2015	70	276	177	1,669	2,710
2016	61	291	167	1,106	2,051

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2017	60	202	132	940	1,370
2018	44	138	102	522	728
2019	44	103	76	378	581
10-year avg.	**78**	**420**	**217**	**2,991**	**4,684**
20-year avg.	**82**	**412**	**224**	**2,147**	**3,932**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 16. Time series of commercial fishing reports for omilu (*Caranx melampygus*; bluefin trevally) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	26	155	75	383	3,633
1966	25	138	61	125	2,114
1967	25	109	60	463	1,851
1968	23	129	55	763	4,397
1969	32	259	81	202	6,876
1970	26	236	71	273	4,545
1971	20	161	60	410	2,912
1972	19	83	50	159	815
1973	19	76	46	35	907
1974	19	122	55	110	1,841
1975	22	118	55	62	1,263
1976	21	61	43	103	1,607
1977	28	87	59	143	1,251
1978	45	130	88	132	2,169
1979	31	57	54	65	1,243
1980	33	87	67	111	1,417
1981	57	179	123	269	2,949
1982	66	173	126	464	2,820
1983	83	245	156	712	5,067
1984	108	316	195	1,879	16,577
1985	117	333	212	850	7,341
1986	115	368	205	1,317	8,671
1987	150	560	337	1,808	12,190
1988	169	567	357	2,084	14,638
1989	160	591	369	2,235	13,604
1990	151	507	341	2,093	14,772
1991	160	408	292	1,417	9,817
1992	59	135	108	343	4,530
1993.1	58	120	94	224	1,960
1993.2	39	64	54	114	1,319
1994	65	127	95	421	3,508

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1995	70	122	104	159	1,836
1996	58	145	111	301	3,141
1997	65	131	111	288	2,590
1998	56	104	89	170	1,579
1999	47	94	72	197	1,290
2000	61	139	110	287	2,447
2001	70	157	118	368	2,641
2002	88	190	146	547	4,605
2003	102	345	233	1,333	7,733
2004	124	361	244	1,214	7,216
2005	113	338	231	1,506	9,271
2006	107	302	228	679	3,650
2007	112	394	260	953	7,402
2008	150	444	319	1,126	7,383
2009	151	457	329	1,483	7,847
2010	143	505	342	1,660	9,082
2011	146	440	301	1,065	6,800
2012	134	507	327	1,272	8,265
2013	121	395	271	951	6,439
2014	130	376	266	1,259	7,618
2015	114	357	255	1,564	6,242
2016	112	362	256	990	5,947
2017	126	388	273	1,424	8,124
2018	100	292	198	1,156	5,173
2019	96	287	202	726	4,782
10-year avg.	**122**	**391**	**269**	**1,207**	**6,847**
20-year avg.	**115**	**352**	**245**	**1,078**	**6,433**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 17. Time series of commercial fishing reports for uhu (parrotfish) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	33	273	105	301	6,653
1966	20	235	94	336	6,460
1967	29	248	112	678	8,428
1968	31	199	104	531	4,572
1969	44	372	153	733	7,710
1970	43	347	163	1,320	9,012
1971	57	348	184	640	7,044
1972	45	255	126	400	3,284
1973	45	253	141	500	4,405

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1974	60	263	151	541	5,215
1975	39	243	123	295	3,624
1976	59	272	159	406	9,633
1977	77	394	229	427	6,468
1978	124	577	369	955	19,795
1979	125	430	364	1,004	19,718
1980	119	534	332	1,418	21,553
1981	116	740	344	1,519	21,487
1982	96	633	316	1,099	16,782
1983	109	568	293	3,103	25,782
1984	117	620	315	3,423	27,586
1985	110	763	337	1,428	27,697
1986	124	823	359	1,991	35,631
1987	134	853	388	3,289	41,016
1988	122	865	356	3,104	44,689
1989	114	760	313	2,044	49,037
1990	75	586	250	2,284	25,999
1991	117	734	358	2,676	26,708
1992	103	964	364	5,388	36,697
1993.1	103	908	336	3,034	27,975
1993.2	79	518	206	2,290	19,382
1994	124	967	413	4,767	39,803
1995	139	1,165	479	2,817	42,036
1996	143	1,047	494	2,579	36,189
1997	131	995	451	2,731	35,968
1998	132	995	446	3,635	35,805
1999	120	952	442	4,511	35,060
2000	116	785	375	3,141	28,510
2001	113	800	386	3,819	21,786
2002	111	869	384	4,265	31,091
2003	92	822	315	8,377	35,483
2004	84	854	340	7,762	33,279
2005	88	737	296	7,967	32,583
2006	80	637	272	7,684	31,698
2007	84	867	353	11,090	40,398
2008	90	954	371	11,445	44,937
2009	118	1,161	459	11,556	50,884
2010	108	1,440	450	17,483	71,239
2011	96	1,190	409	17,675	72,343
2012	117	1,399	462	20,301	84,442

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2013	95	1,163	392	17,343	75,291
2014	89	928	347	14,169	69,846
2015	75	637	274	7,455	33,613
2016	67	596	265	6,431	26,450
2017	70	639	268	7,562	30,939
2018	56	729	242	9,806	47,638
2019	62	611	209	10,194	47,361
10-year avg.	**84**	**933**	**332**	**12,842**	**55,916**
20-year avg.	**91**	**891**	**343**	**10,276**	**45,491**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 18. Time series of commercial fishing reports for he'e (*Octopus cyanea*; day tako) reported by Calendar Year from 2002-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2002	9	28	12	147	341
2003	76	657	218	6,088	17,170
2004	62	749	228	5,966	19,228
2005	80	824	262	6,250	19,614
2006	75	959	277	7,134	19,284
2007	77	817	293	6,286	17,318
2008	92	962	333	10,425	29,998
2009	96	1,056	358	10,581	30,908
2010	115	1,175	393	11,195	34,008
2011	95	996	351	10,735	30,142
2012	92	1,191	405	12,022	34,820
2013	88	1,149	410	13,410	39,079
2014	86	865	311	10,392	33,525
2015	67	735	242	10,607	32,728
2016	57	611	191	8,221	23,128
2017	59	521	204	7,233	19,823
2018	57	428	196	4,503	12,620
2019	49	366	167	4,061	11,045
10-year avg.	**77**	**804**	**287**	**9,238**	**27,092**
20-year avg.	**74**	**783**	**270**	**8,070**	**23,599**

Table 19. Time series of commercial fishing reports for kala (*Naso annulatus*; whitemargin unicornfish) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	27	251	93	823	30,278
1966	20	220	60	174	26,115

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1967	27	168	68	398	35,453
1968	24	160	57	423	23,886
1969	31	182	83	560	32,020
1970	40	226	108	1,114	23,954
1971	45	223	118	1,036	19,925
1972	52	189	106	703	16,421
1973	43	151	99	1,084	17,508
1974	57	166	122	1,034	20,793
1975	72	248	159	905	17,997
1976	73	233	167	1,236	13,697
1977	94	369	244	1,374	18,960
1978	103	279	226	1,143	21,775
1979	95	240	222	805	14,430
1980	89	221	173	799	10,342
1981	80	334	166	1,697	11,990
1982	86	345	179	1,515	13,525
1983	89	335	195	822	14,791
1984	92	257	171	492	11,508
1985	98	348	215	1,004	8,890
1986	98	226	159	926	14,647
1987	86	260	177	1,217	14,644
1988	95	298	184	2,348	13,050
1989	102	345	216	864	8,912
1990	49	218	118	527	3,191
1991	91	359	194	809	8,736
1992	74	295	172	477	6,892
1993.1	73	347	183	724	7,850
1993.2	50	174	90	325	4,445
1994	84	419	229	1,332	12,945
1995	87	478	250	780	17,679
1996	102	496	270	859	15,105
1997	91	500	268	940	12,929
1998	97	497	276	1,413	15,244
1999	90	477	266	1,384	16,439
2000	74	455	223	1,912	18,115
2001	84	426	238	1,832	24,427
2002	77	498	249	2,927	20,036
2003	68	450	188	4,170	21,219
2004	59	419	177	5,074	21,855
2005	51	330	140	5,447	22,502

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2006	48	329	141	5,392	21,693
2007	52	310	163	3,712	13,629
2008	55	372	169	5,022	20,227
2009	85	437	245	4,941	24,919
2010	66	578	253	8,183	33,959
2011	68	514	216	7,303	29,724
2012	69	688	247	8,559	42,464
2013	65	526	237	6,839	32,302
2014	61	480	198	6,674	30,516
2015	48	362	173	4,716	21,911
2016	41	318	146	5,132	17,716
2017	41	292	147	5,330	19,374
2018	32	202	112	2,649	9,904
2019	32	154	100	2,331	8,863
10-year avg.	**52**	**411**	**183**	**5,772**	**24,673**
20-year avg.	**59**	**407**	**188**	**4,907**	**22,768**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 20. Time series of commercial fishing reports for nenue (*Kyphosus bigibbus*; brown chub) from reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	20	113	70	382	6,209
1966	18	97	61	299	6,908
1967	33	132	83	472	11,908
1968	24	70	49	266	2,428
1969	41	111	82	777	8,611
1970	48	120	89	558	3,088
1971	57	163	118	84	4,187
1972	53	146	105	322	4,621
1973	61	131	106	332	4,746
1974	58	175	122	658	10,553
1975	83	208	146	1,110	16,750
1976	78	227	151	971	10,433
1977	104	288	215	1,692	9,426
1978	119	292	239	1,499	10,535
1979	107	247	223	1,294	8,781
1980	83	245	176	799	13,089
1981	92	342	199	963	10,788
1982	80	428	238	2,980	19,782
1983	96	301	207	1,504	8,181
1984	116	360	241	2,223	11,282

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1985	116	423	274	1,619	8,957
1986	124	412	270	2,188	10,980
1987	122	583	307	2,689	17,672
1988	109	542	278	2,483	18,445
1989	94	433	231	2,024	8,826
1990	70	310	173	1,409	6,046
1991	100	413	224	2,349	11,122
1992	80	408	221	812	15,459
1993.1	94	402	222	1,186	7,423
1993.2	57	202	107	734	3,531
1994	98	445	241	1,505	10,753
1995	100	423	259	1,293	10,872
1996	106	525	270	2,206	11,952
1997	102	484	262	2,310	7,515
1998	97	451	243	2,824	15,503
1999	92	474	260	3,492	16,042
2000	83	400	208	1,844	9,704
2001	73	358	209	1,740	11,750
2002	83	373	220	2,007	22,594
2003	64	262	159	5,084	19,476
2004	68	312	194	5,809	19,310
2005	54	252	150	8,867	19,623
2006	59	245	150	12,651	35,621
2007	64	286	173	10,902	26,758
2008	77	334	201	8,287	21,621
2009	104	469	279	5,735	14,583
2010	79	448	239	14,384	31,811
2011	82	506	220	9,900	27,771
2012	91	571	239	7,442	31,238
2013	78	417	222	5,643	27,409
2014	83	417	220	4,663	16,635
2015	56	276	157	3,692	17,429
2016	55	252	153	3,228	10,047
2017	56	243	142	2,395	6,163
2018	44	264	127	5,104	9,655
2019	37	217	104	4,285	10,240
10-year avg.	**66**	**361**	**182**	**6,074**	**18,840**
20-year avg.	**70**	**345**	**188**	**6,183**	**19,472**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 21. Time series of commercial fishing reports for manini (*Acanthurus triostegus*; convict tang) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	40	440	179	9,811	9,244
1966	34	316	158	11,170	7,391
1967	50	293	172	11,480	8,767
1968	41	279	171	11,559	7,046
1969	53	391	188	19,598	12,401
1970	52	372	178	15,977	9,990
1971	79	387	209	11,860	8,527
1972	63	326	182	8,337	7,360
1973	76	424	224	11,859	9,234
1974	89	511	266	11,836	8,682
1975	86	512	246	9,382	9,463
1976	82	483	255	8,714	8,337
1977	103	575	326	6,586	10,236
1978	112	463	352	6,014	9,653
1979	103	437	338	9,687	14,440
1980	86	381	239	4,832	7,121
1981	90	404	251	6,369	15,907
1982	77	463	222	6,405	9,152
1983	87	452	253	2,294	11,091
1984	98	471	266	2,320	9,444
1985	97	533	275	1,737	9,472
1986	98	549	274	4,226	6,971
1987	94	654	299	5,374	11,042
1988	94	670	319	7,739	9,037
1989	101	705	330	8,126	12,686
1990	68	542	224	6,364	6,977
1991	93	641	294	7,595	7,667
1992	85	649	255	5,788	9,575
1993.1	89	733	265	7,803	9,286
1993.2	66	305	139	5,258	8,193
1994	98	778	303	15,968	12,923
1995	106	777	309	11,216	14,961
1996	113	1,007	367	18,570	18,331
1997	98	896	341	16,397	15,032
1998	105	754	325	19,039	13,317
1999	107	704	310	16,454	14,612
2000	86	563	247	12,943	12,152

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2001	78	543	233	10,555	11,919
2002	78	589	254	18,095	15,907
2003	61	559	213	38,552	20,001
2004	61	612	229	20,416	10,045
2005	63	481	220	27,947	12,312
2006	69	539	207	20,059	9,109
2007	66	716	259	26,628	11,426
2008	70	622	272	20,573	11,574
2009	79	718	300	25,386	12,793
2010	85	895	332	30,925	17,511
2011	76	885	297	33,758	17,895
2012	79	768	297	23,949	14,039
2013	65	723	276	27,125	15,276
2014	59	593	247	25,475	11,609
2015	64	405	204	14,260	10,651
2016	48	445	191	18,636	8,934
2017	47	388	173	20,182	9,276
2018	41	456	170	27,016	12,989
2019	40	362	150	18,734	8,821
10-year avg.	**60**	**592**	**234**	**24,006**	**12,700**
20-year avg.	**66**	**593**	**239**	**23,061**	**12,712**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

Table 22. Time series of commercial fishing reports for taape (*Lutjanus kasmira*; bluestripe snapper) reported by Fiscal Year from 1970-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1970	5	26	11	0	534
1971	30	109	57	29	1,723
1972	48	198	100	332	2,591
1973	60	249	135	862	3,749
1974	77	322	178	1,304	7,829
1975	88	353	211	1,085	9,353
1976	142	527	320	8,326	28,405
1977	201	801	436	6,853	28,541
1978	289	1,086	741	14,524	51,042
1979	320	970	845	25,672	58,175
1980	331	1,132	762	17,912	56,043
1981	299	1,448	756	20,295	80,498
1982	298	1,451	782	20,871	71,101
1983	309	1,508	800	11,078	69,225
1984	335	1,485	798	13,861	43,661

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1985	364	1,748	872	12,844	50,787
1986	410	1,944	1,012	16,189	52,328
1987	372	1,629	948	13,519	55,084
1988	416	1,907	1,036	16,966	50,889
1989	389	1,629	957	15,746	36,211
1990	400	1,635	954	17,099	43,888
1991	427	1,770	1,050	17,053	62,504
1992	343	1,865	949	19,302	74,105
1993.1	330	1,739	875	19,735	62,315
1993.2	249	991	507	11,260	30,092
1994	338	1,697	885	16,634	60,130
1995	365	1,783	951	14,943	71,781
1996	352	1,538	904	14,415	44,195
1997	366	1,984	980	23,291	85,506
1998	365	1,754	933	20,894	74,851
1999	297	1,822	842	31,735	70,074
2000	280	1,928	818	27,270	55,047
2001	240	1,593	666	17,328	47,550
2002	230	1,162	621	12,579	38,597
2003	211	1,068	541	28,194	42,130
2004	210	1,145	553	62,413	45,667
2005	177	1,035	488	45,591	39,491
2006	171	1,003	461	28,317	29,438
2007	187	1,130	529	35,662	30,281
2008	247	1,220	619	43,786	40,000
2009	274	1,392	717	49,927	38,390
2010	270	1,519	767	56,888	43,879
2011	265	1,369	693	56,221	41,261
2012	297	1,394	800	37,857	33,008
2013	266	1,387	727	38,861	33,434
2014	261	1,232	657	35,159	30,271
2015	228	1,074	582	31,081	25,824
2016	221	1,164	606	54,757	35,270
2017	238	1,239	662	58,440	35,875
2018	197	861	491	43,303	28,768
2019	177	823	458	44,925	29,663
10-year avg.	**242**	**1,206**	**644**	**45,749**	**33,725**
20-year avg.	**232**	**1,237**	**623**	**40,428**	**37,192**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.4 CRUSTACEAN

1.4.1 Fishery Descriptions

This species group is comprised of the *Heterocarpus* deep water shrimps (*H. laevigatus* and *H. ensifer*) and Kona crab (*Ranina ranina*). The main gear types used are shrimp traps and loop nets.

1.4.2 Dashboard Statistics

The collection of commercial crustacean fishing reports comes from two sources: paper reports received by mail, fax, or PDF copy via e-mail; and reports filed online through the OFR. The crustacean landings are reported by commercial fishers on the Monthly Fishing Report, the Net, Trap, Dive Activity Report, or the MHI Deep 7 Bottomfish Fishing Trip Report.

Similar to the Deep 7 Bottomfish, the time series format for the crustacean fishery begins with an arrangement by the state fiscal year period (July – June) until June 1993 before being reported by fishing year. Refer to data processing procedures documented in the Deep 7 BMUS section (Section 1.1.2) for more information on paper fishing reports and fishing reports filed online. Database assistants and data monitoring associates will enter the paper Monthly Fishing Report information within four weeks, and the Net, Trap, Dive Activity Report and the MHI Deep 7 Bottomfish Fishing Trip Report within two business days.

1.4.2.1 Historical Summary

Table 23. Annual fishing parameters for 2019 in the MHI crustacean fishery compared with short-term (10-year) and long-term (20-year) averages

Fishery	Parameters	2019 Value	2019 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Crustacean	No. License	25	↓ 26.5%	↓ 40.5%
	Trips	280	↑ 9.80%	↑ 11.6%
	No. Caught	23,048	↓ 74.5%	↓ 55.9%
	Lbs. Caught	18,296 lbs.	↓ 17.0%	↓ 30.0%

1.4.2.2 Species Summary

Table 24. Annual fishing parameters for 2019 in the MHI crustacean fishery compared with short-term (10-year) and long-term (20-year) averages

Methods	Fishery Indicator	2019 Value	2019 Comparative Trends	
			Short-Term Avg. (10-year)	Short-Term Avg. (20-year)
Shrimp trap	*H. laevigatus*	n.d.	-	-
	H. ensifer	n.d.	-	-
	No. Lic.	n.d.	-	-
	No. Trips	n.d.	-	-
	Lbs. Caught	n.d.	-	-

	CPUE	n.d.	-	-
Loop Net	Kona crab	5,650 lbs.	↑ 7.03%	↓ 29.3%
	No. Lic. No. Trips Lbs. Caught CPUE	23 70 5,650 lbs. 80.71 lbs./trip	↓ 20.7% ↓ 19.5% ↑ 7.03% ↑ 39.2%	↓ 39.5% ↓ 45.3% ↓ 29.3% ↑ 32.3%
All Other Gears	No. Lic. No. Trips Lbs. Caught CPUE	n.d. n.d. n.d. n.d.	- - - -	- - - -

1.4.3 Time Series Statistics

1.4.3.1 Commercial Fishing Parameters

Table 25. Time series of commercial fishermen reports for the CMUS fishery reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1965	26	171	71	4,238	11,421
1966	22	179	67	3,604	10,033
1967	30	185	82	3,071	17,444
1968	25	167	71	1,764	26,419
1969	29	233	84	3,109	35,955
1970	30	197	78	2,544	35,042
1971	40	254	111	4,162	43,576
1972	41	260	102	3,042	69,331
1973	32	231	97	2,111	62,515
1974	49	211	112	7,562	40,552
1975	59	241	127	5,076	24,616
1976	59	234	136	8,568	26,577
1977	54	233	114	4,144	23,153
1978	61	243	159	5,224	31,675
1979	52	202	128	5,817	28,711
1980	42	108	67	1,920	10,390
1981	49	155	101	4,217	12,858
1982	52	178	108	2,386	8,701
1983	55	180	107	4,204	13,130
1984	76	386	157	6,303	214,792
1985	80	460	190	6,052	82,741
1986	82	312	176	4,196	27,575
1987	76	239	133	3,831	23,876
1988	53	242	101	2,906	30,684
1989	37	147	62	916	58,126

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1990	44	242	84	2,624	361,914
1991	47	187	87	1,620	89,383
1992	73	342	133	7,550	38,552
1993.1	70	398	149	4,580	61,525
1993.2	52	187	80	3,047	31,995
1994	74	342	167	3,193	105,282
1995	88	467	200	4,992	98,478
1996	92	401	180	5,291	62,662
1997	90	347	170	8,229	51,025
1998	102	438	207	7,966	213,067
1999	86	298	170	5,810	53,302
2000	65	199	113	4,075	14,970
2001	64	243	130	3,771	20,209
2002	64	243	131	5,427	15,868
2003	53	217	102	10,082	17,632
2004	51	204	90	7,441	13,469
2005	51	381	106	8,240	124,900
2006	38	203	77	5,941	49,666
2007	34	238	75	26,487	13,469
2008	38	302	88	56,257	21,571
2009	41	237	98	15,960	10,645
2010	48	243	96	15,377	13,481
2011	51	272	114	55,397	19,146
2012	40	273	97	115,257	20,106
2013	43	301	99	95,709	25,757
2014	34	398	94	372,676	50,808
2015	32	272	86	150,614	31,840
2016	23	184	58	30,499	18,499
2017	20	135	45	9,693	8,139
2018	23	191	53	33,648	14,310
2019	25	280	66	23,048	18,296
10-year avg.	**34**	**255**	**81**	**90,192**	**22,038**
20-year avg.	**42**	**251**	**91**	**52,280**	**26,139**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.4.4 Preferred Targets by Gear Type

1.4.4.1 Shrimp Trap

The shrimp trap gear code was established in 1985. Prior to 1985, all trap activities were reported under miscellaneous traps. The principal species taken by shrimp traps/pots are the deep water *Heterocarpus* shrimp. There are only a handful of resident fishers in Hawaii who actively fish for this species. The deep water *Heterocarpus* shrimp fishery pulses every five to seven years; large vessels from the mainland return to the islands to harvest the shrimp and land it in the State for export to external markets. One of the major vessels ported on the mainland but participating in this fishery sunk in the last decade, notably reducing the capacity of this fishery.

Table 26. HDAR MHI annual crustacean catch summary by species for shrimp traps reported by Fiscal Year from 1987-1993 and by Calendar Year from 1994-2019

Year	*Heterocarpus laevigatus*		*Heterocarpus ensifer*	
	No. License	Lbs. Caught	No. License	Lbs. Caught
1987	n.d.	n.d.	n.d.	n.d.
1988	n.d.	n.d.	n.d.	n.d.
1989	n.d.	n.d.	n.d.	n.d.
1990	5	341,780	n.d.	n.d.
1991	n.d.	n.d.	NULL	NULL
1992	n.d.	n.d.	NULL	NULL
1993.1	n.d.	n.d.	NULL	NULL
1993.2	n.d.	n.d.	n.d.	n.d.
1994	5	82,243	n.d.	n.d.
1995	4	66,493	n.d.	n.d.
1996	8	34,588	n.d.	n.d.
1997	6	21,697	n.d.	n.d.
1998	7	180,391	n.d.	n.d.
1999	5	34,381	n.d.	n.d.
2000	n.d.	n.d.	n.d.	n.d.
2001	4	9,225	n.d.	n.d.
2002	n.d.	n.d.	n.d.	n.d.
2003	n.d.	n.d.	n.d.	n.d.
2004	n.d.	n.d.	NULL	NULL
2005	5	109,660	n.d.	n.d.
2006	n.d.	n.d.	n.d.	n.d.
2007	n.d.	n.d.	n.d.	n.d.
2008	n.d.	n.d.	n.d.	n.d.
2009	n.d.	n.d.	n.d.	n.d.
2010	n.d.	n.d.	n.d.	n.d.
2011	4	6,103	n.d.	n.d.
2012	5	11,750	n.d.	n.d.
2013	10	17,972	4	361
2014	9	48,050	4	657
2015	6	28,766	n.d.	n.d.
2016	5	17,158	n.d.	n.d.
2017	n.d.	n.d.	n.d.	n.d.

Year	*Heterocarpus laevigatus*		*Heterocarpus ensifer*	
	No. License	Lbs. Caught	No. License	Lbs. Caught
2018	n.d.	n.d.	n.d.	n.d.
2019	n.d.	n.d.	n.d.	n.d.
10-year avg.	**5**	**16,235**	**n.d.**	**n.d.**
20-year avg.	**4**	**17,188**	**n.d.**	**n.d.**

NULL = no available data; n.d. = non-disclosure due to data confidentiality
1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.4.4.2 Loop Net

The driver species for the loop net gear is the Kona crab. The levels of fishing effort and landings have gradually declined since 2000. The State has established and amended several regulations on the taking and sale of Kona crab. In addition to long-standing restrictions for minimum size, berried females, and season closure, additional prohibitions on the harvesting of females hurt fishing effort and may have discouraged further participation. Another factor that impacted the decline in Kona crab landings was the retirement of a long-time highline fisher several years ago. HDAR is proposing to amend our rules allowing the take of female Kona crab. A 2018 stock assessment showed that the Kona crab fishery is not overfished or experiencing overfishing.

Table 27. HDAR MHI annual crustacean catch summary for loop net catching Kona crab reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	No. License	Lbs. Caught
1965	25	11,378
1966	21	10,029
1967	30	17,444
1968	25	26,419
1969	28	35,939
1970	29	35,033
1971	38	42,977
1972	40	69,328
1973	32	62,455
1974	49	39,121
1975	58	23,996
1976	50	23,195
1977	33	15,966
1978	60	28,582
1979	51	24,674
1980	39	8,162
1981	47	12,102

Year	No. License	Lbs. Caught
1982	48	8,291
1983	48	9,009
1984	58	12,944
1985	71	20,846
1986	80	27,200
1987	62	16,310
1988	47	12,475
1989	32	11,790
1990	32	16,118
1991	44	22,789
1992	71	34,291
1993.1	66	25,305
1993.2	50	15,464
1994	69	19,575
1995	84	27,741
1996	83	27,603
1997	82	28,043
1998	91	30,639
1999	81	18,698
2000	62	14,143
2001	59	10,763
2002	61	11,666
2003	49	11,841
2004	48	12,164
2005	46	9,937
2006	35	6,749
2007	31	9,773
2008	36	10,940
2009	41	9,097
2010	46	9,913
2011	46	10,945
2012	35	7,980
2013	33	7,330
2014	24	2,029
2015	26	3,049
2016	17	1,230
2017	17	2,131
2018	18	2,528
2019	23	5,650
10-year avg.	**29**	**5,279**

Year	No. License	Lbs. Caught
20-year avg.	**38**	**7,993**

1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.4.5 Catch Parameters by Gear

Table 28. Time series of crustacean CPUE (lbs./trip) in the MHI reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2019

Year	Shrimp Trap				Kona Crab Net (Loop)				All Other Gear Types			
	No. Lic.	No. Trips	Lbs. Caught	CPUE	No. Lic.	No. Trips	Lbs. Caught	CPUE	No. Lic.	No. Trips	Lbs. Caught	CPUE
1965	NULL	NULL	NULL	NULL	25	169	11,378	67.33	n.d.	n.d.	n.d.	n.d.
1966	NULL	NULL	NULL	NULL	21	178	10,029	56.34	n.d.	n.d.	n.d.	n.d.
1967	NULL	NULL	NULL	NULL	30	185	17,444	94.29	NULL	NULL	NULL	NULL
1968	NULL	NULL	NULL	NULL	25	167	26,419	158.2	NULL	NULL	NULL	NULL
1969	NULL	NULL	NULL	NULL	28	232	35,939	154.91	n.d.	n.d.	n.d.	n.d.
1970	NULL	NULL	NULL	NULL	29	195	35,033	179.66	n.d.	n.d.	n.d.	n.d.
1971	NULL	NULL	NULL	NULL	38	241	42,977	178.33	n.d.	n.d.	n.d.	n.d.
1972	NULL	NULL	NULL	NULL	40	259	69,328	267.68	n.d.	n.d.	n.d.	n.d.
1973	NULL	NULL	NULL	NULL	32	230	62,455	271.54	n.d.	n.d.	n.d.	n.d.
1974	NULL	NULL	NULL	NULL	49	199	39,121	196.59	n.d.	n.d.	n.d.	n.d.
1975	NULL	NULL	NULL	NULL	58	233	23,996	102.99	n.d.	n.d.	n.d.	n.d.
1976	NULL	NULL	NULL	NULL	50	203	23,195	114.26	20	31	3,382	109.1
1977	NULL	NULL	NULL	NULL	33	133	15,966	120.05	34	100	7,187	71.87
1978	NULL	NULL	NULL	NULL	60	227	28,582	125.91	n.d.	n.d.	n.d.	n.d.
1979	NULL	NULL	NULL	NULL	51	188	24,674	131.24	n.d.	n.d.	n.d.	n.d.
1980	NULL	NULL	NULL	NULL	39	100	8,162	81.62	6	8	2,228	278.5
1981	NULL	NULL	NULL	NULL	47	143	12,102	84.63	7	12	756	63
1982	NULL	NULL	NULL	NULL	48	163	8,291	50.87	8	15	410	27.33
1983	NULL	NULL	NULL	NULL	48	146	9,009	61.71	9	34	4,121	121.21
1984	NULL	NULL	NULL	NULL	58	179	12,944	72.31	29	207	201,848	975.11
1985	NULL	NULL	NULL	NULL	71	309	20,846	67.46	18	151	61,895	409.9
1986	NULL	NULL	NULL	NULL	80	302	27,200	90.07	9	10	375	37.5
1987	4	22	1,831	83.23	62	158	16,310	103.23	17	59	5,735	97.2
1988	n.d.	n.d.	n.d.	n.d.	47	179	12,475	69.69	6	19	5,275	277.63
1989	n.d.	n.d.	n.d.	n.d.	32	134	11,790	87.99	4	8	1,326	165.75
1990	5	87	343,102	3943.7	32	130	16,118	123.98	14	30	2,694	89.8
1991	n.d.	n.d.	n.d.	n.d.	44	161	22,789	141.55	6	11	852	77.45
1992	n.d.	n.d.	n.d.	n.d.	71	316	34,291	108.52	4	21	2,363	112.52
1993.1	n.d.	n.d.	n.d.	n.d.	66	309	25,305	81.89	n.d.	n.d.	n.d.	n.d.
1993.2	n.d.	n.d.	n.d.	n.d.	50	151	15,464	102.41	NULL	NULL	NULL	NULL
1994	5	86	85,657	996.01	69	255	19,575	76.76	n.d.	n.d.	n.d.	n.d.

Year	Shrimp Trap				Kona Crab Net (Loop)				All Other Gear Types			
	No. Lic.	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**
1995	4	140	70,737	505.26	84	327	27,741	84.83	NULL	NULL	NULL	NULL
1996	8	114	34,973	306.78	83	283	27,603	97.54	n.d.	n.d.	n.d.	n.d.
1997	6	51	22,792	446.9	82	289	28,043	97.03	n.d.	n.d.	n.d.	n.d.
1998	7	129	181,912	1410.17	91	299	30,639	102.47	4	10	516	51.6
1999	5	75	34,440	459.2	81	221	18,698	84.61	n.d.	n.d.	n.d.	n.d.
2000	n.d.	n.d.	n.d.	n.d.	62	152	14,143	93.05	n.d.	n.d.	n.d.	n.d.
2001	4	81	9,313	114.98	59	158	10,763	68.12	n.d.	n.d.	n.d.	n.d.
2002	n.d.	n.d.	n.d.	n.d.	61	191	11,666	61.08	n.d.	n.d.	n.d.	n.d.
2003	n.d.	n.d.	n.d.	n.d.	49	158	11,841	74.94	n.d.	n.d.	n.d.	n.d.
2004	n.d.	n.d.	n.d.	n.d.	48	167	12,164	72.84	n.d.	n.d.	n.d.	n.d.
2005	5	178	114,789	644.88	46	161	9,937	61.72	n.d.	n.d.	n.d.	n.d.
2006	n.d.	n.d.	n.d.	n.d.	35	128	6,749	52.73	n.d.	n.d.	n.d.	n.d.
2007	n.d.	n.d.	n.d.	n.d.	31	188	9,773	51.98	4	13	142	10.9
2008	n.d.	n.d.	n.d.	n.d.	36	201	10,940	54.43	4	42	456	10.86
2009	n.d.	n.d.	n.d.	n.d.	41	191	9,097	47.63	n.d.	n.d.	n.d.	n.d.
2010	n.d.	n.d.	n.d.	n.d.	46	178	9,913	55.69	4	45	282	6.26
2011	4	69	8,098	117.36	46	171	10,945	64	6	40	104	2.61
2012	5	143	11,894	83.18	35	122	7,980	65.41	n.d.	n.d.	n.d.	n.d.
2013	10	196	18,333	93.54	33	83	7,330	88.32	n.d.	n.d.	n.d.	n.d.
2014	9	323	48,707	150.8	24	59	2,029	34.38	n.d.	n.d.	n.d.	n.d.
2015	6	201	28,775	143.16	26	62	3,049	49.18	n.d.	n.d.	n.d.	n.d.
2016	5	133	17,203	129.35	17	30	1,230	41	n.d.	n.d.	n.d.	n.d.
2017	n.d.	n.d.	n.d.	n.d.	17	46	2,131	46.33	n.d.	n.d.	n.d.	n.d.
2018	n.d.	n.d.	n.d.	n.d.	18	49	2,528	51.6	n.d.	n.d.	n.d.	n.d.
2019	n.d.	n.d.	n.d.	n.d.	23	70	5,650	80.71	n.d.	n.d.	n.d.	n.d.
10-yr avg.	**5**	**149**	**16,648**	**109**	**29**	**87**	**5,279**	**58**	**n.d.**	**n.d.**	**n.d.**	**n.d.**
20-yr avg.	**4**	**104**	**17,984**	**170**	**38**	**128**	**7,993**	**61**	**n.d.**	**n.d.**	**n.d.**	**n.d.**

NULL = no available data; n.d. = non-disclosure due to data confidentiality
1993.1 = Fiscal Year 1993; 1993.2 = July-December of calendar year 1993.

1.5 PRECIOUS CORALS FISHERY

1.5.1 Fishery Descriptions

This species group is comprised of any coral of the genus *Corallium* in addition to pink coral (also known as red coral, *Corallium secundum*, *C. regale*, *C. laauense*), gold coral (*Gerardia* spp., *Callogorgia gilberti*, *Narella* spp., *Calyptrophora* spp.), bamboo coral (*Lepidisis olapa*, *Acanella* spp.), and black coral (*Antipathes griggi*, *A. grandis*, *A. ulex*).

Only selective gear may be used to harvest corals in federal waters. The top gear for this species group is submersible.

1.5.2 Dashboard Statistics

Future reports will include data as resources allow.

1.5.3 Other Statistics

Commercial fishery statistics for the last ten years are unavailable due to confidentiality, as the number of federal permit holders since 2007 has been fewer than three. Future reports will include data as resources and reporting confidentiality thresholds allow.

1.6 HAWAII ROVING SHORELINE SURVEY

1.6.1 Fishery Descriptions

The State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources (DAR) manages the fishery resources within state waters of the Main Hawaiian Islands (MHI). DAR collaboratively manages fishery resources in federal waters with the National Marine Fisheries Service's (NMFS) Pacific Islands Regional Office (PIRO) and Pacific Islands Fisheries Science Center (PIFSC) and the Western Pacific Regional Fishery Management Council (WPRFMC).

DAR manages the collection of both commercial and non-commercial fishery dependent information in both state and federal waters. Regulatory actions in federal waters are typically proposed by NMFS based mostly on stock assessments produced by PIFSC staff. Proposed regulations in federal waters are then generally agreed upon by NMFS, DAR, and WPRFMC. These three agencies coordinate management in federal waters to simplify regulations for the fishing public, prevent overfishing, and manage the fisheries for long-term sustainability. This shared management responsibility is necessary due to the overlap of various fisheries in both state and federal waters. The information in this section of the report is on the data collected by DAR. The section was not updated for the 2019 annual SAFE report.

1.6.2 Non-Commercial Data Collection Systems

To complement the Hawaii Marine Recreational Fishing Survey (HMRFS), DAR has also been conducting a roving shoreline effort survey on Oahu to collect detailed shoreline fishing effort information (number of fishers and gear types). A total of 216 surveys have been conducted from July 2011 to December 2017 (Table 29).

Table 29. Number of shoreline effort surveys conducted annually and used for the Hawaii roving shoreline survey analysis

Year	# of Surveys Conducted	# of surveys used for analysis
2011	22	18
2012	25	24
2013	42	31
2014	44	26
2015	40	28
2016	30	26
2017	13	11
Total	**216**	**164**

1.6.2.1 Shore-Based Fishing Effort Analysis

Hawaii's coastal terrain and associated nearshore habitats vary from sandy substrates to rocky boulders, and people fish accordingly using different types of gears. Characterizing these spatial variations in fishing effort along the shoreline would thus help support effective fishery management. The roving shoreline survey covered most of Oahu's accessible coastline by driving and/or walking and recorded all fishing effort (number of fishers and gears) and associated waypoints. Based upon survey data from July 2011 to December 2017, an effort "heat" map was developed to ground truth the effort prediction map created from HMRFS data (WPRFMC, 2017).

1.6.2.1.1 Methods

Summing fishing effort

Each fishing event was converted to a geographic infromation system (GIS) point containing the number of fishers and gear types. Fishing methods observed were grouped into four major gear types: gleaning, net fishing, pole fishing, and spear fishing (Table 30). The coastline was divided into equilateral hexagons of 300 m (Figure 1) to summarize fishing events occurring within each boundary; each hexagon was color-coded by the sum of fishing events from high (dark brown) to low (light brown); black dots indicate each fishing event recorded.

Table 30. Fishing methods observed and gear categories used for the analysis

Observed Method	Gear Category
Crab Spearing	Glean
Crabbing	Glean
Look Box (Wading for Tako)	Glean
Paeaea Pole	Glean
Picking Limu	Glean
Picking Opihi	Glean
Wana Collecting	Glean
Aquarium Collecting	Net
Crab Net	Net
Laynet	Net
Scoop Net	Net
Thrownet	Net
Boat Fly Fishing	Pole
Boat Trolling	Pole
Dunking	Pole
Fly Fishing	Pole
Hand Pole	Pole
Handline	Pole
Jet Ski Trolling	Pole
Kayak Trolling	Pole
SUP Trolling	Pole

Whipping	Pole
Speargun	Spear
Three Prong	Spear
Unknown	Unknown

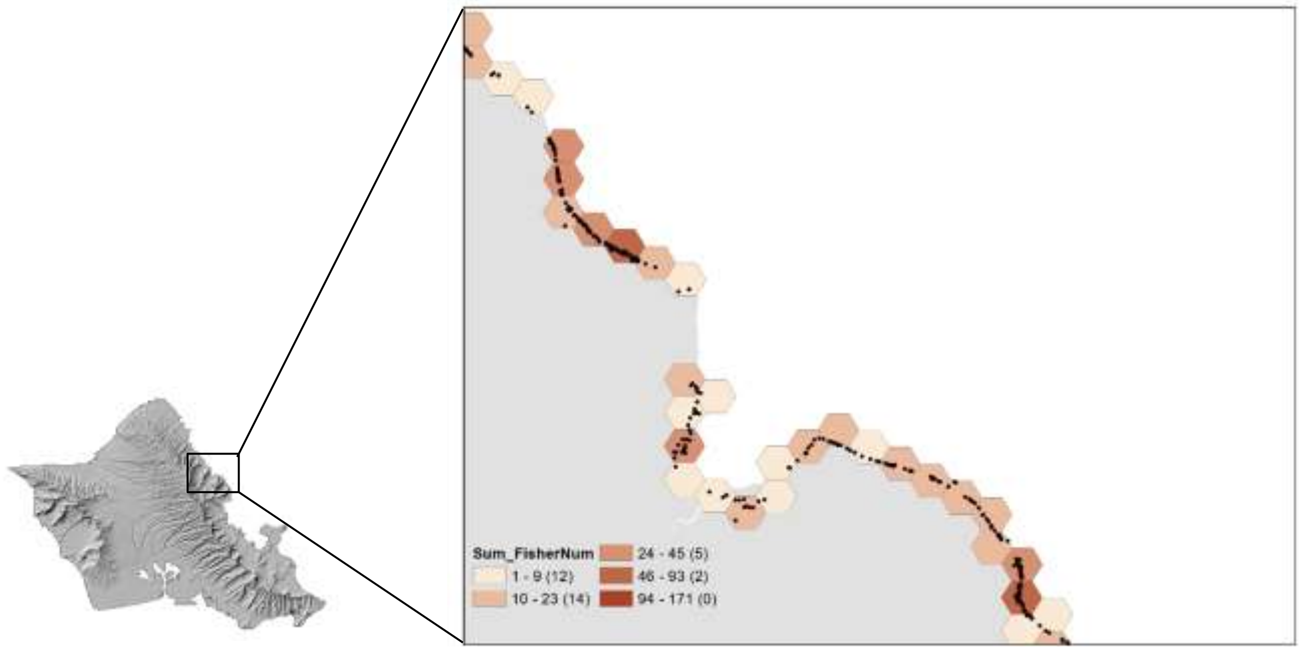

Figure 1. Example of 300 m hexagons around Kahana Bay on Oahu

Standardizing fishing effort by survey effort

Since the shoreline survey was carried out opportunistically, some areas of Oahu were surveyed more than other areas. Therefore, we summed the number of days each hexagon was surveyed to standardize the fishing effort (Figure 2). The sum of all fishing effort for each hexagon was divided by the number of survey-days within each hexagon to get the average fishing effort observed per survey for each hexagon. Each hexagon was color-coded based upon the sum of survey-days from high (dark brown) to low (yellow). Survey effort was concentrated mostly on the northeast, southeast, and west coast of Oahu

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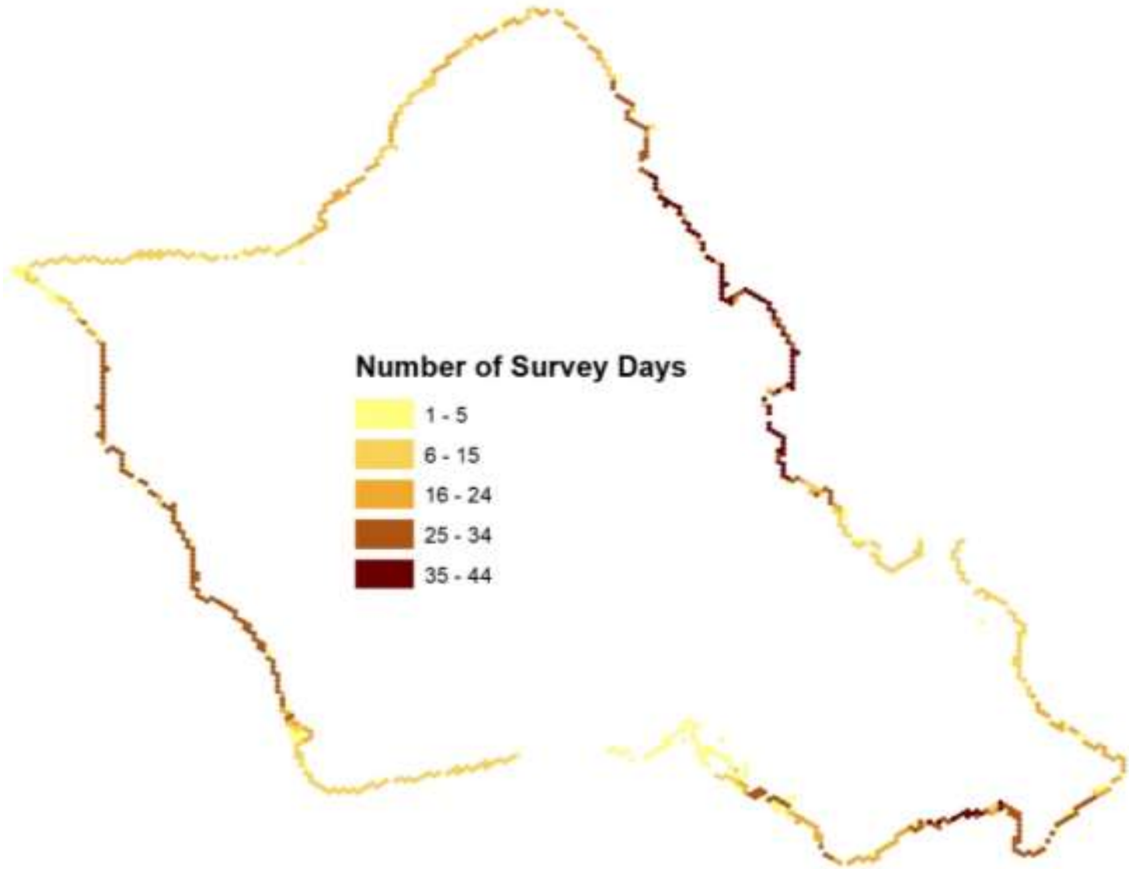


Figure 2. The total number of survey-days by area on Oahu

1.6.2.1.2 Results

Number of fishers

Downtown Honolulu on the south shore had the most consistent effort on average with the highest number of fishers found adjacent to a densely populated urban center. Barber's Point (southwest), Haleiwa (north), Waianae (west), and Kaiwi (southeast) also observed consistently high numbers of fishers. Although the number of fishers was lower than that of Honolulu, Ka'ena point also received a consistently higher number of fishers compared to the other coastal areas of Oahu (Figure 3); the reference height for each value (average count per survey) is shown in the middle of the figure.

Number of gears

The spatial pattern for the number of poles resembled that of fishers counts (Figure 3 and Figure 4) because pole fishing was the dominant fishing mode accounting for 92.7% of the effort observed. Similar to Figure 3, gear type and reference height for each value (average count per survey) is shown in the middle of each quadrant. Spearfishing was the next most observed fishing mode which was 4.4% of the total fishing effort (Table 31). Spearfishing was more localized around the leeward side of Ka'ena point (northwest), Barber's point (southwest), Honolulu (south), and the Kaiwi coast to Waimanalo (southeast). Although not particularly high in number, consistent spear fishing pressure along the eastern coastline from Kualoa ranch to Lāʻie was evident (Figure 4). Net fishing (aquarium collection, crab net, laynet, scoop net, thrownet) was observed infrequently during the survey consisting of only 1.8% of the total fishing effort observed (Table 31). Gleaning (crabbing, tako wading, paeaea pole, limu, opihi, and urchin picking) was rarely observed during the survey and thus no spatial patterns were determined.

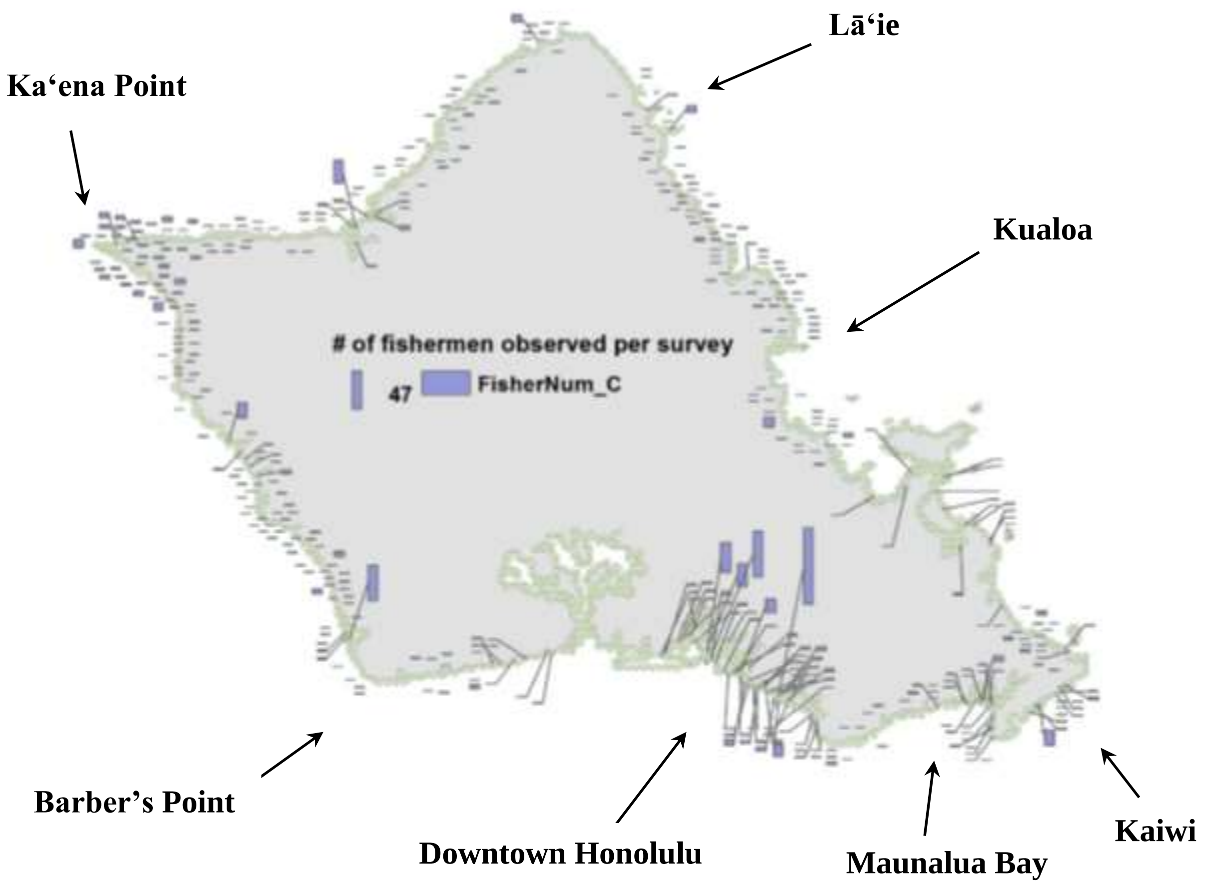


Figure 3. Average number of fishers observed per survey for each hexagon around Oahu

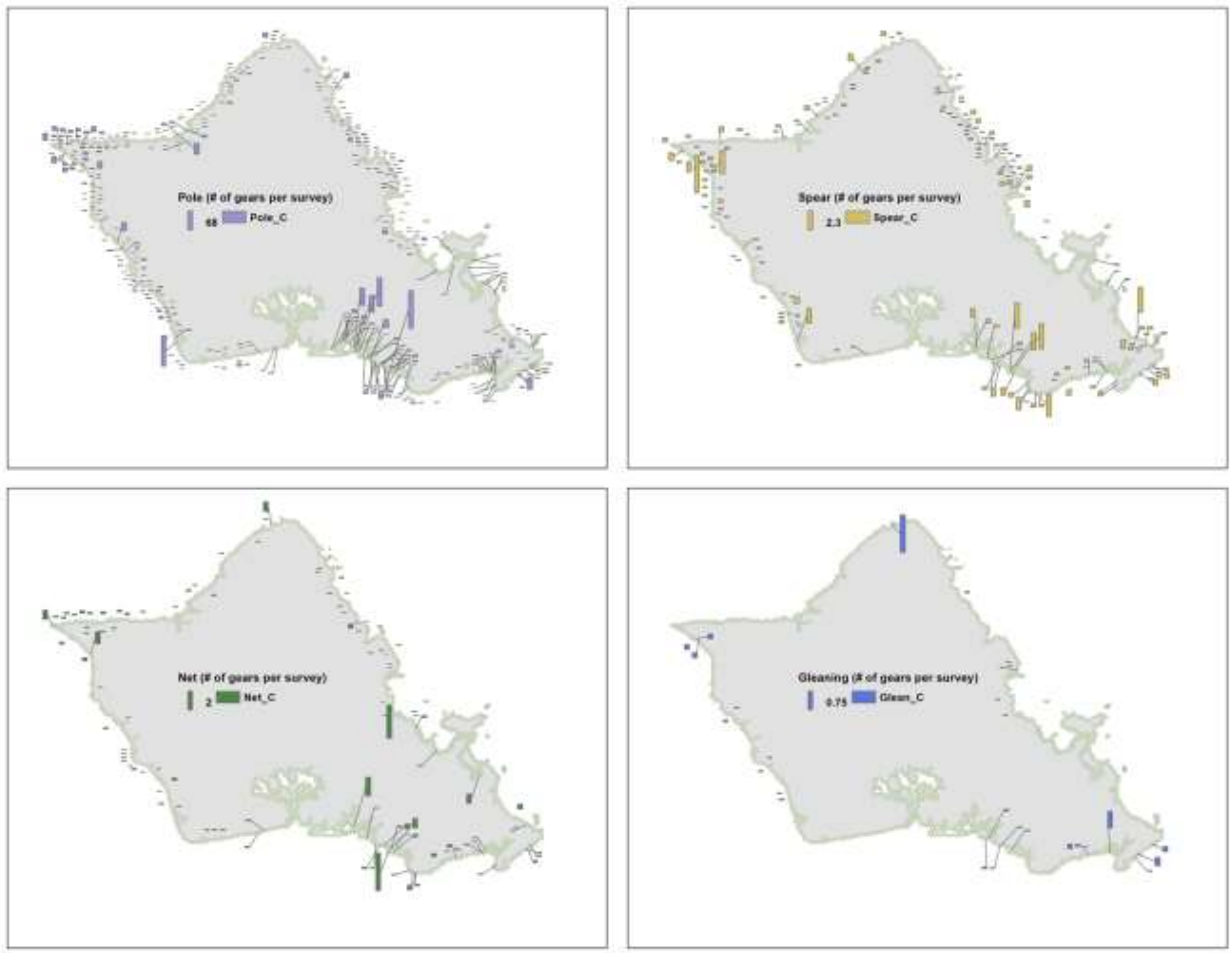


Figure 4. Fishing effort (number of gears) for each gear type observed around Oahu

Table 31. Total number of gears observed per roving shoreline survey

Gear Type	Total # of Gears	%
Glean	4	0.3
Net	25	1.8
Pole	1,314	92.7
Spear	63	4.4
Unknown	12	0.8
Total	**1,418**	**100**

Comparison with prediction model

DAR created a fishing effort prediction map based on HMRFS interview data using a boosted regression model (WPRFMC, 2017). In order to assess the accuracy of the spatial distribution of effort derived from the prediction model, the output for pole fishing was compared to the observed pole fishing effort from the roving shoreline survey. The prediction model estimated fishing effort in gear-hours whereas the roving shoreline survey recorded number of gears observed. To allow for comparison, the fishing effort within each hexagon was converted into a percentage of total fishing effort for Oahu (Figure 5). The comparison (Figure 5) was calculated by plotting the difference between the observed value and the predicted value (Difference = Observed - Predicted). The light blue areas show similar prediction values (within 0.2% difference). Overall, the prediction model over-estimated the fishing effort along the northeast, southeast, and west coast of Oahu, and under-estimated fishing effort around Ka'ena Point.

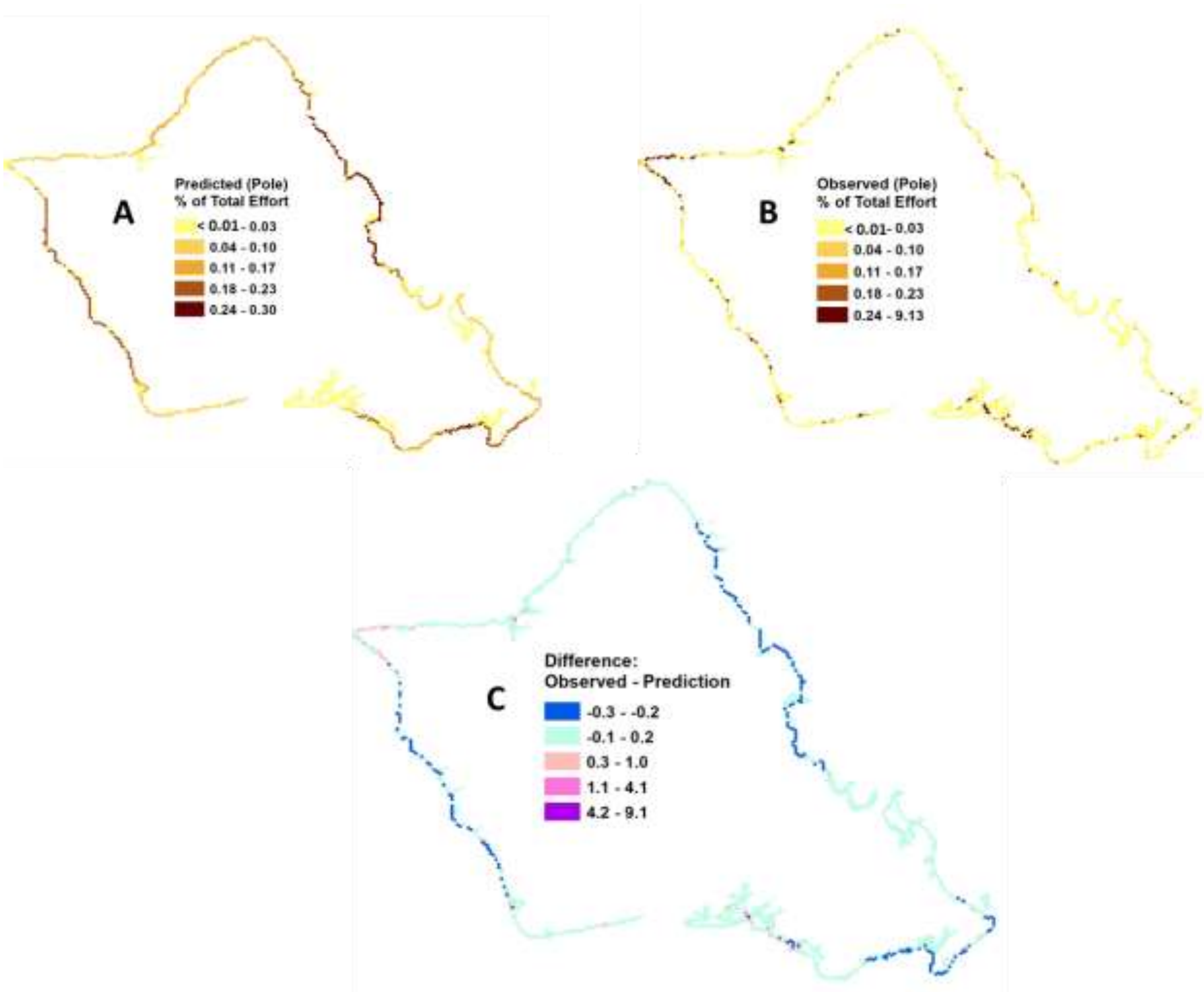


Figure 5. Comparison (C) of pole fishing effort between the prediction model (A) and observed shoreline survey data (B)

1.6.2.1.3 Discussion

The spatial pattern of fishing effort is crucial information when considering ecosystem-based management strategies. DAR Oahu's roving shoreline survey, although opportunistic, is a rare empirical, spatially explicit fishing effort data set. The observational data captures characteristics of the fisheries that can be difficult to predict. Though marine habitat, coastal access, shoreline terrain, and other more consistent factors can be used in a prediction model, other variables such as weather and swell height are highly variable and can influence fishing pressure on a daily basis. For example, the popularity of pole fishing is ubiquitous on Oahu. However, pole fishing effort tended to concentrate in certain areas contrary to what was predicted indicating unknown or highly variable factors affecting the effort. Maunalua Bay, for instance, did not result in uniformly high fishing effort as predicted by the model and was instead mostly concentrated around the beach park adjacent to the boat ramp. Honolulu and Ka'ena Point were two areas with the highest observed fishing pressure regardless of the fishing mode. These two areas are vastly different: Honolulu is a densely populated urban center whereas Ka'ena is very remote, harder to access, and relatively pristine. However, despite opposing differences in accessibility, proximity to domestic conveniences, target fisheries, as well as fishing motives (desired experience and outcome of trip), both areas experience relatively high fishing effort.

In general, the empirical dataset demonstrates that fishing effort does not disperse along the coastline as much as the model predicts. One notable difference between the current roving effort survey and the prediction output is that the roving survey quantifies number of gears and does not account for fishing time whereas the model calculates effort in gear-hours. This difference may further account for discrepancies between predicted versus actual fishing effort. Actual gear-hours can be calculated once the HMRFS shoreline creel survey transitions to a roving survey based on gear-hours. Changes to the HMRFS survey design are pending and are ultimately dependent upon certification and implementation by NOAA Fisheries' Marine Recreational Fishing Program. Once the design changes are approved and implemented, plans to align and merge the current DAR roving survey with the HMRFS survey is the next step.

1.7 NUMBER OF FEDERAL PERMIT HOLDERS

In Hawaii, the following Federal permits are required for fishing in the exclusive economic zone (EEZ) under the Hawaii FEP. Regulations governing fisheries under the Hawaii FEP are in the Code of Federal Regulations (CFR), Title 50, Part 665.

1.7.1 Special Coral Reef Ecosystem Permit

Regulations require the special coral reef ecosystem fishing permit for anyone fishing for coral reef ecosystem ECS in a low-use marine protected area (MPA), fishing for species on the list of Potentially Harvested Coral Reef Taxa or using fishing gear not specifically allowed in the regulations. NMFS will make an exception to this permit requirement for any person issued a permit to fish under any fishery ecosystem plan who incidentally catches Hawaii coral reef ECS while fishing for bottomfish MUS, crustacean MUS or ECS, western Pacific pelagic MUS, precious coral, or seamount groundfish. Regulations require a transshipment permit for any receiving vessel used to land or transship potentially harvested coral reef taxa, or any coral reef ECS caught in a low-use MPA.

1.7.2 Main Hawaiian Islands Non-Commercial Bottomfish

Regulations require this permit for any person, including vessel owners, fishing for bottomfish MUS or bottomfish ECS in the EEZ around the main Hawaiian Islands. If the participant possesses a current State of Hawaii Commercial Marine License, or is a charter fishing customer, he or she is not required to have this permit.

1.7.3 Western Pacific Precious Coral

Regulations require this permit for anyone harvesting or landing black, bamboo, pink, red, or gold corals in the EEZ in the western Pacific. The Papahānaumokuākea Marine National Monument prohibits precious coral harvests in the monument (Federal Register notice of final rule, 71 FR 51134, August 29, 2006). Regulations governing this fishery are in the CFR, Title 50, Part 665, Subpart F, and Title 50, Part 404 (Papahānaumokuākea Marine National Monument).

1.7.4 Western Pacific Crustaceans Permit

Regulations require a permit for the owner of a U.S. fishing vessel used to fish for lobster (now ECS) or deepwater shrimp in the EEZ around American Samoa, Guam, Hawaii, and the Pacific Remote Islands Areas (PRIAs), and in the EEZ seaward of three nautical miles of the shoreline of the CNMI.

Table 32 provides the number of permits issued to Hawaii FEP fisheries between 2010 and 2019. Historical data are from the PIFSC, and 2018–2019 data are from the PIRO Sustainable Fisheries Division permits program.

Table 32. Number of federal permits in Hawaii FEP fisheries from 2010-2019

Year	Special Coral Reef Ecosystem	MHI Non-Commercial Bottomfish	Precious Coral	Crustacean - Shrimp	Crustacean - Lobster
2010	0	28	2	0	3
2011	1	19	2	0	0
2012	1	11	2	2	1
2013	0	3	1	5	2
2014	0	3	1	7	2
2015	0	2	1	5	2
2016	1	1	1	4	1
2017	1	1	1	6	1
2018	1	2	1	11	3
2019	0	3	1	6	2

1.8 STATUS DETERMINATION CRITERIA

1.8.1 Bottomfish and Crustacean Fishery

Status determination criteria (SDC), overfishing criteria, and control rules are specified and applied to individual species within a multi-species stock whenever possible. When this is not possible, they are based on an indicator species for that multi-species stock. It is important to recognize that individual species would be affected differently based on this type of control rule, and it is important that for any given species, fishing mortality does not currently exceed a level that would result in excessive depletion of that species. No indicator species are used for the bottomfish multi-species stock complexes and the coral reef species complex. Instead, the control rules are applied to each stock complex as a whole.

The maximum sustainable yield (MSY) control rule is used as the maximum fishing mortality threshold (MFMT). The MFMT and minimum stock size threshold (MSST) are specified based on the recommendations of Restrepo et al. (1998) and both are dependent on the natural mortality rate (*M*). The value of *M* used to determine the reference point values are not specified in this document. The latest estimate published annually in the SAFE report is used, and the value is occasionally re-estimated using the best available information. The range of *M* among species within a stock complex is taken into consideration when estimating and choosing the *M* to be used for the purpose of computing the reference point values.

In addition to the thresholds MFMT and MSST, a warning reference point, B_{FLAG}, is specified at some point above the MSST to provide a trigger for consideration of management action prior to B_{FLAG} reaching the threshold. MFMT, MSST, and B_{FLAG} are specified as indicated in Table 33. Note that the MFMT listed here only applies to Hawaiian bottomfish.

Table 33. Overfishing threshold specifications for Hawaiian bottomfish and NWHI lobsters

MFMT	MSST	B_{FLAG}
$F(B) = \frac{F_{MSY} B}{c\,B_{MSY}}$ for $B \leq c\,B_{MSY}$ $F(B) = F_{MSY}$ for $B > c\,B_{MSY}$	$c\,B_{MSY}$	B_{MSY}
where c = max (1-M, 0.5)		

Standardized values of fishing effort (E) and catch-per-unit-effort (CPUE) are used as proxies for F and B, respectively, so E_{MSY}, $CPUE_{MSY}$, and $CPUE_{FLAG}$ are used as proxies for F_{MSY}, B_{MSY}, and B_{FLAG}, respectively.

In cases where reliable estimates of $CPUE_{MSY}$ and E_{MSY} are not available, they would be estimated from catch and effort times series, standardized for all identifiable biases. $CPUE_{MSY}$ would be calculated as half of a multi-year average reference CPUE, called $CPUE_{REF}$. The multi-year reference window would be objectively positioned in time to maximize the value of $CPUE_{REF}$. E_{MSY} would be calculated using the same approach or, following Restrepo et al. (1998), by setting E_{MSY} equal to E_{AVG}, where E_{AVG} represents the long-term average effort prior to declines in CPUE. When multiple estimates are available, the more precautionary option is typically used.

Since the MSY control rule specified here applies to multi-species stock complexes, it is important to ensure that no species within the complex has a mortality rate that leads to excessive depletion. In order to accomplish this, a secondary set of reference points is specified to evaluate stock status with respect to recruitment overfishing. A secondary "recruitment overfishing" control rule is specified to control fishing mortality with respect to that status. The rule applies only to those component stocks (species) for which adequate data are available. The ratio of a current spawning stock biomass proxy (SSB_{Pt}) to a given reference level ($SSBP_{REF}$) is used to determine if individual stocks are experiencing recruitment overfishing. SSBP is CPUE scaled by percent mature fish in the catch. When the ratio $SSBP_t/SSBP_{REF}$, or the "SSBP ratio" (SSBPR) for any species drops below a certain limit ($SSBPR_{MIN}$), that species is considered to be recruitment overfished and management measures will be implemented to reduce fishing mortality on that species. The rule applies only when the SSBP ratio drops below the $SSBPR_{MIN}$, but it will continue to apply until the ratio achieves the "SSBP ratio recovery target" ($SSBPR_{TARGET}$), which is set at a level no less than $SSBP_{RMIN}$. These two reference points and their associated recruitment overfishing control rule, which prescribe a target fishing mortality rate ($F_{RO\text{-}REBUILD}$) as a function of the SSBP ratio, are specified as indicated in Table 34. Again, E_{MSY} is used as a proxy for F_{MSY}.

Table 34. Recruitment overfishing control rule specifications for the BMUS in Hawaii

$F_{RO\text{-}REBUILD}$	$SSBPR_{MIN}$	$SSBPR_{TARGET}$
$F(SSBPR) = 0$ for $SSBPR \leq 0.10$ $F(SSBPR) = 0.2\,F_{MSY}$ for $0.10 < SSBPR \leq SSBPR_{MIN}$ $F(SSBPR) = 0.4\,F_{MSY}$ for $SSBPR_{MIN} < SSBPR \leq SSBPR_{TARGET}$	0.20	0.30

The Council adopted a rebuilding control rule for the NWHI lobster stock, which can be found in the supplemental overfishing amendment to the Sustainable Fisheries Act omnibus amendment on the Council's website.

1.8.2 Current Stock Status

1.8.2.1 Deep 7 Bottomfish Management Unit Species Complex

Despite availability of catch and effort (from which CPUE is derived), some life history, and fishery independent information, the Main Hawaiian Island Deep 7 BMUS complex is still considered as data moderate. The stock assessment is conducted on a subset of the population that is being actively managed because of the closure of the NWHI to commercial fishing. The assessment is also conducted on the Deep 7 species complex because the State of Hawaii designates the seven species together, and a typical bottom fishing trip is comprised primarily of these seven species.

Generally, data are only available on commercial fishing and associated CPUE by species. The 2018 benchmark stock assessment by PIFSC utilized a state-space surplus production model with explicit process and observation error terms (Langseth et al., 2018). Determinations of overfishing and overfished status were made by comparing current biomass and harvest rates to MSY-based reference points. As of 2015, the MHI Deep 7 bottomfish complex is not subject to overfishing and is not overfished (Table 35).

Table 35. Stock assessment parameters for the MHI Deep 7 bottomfish complex (Langseth et al., 2018)

Parameter	Value	Notes	Status
MSY for total catch	1.048 ± 0.481	Mean ± std. error, units in million lbs.	
MSY for reported catch	509,000 ± 233,000	Mean ± std. error, units in lbs.	
H_{2015}	4.0%		
H_{MSY}	6.9% ± 2.6%	Mean ± std. error	
H/H_{MSY}	0.51		No overfishing occurring
B_{2015}	20.03	Mean, units in million lbs.	
B_{MSY}	15.4 ± 4.9	Mean ± std. error, units in million lbs.	
B/B_{MSY}	1.31		Not overfished

1.8.2.2 Uku

The application of the SDCs for MUS in the coral reef fisheries of the MHI is limited due to various challenges. First, the thousands of species included in the coral reef MUS makes the SDC and status determination impractical. Second, the species-specific CPUE comes from Hawaii DAR Fisher Reporting System (FRS). The third challenge is that there has been no attempt to estimate MSY for the coral reef MUS until the 2007 re-authorization of the MSA that requires the Council to specify ACLs for species in the FEPs.

27 species of Hawaii reef fish and non-Deep 7 bottomfish were assessed by PIFSC using a length-based spawning potential ratio (SPR) method, with overfishing limits calculated as the catch level required to maintain SPR = 0.30 (defined as C_{30}) using either abundance from diver surveys or commercial catch estimates (Nadon, 2017). Since the assessment was finalized, only one species (uku, *Aprion virescens*) remains a management unit species. Results from the uku assessment are presented in Table 36.

Table 36. Results from 2016 stock assessment for MHI uku (*Aprion virescens*; Nadon, 2017)

Parameter	Value	Notes	Status
F	0.15 ± 0.07	Median ± SD, units yr^{-1}	
F_{30}	0.16 ± 0.01	Median ± SD, units yr^{-1}	
F/F_{30}	0.90 ± 0.5	Median ± SD	No overfishing occurring
SPR	0.33 ± 0.16	Median ± SD	
C_{30} from commercial catch	104,000 ± 226,000	Median ± SD, units kg	
C_{30} from diver survey	60,000 ± 12,100	Median ± SD, units kg	

1.8.2.3 Crustacean

The application of the SDCs for the crustacean MUS is only specified for the NWHI lobster stock. Previous studies conducted in the Main Hawaiian Islands estimated the MSY for spiny lobsters at approximately 15,000 – 30,000 lobsters per year of 8.26 cm carapace length or longer (WPFMC, 1983). There are insufficient data to estimate MSY values for MHI slipper lobsters. MSY for MHI deepwater shrimp has been estimated at 40 kg/nm^2 (Ralston and Tagami, 1992).

A stock assessment model was conducted by PIFSC in 2018 for Kona crab stock in the MHI (Kapur et al., 2019). This assessment used a Bayesian state-space surplus production model to estimate parameters needed to determine stock status. Based on this, the Kona crab stock is not overfished, and overfishing is not occurring (Table 37).

Table 37. Stock assessment parameters for the Hawaiian Kona crab stock (Kapur et al., 2019)

Parameter	Value	Notes	Status
MSY for total catch	73,069	In lbs.	
MSY for reported catch	25,870	In lbs.	
H_{2016}	0.0081	Expressed as proportion	
H_{MSY}	0.114	Expressed as proportion	
H/H_{MSY}	0.0714		No overfishing occurring
B_{2016}	885,057	In lbs.	
B_{MSY}	640,489	In lbs.	
B_{2016}/B_{MSY}	1.3977		Not overfished

For ACL-specification purposes, MSY for spiny lobsters are determined by using the Biomass-Augmented Catch-MSY approach (Sabater and Kleiber, 2014). This method estimates MSY using plausible combination rates of population increase (denoted by *r*) and carrying capacity (denoted by *k*) assumed from the catch time series, resilience characteristics (from FishBase), and biomass from existing underwater census surveys done by the Pacific Island Fisheries Science Center. This method was applied to species complexes grouped by taxonomic families. The most recent MSY estimates are found in Table 38.

Table 38. Best available MSY estimates for the Crustacean MUS in Hawaii

Fishery	Management Unit Species	MSY (lbs.)
Crustacean	Deep-water shrimp	598,328
	Kona crab	73,069

Sources: Deepwater shrimp (Tagami and Ralston, 1992); Kona crab (Kapur et al., 2019).

1.9 OVERFISHING LIMIT, ACCEPTABLE BIOLOGICAL CATCH, AND ANNUAL CATCH LIMITS

1.9.1 Brief description of the ACL process

The Council developed a tiered system of control rules to guide the specification of ACLs and Accountability Measures (AMs; WPRFMC, 2011). The process starts with the use of the best scientific information available (BSIA) in the form of, but not limited to, stock assessments, published papers, reports, and/or available data. These data are categorized into the different tiers in the control rule ranging from Tier 1 (i.e., most information available, typically a stock assessment) to Tier 5 (i.e., catch-only information). The control rules are applied to the BSIA. Tiers 1 to 3 involve conducting a Risk of Overfishing Analysis (denoted by P*) to quantify the scientific uncertainties associated with the assessment to specify the Acceptable Biological Catch (ABC), lowering the MSY-based OFL to the ABC. A Social, Ecological, Economic, and Management (SEEM) Uncertainty Analysis is performed to quantify the uncertainties associated with the SEEM factors, and a buffer is used to lower the ABC to an ACL. For Tier 4, which is comprised of stocks with MSY estimates but no active fisheries, the control rule is 91 percent of MSY. For Tier 5, which has catch-only information, the control rule is a one-third reduction in the median catch depending on a qualitative evaluation of stock status via expert opinion. ACL specification can choose from a variety of methods including the above mentioned SEEM analysis or a percentage buffer (i.e., percent reduction from ABC based on expert opinion) or the use of an Annual Catch Target (ACT). Specifications are done on an annual basis, but the Council normally produces a multi-year specification.

The AM for Hawaii bottomfish fisheries is an overage adjustment. The next ACL is downward adjusted with the amount of overage from the previous ACL based on a three-year running average.

1.9.2 Current OFL, ABC, ACL, and Recent Catch

The most recent multiyear specification of OFL, ABC, and ACL for the Deep 7 bottomfish, uku, crustaceans, and precious coral fisheries in the MHI was completed for fishing years 2019-2021. The fisheries for deep sea precious corals remain relatively inactive. ACLs are no longer specified for coral reef species nor several crustacean species due to the recent ecosystem component species amendment (84 FR 2767). The ACLs shown in Table 39 are the most recently recommended specified ACLs by NMFS.

The most recent multiyear specification of OFL, ABC, and ACL for the main Hawaiian island Deep 7 bottomfish complex was covers fishing years 2019-2021 and just 2019 for Kona crab. Note that the MHI Deep 7 stock complex operates based on fishing year and is still open. Recent average catch for the MHI Deep 7 Bottomfish stock complex (217,846 lbs.) accounted for 44.3% of its prescribed ACL (492,000 lbs.; Table 39).

Table 39. 2019 Hawaii ACL table with three-year recent average catch (lbs.)

Fishery	Management Unit Species	OFL	ABC	ACL	Catch
Bottomfish	MHI Deep 7 stock complex	558,000	508,000	492,000	217,846
	Aprion virescens – uku	132,277	127,205	127,205	98,770

Crustaceans	Deepwater shrimp	N.A.	250,773	250,773	n.d.
	Kona crab	N.A.	3,500	3,500	3,436
Precious coral	Auau channel black coral	8,250	7,500	5,512	n.d.
	Makapuu bed-pink coral	3,307	3,009	2,205	n.d.
	Makapuu bed-bamboo coral	628	571	551	n.d.
	180 fathom bank-pink coral	734	668	489	n.d.
	180 fathom bank-bamboo coral	139	126	123	n.d.
	Brooks bank-pink coral	1,470	1,338	979	n.d.
	Brooks bank-bamboo coral	280	256	245	n.d.
	Kaena point bed-pink coral	220	201	148	n.d.
	Kaena point bed-bamboo coral	42	37	37	n.d.
	Keahole bed-pink coral	220	201	148	n.d.
	Keahole bed-bamboo coral	42	37	37	n.d.
	Precious coral in HI exploratory area	N.A.	2,205	2,205	n.d.

The catch shown in Table 39 takes the average of the recent three years as recommended by the Council at its 160th meeting to avoid large fluctuations in catch due to data quality and outliers. "n.d." indicates that the data could not be disclosed due to issues with data confidentiality (i.e., less than three licenses fishing).

1.10 BEST SCIENTIFIC INFORMATION AVAILABLE

1.10.1 Main Hawaiian Island Deep 7 Bottomfish Fishery

1.10.1.1 Stock Assessment Benchmark

In 2018, NOAA's Pacific Islands Fisheries Science Center (PIFSC) completed a benchmark stock assessment for the MHI Deep 7 bottomfish fishery (2018 stock assessment) using data through 2015 (Langseth et al., 2018). The 2018 stock assessment used a Bayesian state-space surplus production model and included several improvements, such as updated filtering and standardization methods for CPUE from commercial data based on a series of workshops that included input from various management, scientific, and industry participants (Yau, 2018). It also incorporated a fishery-independent estimate of abundance as estimated from Richards et al. (2016).

The 2018 assessment estimates a maximum sustainable yield (MSY) for reported catch of 509,000 lbs. for the MHI Deep 7 bottomfish stock complex. The 2018 stock assessment also included projection results of a range of commercial catches of Deep 7 bottomfish that would produce probabilities of overfishing ranging from 0 percent to 100 percent and 1 percent intervals. If 558,000 lbs. of reported catch occur from fishing years 2018-2022, there is a 50% risk of overfishing in 2022; this is the overfishing limit.

1.10.1.2 Current Best Available Scientific Information

National Standard 2 requires that conservation and management measures be based on the best scientific information available and be founded on comprehensive analyses. National Standard 2 guidelines (78 FR 43087, July 19, 2013) state that scientific information that is used to inform decision making should include an evaluation of its uncertainty and identify gaps in the information (50 CFR 600.315(a)(1). The guidelines also recommend scientific information used to support conservation and management be peer reviewed (50 CFR 600.315(a)(6)(vii)). However, the guidelines also state that mandatory management actions should not be delayed due to limitations in the scientific information or the promise of future data collection or analysis (50 CFR 600.315(a)(6)(v)).

The PIFSC determined that the 2018 benchmark stock assessment by Langseth et al. (2018) was the best scientific information available. This is based on the assessment passing a Western Pacific Stock Assessment Review by a 3-person independent peer review panel.

1.10.2 Uku Fishery

1.10.2.1 Stock Assessment

In February 2017, PIFSC released the final species level assessment for the main Hawaiian Islands (Nadon, 2017). This assessment covers 27 species of fishes, one of which is uku (*Aprion virescens*). The remaining 26 species are no longer management unit species.

This assessment utilized a different approach compared to the existing model used for the FY 2015-2018 specification. It used life history information and a length-based approach to obtain stock status based on spawning potential ratio (SPR) rather than MSY. When life history information is not available for a species, a data-poor approach is used to simulate life history parameters based on known relationships (Nadon and Ault, 2016). Fishery independent size composition and abundance data from diver surveys were combined with fishery dependent catch estimates to calculate current fishing mortality rates (*F*), spawning potential ratios (SPR), SPR-based sustainable fishing rates (F_{30}; *F* resulting in SPR = 30%), and catch levels corresponding to these sustainable rates (C_{30}). A length-based model was used to obtain mortality rates and a relatively simple age-structured population model to find the various SPR-based stock status metrics. The catch level to maintain the population at SPR=30%, notated as C_{30}, was obtained by combining F_{30} estimates with current population biomass estimates derived directly from diver surveys or indirectly from the total catch. The overfishing limits (OFL) corresponding to a 50% risk of overfishing was defined as the median of the C_{30} distribution.

These assessments have undergone substantial peer review starting with the CIE review on September 8 to 11, 2015 (Dichmont, 2015; Pilling, 2015; Stokes, 2015) which focused on the individual method. The assessment author addressed the CIE review comments and recommendations and developed a stock assessment report that was reviewed by a Western Pacific Stock Assessment Review panel from August 29, 2016 to September 2, 2016 (Choat, 2016; Franklin, 2016a; Franklin, 2016b; Stokes, 2016) which was asked to review the application of the method to individual species. The assessment author revised the draft assessment addressing the WPSAR panel comments and recommendation and presented the final stock assessment document at the 125th and 169th meeting of the SSC and Council, respectively. PIFSC and the Council consider these assessments the best scientific information available for these species.

1.10.3 Crustacean Fishery

1.10.3.1 Stock Assessment Benchmark

Deep-water Shrimp: The deep-water shrimp (*Heterocarpus laevigatus* and *H. ensifer*) initial resource assessment was conducted in the early 1990s by Ralston and Tagami (1992). This involved depletion experiments, stratified random sampling of different habitats, and calculation of exploitable biomass using the Ricker equation (Ricker, 1975). Since then no new estimates were calculated for this stock.

Kona Crab: A benchmark stock assessment model was completed by PIFSC scientists in 2019 (Kapur et al., 2019). This assessment utilized a Bayesian state-space surplus production model. Based on this, the Kona crab stock is not overfished and not experiencing overfishing.

PIFSC determined the Kapur et al. (2019) stock assessment to be the best scientific information available for Kona crabs because the assessment passed independent peer review by a WPSAR three-person panel.

1.10.3.2 Stock Assessment Updates

There are no stock assessment updates available for the crustacean MUS.

1.10.3.3 Best Scientific Information Available

To date the best available scientific information for the crustacean MUS are as follows:

- Deepwater shrimp – Ralston and Tagami (1992)
- Kona crab – Kapur et al. (2019)

1.11 HARVEST CAPACITY AND EXTENT

The MSA defines the term "optimum," with respect to the yield from a fishery, as the amount of fish which:

- Will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems.
- Is prescribed based on the MSY from the fishery, as reduced by any relevant social, economic, or ecological factor.
- In the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery [50 CFR §600.310(f)(1)(i)].

Optimum yield (OY) in the bottomfish fisheries is prescribed based on the MSY from the stock assessment and the best available scientific information. In the process of specifying ACLs, social, economic, and ecological factors were considered and the uncertainties around those factors defined the management uncertainty buffer between the ABC and ACL. OY for the bottomfish MUS complex is defined to be the level of harvest equal to the ACL consistent with the goals and objectives of the FEPs and used by the Council to manage the stock.

The Council recognizes that MSY and OY are long-term values whereas the ACLs are yearly snapshots based on the level of fishing mortality at MSY (F_{MSY}). There are situations when the long-term means around MSY are lower than ACLs especially if the stock is known to be productive or relatively pristine or lightly fished. A stock can have catch levels and catch rates exceeding that of MSY over the short-term to lower the biomass to a level around the estimated MSY and still not jeopardize the stock.

The harvest extent, in this case, is defined as the level of catch harvested in a fishing year relative to the ACL or OY. The harvest capacity is the level of catch remaining in the annual catch limit that can potentially be used for the total allowable level of foreign fishing (TALFF). Table 40 summarizes the harvest extent and harvest capacity information for Hawaii in 2019 using three-year average catch.

Table 40. Hawaii proportion of harvest capacity and extent relative to the ACL in 2019

Fishery	Management Unit Species	ACL	Catch (lbs.)	Harvest Extent (%)	Harvest Capacity (%)
Bottomfish	MHI Deep 7 stock complex	492,000	217,846	44.3	55.7
	Aprion virescens – uku	127,205	98,770	77.6	22.4
Crustaceans	Deepwater shrimp	250,773	n.d.	N.A.	N.A.
	Kona crab	3,500	3,436	98.2	1.8
Precious coral	Auau channel-black coral	5,512	n.d.	N.A.	N.A.
	Makapuu bed-pink coral	2,205	n.d.	N.A.	N.A.
	Makapuu bed-bamboo coral	551	n.d.	N.A.	N.A.
	180 fathom bank-pink coral	489	n.d.	N.A.	N.A.
	180 fathom bank-bamboo coral	123	n.d.	N.A.	N.A.

Fishery	Management Unit Species	ACL	Catch (lbs.)	Harvest Extent (%)	Harvest Capacity (%)
	Brooks bank-pink coral	979	n.d.	N.A.	N.A.
	Brooks bank-bamboo coral	245	n.d.	N.A.	N.A.
	Kaena point bed-pink coral	148	n.d.	N.A.	N.A.
	Kaena point bed-bamboo coral	37	n.d.	N.A.	N.A.
	Keahole bed-pink coral	148	n.d.	N.A.	N.A.
	Keahole bed-bamboo coral	37	n.d.	N.A.	N.A.
	Precious coral in HI exploratory area	2,205	n.d.	N.A.	N.A.

"n.d." indicates non-disclosure of data due to issues with confidentiality (i.e., less than three licenses).

1.12 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions NMFS implemented for insular fisheries in the Hawaiian Archipelago during calendar year 2019.

February 8, 2019. Final rule: **Reclassifying Management Unit Species to Ecosystem Component Species**. This final rule reclassified certain management unit species in the Pacific Islands as ecosystem component species. The rule also updated the scientific and local names of certain species. The intent of this final rule was to prioritize conservation and management efforts and to improve efficiency of fishery management in the region. This rule was effective March 11, 2019.

February 21, 2019. Annual harvest guideline: **2019 Northwestern Hawaiian Islands Lobster Harvest Guideline**. NMFS established the annual harvest guideline for the commercial lobster fishery in the NWHI for calendar year 2019 at zero lobsters. Regulations at 50 CFR 665.252(b) require NMFS to publish an annual harvest guideline for lobster Permit Area 1, comprised of Federal waters around the NWHI. Regulations governing the Papahānaumokuākea Marine National Monument in the NWHI prohibit the unpermitted removal of monument resources (50 CFR 404.7) and establish a zero annual harvest guideline for lobsters (50 CFR 404.10(a)). Accordingly, NMFS established the harvest guideline for the NWHI commercial lobster fishery for calendar year 2019 at zero lobsters. Harvest of NWHI lobster resources was not allowed.

June 24, 2019. Final rule: **Annual Catch Limit and Accountability Measures; Main Hawaiian Islands Deep 7 Bottomfish**. This final rule established an ACL of 492,000 lbs. for Deep 7 bottomfish in the MHI for each of the three fishing years 2018–19, 2019–20, and 2020–21. If NMFS projects that the fishery will reach the ACL in any given fishing year, NMFS would close the commercial and non-commercial fisheries for MHI Deep 7 bottomfish in Federal waters for the remainder of that fishing year as an accountability measure. This rule also made housekeeping changes to the Federal bottomfish fishing regulations. This rule supports the long-term sustainability of Deep 7 bottomfish.

2 ECOSYSTEM CONSIDERATIONS

2.1 CORAL REEF FISH ECOSYSTEM PARAMETERS

2.1.1 Regional Reef Fish Biomass and Habitat Condition

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2019. Hard Coral cover is mean cover derived from visual estimates by divers of sites where reef fish surveys occurred.

Rationale: Reef fish biomass has been widely used as an indicator of relative ecosystem status and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime. Hard coral cover is an indicator of relative status of the organisms that build coral reef habitat and has been shown to be sensitive to changes in oceanographic regime, and a range of direct and indirect anthropogenic impacts. Most fundamentally, cover of hard corals has been increasingly impacted by temperature stress as a result of global heating.

Data Category: Fishery-independent

Timeframe: Triennial

Jurisdiction: American Samoa, Guam, Commonwealth of the Northern Mariana Islands (CNMI), Main Hawaiian Islands (MHI), Northwestern Hawaiian Islands (NWHI), and Pacific Remote Island Areas (PRIAs)

Spatial Scale: Regional

Data Source: Data used to generate cover and biomass estimates come from visual surveys conducted by the National Marine Fisheries Service (NMFS) Pacific Island Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) and their partners as part of the Pacific Reef Assessment and Monitoring Program (RAMP). Survey methods are described in detail In Ayotte et al. (2015). In brief, they involve teams of divers conducting stationary point count cylinder (SPC) surveys within a target domain of < 30 meter hard-bottom habitat at each island, stratified by depth zone and, for larger islands, by section of coastline. For consistency among islands, only data from forereef habitats are used. At each SPC, divers record the number, size, and species of all fishes within or passing through paired 15 meter-diameter cylinders over the course of a standard count procedure.

Fish sizes and abundance are converted to biomass using standard length-to-weight conversion parameters, taken largely from FishBase and converted to biomass per unit area by dividing by the area sampled per survey. Site-level data were pooled into island-scale values by first calculating mean and variance within strata, and then calculating weighted island-scale mean and variance using the formulas given in Smith et al. (2011) with strata weighted by their respective sizes.

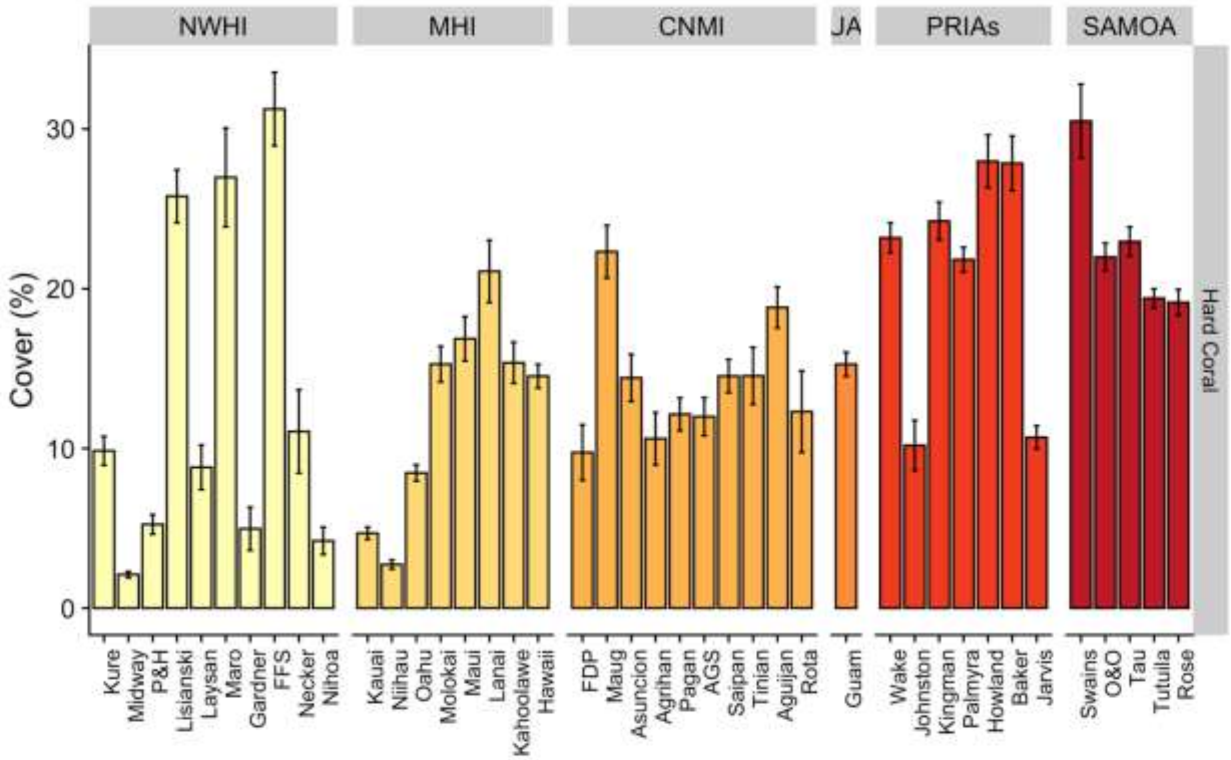


Figure 6. Mean coral cover (%) per U.S. Pacific island averaged over the years 2010-2019 by latitude

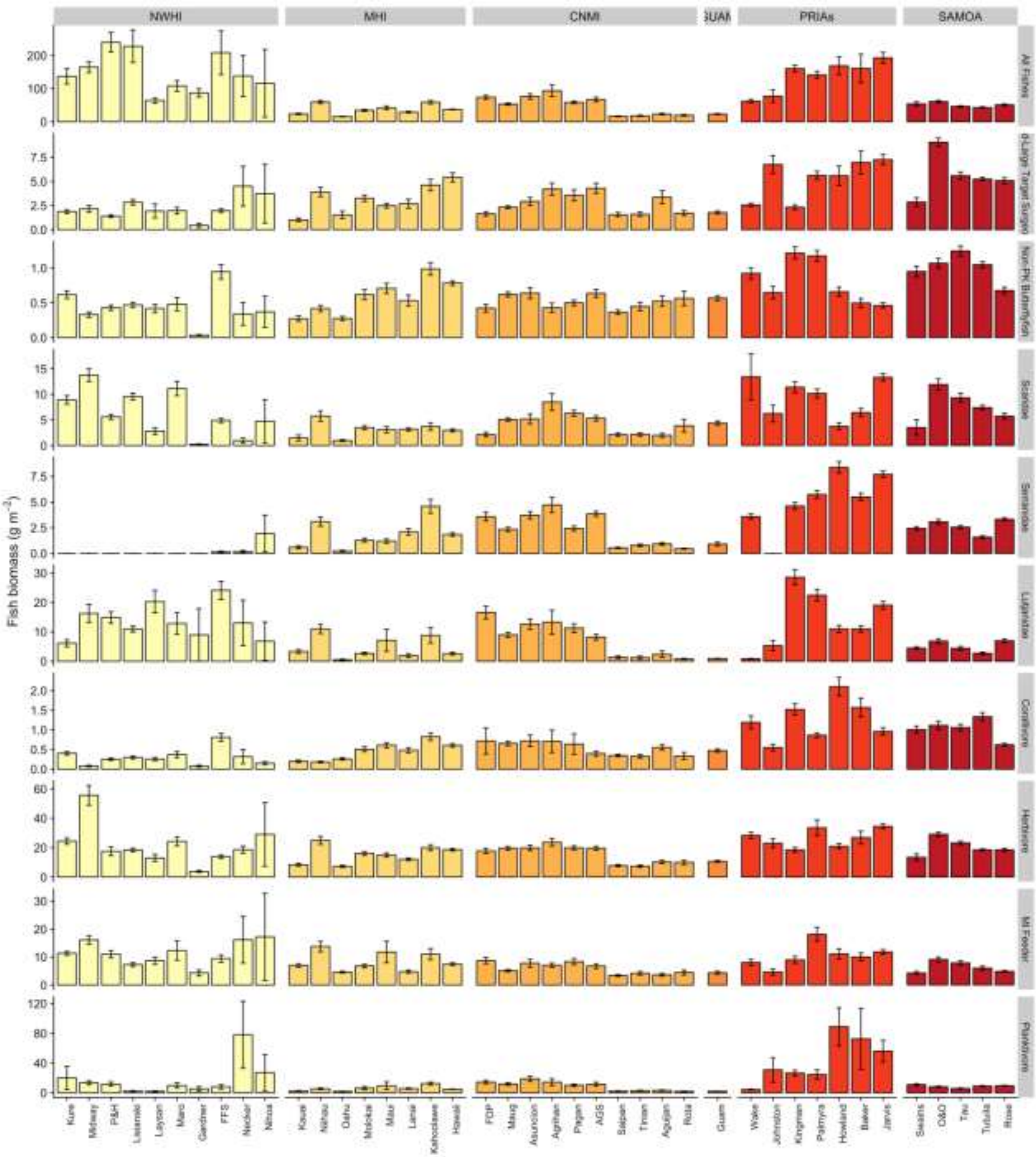


Figure 7. Mean fish biomass (g/m^2 ± standard error) of functional, taxonomic and trophic groups by U.S. Pacific reef area from the years 2010-2019 by latitude. The group Serranidae excludes planktivorous members of that family – i.e. anthias, which can by hyper-abundant in some regions. Similarly, the bumphead parrotfish, *Bolbometopon muricatum*, has been excluded from the corallivore group – as high biomass of that species at Wake overwhelms corallivore biomass at all other locations. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates

2.1.2 Main Hawaiian Islands Reef Fish Biomass and Habitat Condition

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2019. Hard Coral cover is mean cover derived from visual estimates by divers of sites where reef fish surveys occurred.

Rationale: Reef fish biomass has been widely used as an indicator of relative ecosystem status and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime. Hard coral cover is an indicator of relative status of the organisms that build coral reef habitat and has been shown to be sensitive to changes in oceanographic regime, and a range of direct and indirect anthropogenic impacts. Most fundamentally, cover of hard corals has been increasingly impacted by temperature stress as a result of global heating.

Data Category: Fishery-independent

Timeframe: Triennial

Jurisdiction: MHI

Spatial Scale: Island

Data Source: Data used to generate biomass and cover estimates comes from visual surveys conducted by NOAA PIFSC ESD and their partners, as part of the Pacific RAMP. Survey methods and sampling design, and methods to generate reef fish biomass are described in Section 2.1.1.

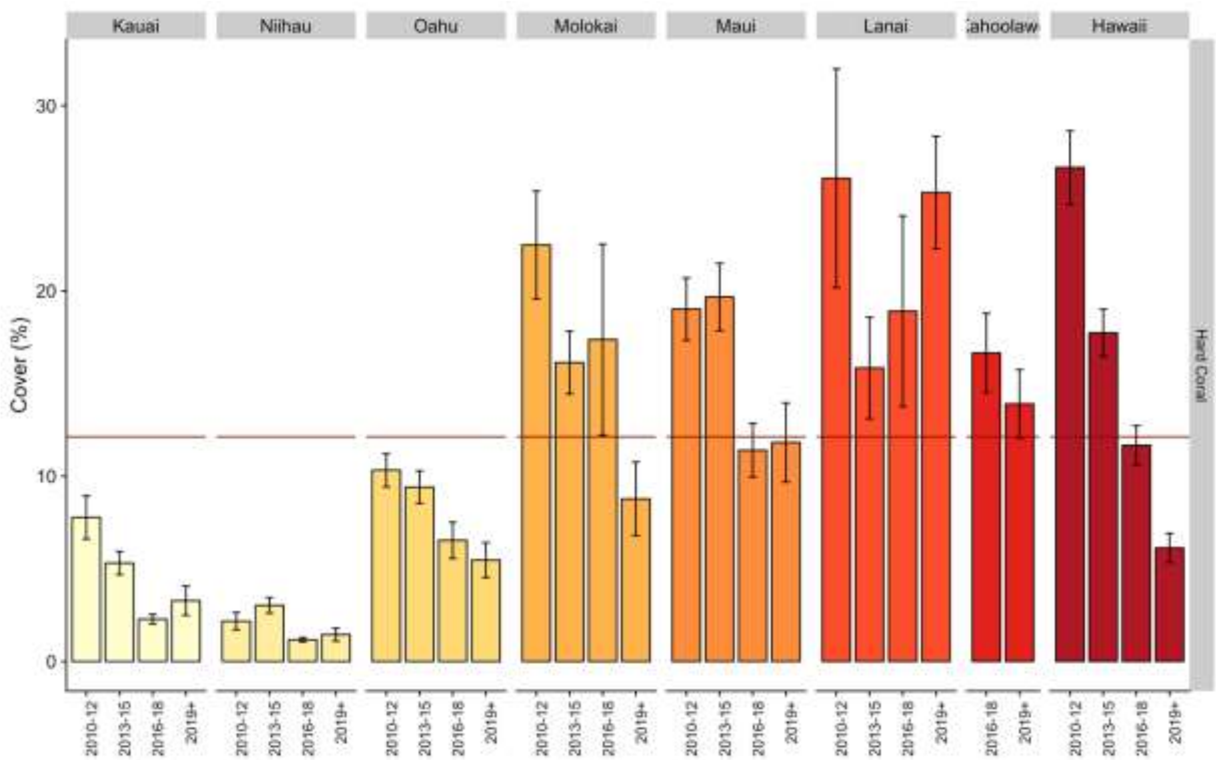


Figure 8. Mean coral cover (%) per island averaged over the years 2010-2019 by latitude with MHI mean estimates plotted for reference (red line)

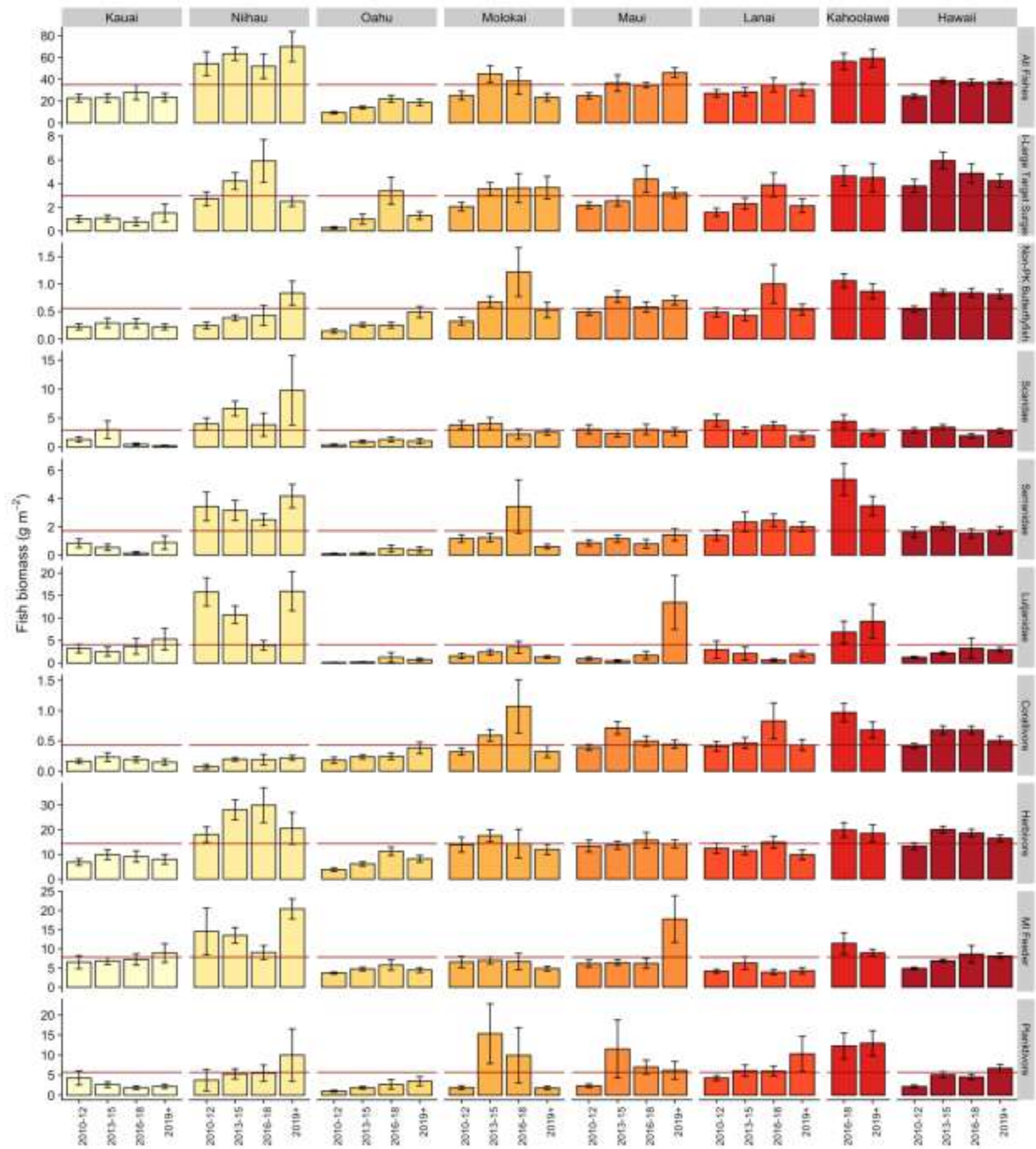


Figure 9. Mean fish biomass (g/m^2 ± standard error) of MHI functional, taxonomic and trophic groups from the years 2010-2019 by island. The group Serranidae excludes planktivorous members of that family – i.e. anthias, which can by hyper-abundant in some regions. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates; with MHI mean estimates plotted for reference (red line)

2.1.3 Northwestern Hawaiian Islands Reef Fish Biomass and Habitat Condition

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2019. Hard Coral cover is mean cover derived from visual estimates by divers of sites where reef fish surveys occurred.

Rationale: Reef fish biomass has been widely used as an indicator of relative ecosystem status and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime. Hard coral cover is an indicator of relative status of the organisms that build coral reef habitat and has been shown to be sensitive to changes in oceanographic regime, and a range of direct and indirect anthropogenic impacts. Most fundamentally, cover of hard corals has been increasingly impacted by temperature stress as a result of global heating.

Data Category: Fishery-independent

Timeframe: Triennial

Jurisdiction: NWHI

Spatial Scale: Island

Data Source: Data used to generate biomass and cover estimates comes from visual surveys conducted by NOAA PIFSC ESD and their partners, as part of the Pacific RAMP. Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2.1.1).

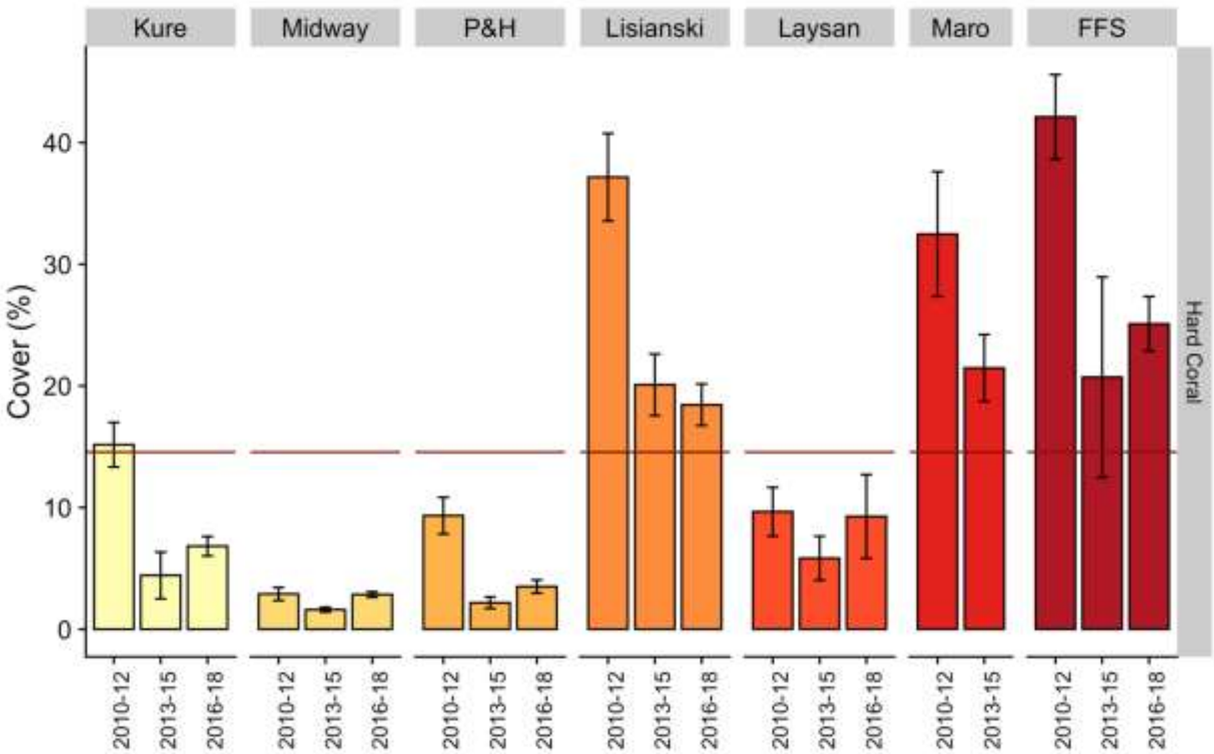


Figure 10. Mean coral cover (%) per island averaged over the years 2010-2019 by latitude with NWHI mean estimates plotted for reference (red line)

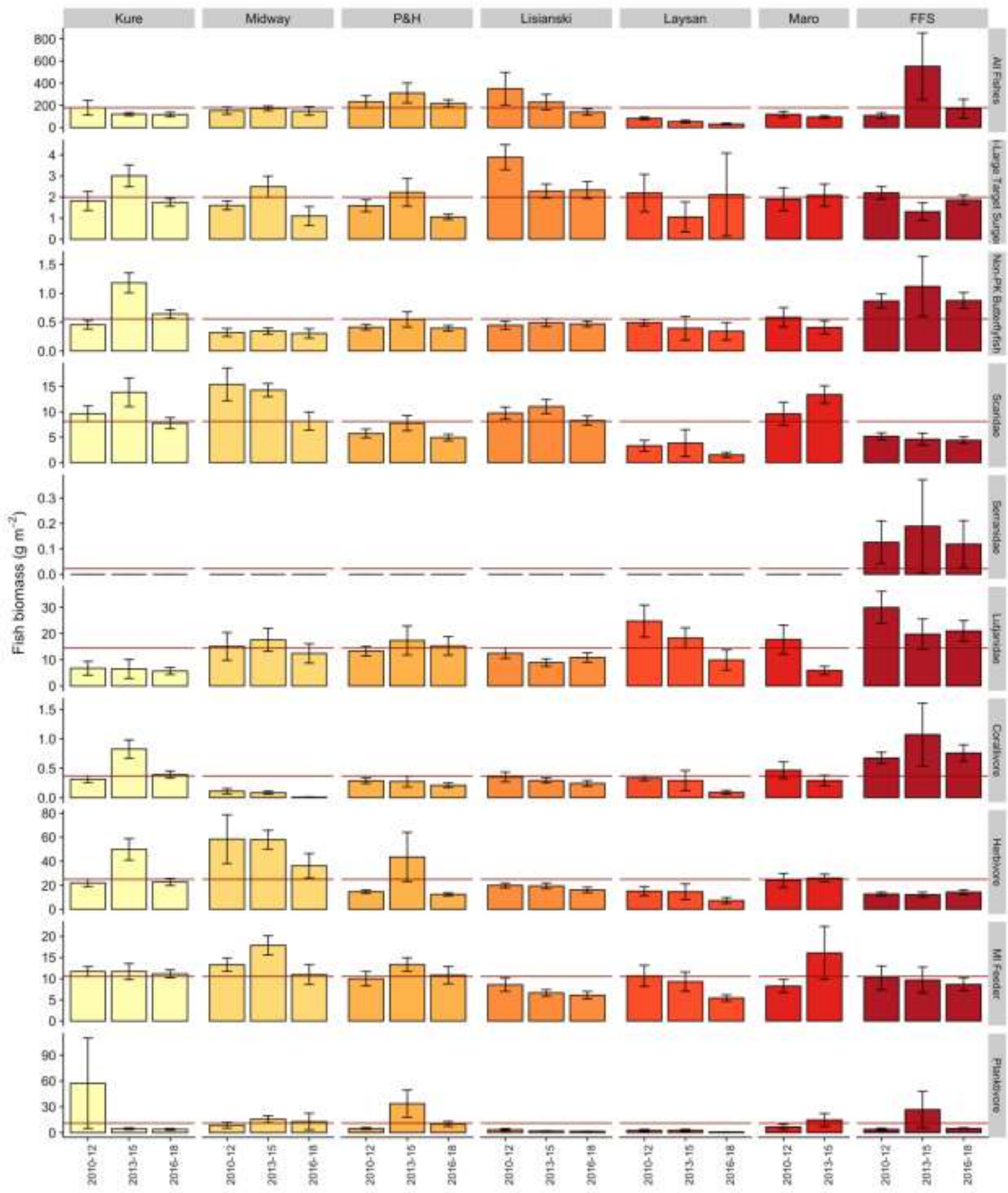


Figure 11. Mean fish biomass (g/m^2 ± standard error) of NWHI functional, taxonomic and trophic groups from the years 2010-2019 by island. The group Serranidae excludes planktivorous members of that family – i.e. anthias, which can by hyper-abundant in some regions. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates; with NWHI mean estimates plotted for reference (red line)

2.2 LIFE HISTORY AND LENGTH DERIVED PARAMETERS

2.2.1 MHI Coral Reef Ecosystem Components Life History

2.2.1.1 Age, Growth, and Reproductive Maturity

Description: Age determination is based on counts of yearly growth marks (annuli) and/or daily growth increments (DGIs) internally visible within transversely cut, thin sections of sagittal otoliths. Validated age determination is based on several methods including an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. Fish growth is estimated by fitting the length-at-age data to a von Bertalanffy growth function (VBGF). This function typically uses three coefficients (L_∞, k, and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex and these data are fitted to a three- or four-parameter logistic function to determine the best fit of these data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region) - such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes - standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and age at 50% sex reversal ($A\Delta_{50}$) is typically derived by referencing the VBGF for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age & growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Data Category: Biological

Timeframe: N/A

Jurisdiction: MHI and NWHI

Spatial Scale: Archipelagic

Data Source: Sources of data are directly derived from research cruises sampling and market samples purchased from local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC Life History Program (LHP). Refer to the "Reference" column in Table 41 for specific details on data sources by species.

Parameter definitions:

T_{max} (maximum age) – The maximum observed age revealed from an otolith-based age determination study. T_{max} values can be derived from ages determined by annuli counts of sagittal otolith sections and/or bomb radiocarbon (^{14}C) analysis of otolith core material. Units are years.

L_∞ (asymptotic length) – One of three coefficients of the VBGF that measures the mean maximum length at which the growth curve plateaus and no longer increases in length with increasing age. This coefficient reflects the estimated mean maximum length and not the observed maximum length. Units are centimeters.

k (growth coefficient) – One of three coefficients of the VBGF that measures the shape and steepness by which the initial portion of the growth function approaches its mean maximum length (L_∞).

t_0 (hypothetical age at length zero) – One of three coefficients of the VBGF whose measure is highly influenced by the other two VBGF coefficients (k and L_∞) and typically assumes a negative value when specimens representing early growth phases) are not available for age determination. This parameter can be fixed at 0. Units are years.

M (natural mortality) – This is a measure of the mortality rate for a fish stock and is considered to be directly related to stock productivity (i.e., high M indicates high productivity and low M indicates low stock productivity). M can be derived through use of various equations that link M to T_{max} and the VBGF coefficients (k and L_∞) or by calculating the value of the slope from a regression fit to a declining catch curve (regression of the natural logarithm of abundance versus age class) derived from fishing an unfished or lightly fished population.

A_{50} (age at 50% maturity) – Age at which 50% of the sampled stock under study has attained reproductive maturity. This parameter is best determined based on studies that concurrently determine both age (otolith-based age data) and reproductive maturity status (logistic function fitted to percent mature by age class with maturity determined via microscopic analyses of gonad histology preparations). A more approximate means of estimating A_{50} is to use an existing L_{50} estimate to find the corresponding age (A_{50}) from an existing VBGF curve. Units are years.

$A\Delta_{50}$ (age of sex switching) – Age at which 50% of the immature and adult females of the sampled stock under study is undergoing or has attained sex reversal. This parameter is best determined based on studies that concurrently determines both age (otolith-based age data) and reproductive sex reversal status (logistic function fitted to percent sex reversal by age class with sex reversal determined via microscopic analyses of gonad histology preparations). A more approximate means of estimating $A\Delta_{50}$ is to use an existing $L\Delta_{50}$ estimate to find the corresponding age ($A\Delta_{50}$) from the VBGF curve. Units are years.

***L_{50}* (length at which 50% of a fish population are capable of spawning)** – Length at which 50% of the females of a sampled stock under study has attained reproductive maturity; this is the length associated with A_{50} estimates. This parameter is derived using a logistic function to fit the percent mature data by length class with maturity status best determined via microscopic analyses of gonad histology preparations. L_{50} information is typically more available than A_{50} since L_{50} estimates do not require knowledge of age and growth. Units are centimeters.

***$L\Delta_{50}$* (length of sex switching)** – Length at which 50% of the immature and adult females of the sampled stock under study is undergoing or has attained sex reversal; this is the length associated with $A\Delta_{50}$ estimates. This parameter is derived using a logistic function to fit the percent sex reversal data by length class with sex reversal status best determined via microscopic analyses of gonad histology preparations. $L\Delta_{50}$ information is typically more available than $A\Delta_{50}$ since $L\Delta_{50}$ estimates do not require knowledge of age and growth. Units are centimeters.

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. Currently, the assessment of coral reef ecosystem resources in Hawaii are data limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and also provide important biological inputs for future stock assessment efforts and enhance our understanding of the species-likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 41. Available age, growth, and reproductive maturity information for coral reef ecosystem component species in the Hawaiian Archipelago

Species	Age, growth, and reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Acanthurus triostegus										
Calotomus carolinus	4[d]					1.3[d]	3.2 [d]	24[d]	37[d]	DeMartini et al., (2017); DeMartini and Howard (2016)
Caranx melampygus										
Cellana spp.										
Chlorurus perspicillatus	19[d]	53.2[d]	0.23[d]	-1.48[d]		3.1[d]	7 [d]	34[d]	46[d]	DeMartini et al., (2017); DeMartini and Howard (2016)
Chlorurus spilurus	11[d]	34.4[d]	0.40[d]	-0.13[d]		1.5[d]	4 [d]	17[d]	27[d]	DeMartini et al., (2017); DeMartini and Howard (2016)
Kyphosus bigibbus										
Lobster										
Lutjanus										

Species	Age, growth, and reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
kasmira										
Naso annulatus										
Octopus cyanea										
Panulirus marginatus		104.33-147.75[d]	0.05-0.58[d]					40.5[d]		O'Malley (2009); DeMartini et al., (2005)
Parupeneus porphyus										
Scaridae										
Scarus psittacus	6[d]	32.7[d]	0.49[d]	-0.01[d]		1[d]	2.4 [d]	14[d]	23[d]	DeMartini et al., (2017); DeMartini and Howard (2016)
Scarus rubroviolaceus	19[d]	53.5[d]	0.41[d]	0.12[d]		2.5[d]	5 [d]	35[d]	47[d]	DeMartini et al., (2017); DeMartini and Howard (2016)
Scyllarides squammosus		X[a]	X[a]					51.1		O'Malley (2009); DeMartini et al., (2005)
Naso unicornis	54[d]	47.8[d]	0.44[d]	-0.12[d]				f=35.5[d] m=30.1[d]		Andrews et al. (2016) DeMartini et al. (2014)

[a] signifies estimate pending further evaluation in an initiated and ongoing study.
[b] signifies a preliminary estimate taken from ongoing analyses.
[c] signifies an estimate documented in an unpublished report or draft manuscript.
[d] signifies an estimate documented in a finalized report or published journal article (including in press).

Parameter estimates are for females unless otherwise noted (F=females, M=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm fork length (FL); k in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable.

2.2.2 MHI Bottomfish Management Unit Species Life History

2.2.2.1 Age, Growth, and Reproductive Maturity

<u>Description</u>: Age determination is based on counts of yearly growth marks (annuli) and/or DGIs internally visible within transversely cut, thin sections of sagittal otoliths. Validated age determination is based on several methods including an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. Fish growth is estimated by fitting the length-at-age data to a VBGF. This function typically uses three coefficients (L_∞, k, and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex and these data are fitted to a three- or four-parameter logistic function to determine the best fit of these data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region) - such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes - standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and age at 50% sex reversal ($A\Delta_{50}$) is typically derived by referencing the VBGF for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age & growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Data Category: Biological

Timeframe: N/A

Jurisdiction: MHI and NWHI

Spatial Scale: Archipelagic

Data Source: Sources of data are directly derived from research cruises sampling and market samples purchased from local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC LHP. Refer to the "Reference" column in Table 42 for specific details on data sources by species.

Parameter Definitions: Identical to Section 2.2.2.1

Table 42. Available age, growth, reproductive maturity, and natural mortality information for bottomfish MUS in the Hawaiian Archipelago

Species	Age, growth, and reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Aphareus rutilans							NA		NA	

Species	Age, growth, and reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Aprion virescens	27[c]	72.7 1[c]	0.33[c]		0.24[c]		NA	42.5-47.5[d]	NA	Everson et al. (1989); O'Malley et al. (in prep.)
Etelis carbunculus	22[c]	50.3[c]	0.07[c]				NA	23.4[d]	NA	Nichols et al. (in prep); DeMartini (2016)
Etelis coruscans	X[a]	X[a]	X[a]	X[a]		X[a]	NA	66.3[d]	NA	LHP (in prep); Everson et al. (1989);
Hyporthodus quernus	76[d]	0.078[d]	95.8[d]					58.0[d]	89.5[d]	Andrews et al. (2019); DeMartini et al. (2010)
Pristipomoides filamentosus	42[d]	67.5[d]	0.24[d]	-0.29[d]			NA	f=40.7[d] m=43.3[d]	NA	Andrews et al. (2012); Leurs et al. (2017)
Pristipomoides sieboldii							NA	23.8[d]	NA	DeMartini (2016)
Pristpomoides zonatus							NA		NA	

[a] signifies estimate pending further evaluation in an initiated and ongoing study.
[b] signifies a preliminary estimate taken from ongoing analyses.
[c] signifies an estimate documented in an unpublished report or draft manuscript.
[d] signifies an estimate documented in a finalized report or published journal article (including in press).

Parameter estimates are for females unless otherwise noted (F=females, M=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm FL; k in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable.

2.3 SOCIOECONOMICS

This section outlines the pertinent economic, social, and community information available for assessing the successes and impacts of management measures or the achievements of Fishery Ecosystem Plan for the Hawaii Archipelago (WPRFMC, 2009). It meets the objective "Support Fishing Communities" adopted at the 165th Council meeting; specifically, it identifies the various social and economic groups within the region's fishing communities and their interconnections. The section begins with an overview of the socioeconomic context for the region, and then provides a summary of relevant studies and data for Hawaii, followed by summaries of relevant studies and data for each fishery within the Hawaiian archipelago.

In 1996, the Magnuson-Stevens Fishery Conservation and Management Act's National Standard 8 (NS8) specified that conservation and management measures take into account the importance of fishery resources to fishing communities, to provide for their sustained participation in fisheries and to minimize adverse economic impacts, provided that these considerations do not compromise the achievement of conservation. Unlike other regions of the U.S., the settlement of the Western Pacific region was intimately tied to the sea (Figure 12), which is reflected in local culture, customs, and traditions.

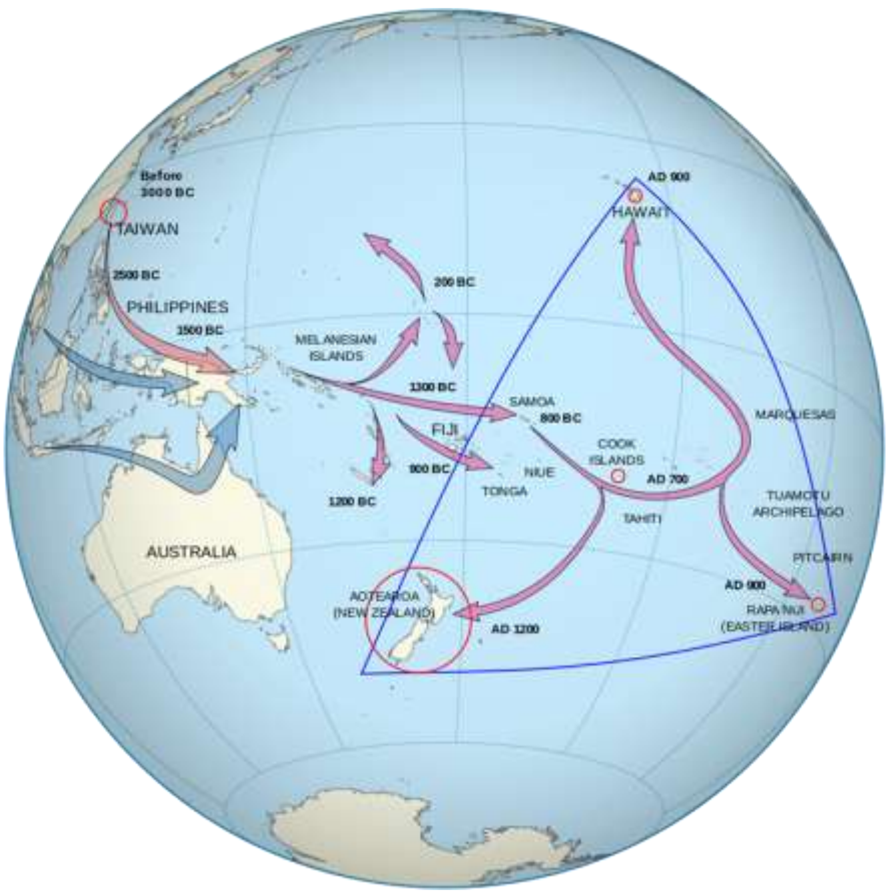


Figure 12. Settlement of the Pacific Islands, courtesy Wikimedia Commons https://commons.wikimedia.org/wiki/File:Polynesian_Migration.svg.

Polynesian voyagers relied on the ocean and marine resources on their long voyages in search of new islands, as well as in sustaining established island communities. Today, the population of the region also represents many Asian cultures from Pacific Rim countries, which reflect similar importance of marine resources. Thus, fishing and seafood are integral local community ways of life. This is reflected in the amount of seafood eaten in the region in comparison to the rest of the United States, as well as the language, customs, ceremonies, and community events. It can also affect seasonality in prices of fish. Because fishing is such an integral part of the culture, it is difficult to cleanly separate commercial from non-commercial fishing, with most trips involving multiple motivations and multiple uses of the fish caught. While the economic perspective is an important consideration, fishermen report other motivations such as customary exchange as being equally, if not more, important. Due to changing economies and westernization, recruitment of younger fishermen is becoming a concern for the sustainability of fishing and fishing traditions in the region.

2.3.1 Response to Previous Council Recommendations

At its 180th meeting held in Utulei, Tutuila, American Samoa in October 2019, the Council requested NMFS continue to support future recreational summits or workshops on noncommercial fisheries data to continue the national exchange on noncommercial fishery reporting issues and initiatives. In 2019, PIFSC conducted a study to describe and characterize fishing activities in the region that do not clearly meet the Magnuson–Stevens Fishery Conservation and Management Act (MSA) definition of recreational fishing. The study included national workshops that included discussion of issues related to data and reporting issues (Leong et al., 2020).

At its 178th meeting held in Honolulu, Hawaiʻi in June 2019, the Council directed staff to work with NMFS and American Samoa Department of Marine and Wildlife Resources (DMWR), CNMI Department of Fish and Wildlife (DFW), Guam Division of Aquatic and Wildlife Resources (DAWR) and Hawaiʻi Division of Aquatic Resources (DAR) on the revisions to the fisheries modules of the Archipelagic Stock Assessment and Fishery Evaluation (SAFE) Reports due to the changes in the MUS brought about by the ecosystem component designation. As a result, this section of the SAFE Report has been reorganized accordingly.

At its 176th meeting held in Honolulu, Hawaiʻi in March 2019, related to the Charter Fishery Cost Earning Survey, the Council encouraged PIFSC to maintain a regular schedule for the economic evaluations and monitoring of the fisheries in the Pacific Islands. To address this, in 2019, PIFSC has added a section titled *Ongoing Research and Information Collection*, which outlines planned economic data collections across the region, included in this and future SAFE reports.

Also at its 176th meeting held in Honolulu, Hawaiʻi in March 2019, the Council requested NMFS PIFSC Socioeconomics Program to evaluate the economic impacts on US Pacific Island fisheries from the 2018 amendment to the Billfish Conservation Act. PIFSC and Joint Institute for Marine and Atmospheric Research staff developed a preliminary analysis of market impacts related to the Billfish Conservation Act. This report was presented to Council staff in June 2019, and further developed as a PIFSC Internal Report (Chan, 2020).

2.3.2 Introduction

The geography and overall history of the Hawaiian Archipelago, including indigenous culture and current demographics and description of fishing communities is described in the Fishery Ecosystem Plan for the Hawaii Archipelago (Western Pacific Regional Fishery Management Council, 2009). Over the past decade, several studies have synthesized more specifics about the role of fishing and marine resources across the Hawaiian archipelago, as well as information about the people who engaging in the fisheries or use fishery resources.

As described in Chapter 1, a number of studies have outlined the importance of fishing for Hawaiian communities through history (e.g., Geslani et al., 2012; Richmond and Levine, 2012). Traditional Native Hawaiian subsistence relied heavily on fishing, trapping shellfish, and collecting seaweed to supplement land-based diets. Native Hawaiians also maintained fishponds, some of which date back thousands of years are still used today. The Native Hawaiian land and marine tenure system, known as ahupua‘a-based management, divided the islands into large parcels called moku, which are reflected in modern political boundaries (Census County Districts).

Immigrants from many other countries with high seafood consumption and cultural ties to fishing and the ocean came to work on the plantations around the turn of the 20th Century, establishing in Hawaii large populations of Chinese, Japanese, Koreans, Filipinos, and Portuguese, among others. In 1985, the Compact of Free Association also encouraged a large Micronesian population to migrate to Hawaii. According to the 2010 Census, the State of Hawaii’s population was almost 1.4 million during the last census. Ethnically, it has the highest percentage of Asian Americans (38.6%) and multiracial Americans (23.6%) while having the lowest percentage of White Americans (24.7%) of all states. Approximately 21% of the population identifies as Native Hawaiian or part Native Hawaiian. Tourism from many Asian countries also increases the demand for fresh, high-quality seafood, especially sushi, sashimi, and related raw fish products such as poke.

Today, fishing continues to play a central role in the local Hawaiian culture, diet, and economy. In 2012, an estimated 486,000 people were employed in marine-related businesses in Hawai‘i, with the level of commercial fishing-related employment well above the national average (Richmond et al., 2015). The Fisheries Economics of the United States 2016 report found that the commercial fishing and seafood industry in Hawai‘i (including the commercial harvest sector, seafood processors and dealers, seafood wholesalers and distributors, importers, and seafood retailers) generated $867.1 million in sales impacts and approximately 9,900 full and part-time jobs that year (NMFS, 2018). Recreational anglers took 1 million fishing trips, and 854 full- and part-time jobs were generated by recreational fishing activities in the state. Similarly, the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior et al., 2011) estimated that 157,000 people over 16 years old participated in saltwater angling in Hawai’i. They fished approximately 1.9 million days, with an average of 12 days per angler. This study estimated that fishing-related expenditures totaled $203 million, with each angler spending an average of $651 on trip-related costs. These numbers are not significantly different from those reported in the 2006 and 2001 national surveys.

Seafood consumption in Hawai’i is estimated at approximately two to three times higher than the rest of the entire U.S., and Hawai’i consumes more fresh and frozen finfish while shellfish and processed seafood is consumed more across the rest of the country (Geslani et al., 2012;

Davidson et al., 2012). In addition, studies have shown that seafood is eaten frequently, at least once a week by most, and at least once a month by almost all respondents (National Coral Reef Monitoring Program, 2016). Fresh seafood is the most popular type of seafood purchased, and while most is purchased at markets or restaurants, a sizeable amount is reported as caught by friends, neighbors, or extended family (National Coral Reef Monitoring Program, 2016; Davidson et al., 2012).

At the same time, local supply is inadequate to meet the high seafood demand. In 2010, 75% of all seafood consumed in the State of Hawaii was imported from either the U.S. mainland or foreign markets, and the rise in imported fish has influenced the price of local catch (Arita et al., 2011; Hospital et al., 2011). In addition, rising costs of fuel and other expenses have made it more difficult to recover trip costs (Hospital et al., 2011). A majority of commercial fishers report selling their fish simply to recover these costs, not necessarily to make income (Hospital et al., 2011). Many describe the importance of sharing fish as a part of maintaining relationships within family or other networks as being more important than earning income from fishing (personal communication, Bottomfish Oral History project, in progress).

Pelagic fish play a large role in seafood consumption, with Hawaii residents regularly consuming substantial amounts of fresh bigeye and yellowfin tuna as ‘ahi poke (bite-sized cubes of seasoned raw tuna) and ahi sashimi (sliced raw tuna). ‘Ahi is also a significant part of cultural celebrations, especially during the holiday period from late November (Thanksgiving) through late January to mid-February (Chinese New Year). Changes in bigeye regulations can have far-reaching effects not only on Hawai‘i's fishing community but also on the general population (Richmond et al., 2015). While most of the fresh tuna consumed in Hawaii is supplied by the local industry, market observations suggest that imported tuna is becoming more commonplace to meet local demands (Pan, 2014).

2.3.3 People Who Fish

Hawaii includes a mix of commercial, non-commercial, and subsistence characteristics across fisheries. Archipelagic fisheries are primarily accessed via a small boat fleet and through shoreline fishing. Within the small boat fleet, there is a nearly continuous gradation from the full-time and part-time commercial fleet to the charter and personal recreation fleets. A single boat (and trip) will often utilize multiple gear types and target fish from multiple fisheries. Thus, other than the longline fishery, these fisheries are typically not studied individually. Rather, studies have typically been conducted based on ability to reach potential respondents. Studies have targeted fishermen via State of Hawaii Commercial Marine Licenses (CMLs) (Chan and Pan, 2017; Madge et al., 2016), shoreline and boat ramp intercepts (Hospital et al., 2011; Madge et al., 2016), and vessel and angler registries (Madge et al., 2016). The number of participants involved in small boat fishing increased between 2003 and 2013 from 1,587 small boat-based commercial marine license holders to 1,843 (excluding charter, aquarium, and precious coral fisheries; Chan and Pan, 2017). Together, these small boat fishermen produced 6.2 million pounds of fish in 2013, with a commercial value of around $16 million.

The Hawaii small boat pelagic fleet was studied in 2007-2008 (hereafter, referred to as the 2008 study), following a design last utilized in 1997 (Hospital et al., 2011). Because respondents also targeted insular fish, the study is included in this report. Their work was updated in 2014 by Chan and Pan (2017) for the small boat fleet in general. Both studies found that the small boat fleet is predominantly owner-operated and a male dominated activity (98% of respondents were male in both studies). The ethnic composition was predominantly Asian (45% in 2008, 41% in 2014) and White (23% in 2008, 26% in 2014), which is similar to the demographics of the state population as a whole. In 2014, proportionally more Native Hawaiians and Pacific Islanders responded to the survey than are represented in the general population (18% vs. 10%). In addition, most respondents had a household income above $50,000 (75% in 2008, 69% in 2014).

These studies also asked respondents to classify themselves based on categories ranging from commercial to non-commercial. In 2014, 7% identified as full-time commercial, 51% identified as part-time commercial, 27% identified as recreational expense where they sold some catch to offset fishing expenses, 11% as purely recreational, 3% as subsistence, and 1% as cultural. Different activities were then compared based on self-classification.

As previously mentioned, the Hawaii small boat fishery is a mixed-gear fishery. In 2008, 47% of respondents reported using more than one gear type, predominantly trolling (for pelagic fish) and handline (for bottomfish). In 2014, 65% of respondents reported trolling as their most common gear, 16% indicated bottomfish handline, and 12% stated pelagic handline was their most commonly used gear. Trolling was more commonly used by recreational fishermen whereas pelagic handline and bottomfish gears were more commonly used by commercial fishermen. The 2014 study also asked about species composition of catch. While 93% of the respondents reporting landing pelagic fish in the past year, about half of respondents also reported they caught and landed bottomfish or reef fish. Thus, the small boat fleet includes not only a mixture of gear types, but also targets both pelagic and insular fish stocks.

Both studies also examined how fishermen self-identified versus their commercial and non-commercial activities. In both cases, many people who considered themselves recreational, subsistence, or cultural fishers still sold fish. In 2008, 42% of fishermen self-classified as commercial fishermen, yet 60% of respondents reported selling fish in the past year. In addition, just over 30% of fishermen who self-classified as recreational reported selling fish in the past year. Results for the 2014 study are shown in Table 43.

Table 43. Catch disposition by fisherman self-classification (from Chan and Pan, 2017)

	Number of respondents (n)	Caught and released (%)	Given away (%)	Consumed at home (%)	Sold (%)
All Respondents	738	5.6	13.9	15.4	65.0
By Fisherman Classification:					
Full-time commercial	*55*	6.2	9.4	11.6	72.8
Part-time commercial	*369*	5.2	12.9	14.4	67.5
Recreational expense	*200*	6.7	19.8	21.7	51.8
Purely recreational	*78*	5.4	37.3	29.6	27.6
Subsistence	*24*	1.9	20.7	31.0	46.5
Cultural	*8*	4.0	36.8	22.5	36.7

In 2014, the average value of fish sold by all respondents was approximately $8,500. Full-time commercial fishermen reported the highest value of fish sold ($35,528 annually and $558 per trip), part-time commercial fishermen reported $8,391 annually and $245 per trip, cultural fishermen $3,900 annually and $150 per trip, recreational expenses fishermen $2,690 annually and $95 per trip, subsistence fishermen $1,905 annually and $79 per trip, and purely recreational fishermen reported selling close to $1,000 annually ($58 per trip). While income from fish selling served as an important source of personal income for full-time commercial fishermen, the majority of fishermen reported selling fish to cover trip expenses, not necessarily to make a profit; few fishermen reported substantial, if any, profits from fishing. In the 2008 study, respondents expressed concern about their ability to cover trip costs, noting that trip costs continued to increase from year to year, but fish prices remained relatively flat.

The 2008 study was also the first attempt to quantify the scale of unsold fish that was shared within community networks. For commercial fishermen, trips where no fish are sold (30.5%) were nearly equal to trips where profit was made (30.9%). In addition, 97% of survey respondents indicated they participated in fish sharing networks with friends and relatives, and more than 62% considered the fish they catch as an important food source for their family. Community networks were also present in the outlets where fish were sold, which included the United Fishing Agency (UFA) auction in Honolulu, dealers/wholesalers, markets/stores, restaurants, roadside, but also sales to friends, neighbors, and coworkers. The 2014 study also documented 27% of sales to friends, neighbors, or coworkers and corroborated the importance of giving away fish for all self-classification categories (Table 43). In addition, 17% of respondents (who all held CMLs) sold no fish in the past 12 months.

Taken together, the results from these studies suggest a disconnect between Hawaii fishermen's attitudes and perceptions of their fishing activity relative to current regulatory frameworks. The small boat fleet is extremely heterogeneous with respect to gear type, target species, and catch disposition, while regulations attempt to treat each separately with clear distinctions between commercial and recreational activities. In addition to providing income, the Hawaii small boat fleet serves many vital nonmarket functions, including building social and community networks, perpetuating fishing traditions, and providing fish to local communities.

A survey was also conducted on the attitudes and preferences of Hawaii non-commercial fishers (see Madge et al., 2016). Nearly all survey respondents were male (96%). Their average age was 53, and, on average, they had engaged in non-commercial saltwater fishing in Hawaii for 31 years. The majority had household income equal to or greater than $60,000, reported high levels of education, and reflected a large racial diversity (primarily various Asian ethnicities and White). They primarily fished via private motorboat (61%), followed by shore, including beach, pier, and bridge (38%). Offshore trolling and whipping/casting, and free-dive spearfishing were the most frequent gears reported as "always" used, and a majority of respondents reported using multiple gears on a single fishing trip.

As with the small boat fleet, even though this study targeted "non-commercial fishermen", 9% reported that their primary motivation for fishing was to sell some catch to recover trip expenses. However, the primary motivation for the majority (51%) was purely for recreational purposes (only for sport or pleasure). A total of 78% of respondents indicated they "always" or "often" share catch with family and friends, and only 35% indicated they "never" supply fish for community/cultural events. Fishing for home/personal consumption was the most important trip catch outcome (36% rated it "extremely important"), followed by catching enough fish to be able to share with friends and family (20%). 36% indicated that their catch was extremely or very important to their regular diet. Thus, similar to the small boat fleet, non-commercial fishermen demonstrate mixed motivations that include commercial activities. They also play an important role in providing fish via social and community networks, even though they report their primary motivation as fishing only for sport or pleasure.

NMFS and the Hawaiʻi DAR have been collecting information on recreational fishing in Hawaiʻi, administered through the Hawaiʻi Marine Recreational Fishing Survey (HMRFS; Allen and Bartlett, 2008; Ma and Ogawa, 2016). The program collected data from 1979-1981, but not from 1982-2000, and then began annual data collection again in 2001. A dual survey approach is currently used. A telephone survey of a random sample of households determines how many have done any fishing in the ocean, their mode of fishing, methods used, and effort. The telephone survey component will be discontinued after 2017 due to declining land line coverage. Concurrently, surveyors conduct in-person intercept surveys at boat launch ramps, small boat harbors, and shoreline fishing sites. Fisher County of residence and zip code is regularly collected in the intercept surveys but has not yet been compared to the composition of the general public. As with the other surveys, this program documented a mix of gears used to catch both pelagic and insular fish. The majority of trips monitored by the on-site interviews were from "pure recreational fishermen", defined as those who do not sell their catch, with an average of nearly 60% to over 80% depending on year and island. However, they also noted that the divisions between commercial, non-commercial, and recreational are not clearly defined in Hawaii, and results suggested that the majority of catch for some categories of fishermen may be consumed by themselves or given away.

2.3.3.1 Bottomfish

This section reviews important community contributions of the MHI bottomfish fishery (Hospital and Pan, 2009; Hospital and Beavers, 2011; Hospital and Beavers, 2012; Chan and Pan, 2017) For studies that examined the small boat fishery in general (Hospital et al., 2011; Chan and Pan, 2017), overall fisher demographics and catch disposition were summarized in Chapter 1, as bottomfishing is only one of the gear types used by the small boat fleet.

Economically, the MHI bottomfish fishery is much smaller scale than the large pelagic fisheries in the region, but it is comparable in terms of rich tradition and cultural significance. Bottomfishing was part of the culture and economy of Native Hawaiians long before European explorers ever visited the region. Native Hawaiians harvested the same species as the modern fishery, and much of the gear and techniques used today are modeled after those used by Native Hawaiians. Most of the bottomfish harvested in Hawaii are red, which is considered an auspicious color in many Asian cultures, symbolic of good luck, happiness, and prosperity. Whole red fish are sought during the winter holiday season to bring good luck for the New Year from start to finish, and for other celebrations, such as birthdays, graduations, and weddings. Many restaurants across the State of Hawaii also serve fresh bottomfish, which are sought by tourists.

The bottomfish fishery grew steadily through the 1970s and into the 1980s but experienced steady declines in the following decades. Much of the decline in domestic production has been attributed to the limited-entry management regime introduced in the early 1990s in the NWHI and reductions in fishing vessels and trips fleet-wide. In the late 1990s, research identified overfishing as a contributor to the declines, which led to establishment of spatial closure areas (bottomfish restricted fishing areas [BRFAs]), a bottomfish boat registry, and a noncommercial bag limit for Deep 7 species. Emergency closures in 2007 also resulted in today's Total Allowable Catch (TAC) management regime, which sets a quota for the MHI Deep 7 bottomfish. Under this system, commercial catch reports are used to determine when the quota has been reached for the season, at which point both the commercial and non-commercial fisheries remain closed. This has implications for the ability of fishermen to build and maintain social and community networks throughout the year, given the cultural significance of this fishery.

In addition, in June 2006 the Northwestern Hawaiian Islands Marine National Monument was established in the NWHI, prohibiting all extractive activity and phasing out the active NWHI bottomfish fishery. This removed a source of approximately 35% of domestic bottomfish from Hawaii markets. The market has increasingly relied on imports to meet market demands, which may affect the fishery's traditional demand and supply relationships.

Overall, 45% of the MHI small boat fleet participated in the bottomfish fishery when last surveyed in 2014 (Chan and Pan, 2017). The MHI bottomfish fleet is a complex mix of commercial, recreational, cultural, and subsistence fishing. The artisanal fishing behavior, cultural motivations for fishing and relative ease of market access do not align well with mainland U.S. legal and regulatory frameworks.

In a 2010 survey, bottomfish fishermen were asked to define what commercial fishing meant to them (Hospital and Beavers, 2012). The majority of respondents agreed that selling fish for profit, earning a majority of income from fishing, and relying solely on fishing to provide income all constituted commercial fishing. However, there was less agreement on other legally established definitions, such as selling one fish, selling a portion of fish to cover trip expenses, the trade and barter of fish, or selling fish to friends and neighbors. In the 2014 survey (Chan and Pan, 2017), fishers whose most common gear was bottomfish handline identified themselves as primarily part-time commercial fishermen (53% selected this category) and recreational expense fishermen (21%). Only a few self-identified as full-time commercial (11%), purely recreational (9%), subsistence (6%) or cultural (1%) fishermen. Overall, bottomfish represented a lower percentage of total catch (11%) than total value (23%). While fishery highliners appear to be able to regularly recover trip expenditures and make a profit from bottomfish fishing trips, they represented only 8% of those surveyed in 2014. It is clear that for a majority of participants that the social and cultural motivations for bottomfishing outweigh economic prospects.

2.3.3.2 Reef Fish

As described in the reef fish fishery profile (Markrich and Hawkins, 2016), coral reef species have been shown by the archaeological record to be part of the customary diet of the earliest human inhabitants of the Hawaiian Islands, including the NWHI. Coral reef species also played an important role in religious beliefs and practices, extending their cultural significance beyond their value as a dietary staple. For example, some coral reef species are venerated as personal, family, or professional gods called ‘aumakua. While the majority of the commercial catch comes from nearshore reef areas around the MHI, harvests of some coral reef species also occur in federal waters (e.g., around Penguin Bank).

From 2014-2015, the National Coral Reef Monitoring Program conducted a household telephone survey of adult residents in the MHI to better understand demographics in coral reef areas, human use of coral reef resources, and knowledge, attitudes, and perceptions of coral reefs and coral reef management. This section summarizes results of the survey, which are available as an online presentation[1].

[1] Presentation is available at: https://data.nodc.noaa.gov/coris/library/NOAA/CRCP/monitoring/SocioEconomic/NCRMPSOCHawaiiReportOut2016_FINAL_061616_update.pdf

Just over 40% of respondents participated in fishing, while almost 60% had never participated. However, almost all respondents reported recreational use of coral reef resources, including swimming or wading (80.9%), beach recreation (80.2%), snorkeling (just under 60%), waterside or beach camping (just over 50%), and wave riding (over 40%). Gathering of marine resources was the least frequently reported, with only about 25% participating in this specific activity.

Of those who fished or harvested marine resources, the reason with the highest level of participation was "to feed myself and my family/household" (80.2%). The reason with the lowest level of participation was "to sell" (82.5% never participate). Other reasons with over 60% each were: for fun, to give extended family members and/or friends, and for special occasions and cultural purposes/events. This indicates a substantial contribution from this fishery to local food security, as well as maintaining cultural connections.

The importance of culture was also evident in perceptions of value related to coral reefs. The statement that respondents agreed the most with was "Coral Reefs are important to Hawaiian culture" (93.8%). They also agreed strongly that healthy coral reefs attract tourists to the Hawaiian Islands and that coral reefs protect the Hawaiian Islands from erosion and natural disasters. The statement that respondents disagreed with the most was "coral reefs are only important to fisherman, divers, and snorkelers" (76.2%).

With respect to management strategies, at least half of respondents agreed with all the presented management strategies, which ranged from catch limits, to gear restrictions, to enforcement, and no take zones. Respondents disagreed most with "establishment of a non-commercial fishing license" (27.2%) and "limited use for recreational activities" (25.2%).

Just over half of the respondents (55%) perceive their local communities as at least moderately involved in protecting and managing coral reefs. However, only about a quarter (26%) of respondents indicated moderate or higher involvement themselves.

The importance of protecting and managing coral reefs was also identified in a 2007 study on spearfishing in Hawaii (Stoffle and Allen, 2012). Spearfishing was not seen as just a sport but a vehicle for learning the appropriate ways to interact with and protect the environment, including how to carry oneself as a responsible fisherman. For many, learning to spearfish was an important part of "who you are" growing up near the ocean. Fishing also was discussed as a means of providing food or extra income during times of hardship, describing the ocean as a place that people turn to in times of economic crisis. Although there is a growing segment of people who spearfish for sport, with motivations focused more on the experience of the hunt, physical activity, and the sense of achievement. Like other methods of fishing, motivations for spearfishing often cross commercial, recreational, and subsistence lines, including sharing catch with family and among cultural networks.

Overall, coral reef fish not only have a long history of cultural significance in this archipelago, but they also continue to play an important role in subsistence as well as in strengthening social networks and maintaining cultural ties.

2.3.3.3 Crustaceans

There is currently no socioeconomic information specific to the crustacean fishery. Subsequent reports will include new data as resources allow.

2.3.3.4 Precious Corals

There is currently no socioeconomics information specific to precious coral fishery. Subsequent reports will include data as resources allow.

2.3.4 Fishery Economic Performance

2.3.4.1 Costs of Fishing

Past research has documented the costs of fishing in Hawaii (Hamilton and Huffman, 1997; Hospital et al., 2011; Hospital and Beavers, 2012). This section presents the most recent estimates of trip-level costs of fishing for boat-based bottomfish and coral reef fishing trips in Hawaii. Fishing trip costs were collected from the 2014 Hawaii small boat survey (Chan and Pan, 2017). Fishermen were asked their fishing trip costs for the most common and second most common gear types they used in the past 12 months and the survey provides information on the variable costs incurred during the operation of vessel including; boat fuel, truck fuel, oil, ice, bait, food and beverage, daily maintenance and repair, and other. Table 44 provides estimates for the cost of an average boat-based bottomfish or reef fish-targeted trip during 2014. Estimates for annual fishing expenditures (fixed costs) and levels of investment in the fishery are also provided in the literature.

Table 44. Bottomfish and reef fish trip costs in 2014 for small boats in Hawaii

Cost	Bottomfish Handline		Reef Spearfish	
	$ per trip	% of total trip cost	$ per trip	% of total trip cost
Fuel	134.24	53%	86.26	54%
Non-fuel	118.34	47%	72.68	46%
Total cost	252.58	100%	158.94	100%

Source: PIFSC Socioeconomics Program: Hawaii small boat cost-earnings data: 2014. Pacific Islands Fisheries Science Center, https://inport.nmfs.noaa.gov/inport/item/29820.

2.3.4.2 Commercial Participations, Landings, Revenues, Prices

Designated by the fishery management council and local fishery management agencies in 2019, the management unit species for the Hawaii archipelago include deep 7 bottomfish, uku, and three species of crustaceans (Kona crab and two shrimp (*levigatus* and *ensifer*). All other non-pelagic species and non-MUS are considered as ecosystem component species (ECS). This section will describe trends in commercial participation, landings, revenues, and prices for MUS and ECS, respectively.

2.3.4.2.1 MUS Commercial Participation, Landings, Revenues, Prices

Figure 13 shows the revenue structure of the three species groups in the MUS. Figure 14 shows number of fishers with MUS sales in 2010-2019. The number of MUS fishers decreased since 2014 and seen continued declines in 2019. However, the percentage of fishers reporting MUS sales has increased since 2013. Deep 7 bottomfish are the main component of the MUS. Figure 15 shows the pounds sold and revenue of Deep 7 of Hawaii bottomfish fishery, 2010-2019. Commercial landings of Deep 7 peaked in 2015 and has decreased since then. Deep 7 revenues show similar trend to commercial landings. Supporting data for Figure 13, Figure 14, and Figure

15 are presented in Table 45. Please note that the commercial data (the number of fishers/CML with MUS sold, pounds sold, and revenue) were sourced from the HDAR dealers data, and the total participation and landings were sourced from the HDAR fishers report. Figure 16 presents the fish price trends of Deep 7 and uku of Hawaii bottomfish fishery, 2010-2019. Supporting data for Figure 16 are presented in Table 46.

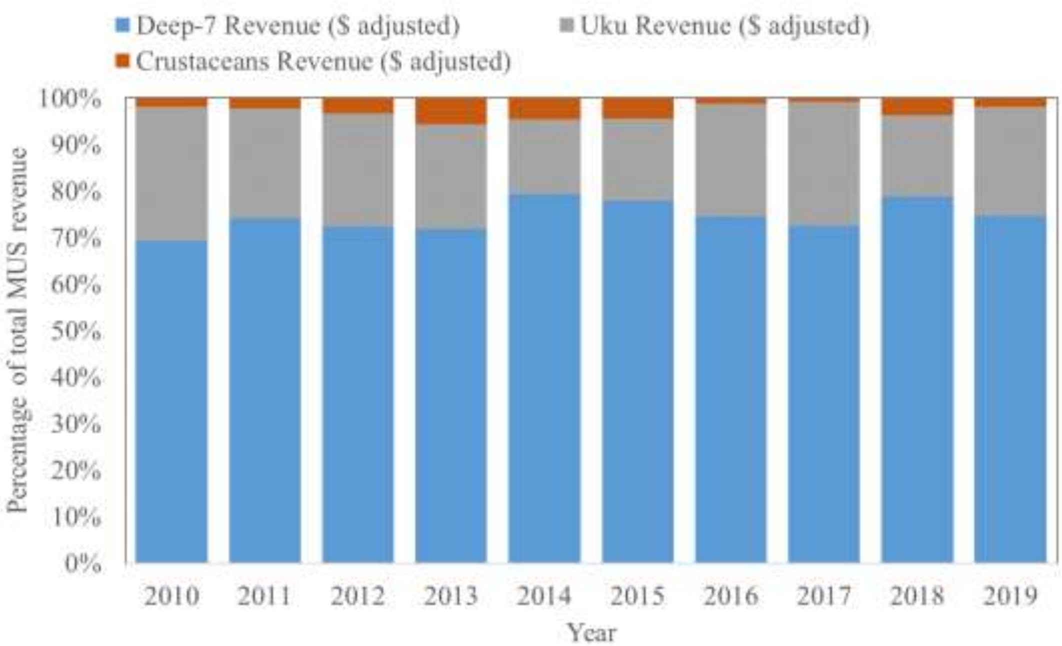


Figure 13. The revenue structure of the three species groups in the MUS, 2010-2019

Table 45. Total participants and revenue structure of the three species groups in the MUS

Year	CML # reported with MUS sold	CML # reported with Deep7 sold	CML # reported with uku sold	CML # reported with Crustanceans sold	MUS Rev adj ($)	% Deep-7 of total rev	% CUku of total rev	% Crustaceans of total rev	CPI adjustor
2010	508	347	298	12	1,781,766	69%	29%	2%	1.199
2011	497	350	293	17	2,037,815	74%	24%	2%	1.156
2012	522	358	328	14	1,955,387	72%	24%	3%	1.129
2013	528	350	328	16	2,116,278	72%	23%	6%	1.109
2014	517	345	313	15	2,488,572	79%	16%	5%	1.093
2015	533	342	343	13	2,596,484	78%	18%	4%	1.082
2016	484	332	321	8	2,475,291	75%	24%	1%	1.061
2017	462	312	319	9	2,350,494	73%	27%	1%	1.035
2018	419	298	243	8	2,144,033	79%	18%	4%	1.016
2019	403	279	246	9	1,791,227	75%	23%	2%	1

Data source: PIFSC WPacFIN from HDAR data.

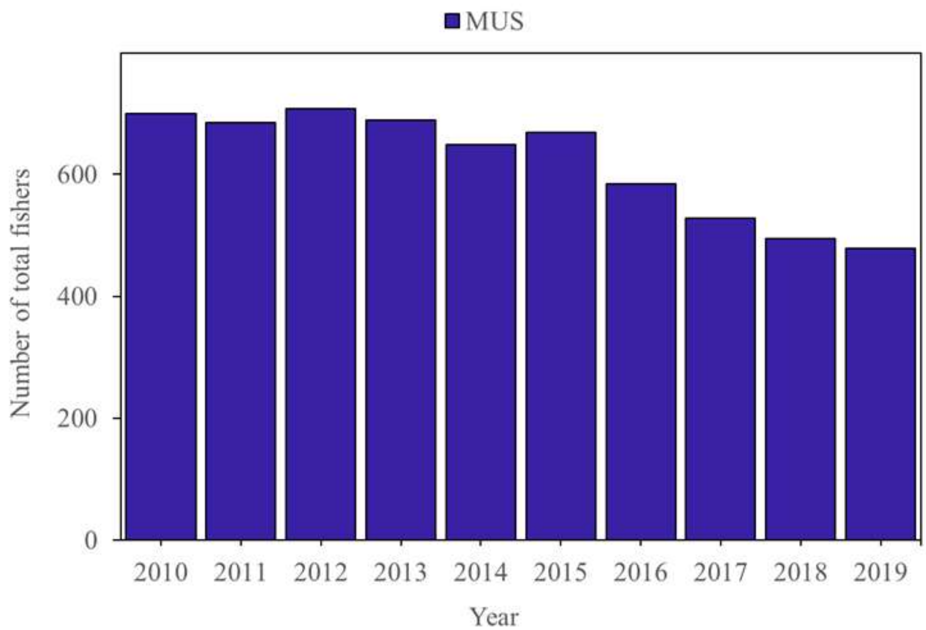


Figure 14. Total fishers in Hawaii MUS, 2010-2019

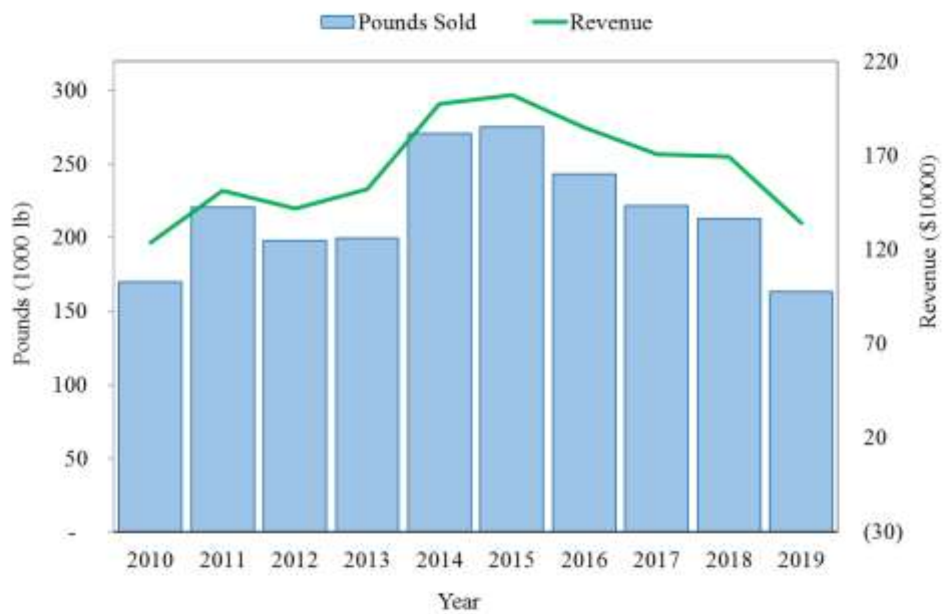


Figure 15. Pounds sold and revenue of Deep 7 of Hawaii bottomfish fishery, 2010-2019, adjusted to 2019 dollars

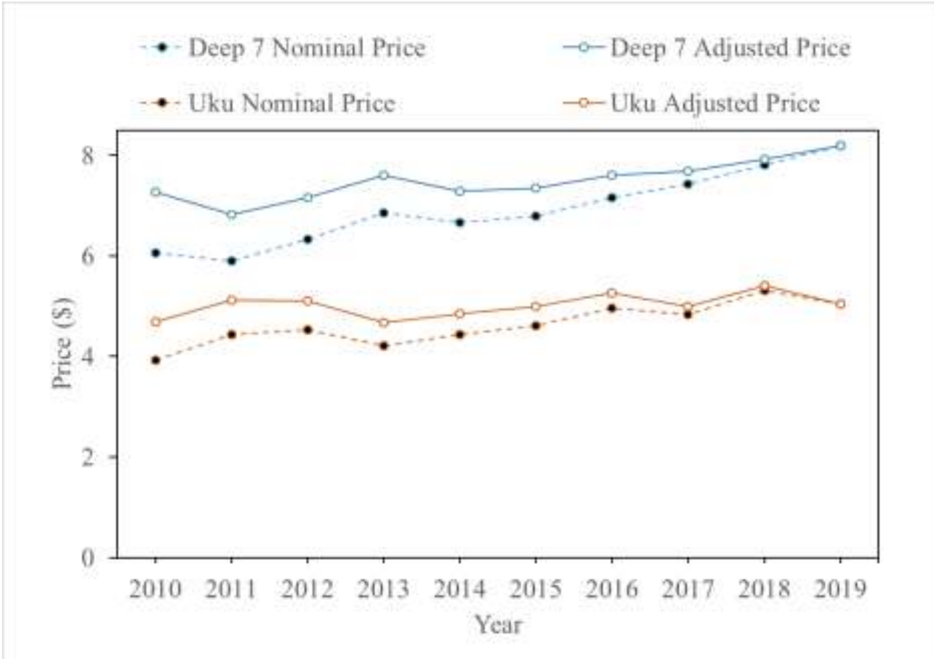


Figure 16. Fish prices of Deep 7 and Uku of Hawaii bottomfish fishery, 2010-2019

Table 46. Fish sold, revenue, and price information of MUS, 2010-2019

Year	MUS pounds sold (lb)	MUS Rev adj ($)	Deep-7 pounds sold (lb)	Deep-7 Rev adj ($)	Deep-7 price adjusted ($/lb)	Uku pounds sold (lb)	Uku Rev adj ($)	Uku price adjusted ($/lb)	Crustacean pounds sold (lb)	Crustacean Rev adj ($)	Crustacean price adj ($/lb)	CPI adjustor
2010	285,458	1,781,766	169,787	1,235,393	7.28	109,125	513,331	4.70	6,546	33,041	5.05	1.199
2011	322,633	2,037,815	220,860	1,509,743	6.83	94,056	481,637	5.12	7,717	46,435	6.02	1.156
2012	300,405	1,955,387	197,766	1,415,952	7.16	92,831	474,404	5.11	9,808	65,032	6.63	1.129
2013	316,339	2,116,278	199,747	1,519,690	7.61	102,079	477,438	4.68	14,513	119,150	8.21	1.109
2014	369,337	2,488,572	270,684	1,973,857	7.29	82,571	401,047	4.85	16,082	113,668	7.07	1.093
2015	383,238	2,596,484	275,262	2,021,119	7.35	92,063	460,185	5.00	15,913	115,181	7.24	1.082
2016	360,657	2,475,291	243,103	1,846,545	7.60	113,662	598,451	5.26	3,892	30,295	7.79	1.061
2017	349,290	2,350,494	221,988	1,706,182	7.69	124,762	624,018	5.00	2,541	20,295	7.99	1.035
2018	291,138	2,144,033	213,157	1,690,710	7.93	69,495	375,487	5.41	8,487	77,835	9.17	1.016
2019	250,814	1,791,227	163,341	1,338,295	8.19	82,756	417,943	5.05	4,717	34,989	7.42	1

Data source: PIFSC WPacFIN from HDAR data. Inflation-adjusted use the Honolulu Consumer Price Index https://www.bls.gov/regions/west/data/consumerpriceindex_honolulu_table.pdf.

2.3.4.2.2 Deep 7 Bottomfish Economic Performance Metrics

NOAA Fisheries has established a national set of economic performance indicators to monitor the economic health of the nation's fisheries (Brinson et al., 2015). PIFSC economists have used this framework to evaluate select regional fisheries; specifically, the Hawaii Longline, American Samoa Longline, and Main Hawaiian Islands (MHI) Deep 7 bottomfish fishery. These indicators include metrics related to catch, effort, and revenues. This section will present revenue performance metrics of; (a) total fishery revenues, (b) fishery revenue per trip, (c) Gini coefficient, and (d) the share of Deep 7 as a percentage of total revenues for the MHI Deep 7 bottomfish fishery.

Revenue per vessel, revenue per trip, and Gini coefficients for the MHI Deep 7 bottomfish fishery include any trip that catches one or more of the Deep 7 bottomfish species in the Main Hawaiian Islands including onaga, ehu, opakapaka, kalekale, gindai, lehi, and hapuupuu. The

Gini coefficient measures the equality of the distribution of revenue among active vessels in the fishery. A value of zero represents a perfectly equal distribution of revenue amongst these vessels, whereas, a value of one represents a perfectly unequal distribution, in the case that a single vessel earns all of the revenue.

The annual total revenue for the MHI Deep 7 bottomfish fishery was estimated based on:

1. The total number of fish kept by species from all MHI Deep 7 fishing trips in a fishing year, as reported by fishermen (including Deep 7 species, non-Deep 7 Bottomfish-Management-Unit-Species (BMUS), and all other species (e.g., pelagic).
2. Fishing years between 2002 and 2006 are defined by calendar year. Since 2007, the fishing year for the MHI Deep 7 bottomfish fishery starts September 1 and ends August 31 of the following year, or earlier if the quota is reached before the end of the season.
3. The weight of the kept catch is estimated as the number of fish kept times the annual average whole weight per fish based on State of Hawaii marine dealer data.
4. The estimated value of the catch is estimated as the weight of the kept catch times the annual average price per pound. This measure assumes all fish landed are sold.

For the MHI Deep 7 bottomfish fishery, revenue was calculated by license (CML) because individual revenues are monitored by CML. Multiple fishermen can fish in the same vessel but report their revenue separately, by individual CML. Additionally, a fisherman may fish in different vessels through the year, so revenue is more attached to CML than to vessel and the Gini coefficient essentially measures the equality of the distribution of revenue among active fishermen (CML holders). The high Gini coefficient in this fishery would imply that a small portion of fishermen account for a large share of fishery revenues. Past research demonstrates evidence of this as participants in this fishery reflect a wide range of motivations and avidity, and there is a relatively small segment of full-time commercial fishery highliners (Hospital and Beavers, 2012; Chan and Pan, 2017).

Trends in fishery revenues per vessel and the distribution of these revenues across the fishery are shown in Figure 17 while trends in revenue per trip and the share of Deep 7 as a percentage of total fishery revenues are shown in Figure 18. In Figure 17, "fishery" revenues refers only to Deep 7 bottomfish species catch and revenues and excludes other species (such as non-Deep 7 bottomfish, pelagic, and other species) caught on Deep 7 fishing trips. However, in Figure 18, the revenue per trip included both Deep-7 and non-Deep-7 species. Supporting data for Figure 17 and Figure 18 are provided in Table 47, where the last column reflects the share of Deep 7 bottomfish in total fishing revenues (all species combined) on Deep 7 fishing trips for fishermen active in the MHI Deep 7 bottomfish fishery.

In 2019, the average annual revenue per vessel from all bottomfish sold was $6,332, of which, 73% were from Deep 7 species sold. The ratio was steady for the period of 2014 to 2018 but went down in 2019. The Gini coefficient was 0.76 in 2019, indicating the variations of annual revenue among vessels were substantial, but it was consistent with the previous years.

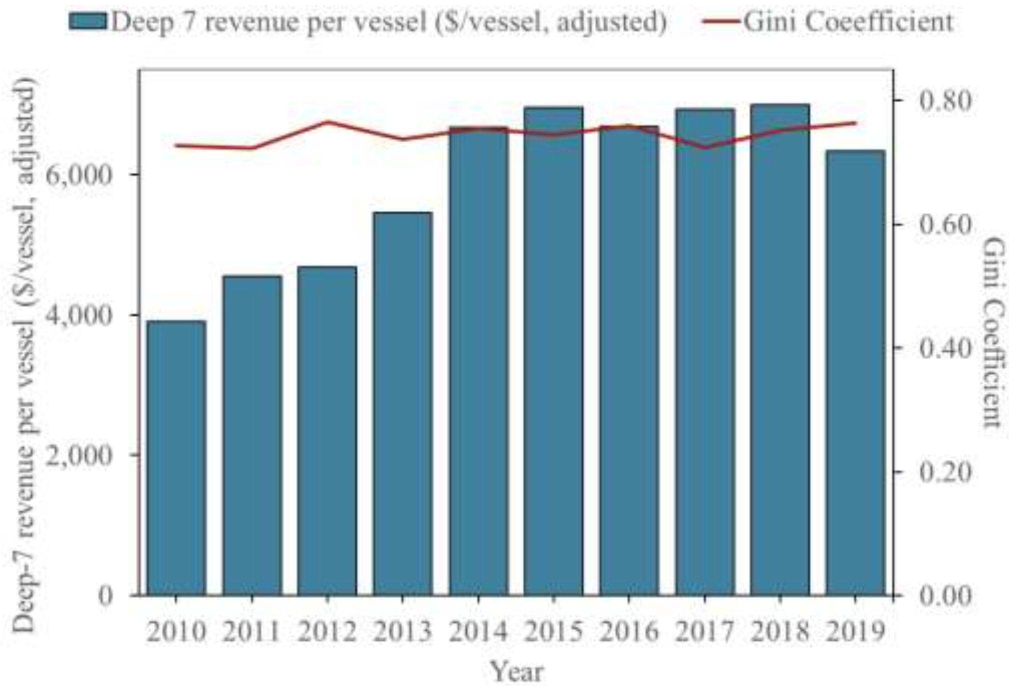


Figure 17. Trends in fishery revenue per vessel and Gini coefficient for the MHI Deep 7 Bottomfish fishery, 2010-2019

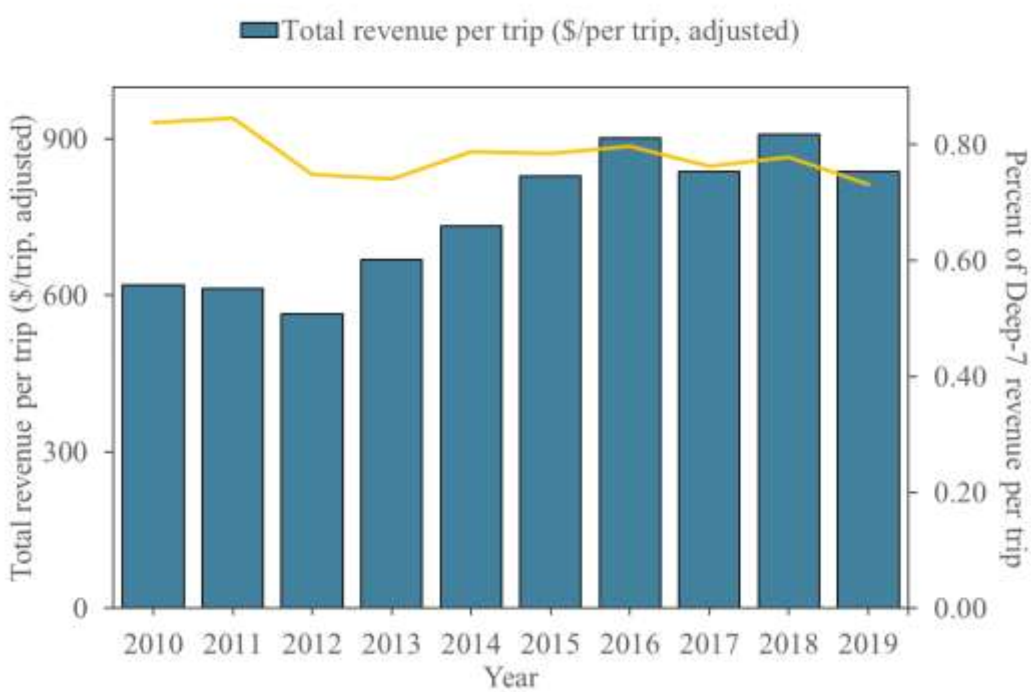


Figure 18. Trends in fishery revenue per trip and Deep 7 as a percentage of total revenues of all Bottomfish sold (2010-2019)

Table 47. MHI Deep 7 bottomfish fishery economic performance measures, 2010-2019

Year	Total revenue per vessel ($)	Total revenue per vessel adjusted ($)	Gini Coeefficient	Deep-7 revenue per day at sea ($)	Deep-7 revenue per day at sea adjusted ($)	Total bottomfish revenue per day at sea ($, adjusted)	% of deep-7 in total revenue	CPI adjustor
2010	3,258	3,907	0.73	433	519	619	0.84	1.199
2011	3,934	4,548	0.72	449	519	614	0.85	1.156
2012	4,152	4,688	0.77	374	423	565	0.75	1.129
2013	4,926	5,463	0.74	446	495	668	0.74	1.109
2014	6,105	6,673	0.75	529	578	733	0.79	1.093
2015	6,430	6,958	0.74	601	651	829	0.78	1.082
2016	6,305	6,689	0.76	677	718	901	0.80	1.061
2017	6,691	6,925	0.72	617	639	837	0.76	1.035
2018	6,890	7,001	0.75	696	707	908	0.78	1.016
2019	6,332	6,332	0.76	613	613	838	0.73	1

Note: Inflation-adjusted revenue (in 2016 dollars) used the Honolulu Consumer Price Index (CPI-U) https://www.bls.gov/regions/west/data/consumerpriceindex_honolulu_table.pdf
Source: PIFSC Socioeconomics Program: Fishery Economic Performance Measures. Pacific Islands Fisheries Science Center, Tier 1 data request, https://inport.nmfs.noaa.gov/inport/item/46097

2.3.4.2.3 Hawaii Ecosystem Component Species

Based on the new guideline for the archipelagic SAFE report from the Council, the SAFE report of this year highlighted the top 10 ecosystem component species (ECS; sorted by landings) and the priority ECS (recommended by the local fishery management agency) caught by small boats or shoreline fishing. Please note that the commercial data (the number of fishers/CML with MUS sold, pounds sold, and revenue) were sourced from the HDAR dealer reporting system, and the total participation and landings were sourced from the HDAR fisher reporting system.

Table 48 shows the commercial landings and revenue of the top 10 ECS in Hawaii. The total pounds sold of the top 10 species/species groups was near half million pounds, valued at $478,279 in 2019. Akule was the leading species of the top 10, which composed 45% of the total revenue of the top 10. Ten fish species were suggested as the priority species (species of interests) for Hawaii (shown in Table 49).

Table 48. Top 10 ECS commercial landings, revenue, and price, 2018 and 2019

	2019						2018					
Local Name	# of fishers	Pounds kept	Pounds sold	Revenue	% rev	Price $/lb	# of fishers	pounds Kept	Pounds sold	Revenue (adj.)	% rev	Price $/lb (adj.)
Akule	205	241,161	222,202	752,295	45%	3.39	223	262,739	236,372	53,333	3%	3.46
Opelu	120	120,917	84,646	236,975	14%	2.80	115	118,618	53,029	817,758	48%	3.17
Uhu	62	47,361	46,029	229,388	14%	4.98	56	47,638	52,776	167,951	10%	4.98
Menpachi	173	45,425	46,893	223,340	13%	4.76	166	41,278	40,759	262,629	15%	4.79
Taape	177	29,663	30,547	49,754	3%	1.63	197	28,768	27,793	195,199	11%	1.70
Palani	47	25,037	28,247	50,334	3%	1.78	42	25,431	31,665	47,234	3%	1.78
Red Weke	55	18,258	15,840	56,960	3%	3.60	55	18,699	20,411	56,287	3%	3.51
Kauahonu Crab	*	*	*	*	*	5.04						
Kahala	153	14,158	3,197	6,127	0%	1.92	129	15621	3262	7232	0%	8
He'e (Day Tako)	49	11,045	9,678	53,333	3%	5.51	57	12,989	12,737	67,971	4%	5.33
Manini							41	12,620	12,574	40,738	2%	3.24
Sum		553,025	487,279	1,658,506		3.40		584,401	491,378	1,716,332		3.49

Table 49. Priority ECS commercial landings, revenue, and price, 2018 and 2019

	2019					2018				
Local Name	# of fishers	Pounds kept	Pounds sold	Revenue	Price per pound	# of fishers	Pounds kept	Pounds sold	Revenue adj	Price per pound (adj)
Uhu	62	47,361	46,029	229,388	4.98	56	47,638	52,776	262,629	4.98
Taape	177	29,663	30,547	49,754	1.63	197	28,768	27,793	47,234	1.70
He'e (Day tako)	49	11,045	9,678	53,333	5.51	57	12,620	12,737	67,971	5.33
Opihi	19	10,976	11,773	86,565	7.35	17	13,336	11,454	81,032	7.07
Nenue	37	10,240	11,145	22,920	2.06	44	9,655	12,467	24,969	2.00
Kala	32	8,863	9,348	17,360	1.86	32	9,904	10,920	20,693	1.90
Manini	40	8,821	9,284	29,868	3.22	41	12,989	12,574	40,738	3.24
Omilu	96	4,782	1,875	5,957	3.18	100	5,173	2,789	8,968	3.22
Lobster	9	4,206	3,437	31,302	9.11	8	5,015	3,417	31,515	9.23
Kumu	44	581	1,364	14,803	10.86	44	728	2,217	25,946	11.70
Sum		136,538	134,480	541,250	4.02		145,826	149,144	611,695	4.10

2.3.5 Ongoing Research and Information Collection

PIFSC reports annually on the status of economic data collections for select regional commercial fisheries. This supports a national economic data monitoring effort known as the Commercial Fishing Economic Assessment Index (CFEAI). Details on the CFEAI and access to data from other regions is available at: https://www.st.nmfs.noaa.gov/data-and-tools/CFEAI-RFEAI/.

The table below represents the most recent data available for CFEAI metrics for select regional commercial fisheries for 2019. Entries for Hawaii insular fisheries are bolded in red. These values represent the most recent year of data for key economic data monitoring parameters (fishing revenues, operating costs, and fixed costs). The assessment column indicates the most recent publication year for specific economic assessments (returns above operating cost, profit), where available.

Table 50. Pacific Islands Region 2018 Commercial Fishing Economic Assessment Index

	2019 Projected CFEAI				
	2019 Reporting Year (e.g. 1/2019-12/2019)				
Pacific Islands Fisheries	Data			Assessment	
	Fishing Revenue Most Recent Year	Operating Cost Most Recent Year	Fixed Cost Most Recent Year	Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year	Profit Assessment Most Recent Year
HI Longline	2019	2019	2013	2019	2016
ASam Longline	2019	2019	2016	2019	2019
HI Offshore Handline	2019	2014	2014	2019	2019
HI Small Boat (pelagic)	2019	2014	2014	2017	2019
HI Small Boat	**2019**	**2014**	**2014**	**2017**	**2019**
HI Small Boat (reef)	**2019**	**2014**	**2014**	**2017**	**2019**
Guam Small boat	2019	2019	2019	2019	
CNMI Small boat	2019	2019	2019	2019	
ASam Small boat	2019	2019	2015	2019	

PIFSC also generates projections for upcoming fiscal years, and the table above provides the projected CFEAI report for 2020 (*all projected activities and analyses are subject to funding*). Based on early projections PIFSC intends to maintain ongoing economic data collections in the CNMI and Guam for small boat fisheries (Chan and Pan, 2019) during 2020.

Table 51. Pacific Islands Region 2020 Commercial Fishing Economic Assessment Index

	2020 Projected CFEAI				
	2020 Reporting Year (e.g. 1/2020-12/2020)				
Pacific Islands Fisheries	Data			Assessment	
	Fishing Revenue Most Recent Year	Operating Cost Most Recent Year	Fixed Cost Most Recent Year	Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year	Profit Assessment Most Recent Year
HI Longline	2020	2020	2019	2020	2016
ASam Longline	2020	2020	2016	2020	2019
HI Offshore Handline	2020	2020	2020	2019	2019
HI Small Boat (pelagic)	2020	2020	2020	2017	2019
HI Small Boat	**2020**	**2020**	**2020**	**2017**	**2019**
HI Small Boat (reef)	**2020**	**2020**	**2020**	**2017**	**2019**
Guam Small boat	2020	2020	2019	2020	
CNMI Small boat	2020	2020	2019	2020	
ASam Small boat	2020	2020	2020	2020	

PIFSC intends to field an update to the Hawaii small boat cost earnings survey (Chan and Pan, 2017; Hospital et al., 2011) during calendar year 2020 (subject to survey approval from the Office of Management and Budget). This survey will provide updated information on operating costs and fixed costs for the Hawaii bottomfish and boat-based reef fisheries.

PIFSC will continue to collect and monitor annual community social indicators (Kleiber et al., 2018) for Hawaii fishing communities, in accordance with a national project to describe and evaluate community well-being in terms of social, economic, and psychological welfare (https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-fishing-communities-0).

During 2019, further progress was made on the Hawaii Bottomfish Heritage Project. Additional "fisher highlight" videos as well as a few longer "thematic" videos were produced and added to a BF Heritage Project YouTube channel:
https://www.youtube.com/channel/UCq0qtWem1RsMqV9f6-bibVA

Additional updates on the Hawaii Bottomfish Heritage Project are posted at
https://www.fisheries.noaa.gov/feature-story/hawaii-bottomfish-heritage-project

2.3.6 Relevant PIFSC Economics and Human Dimensions Publications: 2019

Publication	**MSRA Priority**
Abrams KM, Leong K, Melena S, Teel T. 2019. Encouraging Safe Wildlife Viewing in National Parks: Effects of a Communication Campaign on Visitors' Behavior. Environmental Communication, 1-6. https://doi.org/10.1080/17524032.2019.1649291.	HC3.2.3
Duncan C, Patyk K, Wild MA, Shury T, Leong KM, Stephen C. 2019. Perspectives on wildlife health in national parks: concurrence with recent definitions of health. Human Dimensions of Wildlife. https://doi.org/10.1080/10871209.2019.1650402.	HC3.2.4
Gove JM, Lecky J, Walsh WJ, Ingram RJ, Leong K, Williams I, Polovina J, Maynard J, Whittier R, Kramer L, et al.. 2019. West Hawai`i integrated ecosystem assessment ecosystem status report. Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-19-001, 46 p. https://doi.org/10.25923/t3cc-2361.	HC2.1.2
Hospital J, Schumacher B, Ayers A, Leong K, Severance C. 2019. A structure and process for considering social, economic, ecological, and management uncertainty information in setting of annual catch limits: SEEM* Pacific Islands Fisheries Science Center, PIFSC Internal Report, IR-19-011, 13 p.	IF5.1.2

2.4 PROTECTED SPECIES

This section of the report summarizes information on protected species interactions in fisheries managed under the Hawai`i FEP. Protected species covered in this report include sea turtles, seabirds, marine mammals, sharks, and corals. Most of these species are protected under the Endangered Species Act (ESA), the Marine Mammal Protection Act (MMPA), and/or the Migratory Bird Treaty Act (MBTA). A list of protected species found in or near Hawai`i waters and a list of critical habitat designations in the Pacific Ocean are included in Appendix B.

2.4.1 Indicators for Monitoring Protected Species Interactions

This report monitors the status of protected species interactions in the Hawai`i FEP fisheries using proxy indicators such as fishing effort and changes in gear types, as these fisheries do not have observer coverage. Creel surveys and logbook programs are not expected to provide reliable data about protected species interactions. Discussion of protected species interactions is focused on fishing operations in federal waters and associated transit through state waters.

2.4.1.1 FEP Conservation Measures

No specific regulations are in place to mitigate protected species interactions in the bottomfish, precious coral, coral reef ecosystem and crustacean fisheries currently active and managed under this FEP. Destructive gear such as bottom trawls, bottom gillnets, explosives and poisons are prohibited under this FEP, and these prohibitions benefit protected species by preventing potential interactions with non-selective fishing gear.

The original crustacean Fishery Management Plan (FMP) and subsequent amendments included measures to minimize potential impacts of the Northwestern Hawaiian Islands (NWHI) component of the spiny lobster fishery to Hawaiian monk seals, such as specification of trap gear design and prohibition of nets. The Bottomfish and Seamount Groundfish FMP began requiring protected species workshops for the NWHI bottomfish fishery participants in 1988. These fisheries are no longer active due to the issuance of Executive Orders 13178 and 13196 and the subsequent Presidential Proclamations 8031 and 8112, which closed the fisheries within 50 nm around the NWHI.

2.4.1.2 ESA Consultations

Hawai`i FEP fisheries are covered under the following consultations under section 7 of the ESA, through which NMFS has determined that these fisheries are not likely to jeopardize or adversely affect any ESA-listed species or critical habitat in the Hawai`i Archipelago (Table 52).

Table 52. Summary of ESA consultations for Hawaii FEP Fisheries

Fishery	Consultation Date	Consultation Type[a]	Outcome[b]	Species
Bottomfish	3/18/2008	BiOp	LAA, non-jeopardy	Green sea turtle
			NLAA	Loggerhead sea turtle, leatherback sea turtle, olive ridley sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, northern right whale, sei whale, sperm whale, Hawaiian monk seal
	8/7/2013	BiOp modification	NLAA	False killer whale (MHI insular DPS)
	Initiated 2/1/2019	*Consultation ongoing*		Oceanic whitetip shark, giant manta ray, MHI false killer whale critical habitat
Coral Reef Ecosystem	5/22/2002	LOC (USFWS)	NLAA	Green, hawksbill, leatherback, loggerhead and olive ridley turtles, Newell's shearwater, short-tailed albatross, Laysan duck, Laysan finch, Nihoa finch, Nihoa millerbird, Micronesian megapode, 6 terrestrial plants
	12/5/2013	LOC	NLAA	Loggerhead sea turtle (North Pacific DPS), leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, North Pacific right whale, sei whale, sperm whale, Hawaiian monk seal, false killer whale (MHI insular DPS)
	9/18/2018	No effect memo	No effect	Oceanic whitetip shark, giant manta ray
Coral Reef Ecosystem (Kona Kampachi Special Coral Reef Ecosystem Fishing Permit only)	9/19/2013	LOC (USFWS)	NLAA	Short-tailed albatross, Hawaiian petrel, Newell's shearwater
	9/25/2013	LOC	NLAA	Loggerhead sea turtle (North Pacific DPS), leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, North Pacific right whale, sei whale, sperm whale, Hawaiian monk seal, false killer whale (MHI insular DPS)

Fishery	Consultation Date	Consultation Type[a]	Outcome[b]	Species
Crustacean	12/5/2013	LOC	NLAA	Loggerhead sea turtle (North Pacific DPS), leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, North Pacific right whale, sei whale, sperm whale, Hawaiian monk seal, false killer whale (MHI insular DPS)
	9/18/2018	No effect memo	No effect	Oceanic whitetip shark, giant manta ray, MHI false killer whale critical habitat
Precious Coral	12/5/2013	LOC	NLAA	Loggerhead sea turtle (North Pacific DPS), leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, North Pacific right whale, sei whale, sperm whale, Hawaiian monk seal, false killer whale (MHI insular DPS)
	9/18/2018	No effect memo	No effect	Oceanic whitetip shark, giant manta ray, MHI false killer whale critical habitat
All Fisheries	3/1/2016	LOC	NLAA	Hawaiian monk seal critical habitat

[a] BiOp = Biological Opinion; LOC = Letter of Concurrence.
[b] LAA = likely to adversely affect; NLAA = not likely to adversely affect.

2.4.1.2.1 Bottomfish Fishery

In a March 18, 2008 Biological Opinion (BiOp) covering MHI bottomfish fishery, NMFS determined that the MHI bottomfish fishery is likely to adversely affect but not likely to jeopardize the green sea turtle and included an incidental take statement (ITS) of two animals killed per year from collisions with bottomfish vessels. In the 2008 BiOp, NMFS also concluded that the fishery is not likely to adversely affect any four other sea turtle species (loggerhead, leatherback, olive ridley, and hawksbill turtles) and seven marine mammal species (humpback, blue, fin, Northern right whale, sei and sperm whales, and the Hawaiian monk seal).

In 2013, NMFS re-initiated consultation under ESA in response to listing of the MHI insular false killer whale distinct population segment (DPS) under the ESA. In a modification to the 2008 BiOp dated August 7, 2013, NMFS determined that commercial and non-commercial bottomfish fisheries in the MHI are not likely to adversely affect MHI insular false killer whale because of the spatial separation between the species and bottomfishing activities, the low likelihood of collisions, and the lack of observed or reported fishery interactions were among other reasons. NMFS also concluded that all previous determinations in the 2008 BiOp for other ESA-listed species and critical habitat remained valid.

In August 2015, NMFS revised the Hawaiian monk seal critical habitat in the NWHI and designated new critical habitat in the MHI. In an informal consultation completed on March 1, 2016, NMFS concluded that the Hawai`i bottomfish fishery is not likely to adversely affect monk seal critical habitat.

On February 1, 2019, NMFS reinitiated consultation for the MHI bottomfish fisheries due to ESA listing of the oceanic whitetip shark and giant manta ray, and designation of main Hawaiian Islands insular false killer whale critical habitat. Also, on February 1, 2019, NMFS determined that the conduct of the Hawaii bottomfish fisheries during the period of consultation will not violate ESA Section 7(a)(2) and 7(d).

2.4.1.2.2 Crustacean Fishery

In an informal consultation completed on December 5, 2013, NMFS concluded that the Hawai`i crustacean fisheries are not likely to affect five sea turtle species (North Pacific loggerhead DPS, leatherback, olive ridley, green, and hawksbill turtles) and eight marine mammal species (humpback, blue, fin, North Pacific right whale, sei, and sperm whales, MHI insular false killer whale DPS and the Hawaiian monk seal). In an informal consultation completed on March 1, 2016, NMFS concluded that the Hawai`i crustacean fishery is not likely to adversely affect monk seal critical habitat.

On September 18, 2018, NMFS concluded the Hawai`i crustacean fishery will have no effect on the oceanic whitetip shark, giant manta ray, and MHI false killer whale critical habitat.

2.4.1.2.3 Coral Reef Ecosystem Fishery

On May 22, 2002, the USFWS concurred with the determination of NMFS that the activities conducted under the Coral Reef Ecosystems FMP are not likely to adversely affect ESA-listed species under USFWS's exclusive jurisdiction (i.e., seabirds) and ESA-listed species shared with NMFS (i.e., sea turtles).

In an informal consultation completed on December 5, 2013, NMFS concluded that the Hawai`i coral reef ecosystem fisheries are not likely to affect five sea turtle species (North Pacific loggerhead DPS, leatherback, olive ridley, green, and hawksbill turtles) and eight marine mammal species (humpback, blue, fin, Northern right, sei, and sperm whales, MHI insular DPS false killer whales and the Hawaiian monk seal). In an informal consultation completed on March 1, 2016, NMFS concluded that the Hawai`i coral reef ecosystem fishery is not likely to adversely affect monk seal critical habitat.

On September 18, 2018, NMFS concluded the Hawai`i coral reef ecosystem fishery will have no effect on the oceanic whitetip shark and giant manta ray.

2.4.1.2.4 Precious Coral Fishery

In an informal consultation completed on December 5, 2013, NMFS concluded that the Hawai`i precious coral fisheries are not likely to affect five sea turtle species (North Pacific loggerhead DPS, leatherback, olive ridley, green, and hawksbill turtles) and eight marine mammal species (humpback, blue, fin, North Pacific right, sei, and sperm whales, MHI insular false killer whale DPS and the Hawaiian monk seal). In an informal consultation completed on March 1, 2016, NMFS concluded that the Hawai`i precious coral fishery is not likely to adversely affect monk seal critical habitat.

On September 18, 2018, NMFS concluded the Hawai`i precious coral fishery will have no effect on the oceanic whitetip shark, giant manta ray, and MHI false killer whale critical habitat.

2.4.1.3 Non-ESA Marine Mammals

The MMPA requires NMFS to annually publish a List of Fisheries (LOF) that classifies commercial fisheries in one of three categories based on the level of mortality and serious injury of marine mammals associated with that fishery. According to the 2020 LOF (85 FR 20179, April 16, 2020), the bottomfish (HI bottomfish handline), precious coral (HI black coral diving), coral fish (HI spearfishing), and crustacean (HI crab trap, lobster trap, shrimp trap, crab net, Kona crab loop net, lobster diving) fisheries are classified as Category III fisheries (i.e. a remote likelihood of or no known incidental mortality and serious injury of marine mammals).

2.4.2 Status of Protected Species Interactions in the Hawaii FEP Fisheries

2.4.2.1 Bottomfish Fishery

2.4.2.1.1 Sea Turtle, Marine Mammal, and Seabird Interactions

Fisheries operating under the Hawai`i FEP currently do not have federal observers on board. The NWHI component of the bottomfish fishery had observer coverage from 1990 to 1993 and 2003 to 2005. The NWHI observer program reported several interactions with non-ESA-listed seabirds during that time, and no interactions with marine mammals or sea turtles (Nitta, 1999; WPRFMC, 2017).

To date, there have been no reported interactions between MHI bottomfish fisheries and ESA-listed species of sea turtles, marine mammals, and seabirds. Furthermore, the commercial and non-commercial bottomfish fisheries in the MHI are not known to have the potential for a large and adverse effect on non-ESA-listed marine mammals. Although these species of marine mammals occur in the Exclusive Economic Zone (EEZ) waters where the fisheries operate and depredation of bait or catch by dolphins (primarily bottlenose dolphins) occurs (Kobayashi and Kawamoto, 1995), there have been no observed or reported takes of marine mammals by the bottomfish fishery.

The 2008 BiOp included an ITS of two green turtle mortalities per year from collisions with bottomfish vessels. There have not been any reported or observed collisions of bottomfish vessels with green turtles, and data are not available to attribute stranded turtle mortality to collisions with bottomfish vessels. However, the BiOp analysis to determine the estimated level of take from vessel collisions was based on an estimated 71,800 bottomfish fishing trips per year. The total annual number of commercial and non-commercial bottomfishing trips since 2008 has been less than 3,500 per year. Therefore, the potential for collisions with bottomfish vessels is substantially lower than was estimated in the 2008 BiOp.

Based on fishing effort and other characteristics described in Chapter 1 of this report, no notable changes have been observed in the fishery. There is no other information to indicate that impacts to sea turtle, marine mammal, and seabird species from this fishery have changed in recent years.

2.4.2.1.2 Elasmobranch Interactions

As described in Section 2.4.1.2, ESA consultation for newly listed elasmobranch species is ongoing. Available information on elasmobranch interactions in the MHI bottomfish fishery is included here, based on the Biological Evaluation (BE) initiating ESA Section 7 consultation for the fishery (NMFS, 2019).

A Federal observer program monitored the Northwestern Hawaiian Islands (NWHI) bottomfish fishery from October 2003 to April 2006. Observer data from that period reported five interactions with oceanic whitetip sharks. However, a recent review of these data by the NMFS Observer Program indicated that species identification for these records is uncertain and some or all of these interactions could have been whitetip reef sharks (NMFS, 2019). Additionally, the characteristics of the NWHI bottomfish fishery, which ceased operations in 2011 pursuant to the presidential proclamation establishing the Papahānaumokuākea Marine National Monument, differ from the MHI bottomfish fishery that operates today. The NWHI bottomfish fishery was comprised of larger vessels than those in the MHI due to the distance to the fishing grounds, and was conducted solely by commercial fishermen using heavier gear than those used in the MHI.

Cooperative research fishing surveys conducted by Kendall Enterprise Incorporated and Pacific Islands Fisheries Group as part of the MHI Bottomfish Fishery-Independent Survey contract local Deep-7 commercial fishermen to collect data using a standardized traditional fishing method (Kendall, 2014). In the 2016 to 2017 surveys comprising 814 fishing samples (each sample being 30 minutes in duration) and 2,545 records of fish catch, three whitetip reef sharks and no oceanic whitetip sharks were recorded (PIFSC unpublished data, cited in NMFS, 2019).

In addition to the bottomfish surveys, PIFSC researchers have conducted limited bottomfish fishing in the Pacific Islands region for life history research and fishery-independent survey purposes. Each research cruise may land a maximum of 1,200 kg of bottomfish. There have been seven such cruises in the Main Hawaiian Islands since 2007. However, there are no records of researchers catching oceanic whitetip sharks while conducting these activities (NMFS, 2019).

The Hawaii Department of Aquatic Resources (DAR) CML reports has a single code for "whitetip sharks", and thus interactions with "whitetip sharks" could be either oceanic whitetip sharks or whitetip reef sharks. In the Hawaii commercial catch database, bottomfish fishermen recorded 23 sharks under the "whitetip sharks" reporting code between 2000 and 2017. Based on the area fished, the catch composition associated with the captured sharks, and the size of the shark, DAR ascertained that eight were likely oceanic whitetip sharks, of which four occurred in the NWHI (NMFS, 2019).

Notwithstanding the sparsity of data and potential for species misidentification in self-reported data, available information indicates that oceanic whitetip shark captures in the MHI bottomfish fishery are rare. Sharks generally do not experience barotrauma when brought up from depth, and fishermen in Hawaii bottomfish fisheries tend to release hooked sharks alive by cutting their hook leaders (WPFMC and NMFS, 2007). However, quantitative estimates of post-release mortality are not available.

There are no records of giant manta ray incidental captures or entanglements in the Federally managed bottomfish fisheries in Hawaii.

2.4.2.2 Crustacean, Coral Reef, and Precious Coral Fisheries

There are no observer data available for the crustacean, coral reef, or precious coral fisheries operating under the Hawai`i FEP. However, based on current ESA consultations, these fisheries are not expected to interact with any ESA-listed species in federal waters around the Hawai`i Archipelago. NMFS has also concluded that the Hawai`i crustacean, coral reef, and precious coral commercial fisheries will not affect marine mammals in any manner not considered or authorized under the MMPA.

In 1986, one Hawaiian monk seal died as a result of entanglement with a bridle rope from a lobster trap. There have been no other reports of protected species interactions with any of these fisheries since then (WPRFMC, 2009; WPRFMC, 2017).

Based on fishing effort and other characteristics described in Chapter 1 of this report, no notable changes have been observed in these fisheries. There is no other information to indicate that impacts to protected species from this fishery have changed in recent years.

2.4.3 Identification of Emerging Issues

Table 53 summarizes current candidate ESA species, recent listing status, and post-listing activity (critical habitat designation and recovery plan development). Impacts from FEP-managed fisheries on any new listings and critical habitat designations will be considered in future versions of this report.

Table 53. Status of candidate ESA species, recent ESA listing processes, and post-listing activities

Species		Listing Process			Post-Listing Activity	
Common Name	**Scientific Name**	**90-Day Finding**	**12-Month Finding / Proposed Rule**	**Final Rule**	**Critical Habitat**	**Recovery Plan**
Oceanic Whitetip Shark	*Carcharhinus longimanus*	Positive (81 FR 1376, 1/12/2016)	Positive, threatened (81 FR 96304, 12/29/2016)	Listed as threatened (83 FR 4153, 1/30/18)	Designation not prudent; no areas within US jurisdiction that meet definition of critical habitat (85 FR 12898, 3/5/2020)	In development; recovery planning workshops convened in 2019; draft plan anticipated in late 2020.
Giant Manta Ray	*Manta birostris*	Positive (81 FR 8874, 2/23/2016)	Positive, threatened (82 FRN 3694, 1/12/2017)	Listed as threatened (83 FR 2916, 1/22/18)	Designation not prudent; no areas within US jurisdiction that meet definition of critical habitat (84 FR 66652, 12/5/2019)	Recovery outline published 12/4/19 to serve as interim guidance until full recovery plan is developed.

Species		Listing Process			Post-Listing Activity	
Common Name	**Scientific Name**	**90-Day Finding**	**12-Month Finding / Proposed Rule**	**Final Rule**	**Critical Habitat**	**Recovery Plan**
False Killer Whale (MHI Insular DPS)	*Pseudorca crassidens*	Positive (75 FR 316, 1/5/2010)	Positive, endangered (75 FR 70169, 11/17/2010)	Listed as endangered (77 FR 70915, 11/28/2012)	Designated in waters from the 45 m depth contour to the 3,200 m depth contour around the MHI from Niihau east to Hawaii (83 FR 35062, 07/24/2018)	In development, draft plan and public comment period anticipated in 2020
Green Sea Turtle	*Chelonia mydas*	Positive (77 FR 45571, 8/1/2012)	Identification of 11 DPSs, endangered and threatened (80 FR 15271, 3/23/2015)	11 DPSs listed as endangered and threatened (81 FR 20057, 4/6/2016)	In development, proposal expected TBA	TBA
Leatherback Sea Turtle	*Dermochelys coriacea*	Positive 90-day finding on a petition to identify the Northwest Atlantic leatherback turtle as a DPS (82 FR 57565, 12/06/2017)	TBA (status review and 12-month finding anticipated in 2020)	TBA	N/A	N/A
Cauliflower Coral	*Pocillopora meandrina*	Positive (83 FR 47592, 9/20/2018)	12-month finding anticipated by June 2020	TBA	N/A	N/A

Species		**Listing Process**			**Post-Listing Activity**	
Common Name	**Scientific Name**	**90-Day Finding**	**12-Month Finding / Proposed Rule**	**Final Rule**	**Critical Habitat**	**Recovery Plan**
Giant Clams	*Hippopus hippopus, H. porcellanus, Tridacna costata, T. derasa, T. gigas, T. Squamosa, and T. tevoroa*	Positive (82 FR 28946, 06/26/2017)	TBA (status review ongoing)	TBA	N/A	N/A

2.4.4 Identification of Research, Data, and Assessment Needs

The following research, data, and assessment needs for insular fisheries were identified by the Council's Plan Team:

- Improve species identification of commercial and non-commercial fisheries data (e.g., outreach, use FAO species codes) to improve understanding of potential protected species impacts.
- Define and evaluate innovative approaches to derive robust estimates of protected species interactions in insular fisheries.
- Conduct genetic and telemetry research to improve understanding of population structure and movement patterns for listed elasmobranchs.

2.5 CLIMATE AND OCEANIC INDICATORS

2.5.1 Introduction

Over the past few years, the Council has incorporated climate change into the overall management of the fisheries over which it has jurisdiction. This 2019 Annual SAFE Report includes a now standard chapter on indicators of climate and oceanic conditions in the Western Pacific region. These indicators reflect global climate variability and change as well as trends in local oceanographic conditions.

The reasons for the Council's decision to provide and maintain an evolving discussion of climate conditions as an integral and continuous consideration in their deliberations, decisions, and reports are numerous:

- Emerging scientific and community understanding of the impacts of changing climate conditions on fishery resources, the ecosystems that sustain those resources, and the communities that depend upon them;
- Recent Federal Directives including the 2010 implementation of a National Ocean Policy that identified Resiliency and Adaptation to Climate Change and Ocean Acidification as one of nine National priorities as well as the development of a Climate Science Strategy by NMFS in 2015 and the subsequent development of the Pacific Islands Regional Action Plan for climate science; and
- The Council's own engagement with NOAA as well as jurisdictional fishery management agencies in American Samoa, CNMI, Guam, and Hawaii as well as fishing industry representatives and local communities in those jurisdictions.

In 2013, the Council began restructuring its Marine Protected Area/Coastal and Marine Spatial Planning Committee to include a focus on climate change, and the committee was renamed as the Marine Planning and Climate Change (MPCC) Committee. In 2015, based on recommendations from the committee, the Council adopted its Marine Planning and Climate Change Policy and Action Plan, which provided guidance to the Council on implementing climate change measures, including climate change research and data needs. The revised Pelagic FEP (February 2016) included a discussion on climate change data and research as well as a new objective (Objective 9) that states the Council should consider the implications of climate change in decision-making, with the following sub-objectives:

- To identify and prioritize research that examines the effects of climate change on Council-managed fisheries and fishing communities.
- To ensure climate change considerations are incorporated into the analysis of management alternatives.
- To monitor climate change related variables via the Council's Annual Reports.
- To engage in climate change outreach with U.S. Pacific Islands communities.

Beginning with the 2015 report, the Council and its partners began providing continuing descriptions of changes in a series of climate and oceanic indicators.

This annual report focuses previous years' efforts by refining existing indicators and improving communication of their relevance and status. Future reports will include additional indicators as the information becomes available and their relevance to the development, evaluation, and revision of the FEPs becomes clearer. Working with national and jurisdictional partners, the

Council will make all datasets used in the preparation of this and future reports available and easily accessible.

2.5.2 Response to Previous Plan Team and Council Recommendations

There were no Council recommendations relevant to the climate and oceanic indicators section of the Annual SAFE Report in 2019.

At its 170th meeting from June 20-22, 2017, the Council directed staff to support the development of community training and outreach materials and activities on climate change. In addition, the Council directed staff to coordinate a "train-the-trainers" workshop that includes NOAA scientists who presented at the 6th Marine Planning and Climate Change Committee (MPCCC) meeting and the MPCCC members in preparation for community workshops on climate and fisheries. The Council and NOAA partnered to deliver the workshops in the fall of 2017 to the MPCCC members in Hawaii (with the Hawaii Regional Ecosystem Advisory Committee), as well as American Samoa, Guam, and the CNMI (with their respective Advisory Panel groups). Feedback from workshop participants has been incorporated into this year's climate and oceanic indicator section. To prepare for community outreach, Guam-based MPCCC members conducted a climate change survey and shared the results with the MPCCC at its 7th meeting on April 10th and 11th, 2018. The Council also directed staff to explore funding avenues to support the development of additional oceanic and climate indicators, such as wind and extratropical storms. These indicators were added to this module by corresponding Plan Team members in 2018.

Prior to holding its 8th meeting, the MPCCC was disbanded in early 2019, re-allocating its responsibilities among its members already on other committees or teams, such as the Fishery Ecosystem Plan Teams.

2.5.3 Conceptual Model

In developing this chapter, the Council relied on a number of recent reports conducted in the context of the U.S. National Climate Assessment including, most notably, the 2012 Pacific Islands Regional Climate Assessment (PIRCA) and the Ocean and Coasts chapter of the 2014 report on a Pilot Indicator System prepared by the National Climate Assessment and Development Advisory Committee (NCADAC).

The Advisory Committee Report presented a possible conceptual framework designed to illustrate how climate factors can connect to and interact with other ecosystem components to ocean and coastal ecosystems and human communities. The Council adapted this model with considerations relevant to the fishery resources of the Western Pacific Region:

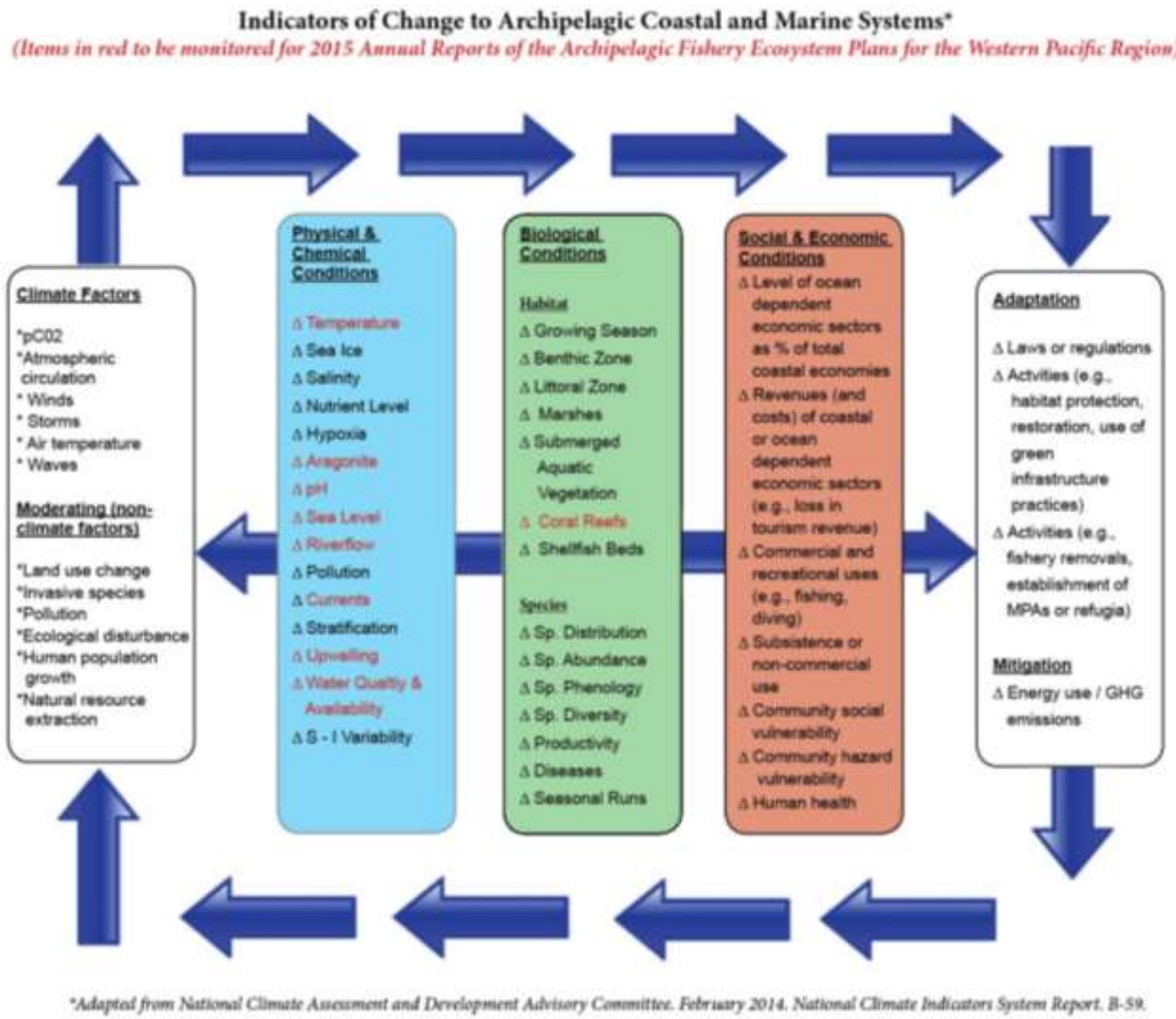


Figure 19. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability

As described in the 2014 NCADAC report, the conceptual model presents a "simplified representation of climate and non-climate stressors in coastal and marine ecosystems." For the purposes of this Annual Report, the modified Conceptual Model allows the Council and its partners to identify indicators of interest to be monitored on a continuing basis in coming years. The indicators shown in red were considered for inclusion in the Annual SAFE Reports, though the final list of indicators varied somewhat. Other indicators will be added over time as data become available and an understanding of the causal chain from stressors to impacts emerges.

The Council also hopes that this Conceptual Model can provide a guide for future monitoring and research. This guide will ideally enable the Council and its partners to move forward from observations and correlations to understanding the specific nature of interactions, and to develop capabilities to predict future changes of importance in the developing, evaluating, and adapting of FEPs in the Western Pacific region.

2.5.4 Selected Indicators

The primary goal for selecting the Indicators used in this (and future reports) is to provide fisheries-related communities, resource managers, and businesses with climate-related situational awareness. In this context, Indicators were selected to:

- Be fisheries relevant and informative;
- Build intuition about current conditions in light of changing climate;
- Provide historical context; and
- Recognize patterns and trends.

In this context, this section includes the following climate and oceanic indicators:

- Atmospheric concentration of carbon dioxide (CO_2)
- Oceanic pH at Station ALOHA;
- Oceanic Niño Index (ONI);
- Pacific Decadal Oscillation (PDO);
- Tropical cyclones;
- Sea surface temperature (SST);
- Coral Thermal Stress Exposure
- Chlorophyll-A
- Rainfall
- Sea Level (Sea Surface Height)

Figure 20 and Figure 21 provide a description of these indicators and illustrate how they are connected to each other in terms of natural climate variability and anthropogenic climate change.

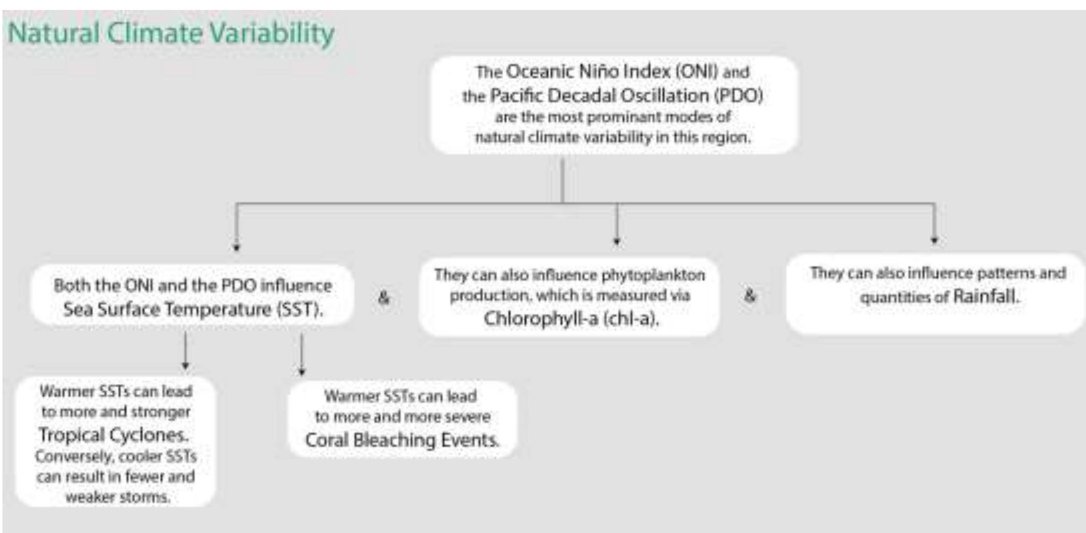


Figure 20. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability

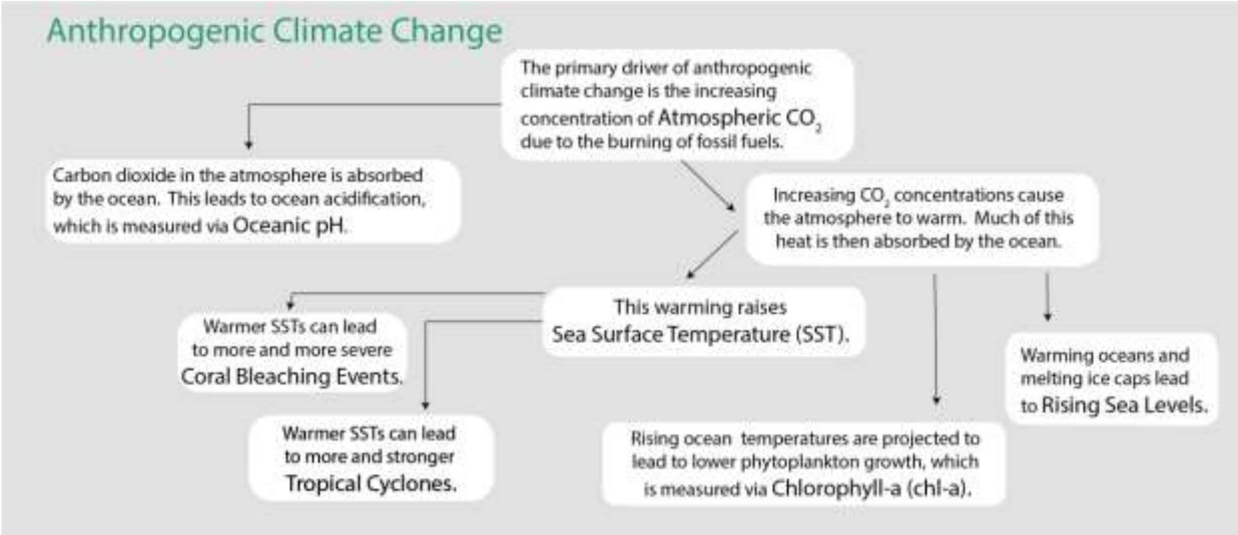


Figure 21. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of anthropogenic climate change

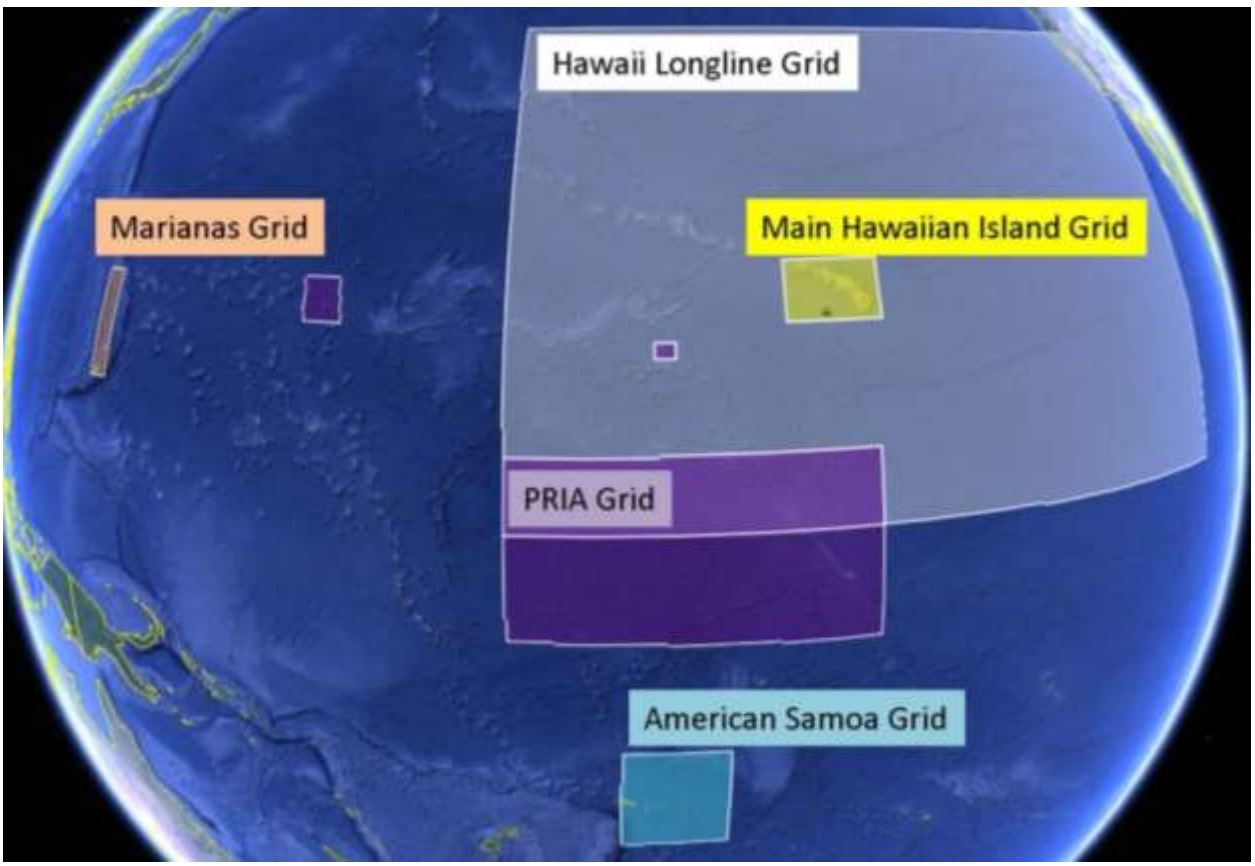


Figure 22. Regional spatial grids representing the scale of the climate change indicators being monitored

2.5.4.1 Atmospheric Concentration of Carbon Dioxide (CO_2) at Mauna Loa

Rationale: Atmospheric carbon dioxide is a measure of what human activity has already done to affect the climate system through greenhouse gas emissions. It provides quantitative information in a simplified, standardized format that decision makers can easily understand. This indicator demonstrates that the concentration (and, in turn, warming influence) of greenhouse gases in the atmosphere has increased substantially over the last several decades.

Status: Atmospheric CO_2 is increasing exponentially. This means that atmospheric CO_2 is increasing at a faster rate each year. In 2019, the annual mean concentration of CO_2 was 411 ppm. In 1959, the first year of the time series, it was 316 ppm. The annual mean passed 350 ppm in 1988 and 400 ppm in 2015 (NOAA, 2020a).

Description: Monthly mean atmospheric CO_2 at Mauna Loa Observatory, Hawaii in parts per million (ppm) from March 1958 to present. The observed increase in monthly average carbon dioxide concentration is primarily due to CO_2 emissions from fossil fuel burning. Carbon dioxide remains in the atmosphere for a very long time, and emissions from any location mix throughout the atmosphere in about one year. The annual oscillations at Mauna Loa, Hawaii are due to the seasonal imbalance between the photosynthesis and respiration of plants on land. During the summer growing season photosynthesis exceeds respiration and CO_2 is removed from the atmosphere, whereas outside the growing season respiration exceeds photosynthesis and CO_2 is returned to the atmosphere. The seasonal cycle is strongest in the northern hemisphere because of this hemisphere's larger land mass.

Timeframe: Annual, monthly.

Region/Location: Mauna Loa, Hawaii but representative of global atmospheric carbon dioxide concentration.

Measurement Platform: *In-situ* station.

Sourced from: Keeling et al. (1976), Thoning et al. (1989), and NOAA (2020a).

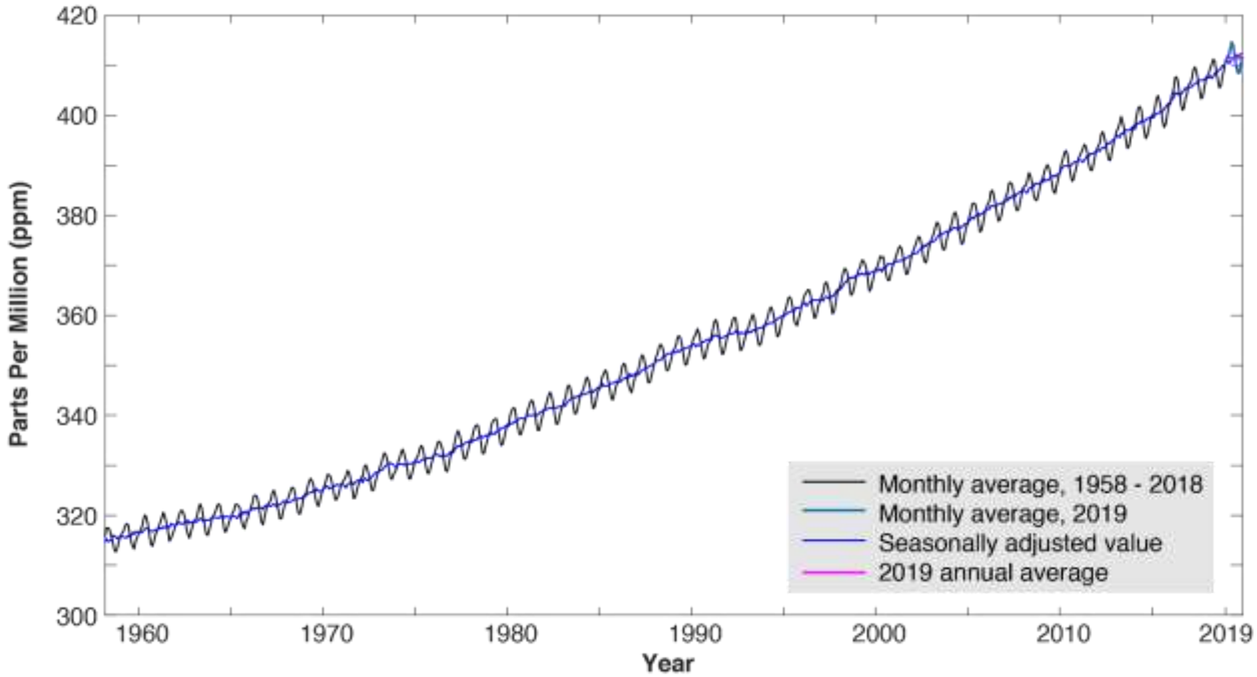


Figure 23. Monthly mean (red) and seasonally corrected (black) atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii

2.5.4.2 Oceanic pH

Rationale: Oceanic pH is a measure of how greenhouse gas emissions have already impacted the ocean. This indicator demonstrates that oceanic pH has decreased significantly over the past several decades (i.e. the ocean has become more acidic). Increasing ocean acidification limits the ability of marine organisms to build shells and other calcareous structures. Recent research has shown that pelagic organisms such as pteropods and other prey for commercially valuable fish species are already being negatively impacted by increasing acidification (Feely et al., 2016). The full impact of ocean acidification on the pelagic food web is an area of active research (Fabry et al., 2008).

Status: The ocean is roughly 9.7% more acidic than it was 30 years ago at the start of this time series. Over this time, pH has declined by 0.0401 at a constant rate. In 2018, the most recent year for which data are available, the average pH was 8.07. Additionally, small variations seen over the course of the year are now outside the range seen in the first year of the time series. The highest pH value reported for the most recent year (8.0743, down from a high of 8.0830 in 2017) is lower than the lowest pH value reported in the first year of the time series (8.0845).

Description: Trends in surface (5 m) pH at Station ALOHA, north of Oahu (22.75°N, 158°W), collected by the Hawai`i Ocean Time Series (HOT) from October 1988 to 2017 (2018 data are not yet available). Oceanic pH is a measure of ocean acidity, which increases as the ocean absorbs carbon dioxide from the atmosphere. Lower pH values represent greater acidity. Oceanic pH is calculated from total alkalinity (TA) and dissolved inorganic carbon (DIC). Total alkalinity represents the ocean's capacity to resist acidification as it absorbs CO_2 and the amount of CO_2 absorbed is captured through measurements of DIC. The multi-decadal time series at Station ALOHA represents the best available documentation of the significant downward trend in oceanic pH since the time series began in 1988. Oceanic pH varies over both time and space, though the conditions at Station ALOHA are considered broadly representative of those across the Western and Central Pacific's pelagic fishing grounds.

Timeframe: Monthly.

Region/Location: Station ALOHA: 22.75°N, 158°W.

Measurement Platform: *In-situ* station.

Sourced from: Fabry et al. (2008), Feely et al. (2016). These data are based upon Hawaii Ocean Time-series observations supported by the U.S. National Science Foundation under Grant OCE-12-60164 a as described in Karl et al. (1996) and on its website (HOT, 2019).

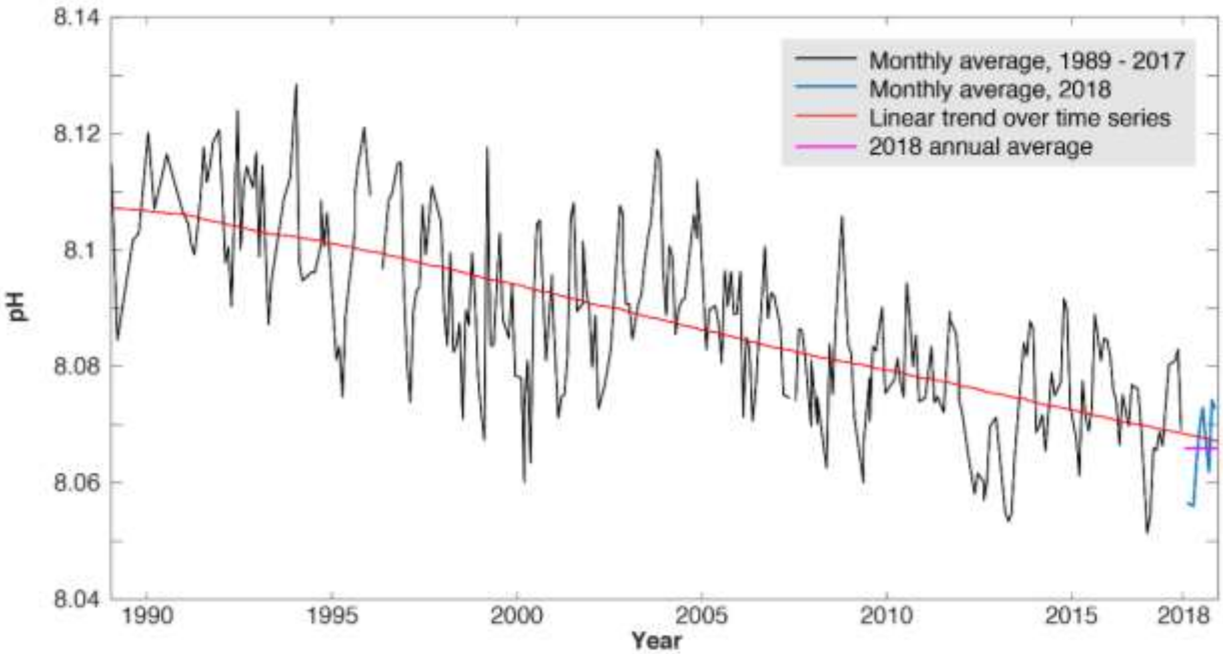


Figure 24. Oceanic pH (black) and its trend (red) at Station ALOHA from 1989 – 2018

2.5.4.3 Oceanic Niño Index

Rationale: The El Niño – Southern Oscillation (ENSO) cycle is known to have impacts on Pacific fisheries including tuna fisheries. The Oceanic Niño Index (ONI) focuses on ocean temperature, which has the most direct effect on these fisheries.

Status: In 2019, the ONI transitioned from a weak El Niño to neutral conditions.

Description: The three-month running mean of satellite remotely-sensed sea surface temperature (SST) anomalies in the Niño 3.4 region (5°S – 5°N, 120° – 170°W). The ONI is a measure of the ENSO phase. Warm and cool phases, termed El Niño and La Niña respectively, are based in part on an ONI threshold of ± 0.5 °C being met for a minimum of five consecutive overlapping seasons. Additional atmospheric indices are needed to confirm an El Niño or La Niña event, as the ENSO is a coupled ocean-atmosphere phenomenon. The atmospheric half of ENSO is measured using the Southern Oscillation Index.

Timeframe: Every three months.

Region/Location: Niño 3.4 region, 5°S – 5°N, 120° – 170°W.

Measurement Platform: *In-situ* station, satellite, model.

Sourced from NOAA CPC (2020).

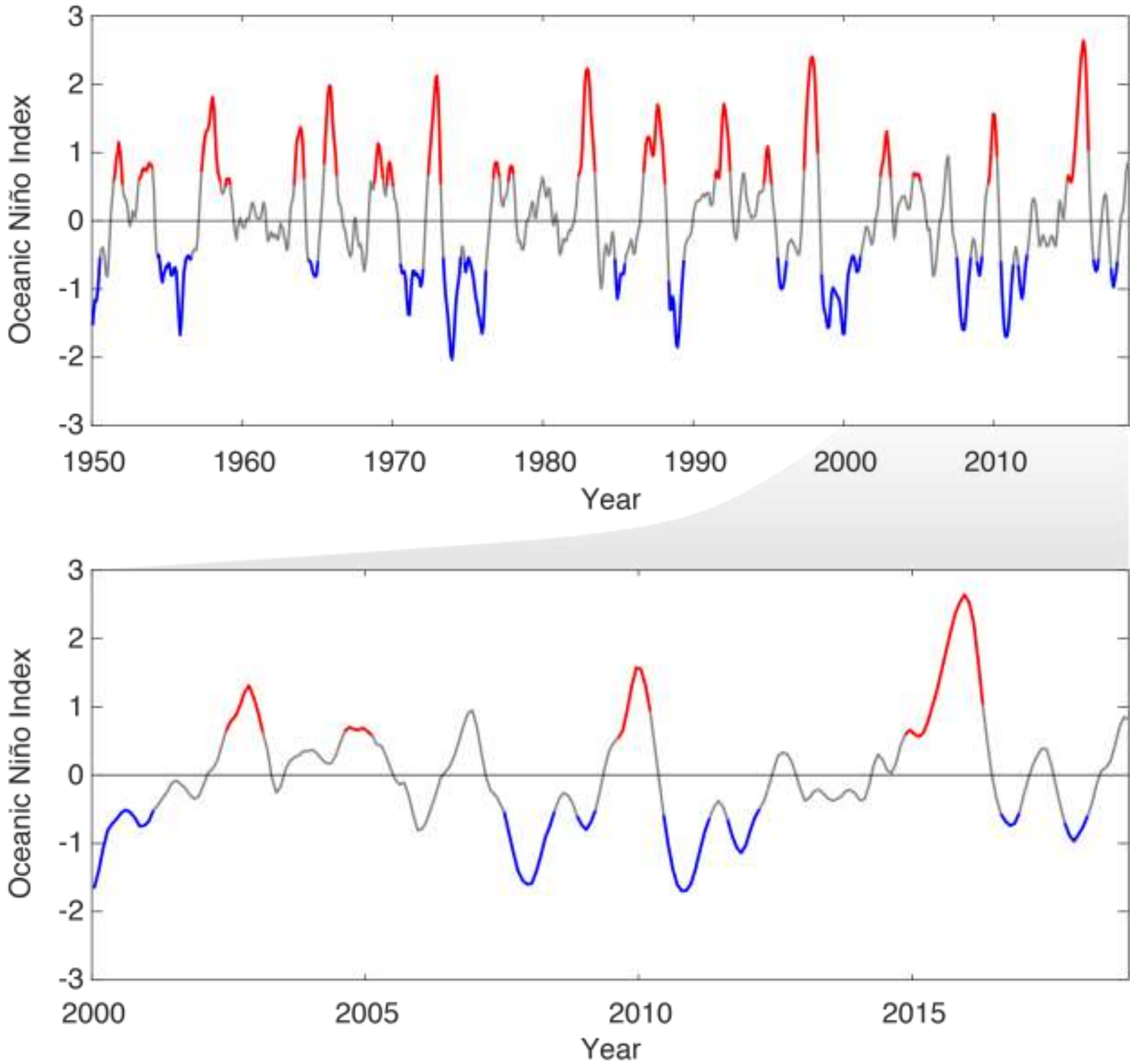


Figure 25. Oceanic Niño Index from 1950-2019 (top) and 2000–2019 (bottom) with El Niño periods in red and La Niña periods in blue

2.5.4.4 Pacific Decadal Oscillation

Rationale: The Pacific Decadal Oscillation (PDO) was initially named by fisheries scientist Steven Hare in 1996 while researching connections between Alaska salmon production cycles and Pacific climate. Like ENSO, the PDO reflects changes between periods of persistently warm or persistently cool ocean temperatures, but over a period of 20 to 30 years (versus six to 18 months for ENSO events). The climatic fingerprints of the PDO are most visible in the Northeastern Pacific, but secondary signatures exist in the tropics.

Status: The PDO hovered around zero in 2019. The year was nearly evenly split between values that were slightly negative (seven months) and values that were slightly positive (5 months).

Description: The PDO is often described as a long-lived El Niño-like pattern of Pacific climate variability. As seen with the better-known ENSO, extremes in the PDO pattern are marked by widespread variations in the Pacific Basin and the North American climate. In parallel with the ENSO phenomenon, the extreme cases of the PDO have been classified as either warm or cool, as defined by ocean temperature anomalies in the northeast and tropical Pacific Ocean. When SST is below average in the interior North Pacific and warm along the North American coast, and when sea level pressures are below average in the North Pacific, the PDO has a positive value. When the climate patterns are reversed, with warm SST anomalies in the interior and cool SST anomalies along the North American coast, or above average sea level pressures over the North Pacific, the PDO has a negative value NOAA (2020b).

Timeframe: Annual, monthly.

Region/Location: Pacific Basin north of 20°N.

Measurement Platform: *In-situ* station, satellite, model.

Sourced from: NOAA (2020b).

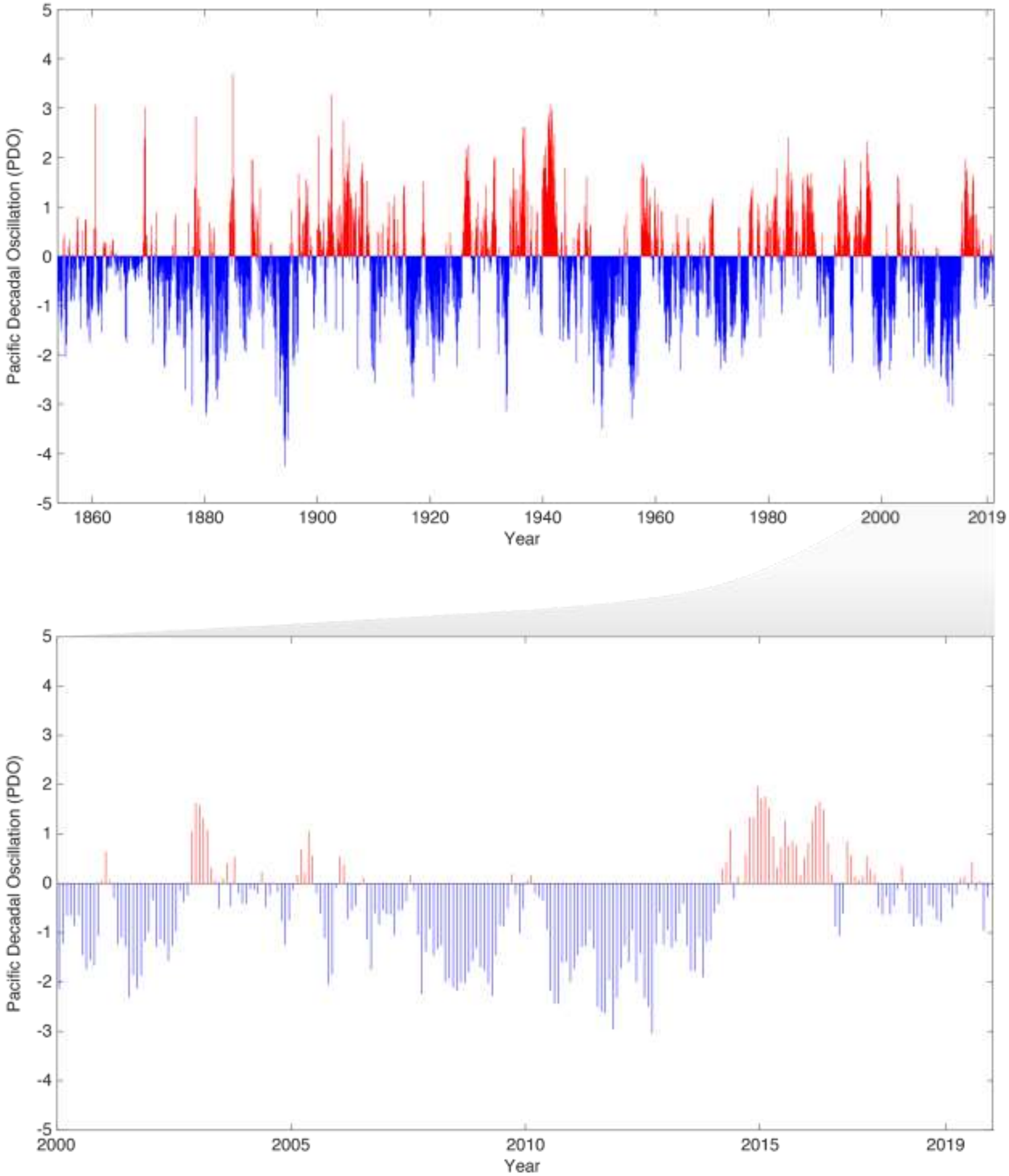


Figure 26. Pacific Decadal Oscillation from 1950–2019 (top) and 2000–2019 (bottom) with positive warm periods in red and negative cool periods in blue

2.5.4.5 Tropical Cyclones

Rationale: The effects of tropical cyclones are numerous and well known. At sea, storms disrupt and endanger shipping traffic as well as fishing effort and safety. The Hawai`i longline fishery, for example, has had serious problems with vessels dodging storms at sea, delayed departures, and inability to make it safely back to Honolulu because of bad weather. When cyclones encounter land, their intense rains and high winds can cause severe property damage, loss of life, soil erosion, and flooding. Associated storm surge, the large volume of ocean water pushed toward shore by cyclones' strong winds, can cause severe flooding and destruction.

Status:

Eastern North Pacific. Overall, the 2019 eastern Pacific hurricane season featured near average activity. There were 17 named storms, of which seven became hurricanes and three became major hurricanes - category 3 or higher on the Saffir-Simpson Hurricane Wind Scale. This compares to the long-term averages of fifteen named storms, eight hurricanes, and four major hurricanes. There were also two tropical depressions that did not reach tropical storm strength. In terms of Accumulated Cyclone Energy (ACE), which measures the strength and duration of tropical storms and hurricanes, activity in the basin in 2019 was a little below the long-term mean. Summary inserted from https://www.nhc.noaa.gov/text/MIATWSEP.shtml.

Central North Pacific. Tropical cyclone activity in the central Pacific in 2019 was average. There were four named storms, of which one became a hurricane and one became a major hurricane. The ACE index was slightly below the 1981 – 2010 average of roughly 20 (x 10^4 knots^2).

Western North Pacific. Tropical cyclone activity was roughly average in the western Pacific in 2019. There were 26 named storms. Sixteen of these storms developed into typhoons, and ten of these typhoons were major. The ACE Index was below the 1981 – 2010 average. Of note was Super typhoon Hagibis. Hagibis was just the third category 5 tropical cyclone globally in 2019 (Super Typhoon Wutip and Hurricane Dorian were the others). Hagibis weakened to a category 2 storm before making landfall in Japan but was still one of the most damaging typhoons in history. The remnants of Hagibis transitioned to an extratropical cyclone that affected the Aleutian Islands and significantly altered the weather patterns over the North America in the subsequent days. Summary inserted from https://www.ncdc.noaa.gov/sotc/tropical-cyclones/201910.

South Pacific. Tropical cyclone activity was average in the south Pacific region in 2019. There were nine named storms, four of which developed into cyclones and one of which was a major cyclone. The ACE Index were below average in 2018.

Description: This indicator uses historical data from the NOAA National Climate Data Center (NCDC) International Best Track Archive for Climate Stewardship to track the number of tropical cyclones in the western, central, eastern, and southern Pacific basins. This indicator also monitors the Accumulated Cyclone Energy (ACE) Index and the Power Dissipation Index which are two ways of monitoring the frequency, strength, and duration of tropical cyclones based on wind speed measurements.

The annual frequency of storms passing through each basin is tracked and a stacked time series plot shows the representative breakdown of Saffir-Simpson hurricane categories.

Every cyclone has an ACE Index value, which is a number based on the maximum wind speed measured at six-hourly intervals over the entire time that the cyclone is classified as at least a tropical storm (wind speed of at least 34 knots; 39 mph). Therefore, a storm's ACE Index value accounts for both strength and duration. This plot shows the historical ACE values for each hurricane/typhoon season and has a horizontal line representing the average annual ACE value.

Timeframe: Annual.

Region/Location:

Eastern North Pacific: east of 140° W, north of the equator.

Central North Pacific: 180° - 140° W, north of the equator.

Western North Pacific: west of 180°, north of the equator.

South Pacific: south of the equator.

Measurement Platform: Satellite.

Sourced from: Knapp et al. (2010), Knapp et al. (2018).

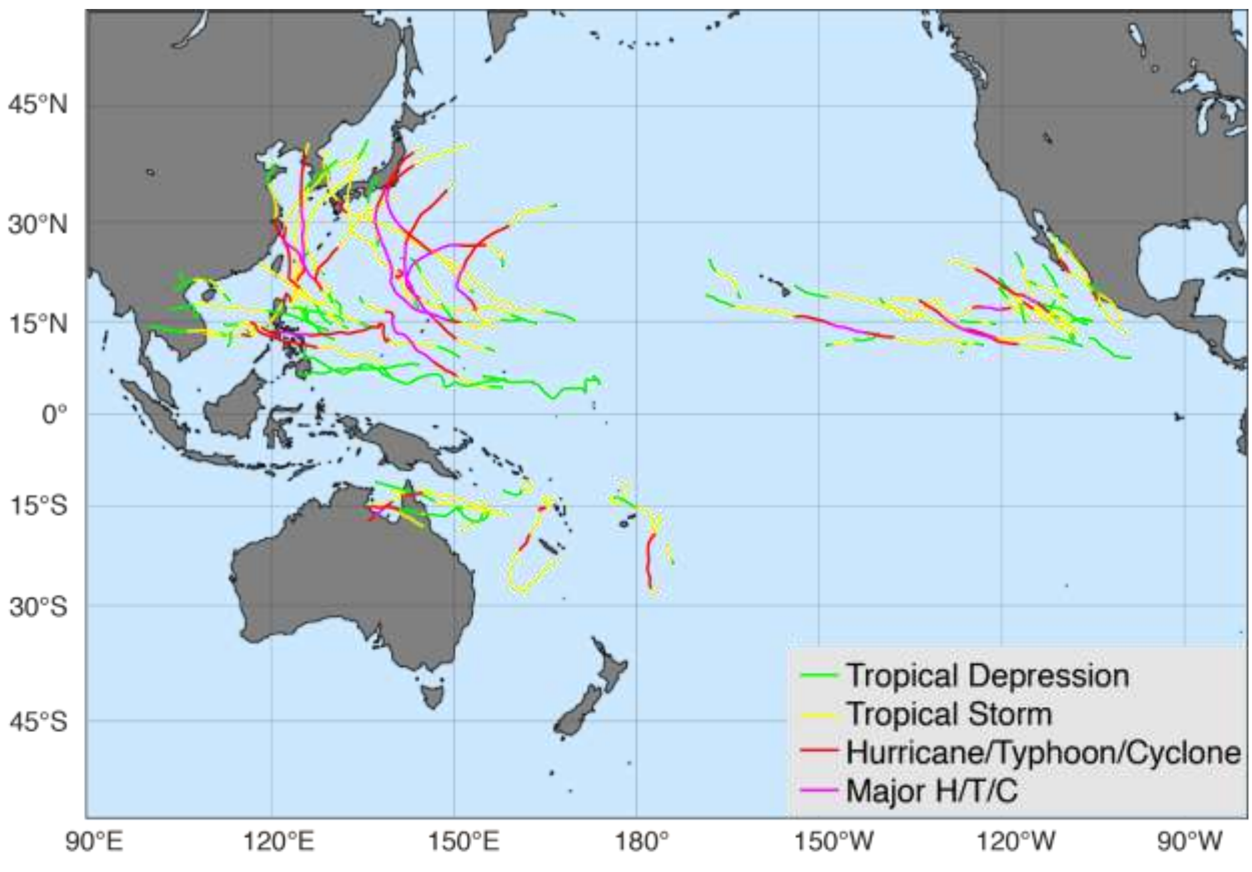


Figure 27. 2019 Pacific basin tropical cyclone tracks

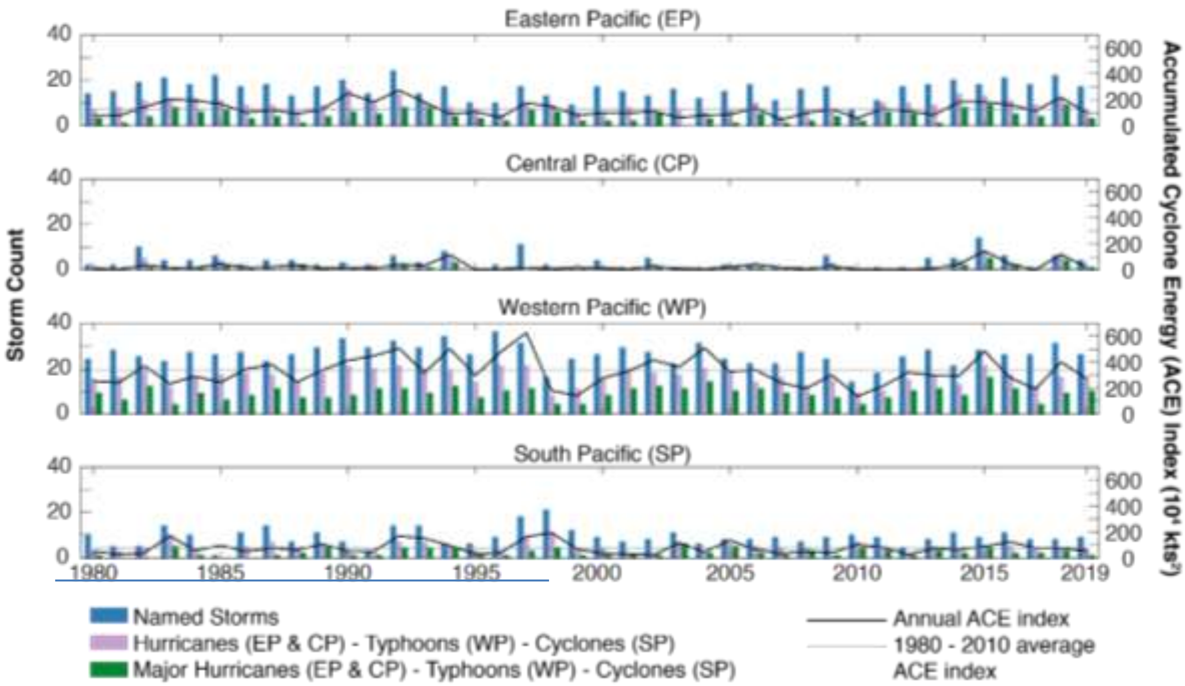


Figure 28. 2019 tropical storm totals by region

2.5.4.6 Sea Surface Temperature & Anomaly

Rationale: Sea surface temperature is one of the most directly observable existing measures for tracking increasing ocean temperatures. SST varies in response to natural climate cycles such as the El Niño – Southern Oscillation (ENSO) and is projected to rise as a result of anthropogenic climate change. Both short-term variability and long-term trends in SST impact the marine ecosystem. Understanding the mechanisms through which organisms are impacted and the time scales of these impacts is an area of active research.

Status*:* Annual mean SST was 26.24ºC in 2019. Over the period of record, annual SST has increased at a rate of 0.017 ºC yr^{-1}. Monthly SST values in 2019 ranged from 23.88 – 28.01 ºC, outside the climatological range of 23.28 – 28.47 ºC. The annual anomaly was 0.72 ºC hotter than average, with some intensification along leeward shores.

Note that from the top to bottom in Figure 29, panels show climatological SST (1985-2018), 2019 SST anomaly, time series of monthly mean SST, and time series of monthly SST anomaly. The white box in the upper panels indicates the area over which SST is averaged for the time series plots.

Description: Satellite remotely-sensed monthly sea surface temperature (SST) is averaged across the Main Hawaiian Island Grid (18.5° – 22.5°N, 161° – 154°W). A time series of monthly mean SST averaged over the Main Hawaiian Island region is presented. Additionally, spatial climatology and anomalies are shown.

Timeframe: Monthly.

Region/Location: Main Hawaiian Island Grid (18.5° – 22.5°N, 161° – 154°W).

Measurement Platform: Satellite.

Measurement Platform: *AVHRR*, *POES Satellite*, *GOES 12 and 12 Satellites*.

Sourced from: NOAA OceanWatch (2020).

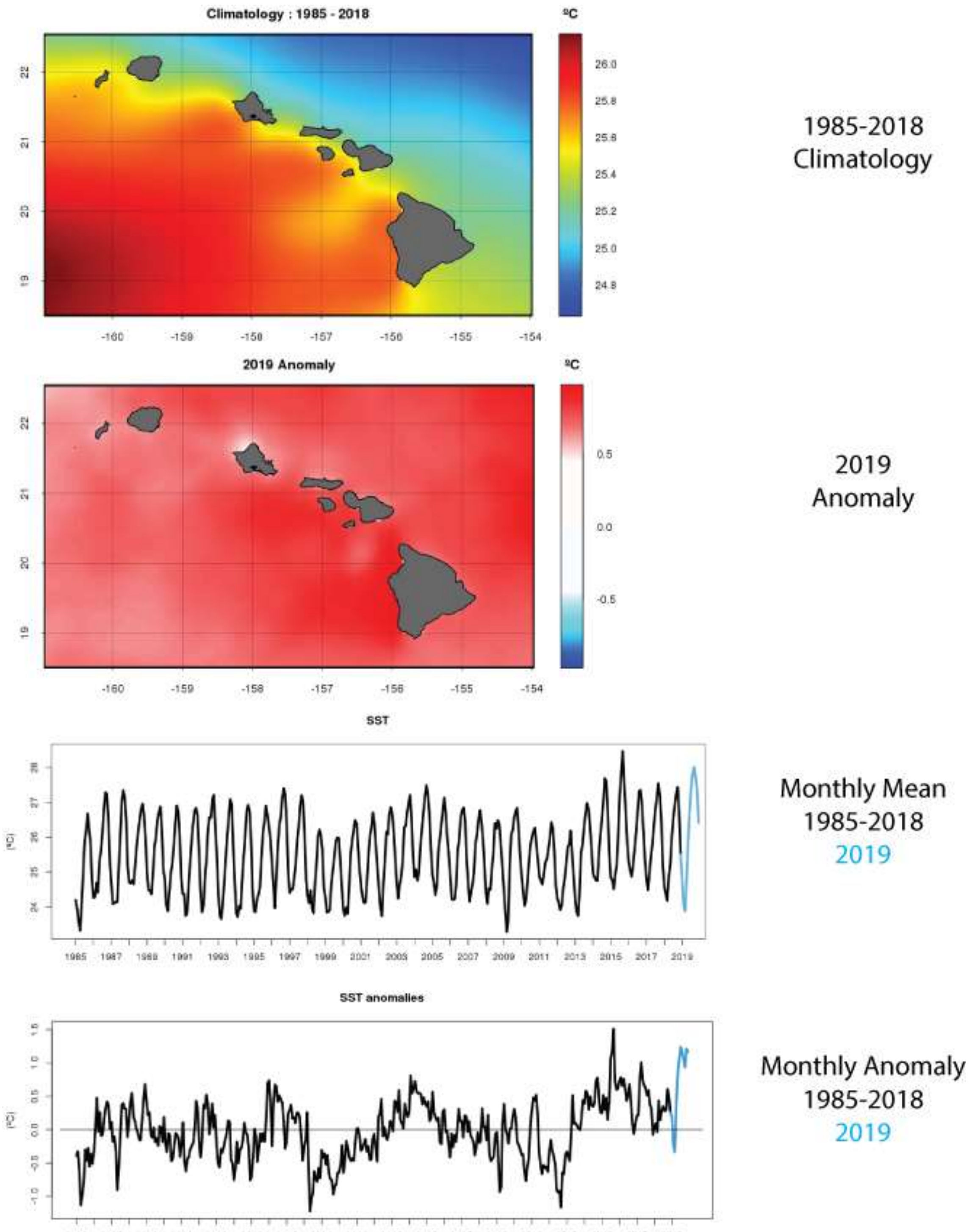


Figure 29. Sea surface temperature climatology and anomalies from 1982-2019

2.5.4.7 Coral Thermal Stress Exposure: Degree Heating Weeks

Rationale: Degree heating weeks are one of the most widely used metrics for assessing exposure to coral bleaching-relevant thermal stress.

Status: After a series of stress events in 2014, 2015, and 2017, the main Hawaiian Islands experienced a coral heat stress event in 2019 which reached it maximum in October 2019.

Description: Here we present a metric of exposure to thermal stress that is relevant to coral bleaching. Degree Heating Weeks (DHW) measure time and temperature above a reference 'summer maximum', presented as rolling sum weekly thermal anomalies over a 12-week period. Higher DHW measures imply a greater likelihood of mass coral bleaching or mortality from thermal stress.

The NOAA Coral Reef Watch program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Bleaching is the process by which corals lose the symbiotic algae that give them their distinctive colors. If a coral is severely bleached, disease and death become likely.

The NOAA Coral Reef Watch (CRW) daily 5-km satellite coral bleaching Degree Heating Week (DHW) product presented here shows accumulated heat stress, which can lead to coral bleaching and death. The scale goes from 0 to 20 °C-weeks. The DHW product accumulates the instantaneous bleaching heat stress (measured by Coral Bleaching HotSpots) during the most-recent 12-week period. It is directly related to the timing and intensity of coral bleaching. Significant coral bleaching usually occurs when DHW values reach 4 °C-weeks. By the time DHW values reach 8 °C-weeks, widespread bleaching is likely and significant mortality can be expected (NOAA Coral Reef Watch 2020).

Timeframe: 2013-2018, Daily data.

Region/Location: Global.

Sourced from: NOAA Coral Reef Watch (2020); https://coralreefwatch.noaa.gov/product/vs/timeseries/polynesia.php#hawaii.

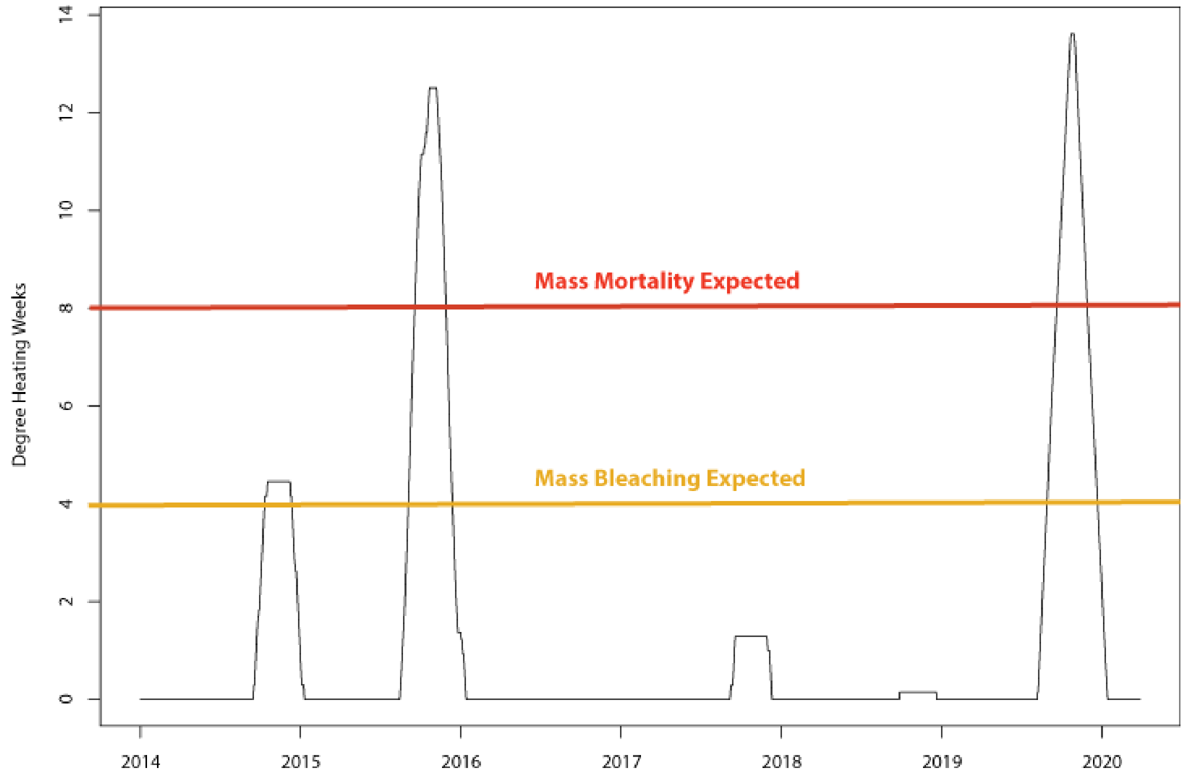


Figure 30. Coral Thermal Stress Exposure, Main Hawaiian Island Virtual Station from 2014-2019, measured in Coral Reef Watch Degree Heating Weeks

2.5.4.8 Chlorophyll-A and Anomaly

Rationale: Chlorophyll-A is one of the most directly observable measures we have for tracking increasing ocean productivity.

Status: Annual mean Chl-A was 0.065 mg/m^3 in 2019. Over the period of record, annual Chl-A has shown no significant temporal trend. Monthly Chl-A values in 2019 ranged from 0.057-0.081 mg/m^3, within the climatological range of 0.053 – 0.11 mg/m^3. The annual anomaly was 0.0053 mg/m^3 lower than average, with some intensification in the northwestern section of the region.

Description: Chlorophyll-A Concentration from 1998-2019, derived from the ESA Ocean Color Climate Change Initiative dataset, v4.2. A monthly climatology was generated across the entire period (1982-2018) to provide both a 2019 spatial anomaly, and an anomaly time series.

ESA Ocean Color Climate Change Initiative dataset is a merged dataset, combining data from SeaWIFS, MODIS-Aqua, MERIS, and VIIRS to provide a homogeneous time-series of ocean color. Data was accessed from the OceanWatch Central Pacific portal.

Timeframe: 2003-2018, Daily data available, Monthly means shown.

Region/Location: Global.

Measurement Platform: SeaWIFS, MODIS-Aqua, MERIS, and VIIRS

Sourced from: NOAA OceanWatch (2020) Central Pacific Node; https://oceanwatch.pifsc.noaa.gov/.

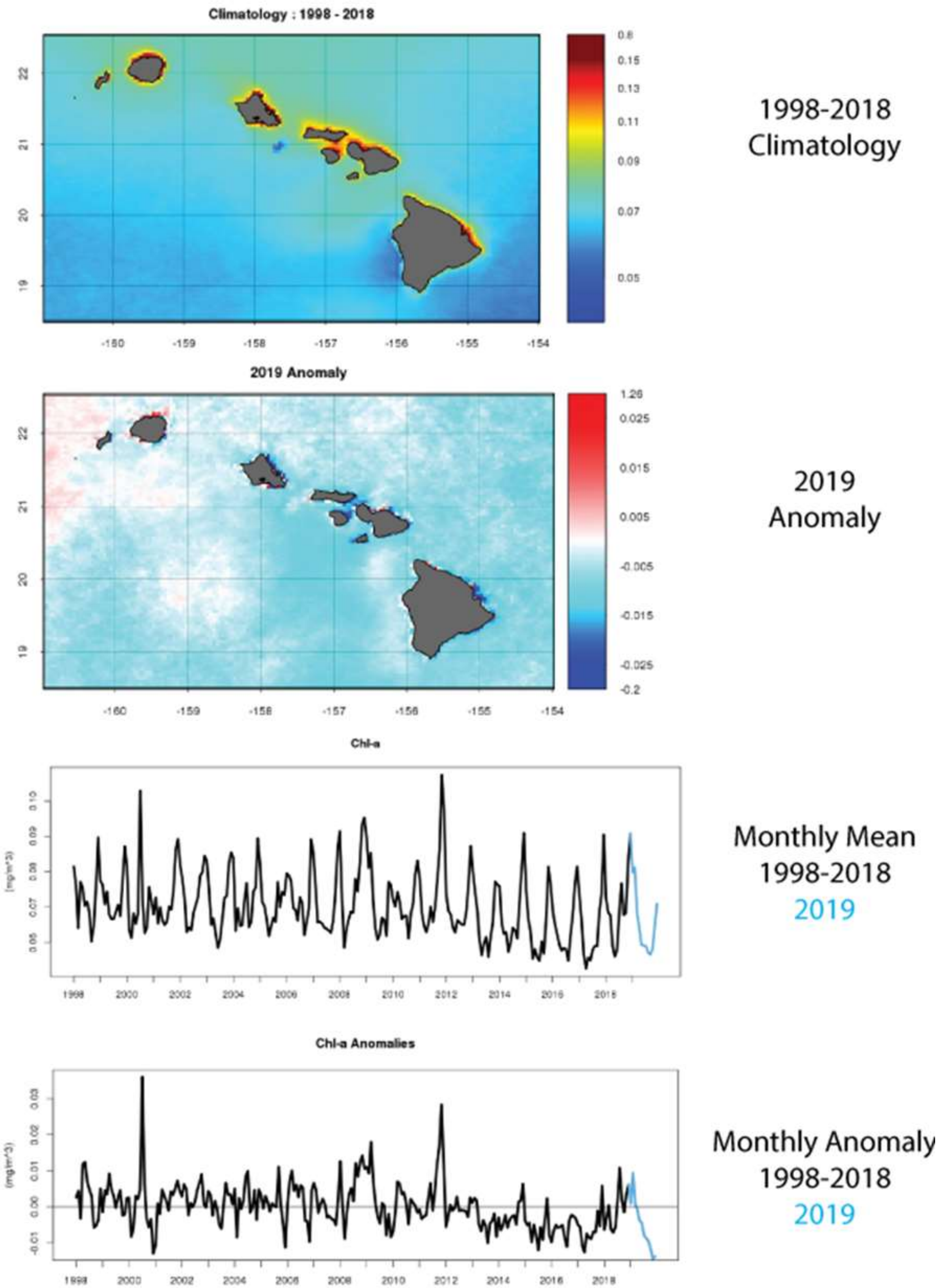


Figure 31. Chlorophyll-A (Chl-A) and Chl-A Anomaly from 1998-2019

2.5.4.9 Rainfall

Rationale: Rainfall may have substantive effects on the nearshore environment and is a potentially important co-variate with the landings of particular stocks.

Description: The CPC Merged Analysis of Precipitation (CMAP) is a technique which produces pentad and monthly analyses of global precipitation in which observations from rain gauges are merged with precipitation estimates from several satellite-based algorithms, such as infrared and microwave (NOAA 2002). The analyses are on a 2.5 x 2.5-degree latitude/longitude grid and extend back to 1979. CMAP Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at https://www.esrl.noaa.gov/psd/. The data are comparable (but should not be confused with) similarly combined analyses by the Global Precipitation Climatology Project described in Huffman et al. (1997).

It is important to note that the input data sources to make these analyses are not constant throughout the period of record. For example, SSM/I (passive microwave - scattering and emission) data became available in July 1987; prior to that the only microwave-derived estimates available are from the MSU algorithm (Spencer, 1993) which is emission-based thus precipitation estimates are available only over oceanic areas. Furthermore, high temporal resolution IR data from geostationary satellites (every 3-hr) became available during 1986; prior to that, estimates from the OPI technique (Xie and Arkin, 1997) are used based on OLR from orbiting satellites.

The merging technique is thoroughly described in Xie and Arkin (1997). Briefly, the methodology is a two-step process. First, the random error is reduced by linearly combining the satellite estimates using the maximum likelihood method, in which case the linear combination coefficients are inversely proportional to the square of the local random error of the individual data sources. Over global land areas the random error is defined for each time period and grid location by comparing the data source with the rain gauge analysis over the surrounding area. Over oceans, the random error is defined by comparing the data sources with the rain gauge observations over the Pacific atolls. Bias is reduced when the data sources are blended in the second step using the blending technique of Reynolds (1988).

Timeframe: Monthly.

Region/Location: Global.

Measurement Platform: *In-situ* station gauges and satellite data.

Sourced from: CMAP Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their web site at https://www.esrl.noaa.gov/psd/; http://apdrc.soest.hawaii.edu/datadoc/cmap_month.php.

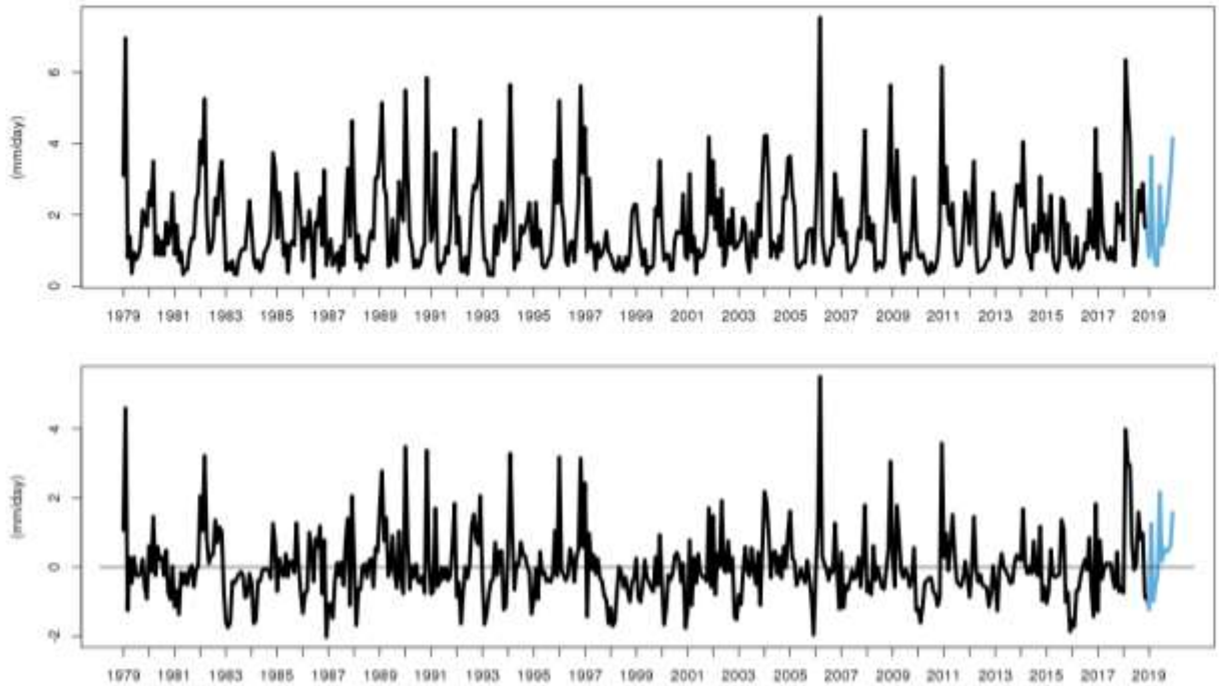


Figure 32. CMAP precipitation across the MHI Grid with 2019 values in blue

2.5.4.10 Sea Level (Sea Surface Height and Anomaly)

Rationale: Coastal: Rising sea levels can result in a number of coastal impacts, including inundation of infrastructure, increased damage resulting from storm-driven waves and flooding, and saltwater intrusion into freshwater supplies.

Description: Monthly mean sea level time series of local and basin-wide sea surface height and sea surface height anomalies, including extremes.

Timeframe: Monthly.

Region/Location: Observations from selected sites within the Hawaiian Archipelago.

Measurement Platform: Satellite and *in situ* tide gauges.

Sourced from: Aviso (2020) and https://tidesandcurrents.noaa.gov/datum_options.html

2.5.4.10.1 Basin-Wide Perspective

This image of the mean sea level anomaly for March 2019 compared to 1993-2013 climatology from satellite altimetry provides a glimpse into how the current weak El Niño continues to affect sea level across the Pacific Basin. The image captures the fact that sea level continues to be lower in the Western Pacific and higher in the Central and Eastern Pacific (a standard pattern during El Niño events - this basin-wide perspective provides a context for the location-specific sea level/sea surface height images that follow).

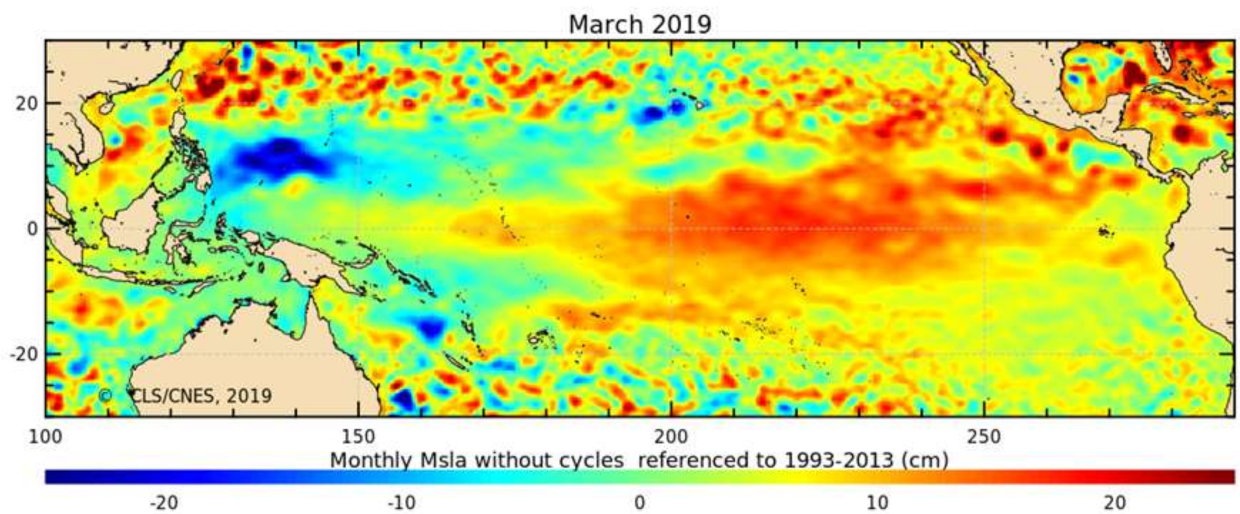


Figure 33a. Sea surface height and anomaly

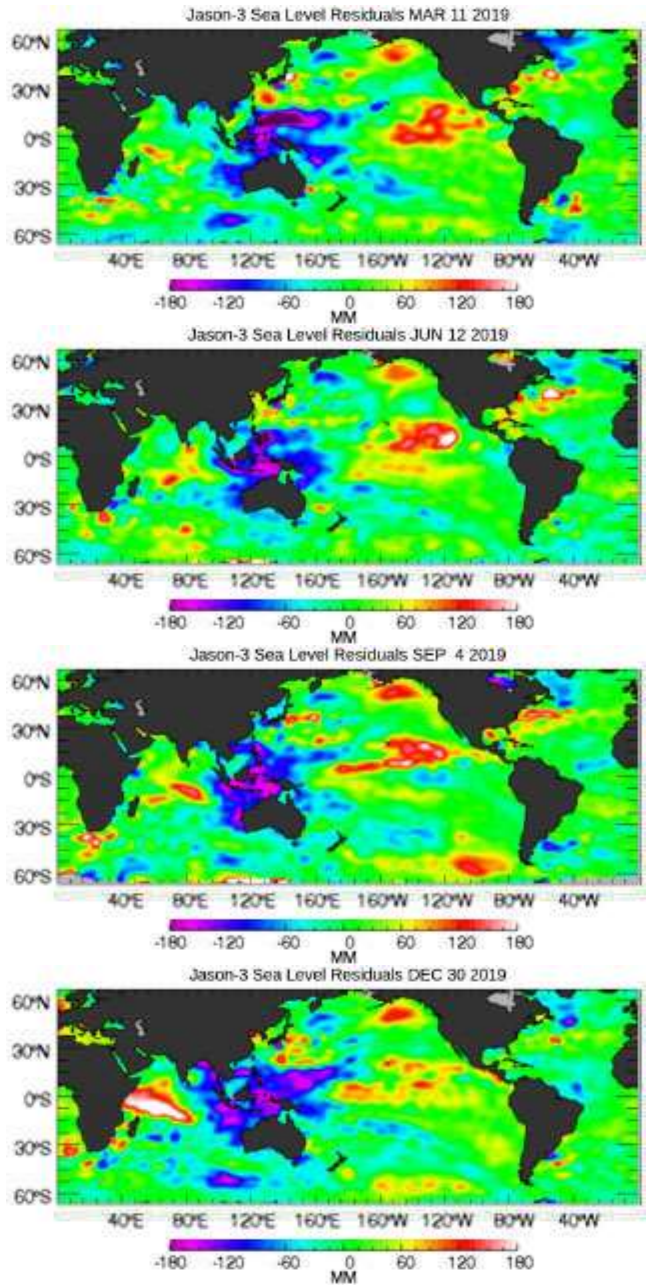
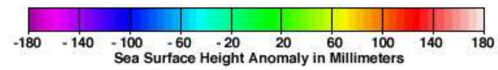


Figure 33b. Quarterly time series of mean sea level anomalies during 2019 show no pattern of El Niño throughout the year according to satellite altimetry measurements of sea level height (unlike 2015).

(https://sealevel.jpl.nasa.gov/science/elninopdo/latestdata/archive/index.cfm?y=2019.)



2.5.4.10.2 Local Sea Level

These time-series from *in situ* tide gauges provide a perspective on sea level trends within each Archipelago (Tide Station Time Series from NOAA Center for Operational Oceanographic Products and Services [CO-OPS]).

The following figures and descriptive paragraphs were inserted from the NOAA tides and currents website. Figure 34 shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS. The calculated trends for all stations are available as a table in millimeters/year and in feet/century. If present, solid vertical lines indicate times of any major earthquakes in the vicinity of the station and dashed vertical lines bracket any periods of questionable data or datum shift.

The relative sea level trend is 1.51 millimeters/year with a 95% confidence interval of +/- 0.21 mm/yr based on monthly mean sea level data from 1905 to 2019 which is equivalent to a change of 0.5 feet in 100 years.

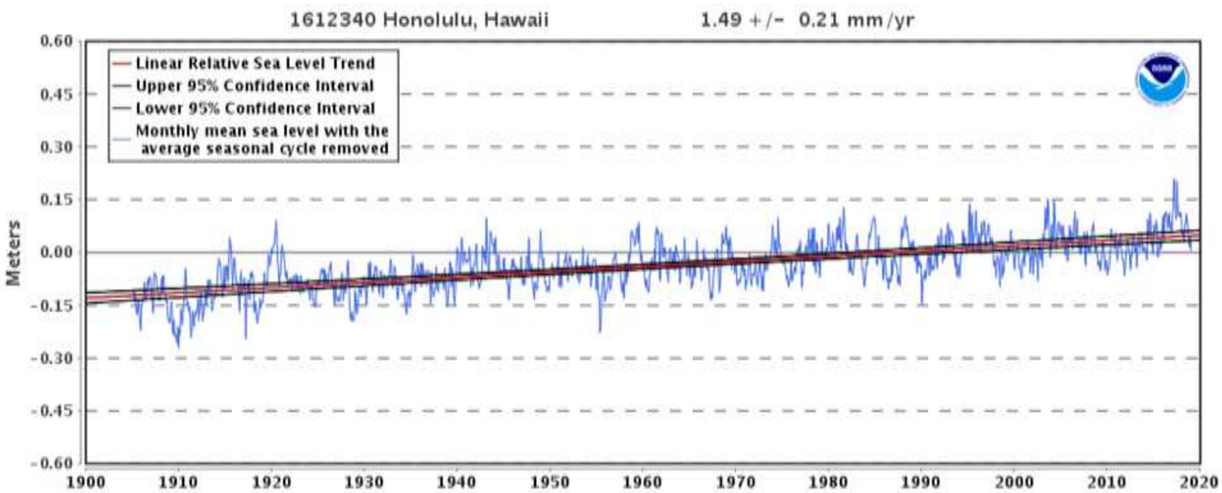


Figure 34. Monthly mean sea level without regular seasonal variability due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents

2.6 ESSENTIAL FISH HABITAT

2.6.1 Introduction

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) includes provisions concerning the identification and conservation of essential fish habitat (EFH) and, under the EFH final rule, habitat areas of particular concern (HAPC) (50 Code of Federal Regulations [CFR] 600.815). The MSA defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." HAPC are those areas of EFH identified pursuant to 50 CFR 600.815(a)(8), and meeting one or more of the following considerations: (1) ecological function provided by the habitat is important; (2) habitat is sensitive to human-induced environmental degradation; (3) development activities are, or will be, stressing the habitat type; or (4) the habitat type is rare.

NMFS and the regional fishery management councils must describe and identify EFH in fishery management plans (FMPs) or fishery ecosystem plans (FEPs), minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with NMFS, and NMFS must provide conservation recommendations to federal and state agencies regarding actions that would adversely affect EFH. Councils also have the authority to comment on federal or state agency actions that would adversely affect the habitat, including EFH, of managed species.

The EFH Final Rule strongly recommends regional fishery management councils and NMFS to conduct a review and revision of the EFH components of FMPs every five years (600.815(a)(10)). The Council's FEPs state that new EFH information should be reviewed, as necessary, during preparation of the annual reports by the Plan Teams. Additionally, the EFH Final Rule states "Councils should report on their review of EFH information as part of the annual Stock Assessment and Fishery Evaluation (SAFE) report prepared pursuant to §600.315(e)." The habitat portion of the annual SAFE report is designed to meet the FEP requirements and EFH Final Rule guidelines regarding EFH reviews.

National Standard 2 guidelines recommend that the SAFE report summarize the best scientific information available concerning the past, present, and possible future condition of EFH described by the FEPs.

2.6.1.1 EFH Information

The EFH components of FMPs include the description and identification of EFH, lists of prey species and locations for each managed species, and optionally, HAPC. Impact-oriented components of FMPs include federal fishing activities that may adversely affect EFH, non-federal fishing activities that may adversely affect EFH, non-fishing activities that may adversely affect EFH, conservation and enhancement recommendations, and a cumulative impacts analysis on EFH. The last two components include the research and information needs section, which feeds into the Council's Five-Year Research Priorities, and the EFH update procedure, which is described in the FEP but implemented in the annual SAFE report.

The Council has described EFH for five management unit species (MUS) under its management authority, some of which are no longer MUS: pelagic (PMUS), bottomfish (BMUS), crustaceans

(CMUS), former coral reef ecosystem (CREMUS), and precious corals (PCMUS). The Hawaii FEP describes EFH for the BMUS, CMUS, and PCMUS.

EFH reviews of the biological components, including the description and identification of EFH, lists of prey species and locations, and HAPC, consist of three to four parts:

- Updated species descriptions, which can be found appended to the SAFE report. These can be used to directly update the FEP;
- Updated EFH levels of information tables, which can be found in this Section 2.6.4;
- Updated research and information needs, which can be found in Section 2.6.5. These can be used to directly update the FEP; and
- An analysis that distinguishes EFH from all potential habitats used by the species, which is the basis for an options paper for the Council. This part is developed if enough information exists to refine EFH.

2.6.1.2 Habitat Objectives of FEP

The habitat objective of the FEP is to refine EFH and minimize impacts to EFH, with the following sub-objectives:

- Review EFH and HAPC designations every five years based on the best available scientific information and update such designations based on the best available scientific information, when available; and
- Identify and prioritize research to assess adverse impacts to EFH and HAPC from fishing (including aquaculture) and non-fishing activities, including, but not limited to, activities that introduce land-based pollution into the marine environment.

The annual report has reviewed the precious coral EFH components, crustacean EFH components, and non-fishing impacts components, resetting the five-year timeline for review. The Council’s support of non-fishing activities research is monitored through the program plan and five-year research priorities, not the annual report.

2.6.1.3 Response to Previous Council Recommendations

At its 172nd meeting in March 2018, the Council recommended that staff develop an omnibus amendment updating the non-fishing impact to EFH sections of the FEPs, incorporating the non-fishing impacts EFH review report by Minton (2017) by reference. An options paper has been developed.

At its 173rd meeting in June 2018, the Council directed staff to develop options to redefine EFH precious corals in Hawaii for Council consideration for an FEP amendment. An options paper was developed and presented to the Council.

At its 174th meeting in October 2018, the Council directed staff to prepare an amendment to the Hawaii FEP to revise EFH for precious corals and selected the following preliminarily preferred options for the staff to further analyze: revise existing beds and designate new beds as EFH, update geographic extent and habitat characteristics, and update the FEPs.

At its 178th meeting in July 2019, the Council approved the draft amendment to the Hawaii FEP to revise precious coral EFH and directed staff to send the document to NMFS PIRO for completion, however, there were issues during the final transmittal associated with the designations of the new precious coral EFH as coral beds.

At its 181st meeting in March 2020, the Council directed staff to continue working with NOAA General Counsel and PIRO Sustainable Fisheries Division on the EFH amendment to ensure its transmittal. Additionally, the Council directed staff to develop options for designating the new EFH areas as precious coral beds under the Hawaii FEP.

2.6.2 Habitat Use by MUS and Trends in Habitat Condition

The Hawaiian Archipelago is an island chain in the central North Pacific Ocean. It runs for approximately 1,500 miles in a northwest direction, from Hawaii Island in the southeast to Kure Atoll in the northwest and is among the most isolated island areas in the world. The chain can be divided according to the large and mountainous Main Hawaiian Islands (MHI; Hawaii, Maui, Lanai, Molokai, Kahoolawe, Oahu, Kauai, and Niihau) and the small, low-lying Northwest Hawaiian Islands (NWHI), which include Necker, French Frigate Shoals, Laysan, and Midway atoll. The largest of the MHI is Hawaii Island at just over 4,000 square miles – the largest in Polynesia, while Kahoolawe is the smallest at 44.6 square miles.

The archipelago developed as the Pacific plate moved slowly over a hotspot in the Earth's mantle. Thus, the islands on the northwest end of the archipelago are older; it is estimated that Kure Atoll is approximately 28 million years old while Hawaii Island is approximately 400,000 years old. The highest point in Hawaii is Mauna Kea, at approximately 13,800 feet.

The MHI are all in tropical latitudes. The archipelago becomes subtropical at about French Frigate Shoals (23°46' N). The climate of the Hawaiian Islands is generally tropical, but there is great climactic variation, due primarily to elevation and leeward versus windward areas. Easterly trade winds bring much of the rain, and so the windward sides of all the islands are typically wetter. The south and west (leeward) sides of the islands tend to be drier. Hawaii receives the majority of its precipitation from October to April, while drier conditions generally prevail from May to September. Tropical storms and hurricanes occur in the northern hemisphere hurricane and typhoon season, which runs from June through November.

There is fairly little shallow water habitat in Hawaii, owing to the islands' steep rise from the abyssal deep. However, there are some larger areas, such as Penguin Bank between Oahu and Molokai, which are relatively shallow. Hawaii has extensive coral reef habitat throughout the MHI as they are much younger and have more fringing reef habitat than the NWHI, which has shallower reef habitat overall.

EFH in the Hawaiian Archipelago for the MUS comprises all substrate from the shoreline to the 700 m isobath. The entire water column is described as EFH from the shoreline to the 700 m isobath, and the water column to a depth of 400 m is described as EFH from the 700 m isobath to the limit or boundary of the EEZ. The coral reef ecosystems surrounding the islands in the MHI and NWHI been the subject of a comprehensive monitoring program through the PIFSC Coral Reef Ecosystem Division (CRED) biennially since 2002, surveys are focused on the nearshore environments surrounding the islands, atolls, and reefs.

PIFSC CRED is now the Coral Reef Ecosystem Program (CREP) within the PIFSC Ecosystem Sciences Division (ESD) whose mission is to conduct multidisciplinary research, monitoring, and analysis of integrated environmental and living resource systems in coastal and offshore waters of the Pacific Ocean. This mission includes field research activities that cover near-shore island ecosystems such as coral reefs to open ocean ecosystems on the high seas. The ESD research focus includes oceanography, coral reef ecosystem assessment and monitoring, benthic habitat mapping, and marine debris surveys and removal. This broad focus enables ESD to analyze not only the current structure and dynamics of marine environments, but also to examine potential projections of future conditions such as those resulting from climate change impacts. Because humans are a key part of the ecosystem, our research includes the social, cultural, and economic aspects of fishery and resource management decisions (PIFSC, 2020. https://www.fisheries.noaa.gov/about/pacific-islands-fisheries-science-center). The CREP continues to "provide high-quality, scientific information about the status of coral reef ecosystems of the U.S. Pacific islands to the public, resource managers, and policymakers on local, regional, national, and international levels" (PIFSC, 2011). CREP conducts comprehensive ecosystem monitoring surveys at about 50 islands, atolls, and shallow bank sites in the Western Pacific Region on a rotating schedule, based on operational capabilities. CREP coral reef monitoring reports provide the most comprehensive description of nearshore habitat quality in the region.

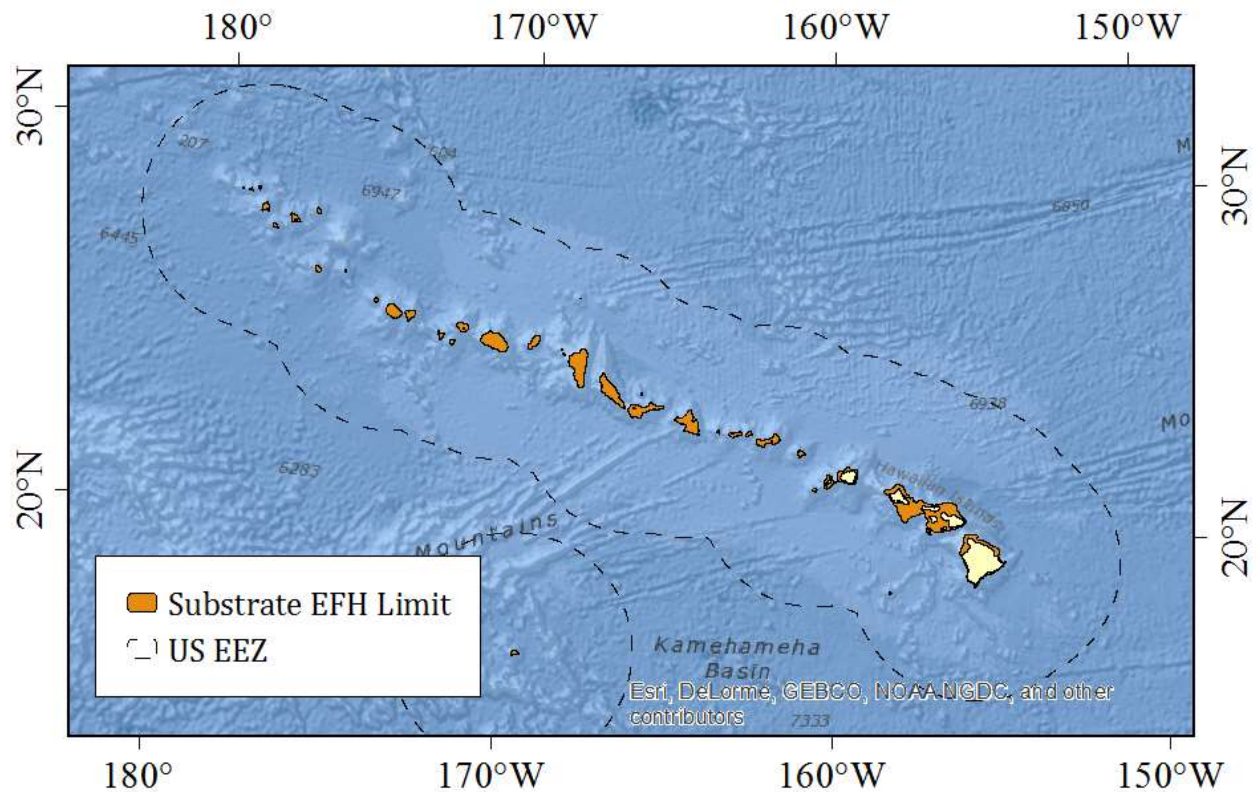


Figure 35. Substrate EFH limit of 700 m isobath around the Hawaiian Archipelago (from GMRT; Ryan et al., 2009)

2.6.2.1 Habitat Mapping

Interpreted IKONOS benthic habitat maps in the 0 – 30 m depth range have been completed for all islands in the MHI and NWHI (Miller et al., 2011). While there are gaps in multibeam coverage in the MHI (Miller et al., 2011), 60 m resolution bathymetry and backscatter are available from the Falkor for much of the NWHI (Hawaii Mapping Research Group, 2014).

Table 54. Summary of habitat mapping in the MHI

Depth Range	Timeline/Mapping Product	Progress	Source
0-30 m	IKONOS Benthic Habitat Maps	All islands complete	Miller et al. (2011)
	2000-2010 Bathymetry	84%	DesRochers (2016)
	2011-2015 Multibeam Bathymetry	4%	DesRochers (2016)
	2011-2015 Satellite WorldView 2 Bathymetry	5%	DesRochers (2016)
0-150 m	Multibeam Bathymetry	Gaps exist around Maui, Lanai, and Kahoolawe. Access restricted at Kahoolawe.	Miller et al. (2011)
30-150 m	2000-2010 Bathymetry	86%	DesRochers (2016)
	2011-2015 Multibeam Bathymetry	2%	DesRochers (2016)
Overall multibeam depths	Derived Products	Few exist	Miller et al. (2011)

Table 55. Summary of habitat mapping in the NWHI

Depth Range	Timeline/Mapping Product	Progress	Source
0-30 m	IKONOS Benthic Habitat Maps	All islands complete	Miller et al. (2011)
	2000-2010 Bathymetry	6%	DesRochers (2016)
	2011-2015 Multibeam Bathymetry	-	DesRochers (2016)
	2011-2015 Satellite WorldView 2 Bathymetry	-	DesRochers (2016)
30-150 m	2000-2010 Bathymetry	49%	DesRochers (2016)
	2011-2015 Multibeam Bathymetry	4%	DesRochers (2016)

The land and seafloor area surrounding the islands of the MHI as well as primary data coverage are reproduced from Miller et al. (2011) in Figure 36. The land and seafloor area surrounding the islands of the NWHI as well as primary data coverage are similarly reproduced in Figure 37.

ISLAND CODE	KAL	NII	KAU	OAH	MOL	LAN	MAI	MOI	KAH	NUI	HAW
SHAPE & RELATIVE SIZE											
LAND AREA (km²)	<1	187	1437	1549	670	365	1886	<1	116		10442
SEA FLOOR AREA 0-30 m (km²)	3	108	242	423	199	55	197	?	4		202
SEA FLOOR AREA 30-150 m (km²)	62	182	297	467	*	*	*	*	*	2801	699
BATHYMETRY 0-30 m (km²)	0	41	237	422	144	17	178	?	0		134
BATHYMETRY 30-150 m (km²)	19	181	292	454	*	*	*	*	*	2346	584
OPTICAL COVERAGE 0-30 m (km)	4	41	45	44	30	32	66	1	0		91
OPTICAL COVERAGE 30-150 m (km)	0	13	11	23	*	*	*	*	*	161	0

? unknown
— no data
*combined and presented as Maui Nui

Figure 36. MHI land and seafloor with primary data coverage

ISLAND CODE	KUR	MID	PHR	NEV	LIS	PIO	NHS	LAY	MAR	RAI	GAR	SRW	BBW	BBM	BBB	FFS	NEC	TWI	WNB	NIH
LAND AREA (km²)	<1	6	<1	0	2	0	0	4	0	0	0	0	0	0	0	<1	<1	0	0	<1
SEA FLOOR AREA 0-30 m (km²)	83	102	467	0	1004	306	0	488	1075	128	1269	250	3	<1	0	678	1028	0	0	<1
SEA FLOOR AREA 30-150 m (km²)	218	236	276	90	226	125	360	69	696	310	1136	124	142	135	23	244	473	63	320	573
BATHYMETRY 0-30 m (km²)	25	24	23	0	0	<1	0	0	73	0	<1	<1	2	<1	0	222	8	0	<1	<1
BATHYMETRY 30-150 m (km²)	218	180	251	34	125	54	20	58	588	0	126	40	142	135	23	214	312	13	165	163
OPTICAL COVERAGE 0-30 m (km)	32	43	63	0	57	0	0	14	40	1	4	0	<1	<1	0	106	8	0	0	0
OPTICAL COVERAGE 30-150 m (km)	21	13	20	0	8	0	0	<1	2	<1	<1	1	3	<1	<1	90	6	0	0	0

? unknown
— no data
*numbers refer to area from 0-150 m

Figure 37. NWHI land and seafloor with primary data coverage

2.6.2.2 Benthic Habitat

Juvenile and adult life stages of former CREMUS and crustaceans including spiny and slipper lobsters and Kona crab extends from the shoreline to the 100 m isobath (64 FR 19067, April 19, 1999). All benthic habitat is considered EFH for crustacean species (64 FR 19067, April 19, 1999), while the type of bottom habitat varies by family for coral reef species (69 FR 8336, February 24, 2004). Juvenile and adult bottomfish EFH extends from the shoreline to the 400 m isobath (64 FR 19067, April 19, 1999), and juvenile and adult deepwater shrimp habitat extends from the 300m isobath to the 700 m isobath (73 FR 70603, November 21, 2008).

2.6.2.2.1 RAMP Indicators

Benthic percent cover of coral, macroalgae, and crustose coralline algae are surveyed as a part of the Pacific Reef Assessment and Monitoring Program (RAMP) led by the PIFSC Ecosystem Sciences Division (ESD). Previously, Pacific RAMP surveys had benthic cover data summarized by island; these data are shown in Table 56 through Table 61. The benthic towed-diver survey method was used to monitor change in benthic communities. In this method, a pair of scuba divers (one collecting fish data, the other collecting benthic data) would be towed about one meter above the reef roughly 60 m behind a small boat at a constant speed of about 1.5 kt. Each diver maneuvers a tow board platform, which is connected to the boat by a bridle and towline and outfitted with a communications telegraph and various survey equipment including a downward-facing digital SLR camera. The benthic towed diver records general habitat complexity and type (e.g., spur and groove, pavement), percent cover by functional-group (hard corals, stressed corals, soft corals, macroalgae, crustose coralline algae, sand, and rubble) and for macroinvertebrates (crown-of-thorns sea stars, sea cucumbers, free and boring urchins, and giant clams). The surveys are typically 50 minutes long and cover about two to three kilometers of habitat (PIFSC, 2016). However, this method was retired in 2016, and no new data will be appended to the time series.

More recently, the surveys began focusing on geographic sub-regions of islands for a more fine-scale summary of benthic cover; these data are shown in Table 62 through Table 64. A stratified random sampling design is used to determine status, trends, and variability of benthic communities at Rapid Ecological Assessment (REA) sites. In 2018, surveys at each REA site were conducted with one 10-meter squared belt transects, whereas two belt transects were used from 2013 to 2017. The survey domain encompasses the majority of the mapped area of reef and hard bottom habitats from 0 to 30 m depth. The stratification scheme includes (1) three depth categories (shallow: 0 to 6 m; mid-depth: >6 to 18 m; and deep: >18 to 30 m); (2) regional sub-island sectors; (3) reef zone components, including back reef, lagoon, and fore reef.

Coral colonies and their morphology are identified before measuring the colony size and assessing colony condition. Photoquadrats are used to derive estimates of benthic cover. The photoquadrat consists of a high-resolution digital camera mounted on a photoquadrat pole. Photoquadrat images are collected along the same two transects used for coral surveys at one-meter intervals, starting at 1 m and progressing to the 15-meter mark (images are not collected at the 0 m mark). This provides a total of 15 images per transect and 30 per site. In 2018, a single stage sampling scheme was implemented, which designates primary sample units (referred to sites) as grid cells containing >10% hard-bottom reef habitats. Also in 2018, a new method of determining survey effort was used by first determining the number of days spent at each island then by strata area and variance of target species at the island level (Swanson et al, 2018; Winston et al., 2019).

Table 56. Mean percent cover of live coral at RAMP sites collected from towed-diver surveys using previous methodology in the MHI

Island	2005	2006	2008	2010	2016
Hawaii		18.38	17.11	22.1	25.65
Kauai	6.06	12.27	7.04	6.04	6.99
Kaula		6.9			
Lanai	30.48	26.61	22.42	23.34	30.42
Maui	18.99	20.33	12.06	14.62	11.91
Molokai	35.66	6.96	6.92	52.17	18.85
Niihau	5.03	2.39	2.29	2.26	3.44
Oahu	9.36	12.21	9.45	8.19	

Table 57. Mean percent cover of macroalgae at RAMP sites collected from towed-diver surveys using previous methodology in the MHI

Island	2005	2006	2008	2010	2016
Hawaii		5.46	1.01	1.05	0.29
Kauai	35.67	27.92	16.45	16.25	9.61
Kaula		5.94			
Lanai	7.38	13.18	17.13	11.14	2.69
Maui	17.84	16.24	12.04	2.13	12.12
Molokai	23.31	24.22	12.71	4.75	9.47
Niihau	41.30	14.57	2.58	2.22	0.03
Oahu	37.03	27.41	12.58	13.03	

Table 58. Mean percent cover of crustose coralline algae from RAMP sites collected from towed-diver surveys using previous methodology in the MHI

Island	2005	2006	2008	2010	2016
Hawaii		14.82	16.09	6.94	5.97
Kauai	3.67	2.94	4.14	1.71	2.70
Kaula		7.40			
Lanai	2.42	1.31	3.72	2.82	0.03
Maui	4.37	4.83	6.82	4.31	1.22
Molokai	3.71	3.79	5.24	4.19	0.65
Niihau	10.87	6.68	8.05	1.88	0.28
Oahu	13.95	2.74	4.28	2.42	

Table 59. Mean percent cover of live coral at RAMP sites collected from towed-diver surveys using previous methodology in the NWHI

Island	2000	2001	2002	2003	2004	2006	2008	2010	2016
French Frigate	27.23	5.00	14.22	13.47	11.29	18.25	15.23	13.28	17.53

Island	2000	2001	2002	2003	2004	2006	2008	2010	2016
Gardner	3.00			2.50	1.65				
Kure	7.3		9.61	12.34	12.63	17.2	17.6	14.57	13.08
Laysan	9.96		9.76	4.00	7.33	6.96	8.43		
Lisianski	28.17		24.29	15.2	26.81	27.22	25.69	27.56	26.96
Maro	27.38	18.31	13.77	16.54	25.59	22.67	19.78		
Midway			5.58	3.06	1.24	3.91	2.66		
Necker	6.50			14.52		14.92			
Nihoa	3.89								
Pearl & Hermes	15.82		10.71	6.47	9.45	11.64	10.79	8.25	7.91
Raita		2.50							

Table 60. Mean percent cover of macroalgae at RAMP sites collected from towed-diver surveys using previous methodology in the NWHI

Island	2000	2001	2002	2003	2004	2006	2008	2010	2016
French Frigate	0.00	10.50	30.13	29.05	23.15	17.33	17.81	18.42	9.60
Gardner	0.00			73.63	26.94				
Kure	0.00		38.84	42.79	29.84	23.14	26.22	12.99	11.00
Laysan	0.00		26.90	47.03	30.63	28.66	25.70		
Lisianski	0.00		20.04	24.61	17.14	21.46	20.83	13.85	10.92
Maro	0.00	17.01	20.39	17.69	30.01	20.79	18.19		
Midway			42.28	44.90	24.86	11.02	19.93		
Necker	0.00			23.39		33.51			
Nihoa	0.00								
Pearl & Hermes	0.00		36.94	41.51	114.87	33.56	33.79	36.96	39.84
Raita		68.83							

Table 61. Mean percent cover of crustose coralline algae at RAMP sites collected from towed-diver surveys using previous methodology in the NWHI

Island	2000	2001	2002	2003	2004	2006	2008	2010	2016
French Frigate	0.00	0.00	8.55	8.56	2.52	9.46	8.55	1.87	4.21
Gardner	0.00			9.13	1.50				
Kure	0.00		3.38	7.65	5.87	7.31	6.91	4.11	7.18
Laysan	0.00		3.95	11.17	5.11	10.21	7.93		
Lisianski	0.00		14.21	7.97	12.11	17.19	17.42	11.78	13.29
Maro	0.00	13.95	15.17	12.89	4.36	16.54	15.29		
Midway			7.58	3.69	7.17	5.80	5.62		
Necker	0.00			7.86		1.48			
Nihoa	0.00								
Pearl & Hermes	0.00		14.13	14.38	11.84	10.07	12.43	7.61	14.44
Raita		0.42							

Table 62. Mean percent cover of live coral at RAMP sites collected from belt transect surveys using updated methodology in the MHI

Island	Island Area	2010-12	2013-15	2016	2019
Hawaii	Hamakua	8.49	6.83		4.55
Hawaii	Kona	27.59	26.87	15.84	13.80
Hawaii	Puna	13.87	16.88	9.00	5.03
Hawaii	Southeast		23.33	16.19	
Kahoolawe	North			32.67	27.64
Kahoolawe	South			5.04	4.40
Kauai	East	8.01	6.10	3.23	3.40
Kauai	Nā Pali	4.50	3.55	0.92	1.25
Lanai	North	26.99	12.62	20.59	39.07
Lanai	South	20.61	17.55	26.67	16.39
Maui	Hana	4.45			
Maui	Kahului		25.22		
Maui	Kihei	36.06	42.28	29.48	25.48
Maui	Lahaina	13.20	12.27	7.89	15.49
Maui	Northeast	3.03	5.37	5.63	2.03
Maui	Northwest	5.26			
Maui	Southeast				11.92
Molokai	Northwest		4.67		
Molokai	Pali	3.57	1.98	3.17	2.54
Molokai	South	38.13	30.47	31.18	17.40
Molokai	West	5.28	6.98	3.14	5.76
Niihau	East	1.81	2.38		0.67
Niihau	Lehua		3.19	2.88	2.67
Niihau	West	0.95	1.42	0.84	0.41
Oahu	East	8.29	13.51	17.07	
Oahu	Ka‘ena	24.05	9.17	5.28	2.90
Oahu	Northeast	11.68	12.94	16.08	14.85
Oahu	North	7.25	8.31	2.87	2.75
Oahu	South	4.64	4.36	3.37	4.54

Table 63. Mean percent cover of macroalgae at RAMP sites collected from belt transect surveys using updated methodology in the MHI

Island	Island Area	2010-12	2013-15	2016	2019
Hawaii	Hamakua	5.40	0.84		1.24
Hawaii	Kona	1.36	0.52	0.89	0.36
Hawaii	Puna	1.98	0.59	0.43	0.21
Hawaii	Southeast		0.81	0.11	
Kahoolawe	North			1.64	0.35
Kahoolawe	South			2.69	2.14
Kauai	East	5.37	1.38	2.29	0.50

Island	Island Area	2010-12	2013-15	2016	2019
Kauai	Nā Pali	5.97	1.91	2.49	4.62
Lanai	North	9.33	10.54	1.21	1.03
Lanai	South	2.94	2.54	0.29	0.80
Maui	Hana	6.69			
Maui	Kahului		3.66		
Maui	Kihei	1.50	0.71	2.14	2.51
Maui	Lahaina	4.76	0.95	0.27	1.68
Maui	Northeast	7.28	3.96	1.68	1.91
Maui	Northwest	3.60			
Maui	Southeast				0.21
Molokai	Northwest		0.96		
Molokai	Pali	1.31	5.88	0.53	1.06
Molokai	South	1.78	0.73	0.87	1.94
Molokai	West	5.23	3.32	3.15	8.68
Niihau	East	13.59	0.78		0.00
Niihau	Lehua		1.22	2.05	0.60
Niihau	West	5.27	3.35	2.24	4.00
Oahu	East	10.48	4.21	2.72	
Oahu	Ka‘ena	2.64	3.72	2.01	1.05
Oahu	Northeast	9.53	6.29	3.24	0.93
Oahu	North	0.31	1.92	3.45	1.30
Oahu	South	5.55	4.88	1.41	1.47

Table 64. Mean percent cover of crustose coralline algae at RAMP sites collected from belt transect surveys using updated methodology in the MHI

Island	Island Area	2010-12	2013-15	2016	2019
Hawaii	Hamakua	5.91	2.51		3.99
Hawaii	Kona	9.02	9.91	7.61	7.58
Hawaii	Puna	16.4	9.93	5.97	4.25
Hawaii	Southeast		10.53	7.3	
Kahoolawe	North			2.36	0.98
Kahoolawe	South			2.64	3.56
Kauai	East	9.75	2.47	4.98	1.92
Kauai	Nā Pali	2.63	1.16	1.26	1.43
Lanai	North	5.45	1.94	0.36	0.81
Lanai	South	3.16	1.98	1.59	1.95
Maui	Hana	8.02			
Maui	Kahului		6.8		
Maui	Kihei	6.48	2.41	3.83	4.1
Maui	Lahaina	1.53	0.43	0.8	0.77
Maui	Northeast	5.05	2.19	3.96	5.73
Maui	Northwest	5.09			

Island	Island Area	2010-12	2013-15	2016	2019
Maui	Southeast				3.71
Molokai	Northwest		1.14		
Molokai	Pali	5.58	3.88	2.41	4.02
Molokai	South	2.04	2.82	3.22	6.71
Molokai	West	1.58	0.79	0.87	3.3
Niihau	East	2.84	0.83		1.34
Niihau	Lehua		4.62	2.75	2.97
Niihau	West	4.86	1.76	1.39	0.86
Oahu	East	3.55	1.6	2.7	
Oahu	Ka‘ena	0.74	2.79	0.74	2.04
Oahu	Northeast	10.43	2.38	7.13	1.68
Oahu	North	1.58	1.32	1.51	1.55
Oahu	South	2.12	0.91	3.24	0.67

2.6.2.3 Oceanography and Water Quality

The water column is also designated as EFH for selected MUS life stages at various depths. For larval stages of all species except deepwater shrimp, the water column is EFH from the shoreline to the EEZ. Coral reef species egg and larval EFH is to a depth of 100 m; crustaceans, 150m; and bottomfish, 400 m. Please see the Ecosystem and Climate Change section (Section 0) for information related to oceanography and water quality.

2.6.3 Report on Review of EFH Information

A review of the biological components of crustacean EFH in Guam and Hawaii was finalized in 2019. This review can be found in Appendix C of this report. The non-fishing impacts and cumulative impacts components were reviewed in 2016 through 2017, which can be found in Minton (2017).

2.6.4 EFH Levels

NMFS guidelines codified at 50 C.F.R. § 600.815 recommend Councils organize data used to describe and identify EFH into the following four levels:

- Level 1: Distribution data are available for some or all portions of the geographic range of the species.
- Level 2: Habitat-related densities of the species are available.
- Level 3: Growth, reproduction, or survival rates within habitats are available.
- Level 4: Production rates by habitat are available.

The Council adopted a fifth level, denoted Level 0, for situations in which there is no information available about the geographic extent of a particular managed species’ life stage. The existing level of data for individual MUS in each fishery are presented in tables per fishery.

The Hawai‘i Undersea Research Laboratory (HURL) is a center operating under the School of Ocean and Earth Sciences and Technology (SOEST) at the University of Hawai‘i (UH) and NOAA’s Office of Ocean Exploration and Research. The unique deep-sea research operation runs the Pisces IV and V manned submersibles and remotely operated vehicles (ROVs) for investigating the undersea environment through hypothesis driven projects that address gaps in knowledge or scientific needs. HURL maintains a comprehensive video database, which includes biological and substrate data extracted from their dive video archives. Submersible and ROV data are collected from depths deeper than 40 m. Observations from the HURL video archives are considered Level 1 EFH information for deeper bottomfish and precious coral species which exist in the database though cannot be considered to observe absence of species. Survey effort is low compared to the range of species observed.

2.6.4.1 Precious Corals

EFH for precious corals was originally designated in Amendment 4 to the Precious Corals FMP (64 FR 19067, April 19, 1999), using the level of data found in Table 65.

Table 65. Level of EFH available for Hawaii former and current precious corals MUS

Species	Pelagic Phase (Larval Stage)	Benthic Phase	Source(s)
Pink Coral (*Corallium*)			
Pleurocorallium secundum (prev. *Corallium secundum*)	0	1	Figueroa and Baco (2014); HURL Database
C. regale	0	1	HURL Database
Hemicorallium laauense (prev. *C. laauense*)	0	1	HURL Database
Gold Coral			
Kulamanamana haumeaae (prev. Gerardia spp.)	0	1	Sinniger et al. (2013); HURL Database
Callogorgia gilberti	0	1	HURL Database
Narella spp.	0	1	HURL Database
Bamboo Coral			
Lepidisis olapa	0	1	HURL Database
Acanella spp.	0	1	HURL Database
Black Coral			
Antipathes griggi (prev. *Antipathes dichotoma)*	0	1	Opresko (2009); HURL Database
A. grandis	0	1	HURL Database
Myriopathes ulex (prev. *A. ulex)*	0	1	Opresko (2009); HURL Database

2.6.4.2 Bottomfish and Seamount Groundfish

EFH for bottomfish and seamount groundfish was originally designated in Amendment 6 to the Bottomfish and Seamount Groundfish FMP (64 FR 19067, April 19, 1999).

Table 66. Level of EFH information available for Hawaii bottomfish and seamount groundfish former and current MUS

Life History Stage	Eggs	Larvae	Juvenile	Adult
Aphareus rutilans (red snapper/silvermouth)	0	0	0	1
Aprion virescens (gray snapper/jobfish)	0	0	1	1

Life History Stage	Eggs	Larvae	Juvenile	Adult
Caranx ignoblis (giant trevally/jack)	0	0	1	1
C. lugubris (black trevally/jack)	0	0	0	1
Epinephelus faciatus (blacktip grouper)	0	0	0	1
E quernus (sea bass)	0	0	1	1
Etelis carbunculus (red snapper)	0	0	1	1
E. coruscans (red snapper)	0	0	1	1
Lethrinus amboinensis (ambon emperor)	0	0	0	1
L. rubrioperculatus (redgill emperor)	0	0	0	1
Lutjanus kasmira (blueline snapper)	0	0	1	1
Pristipomoides auricilla (yellowtail snapper)	0	0	0	1
P. filamentosus (pink snapper)	0	0	1	1
P. flavipinnis (yelloweye snapper)	0	0	0	1
P. seiboldi (pink snapper)	0	0	1	1
P. zonatus (snapper)	0	0	0	1
Pseudocaranx dentex (thicklip trevally)	0	0	1	1
Seriola dumerili (amberjack)	0	0	0	1
Variola louti (lunartail grouper)	0	0	0	1
Beryx splendens (alfonsin)	0	1	2	2
Hyperoglyphe japonica (ratfish/butterfish)	0	0	0	1
Pseudopentaceros richardsoni (armorhead)	0	1	1	3

2.6.4.3 Crustaceans

EFH for crustaceans was originally designated in Amendment 10 to the Crustaceans FMP (64 FR 19067, April 19, 1999). EFH definitions were also approved for deepwater shrimp through an amendment to the Crustaceans FMP in 2008 (73 FR 70603, November 21, 2008).

Table 67. Level of EFH information available for former and current Hawaii CMUS

Life History Stage	Eggs	Larvae	Juvenile	Adult
Spiny lobster (*Panulirus marginatus*)	2	1	1-2	2-3
Spiny lobster (*Panulirus pencillatus*)	1	1	1	2
Common slipper lobster (*Scyllarides squammosus*)	2	1	1	2-3
Ridgeback slipper lobster (*Scyllarides haanii*)	2	0	1	2-3
Chinese slipper lobster (*Parribacus antarcticus*)	2	0	1	2-3
Kona crab (*Ranina ranina*)	1	0	1	1-2

2.6.5 Research and Information Needs

Based, in part, on the information provided in the tables above the Council identified the following scientific data which are needed to more effectively address the EFH provisions:

2.6.5.1 All FMP Fisheries

- Distribution of early life history stages (eggs and larvae) of MUS by habitat.
- Juvenile habitat (including physical, chemical, and biological features that determine suitable juvenile habitat).

- Food habits (feeding depth, major prey species etc.).
- Habitat-related densities for all MUS life history stages.
- Growth, reproduction, and survival rates for MUS within habitats.

2.6.5.2 Bottomfish Fishery

- Inventory of marine habitats in the EEZ of the Western Pacific region.
- Data to obtain a better SPR estimate for American Samoa's bottomfish complex.
- Baseline (virgin stock) parameters (CPUE, percent immature) for the Guam/NMI deep-water and shallow water bottomfish complexes.
- High resolution maps of bottom topography/currents/water masses/primary productivity.
- Habitat utilization patterns for different life history stages and species.

2.6.5.3 Crustaceans Fishery

- Identification of post-larval settlement habitat of all CMUS.
- Identification of "source/sink" relationships in the NWHI and other regions (i.e. relationships between spawning sites settlement using circulation models, genetic techniques, etc.).
- Establish baseline parameters (CPUE) for the Guam/Northern Marinas crustacean populations.
- Research to determine habitat related densities for all CMUS life history stages in American Samoa, Guam, Hawaii, and CNMI.
- High resolution mapping of bottom topography, bathymetry, currents, substrate types, algal beds, and habitat relief.

2.6.5.4 Precious Coral Fishery

- Statistically sound estimates of distribution, abundance, and condition of precious corals throughout the MHI. Targeted surveys of areas that meet the depth and hardness criteria could provide very accurate estimates.
- Environmental conditions necessary for precious coral settlement, growth, and reproduction. The same surveys used for abundance and distribution could collect these data as well.
- Quantitative measures of growth and productivity.
- Taxonomic investigations to ascertain if the *H. laauense* that is commonly observed between 200- and 600-meters depth is the same species as those *H. laauense* observed below 1,000 meters in depth.
- Continuous backscatter or LIDAR data in depths shallower than 60 m.

2.7 MARINE PLANNING

2.7.1 Introduction

Marine planning is a science-based management tool being utilized regionally, nationally, and globally to identify and address issues of multiple human uses, ecosystem health, and cumulative impacts in the coastal and ocean environment. Efforts by the Western Pacific Regional Fishery Management Council (the Council) to formalize incorporation of marine planning in its actions began in response to Executive Order (EO) 13547, *Stewardship of the Ocean, Our Coasts, and the Great Lakes*. EO 13158, *Marine Protected Areas*, proposes that agencies strengthen the management, protection, and conservation of existing marine protected areas (MPAs), develop a national system of MPAs representing diverse ecosystems, and avoid causing harm to MPAs through federal activities. MPAs, or marine managed areas (MMAs), are one tool used in fisheries management and marine planning.

At its 165th meeting in March 2016, in Honolulu, Hawaii, the Council approved the following objective for the FEPs: To consider the implications of spatial management arrangements in Council decision-making. The following sub-objectives apply:

- Identify and prioritize research that examines the positive and negative consequences of areas that restrict or prohibit fishing to fisheries, fishery ecosystems, and fishermen, such as the Bottomfish Fishing Restricted Areas (BRFAs), military installations, NWHI restrictions, and Marine Life Conservation Districts (MLCDs).
- Establish effective spatially based fishing zones.
- Consider modifying or removing spatial-based fishing restrictions that are no longer necessary or effective in meeting their management objectives.
- As needed, periodically evaluate the management effectiveness of existing spatial-based fishing zones in Federal waters.

To monitor implementation of this objective, this annual report includes the Council's spatially based fishing restrictions and MMAs, the goals associated with those, and the most recent evaluation. Council research needs are not tracked in this report.

To meet the EFH and National Environmental Policy Act (NEPA) mandates, this annual report tracks activities that occur in the ocean that are of interest to the Council and incidents and facilities that may contribute to cumulative impact. The National Marine Fisheries Service (NMFS) is responsible for NEPA compliance, and the Council must assess the environmental effects of ocean activities for the EFH cumulative impacts section of the FEP.

2.7.2 Response to Previous Council Recommendations

There are no standing Council recommendations indicating review deadlines for Hawaii MMAs.

2.7.3 Marine Managed Areas Established Under FEPs

Council-established MMAs were compiled in Table 68 from 50 CFR § 665, Western Pacific Fisheries, the Federal Register, and Council amendment documents. Regulated fishing areas of Hawaii, including the Papahānaumokuākea Marine National Monument, are shown in Figure 38.

Table 68. MMAs established under FEP from 50 CFR § 665

Name	FEP	Island	50 CFR /FR /Amendment Reference	Marine Area (km^2)	Fishing Restriction	Goals	Most Recent Evaluation	Review Deadline
Pelagic Restrictions								
NWHI Longline Protected Species Zone	Pelagic (Hawaii)	NWHI	665.806(a)(1) 56 FR 52214 76 FR 37288 Pelagic FMP Am. 3	351,514.00	Longline fishing prohibited	Prevent longline interaction with monk seals	1991	-
MHI Longline Prohibited Area	Pelagic (Hawaii)	MHI	665.806(a)(2) 57 FR 7661 77 FR 71286 Pelagic FMP Am. 5	248,682.38	Longline fishing prohibited	Prevent gear conflicts between longline vessels and troll/handline vessels	1992	-
Bottomfish Restrictions								
Hancock Seamounts Ecosystem Management Area (HSEMA)	Hawaii Archipelago	NW of Midway Island	HSEMA: 665.209 75 FR 52921 84 FR 2772 Moratorium: 51 FR 27413 Bottomfish FMP	60,826.75	Moratorium	The intent of the continued moratorium is to facilitate rebuilding of the armorhead stock, and the intent of the ecosystem management area is to facilitate research on armorhead and other seamount groundfish	2010	-
Precious Coral Permit Areas								
Keahole Point	Hawaii Archipelago	Hawaii Island	665.261(2)(i) 73 FR 47098 84 FR 2773 Precious Corals FMP Am. 7	2.7	Fishing by permit only	Manage harvest	2008	-
Kaena Point	Hawaii Archipelago	Oahu	665.261(2)(ii) 73 FR 47098 84 FR 2773 Precious Corals FMP Am. 7	2.7	Fishing by permit only	Manage harvest	2008	-
Makapuu	Hawaii Archipelago	Oahu	665.261(1)(i) 73 FR 47098 84 FR 2773 Precious Corals FMP Am. 7	43.15	Fishing by permit only	Manage harvest	2008	-
Brooks Bank	Hawaii Archipelago	NWHI	665.261(2)(iii) 73 FR 47098 84 FR 2773 Precious Corals FMP Am. 7	43.15	Fishing by permit only	Manage harvest	2008	-
180 Fathom Bank	Hawaii Archipelago	NWHI	665.261(2)(iv) 73 FR 47098 84 FR 2773 Precious Corals FMP Am. 7	43.15	Fishing by permit only	Manage harvest	2008	-
Westpac Bed	Hawaii Archipelago	NWHI	665.261(3) 73 FR 47098 84 FR 2773 Precious Corals FMP Am. 7	43.15	Fishing prohibited	Manage harvest	2008	-
Auau Channel	Hawaii Archipelago	Maui Nui	665.261(1)(ii) 73 FR 47098 84 FR 2773 Precious Corals FMP Am. 7	728.42	Fishing by permit only	Harvest quota for black coral of 5,000 kg every two years for federal and state waters	2008	-

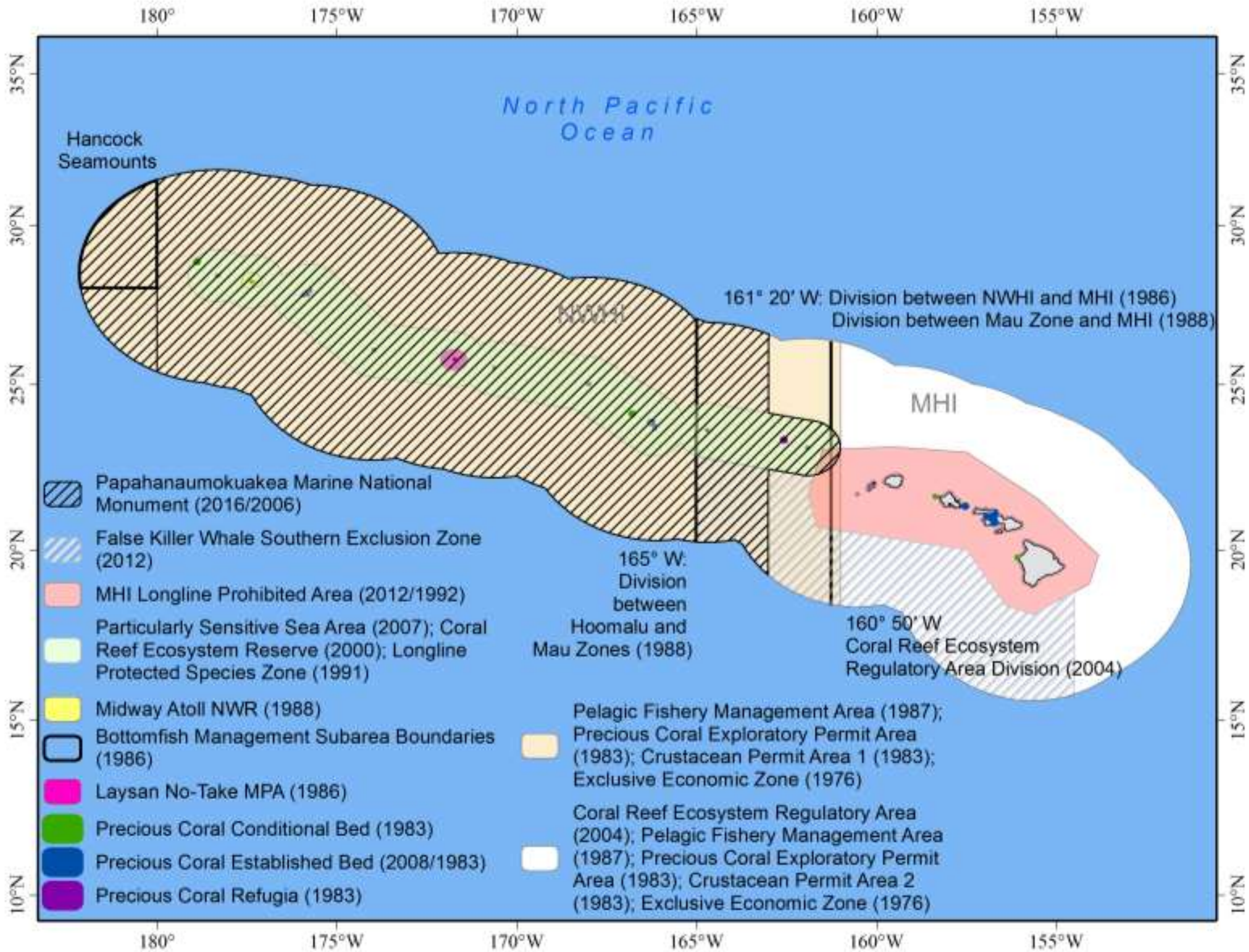


Figure 38. Regulated fishing areas of the Hawaii Archipelago

2.7.4 Fishing Activities and Facilities

2.7.4.1 Aquaculture Facilities

Hawaii has one offshore aquaculture facility operating in Federal waters that was owned by Ocean Era (formerly Kampachi Farms), but the associated Special Coral Reef Ecosystem Fishing Permit (SCREFP) been transferred to Forever Oceans (see Table 69).

There is one permitted offshore aquaculture facility currently operational in Hawaii State waters located off Unualoha Point, North Kona and owned by Blue Ocean Mariculture, which is cultivating *Seriola rivoliana*. Ocean Era is also researching the feasibility of a macro algae array off the Kona coast to produce four native Hawaiian limu species that would be located one mile south of Keahuolo Point in approximately 400 feet of water. Ocean Era received funding for this research through the Department of Energy's Advanced Research Projects Agency - Energy grant program and could begin operation in 2020. Another permit for a separate nearshore aquaculture facility has been approved for Māmāla Bay Seafood located in the Reef Runway Borrow Pit at Ke'ehi Lagoon, Honolulu to cultivate moi (*Polydactylus sexifilis*), but the permit holder is currently in lease negotiations for the site.

Table 69. Offshore aquaculture facilities in Hawaii

Name	Size	Location	Species	Status
Forever Oceans, transferred from Ocean Era (formerly Kampachi Farms)	Shape: Cylindrical Height: 33 ft. Diameter: 39 ft. Volume: 36,600 ft^3	5.5 nautical miles (nm) west of Keauhou Bay and 7 nm south-southwest of Kailua Bay, off the west coast of Hawaii Island 19° 33' N, 156° 04' W. Mooring scope is 10,400-foot radius.	*Seriola rivoliana*	On July 6, 2016, NMFS authorized SCREFP for culture and harvest of 30,000 kampachi over two years on July 6, 2016. Array broke loose from mooring and net pen sank in 12,000 feet of water on Dec. 12, 2016. The mooring was redeployed under guidance from the U.S. Army Corps of Engineers (USACE) in late 2018 and stocked with a cohort of 10,000 fish in early 2019. On March 30, 2017. NMFS authorized transfer of the two-year SCREFP from Ocean Era to Forever Oceans. Forever Oceans recently renewed the SCREFP under the same terms and conditions through June 30, 2021, which will allow them to harvest two cohorts of fish.

2.7.5 Non-Fishing Activities and Facilities

The following section includes activities or facilities associated with known uses and predicted future uses. The Plan Team will update this section as new facilities are proposed and/or built. Due to the sheer volume of ocean activities and the annual frequency of this report, only major activities on multi-year planning cycles are tracked. Activities which are no longer reasonably foreseeable or have been replaced with another planning activity are removed from the report, though may occur in previous reports.

2.7.5.1 Alternative Energy Facilities

Hawaii previously had four proposed wind energy facilities of commercial interest nominated by the Bureau of Ocean Energy Management (BOEM) in its Call Areas northwest and south of Oahu, all of which were in the area identification and environmental assessment stage of the leasing process (Progression Energy, 2015), but these projects have been disengaged (BOEM, Hawaii Activities). There are, however, several alternative energy facilities already existing or in development).

Table **70**).

Table 70. Alternative energy facilities and development offshore of Hawaii

Name	Type	Location	Impact to Fisheries	Stage of Development	Source
Makai Ocean Engineering, Inc., Natural Energy Laboratory of Hawaii Authority (NELHA)	120 kW Ocean Thermal Energy Conversion (OTEC) Test Site/ 1 MW OTEC Test Site	Ke'ahole, North Kona, West Hawaii	Intake	120 kW OTEC operational; Final EA for 1 MW OTEC Site using existing infrastructure submitted July 2012 and finalizing lease negotiations currently; HEPA Exemption List memo Dec. 27, 2016.	NELHA Energy Projects Final Environmental Assessment, NELHA, July 2012
Honolulu Sea Water Air Conditioning (SWAC)	SWAC	4 miles S of Kaka'ako, Oahu	Benthic impacts; intake	USACE Record of Decision (ROD) signed in 2015. In October 2018, HSWAC and the State of Hawaii finalized an agreement to provide seawater air conditioning for eight state buildings. Construction to start in late 2019 or early 2020 and planned to take an estimated 18-22 months.	Honolulu SWAC Press Room Final Environmental Assessment, June 2014
Marine Corps Base Hawaii Wave Energy Test Site (WETS)	Shallow- and Deep-Water Wave Energy	1, 2 and 2.5 km N of Mokapu, Oahu	Hazard to navigation	Shallow and Deep-water wave energy units operational in mid-2015. 1.25 MW OE 35 Buoy planned to be connected in early 2020.	Final Environmental Assessment, NAVFAC PAC, January 2014 E&E News Hawaii Natural Energy Institute

2.7.5.2 Military Training and Testing Activities and Impacts

The Department of Defense major planning activities in the region are summarized in Table 71.

Table 71. Military training and testing activities offshore of Hawaii

Action	Description	Phase	Impacts

Rim of the Pacific (RIMPAC) Exercise	Multinational, sea control/power projection fleet exercise that has been performed biennially for currently headquartered in Pearl Harbor, Hawaii. RIMPAC exercise locations are present throughout the State of Hawaii.	RIMPAC Programmatic EA developed in 2002 and a Supplemental Programmatic EA was finalized in 2006 (71 FR 31170). Biennial exercises continue through the present, with the next RIMPAC scheduled for summer 2020.	Programmatic Environmental Assessment, June 2002
Hawaii-Southern California Training and Testing (HSTT)	Increased naval testing and training activities, including the use of active sonar and explosives	Record of Decision (ROD) available in December 2018 to conduct training and testing activities as identified in Alternative 1 of the HSTT Final Environmental Impact Statement (EIS)/Overseas EIS (OEIS) published in October 2018 (83 FR 66255).	The 2018 HSTT EIS/OEIS predicts impacts to access and habitat impact similar to previous analysis in the 2013 HSTT EIS/OEIS.
Long Range Strike Weapon Systems Evaluation Program (WSEP)	Conduct operational evaluations of Long-Range Strike weapons and other munitions as part of Long-Range Strike WSEP operations at the Pacific Missile Range Facility at Kauai, Hawaii.	Comment period closed Feb. 6, 2017, and final rule on Aug. 22, 2017, for NMFS authorization to take marine mammals incidental to conducting munitions testing for their Long-Range Strike Weapons Systems Evaluation Program (LRS WSEP) over the course of five years, from August 21, 2017 through August 22, 2022 (82 FR 1702; 82 FR 39684).	Access – closures during training. Final Environmental Assessment, October 2016 NMFS Biological Opinion, August 2017

2.7.6 Pacific Islands Regional Planning Body Report

In June 2018, President Trump signed the EO 13840 *Regarding the Ocean Policy to Advance Economic, Security, and Environmental Interests of the United States*, which revoked EO 13547. The new EO eliminated the mandate for the federal government to participate in ocean planning at a regional level and eliminated the regional planning bodies. As such, the Pacific Islands Regional Planning Body (RPB) no longer exists and ocean planning will now occur at a local level led by Hawaii and the territories.

EO 13840 established a policy focused on public access to marine data and information and requires federal agencies to 1) coordinate activities regarding ocean-related matters and 2) facilitate the coordination and collaboration of ocean-related matters with governments and ocean stakeholders. To that end, the American Samoa Coastal and Marine Spatial Planning Data Portal was created by Marine Cadastre. The intent is for it to be expanded to include the Marianas, the Pacific Remote Island Areas, and Hawaii and be titled the Pacific Islands Regional Marine Planner.

Hawaii has several initiatives ongoing, including its 30x30 Plan and update of its Ocean Resource Management Plan. Interested parties are encouraged to provide input to and track the progress of the development of these plans.

3 DATA INTEGRATION

3.1 INTRODUCTION

3.1.1 Potential Indicators for Insular Fisheries

The purpose of this section of the annual Stock Assessment and Fishery Evaluation (SAFE) report is to identify and evaluate potential fishery ecosystem relationships between fishery parameters and ecosystem variables to assess how changes in the ecosystem affect fisheries in the Main Hawaiian Islands (MHI) and across the Western Pacific region. Fishery ecosystem relationships are those associations between various fishery-dependent data measures (e.g., catch, catch-per-unit-effort [CPUE]) and other environmental attributes (e.g. wind, sea surface temperature [SST], currents, etc.) that may contribute to observed trends or act as potential indicators of the status of prominent stocks in the fishery. These analyses represent a first step in a sequence of exploratory analyses that will be utilized to inform new assessments of in determining ecological factors that may be useful to monitor in the context of ecosystem-based fisheries management going forward.

In late 2016, staff from the Council, National Marine Fisheries Service (NMFS), Pacific Islands Fisheries Science Center (PIFSC), Pacific Islands Regional Offices (PIRO), and other fishery resource professionals held a SAFE Report Data Integration Workshop to identify potential fishery ecosystem relationships relevant to local policy in the Western Pacific region and determine appropriate methods to analyze them. Among the ranked potential relationships were bottomfish catch/CPUE and eddy features as well as bottomfish catch/CPUE and surface current, speed, and direction. This chapter reflects exploratory analyses in search of these potential fishery ecosystem relationships.

For the 2017 report, exploratory analyses were performed comparing coral reef fishery species data in the Western Pacific with precipitation, primary productivity, and SST. The Archipelagic Fishery Ecosystem Plan (FEP) Team (Plan Team) suggested several improvements to implement to the initial evaluation, which are reflected in the following preliminary analysis for uku first presented in the 2018 report. The results are prefaced by the Plan Team recommendations for ongoing development and improvement of the Data Integration chapter. Then, the chapter includes brief descriptions of past work on fishery ecosystem relationship assessment in the U.S. Western Pacific, followed by initial evaluations of relationships between uku and ENSO as well as surface zonal currents. The evaluations completed were exploratory in nature and were used as initial analyses to know which comparisons may hold more utility going forward. In subsequent years, this chapter will be updated with analyses through the SAFE report process to include more of the described climate change indicators from Section 2.5.4, and as the strength of certain fishery ecosystem relationships relevant to advancing ecosystem-based fishery management are determined.

3.1.2 2018 Plan Team Recommendations for Section Development

At the Plan Team meeting held on April 30th and May 1st, 2018, participants were presented preliminary data integration results on comparisons between coral reef species and various climate indicators. The Plan Team provided detailed recommendations to support the ongoing development of the data integration section of the Archipelagic annual SAFE report. These suggestions, both general and specific, will continue to be implemented in the coming years to ensure that more refined analyses comprise the data integration section.

Plan Team participants recommended that:

- CPUE data should be standardized and calculated in a more robust fashion, measuring the average catch per unit effort rate over the course of a year to analyze variance.
- Analyses of fishery performance data against environmental variables should focus on dominant gear types rather than the entirety of the fishery or other gear aggregates;
- There should be additional phase lag implemented in the analyses;
- Local knowledge of fishery dynamics, especially pertaining to shifting gear preferences, should be utilized. Changes in dynamics that may have impacted observed fishery trends over the course of available time series, both discreetly and long-term for taxa-specific and general changes should be emphasized; and
- Spatial specificity and precision should be increased for analyses of environmental variables in relation to areas commonly fished.

The analyses presented in this chapter reflect a thoughtful re-approaching to data integration evaluations. Data from 2002 to 2012 were utilized because all data products had consistent coverage within this range. Additional data can be added to either time series as they are made available. Moving forward, incorporating Plan Team recommendations into the annual SAFE report will mark the beginning of a standardized process to implement current data integration analyses on an annual basis. Doing so will promote more proactive management action with respect to ecosystem-based fishery management objectives.

3.1.3 Background Information

Fishery Ecosystem Relationships

There is growing concern that the effects of increased variability in environmental and ecological parameters attributed to climate change may impact fish stocks and the fisheries that harvest them. A recent meta-analysis looking at 235 populations of 124 species of fish nationwide recently suggested that the maximum sustainable yield of fish species has generally declined over the last 80 years in response to ocean warming (Free et al., 2019). In addition to impacts from gradual warming, changes in storm frequency and intensity associated with climate change also threaten fisheries worldwide by disrupting fishing effort and infrastructure of coastal communities, and these impacts are likely to be realized in a more immediate manner (Sainsbury et al., 2018).

In response to elevated awareness of potential impacts to fish stocks and their associated fisheries, there have been increased efforts by scientific researchers to understand how a changing environment may influence commercially important fishery species. Richards et al. (2012) performed a study on a range environmental factors that could potentially affect the distribution of large-bodied coral reef fish in Mariana Archipelago. Large-bodied reef fish were determined to typically be at the greatest risk of overfishing, and their distribution in the region was shown to be negatively associated with human population density. Additionally, depth, sea surface temperature (SST), and distance to deep water were identified as important environmental factors to large-bodied coral reef fish, whereas topographic complexity, benthic habitat structure, and benthic cover had little association with reef fish distribution in the

Mariana Archipelago. Kitiona et al. (2016) completed a study of the impacts climate and ecosystem change on coral reefs fish stocks of American Samoa using climate and oceanic indicators (see Section 2.5.4). The evaluation of environmental variables showed that certain climate parameters (e.g. SST anomaly, sea level height, precipitation, and tropical storm days) are likely linked to fishery performance. It has also noted that larger natural disturbances in recent decades, such as cyclones and tsunamis, negatively impacted reef fish assemblages and lowered CPUE of reef fish in American Samoa (Ochavillo et al., 2012).

Little information exists on the larval and juvenile life stages of bottomfish in the MHI, though the larvae and juveniles are typically found in very different habitats than their adult counterparts (Moffitt, 2006). Larvae in the MHI exhibit a high degree of self-recruitment and connectivity, and the presence of zonal currents may play a part in influencing larval transport and connectivity (Wren et al., 2016). In addition, mesoscale eddies are thought to play a major role in retention of larvae and recruitment for fish stocks around the MHI, and parrotfish in the MHI likely utilize eddies to retain larvae near their settling grounds (Lobel and Robinson, 1986; Lobel, 1989; Shulzitski et al., 2017; Wren and Kobayashi, 2016). A more recent project evaluating larval fish assemblages in association with water masses and mesoscale dynamics that govern them suggested that larval assemblages depend on species-based interactions between their spawning strategies and these processes (León-Chávez et al., 2010). Similarly, a study on the impact of mesoscale eddies on the migration of Japanese eel larvae found that there was a negative relationship between the eel recruitment index and the eddy index subtropical countercurrent, indicating that eddies play some sort of role in migration of the species (Chang et al., 2017).

Uku and its Fishery in the Main Hawaiian Islands

The green jobfish (*Aprion virescens*), known as uku in Hawaii, is a non-Deep 7 bottomfish that inhabits deep lagoons, channels, and inshore reefs from the surface down to about 100 - 135 m (Asher et al., 2017; Haight et al., 1993b). It is among the most common roving predatory marine species in the MHI (Asher et al., 2017). The most recent stock assessment of uku in the MHI was done by Nadon (2017), where it was suggested that population abundance appeared to be increasing from 2003 to 2016.

Uku reach sexual maturity during the spring and summer before spawning until fall or early winter; they begin spawning in May before their peak in June (Everson et al., 1989). The green jobfish are generally known to aggregate in shallower waters, such as those above Penguin Banks, during summer months for spawning purposes and are caught during daylight hours (Haight et al., 1993a; Haight et al., 1993b). The timing of their spawning aggregations may also be associated with increases in SST and/or day length to ensure ideal conditions for their larvae (Walsh, 1987). It has been found that areas active with spawning during the summer had prolonged absences of the species from October to April due to seasonal migrations (Meyer et al., 2007). Unsurprisingly, around the MHI, the majority of uku are typically caught over Penguin Banks during the summer, as are typically targeted when they aggregate for spawning (Everson et al., 1989; Parke, 2007).

Uku size at 50 percent sexual maturity for females is 425 to 475 mm fork length (FL), and the smallest uku with vitellogenic (stage II) ovaries during spawning was just 429 mm (Everson et al., 1989; Haight et al., 1993). The slope of the logistic curve fit to size at sexual maturity data for uku was relatively steep, suggesting that uku grow rapidly and quickly recruit into the fishery

(Everson et al., 1989). Uku congregate around the MHI in expected 1:1 sex ratio, and likely release multiple egg batches over the course of a spawning season (Everson et al., 1989).

Uku are harvested by a wide range of gear types, including deep- and shallow-set (i.e., inshore) handlining, cast netting, and trolling. Deep-set handline was primarily focused on for this data integration assessment due to the amount of consistent data available and its apparent dominance in the MHI uku fishery. There was generally more structural variability apparent in handline trips, as the fishermen should catch uku with handline if that is what they are targeting due to the gear's high selectivity. Of all gear types that are used to harvest uku, the deep-set handline consistently had the highest CPUE of the four gears considered by nearly an order of magnitude; however, while CPUE for deep-set handline trended downwards over the course of the time series, the CPUE for inshore handline, cast netting, and trolling with lures slightly increased over the same period (Figure 39). Trolling (with lure) to harvest uku had the second-highest CPUE for several years of the CPUE time series, but this gear type was not taken further in the assessment because there is no good understanding of trolling effort for uku; troll fishers are usually targeting pelagic species, and are not reporting "zero" catch on trips where there is no uku catch.

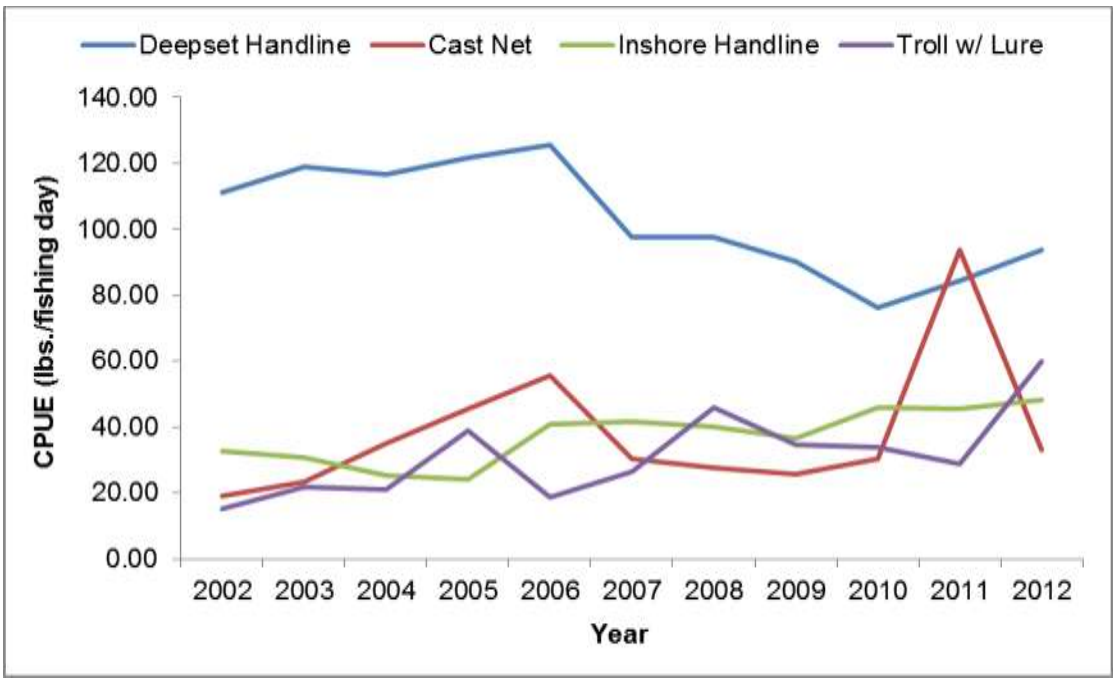


Figure 39. CPUE for uku harvested in the MHI for four top gear types from 2002-2012

The annual average weight per fish from 2002 to 2012 was 8.59 pounds, ranging from 8.25 pounds in 2008 to 8.94 pounds in 2014 (Figure 40). These results agree well with the annual average weight-per-fish determined by Moffitt et al. (2005). Using a weight-to-length conversion for uku (Sundberg et al., 2011) it was determined that the average length per fish was roughly 63 to 65 cm Total Length (TL). From there, a length-to-age curve was utilized (O'Malley et al., 2016) to estimate the approximate age that uku individuals recruit into the fishery around the MHI to be about two years. It is reasonable to infer that the CPUE data analyzed here is comprised mostly of fish that recruited into the fishery at two years of age.

Though Sundberg et al. (2011) suggested that an uku of eight to nine pounds is likely 63 to 65 cm TL, Everson et al. (1989) noted that uku of such size in the main Hawaiian islands were 95 percent mature, indicating that the uku may have recruited to the fishery earlier as well. For uku, it was determined that 100 percent maturity was reached by the 50 cm size classes, but it is important to note that disparities in size and at sexual maturity between areas may reflect differences in resource utilization and growth allocation (Everson et al., 1989). Uku have been found to be homogenously dispersed across all available depth and habitat strata with significant regional differences no matter the depth strata or inclusion of habitat (Asher et al., 2017).

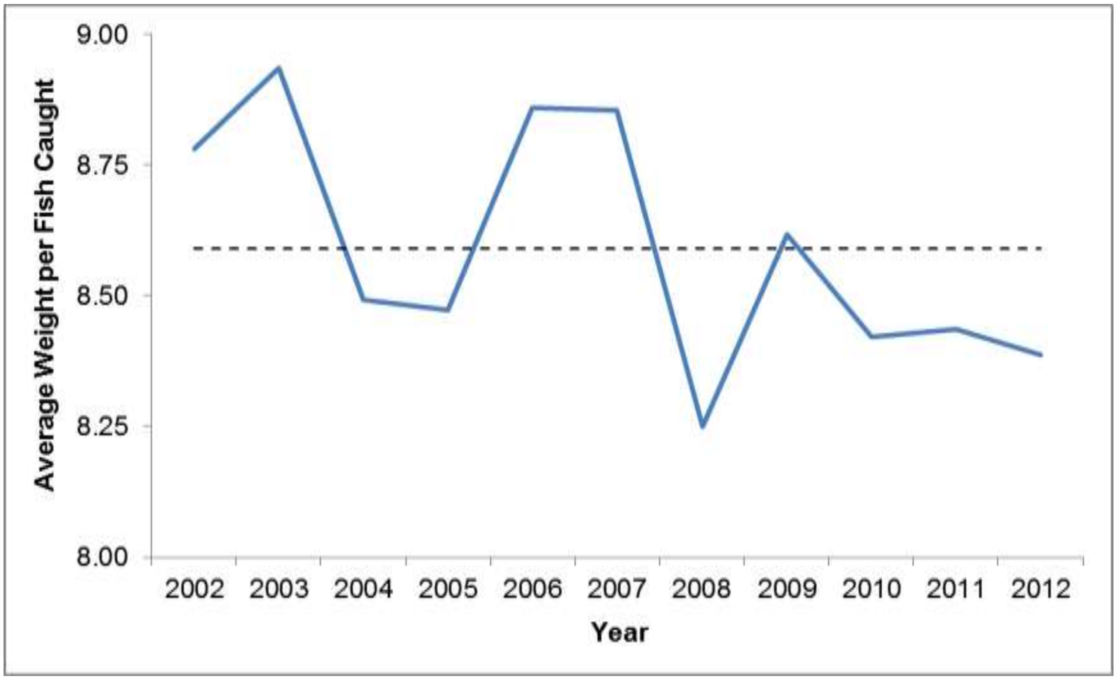


Figure 40. Average annual weight per fish (lbs.) for uku (*Aprion virescens*) harvested around the Main Hawaiian Islands from 2002-2012

3.2 MULTIVARIATE ENSO INDEX

The El Niño Southern Oscillation (ENSO) is Earth's strongest interannual climate fluctuation and is the most important and representative phenomenon in the ocean-atmosphere system on these time scales (Mazzarella et al., 2013; Wolter and Timlin, 2011). To measure the response of the uku fishery to interannual environmental shifts, such as those due to ENSO, data were drawn from a relatively recent index that utilizes an ensemble approach and has become the leading ENSO index called the Multivariate ENSO Index Version 2 (MEI.v2). The MEI utilizes of five different environmental parameters across the tropical Pacific Ocean to derive its value: SST, sea level pressure (SLP), surface zonal winds, surface meridional winds, and outgoing longwave radiation (OLR; NOAA, 2019). Notable environmental features during the typical peak of ENSO during late Fall/early Winter are anomalously warm SST across the east-central equatorial Pacific, anomalously low SLP over the eastern tropical Pacific, reduction of tropical Pacific easterly trade winds, and increased OLR over the Western Pacific (Figure 41; NOAA, 2019). In MEI.v2, the measures of SST, SLP, and surface zonal and meridional winds are obtained from the JRA-55 global atmospheric reanalysis by the Japan Meteorological Agency (see Kobayashi et al., 2015), while the measures of OLR were gathered from the NOAA Climate Data Record of Monthly OLR (Lee ,2018). While there are positive MEI values every few years, the last several major ENSO events occurred in 1983, 1998, and 2016 (Figure 42; NOAA, 2019).

The CPUE (catch in pounds per fishing trip/day) and environmental data were standardized by both average and standard deviation so the time series would be comparable, and all covariates would have equitability. Phase lag was incorporated from one to six years. The correlation coefficient for the comparison between standardized uku CPUE from the MHI and the standardized MEI.v2 was -0.729 (Figure 43) and the coefficient of determination (R^2) was 0.53 (Figure 44), indicating a strong inverse relationship between the variables. The covariates suggest that as the MEI.v2 increases, uku CPUE in the MHI decreases, and vice versa.

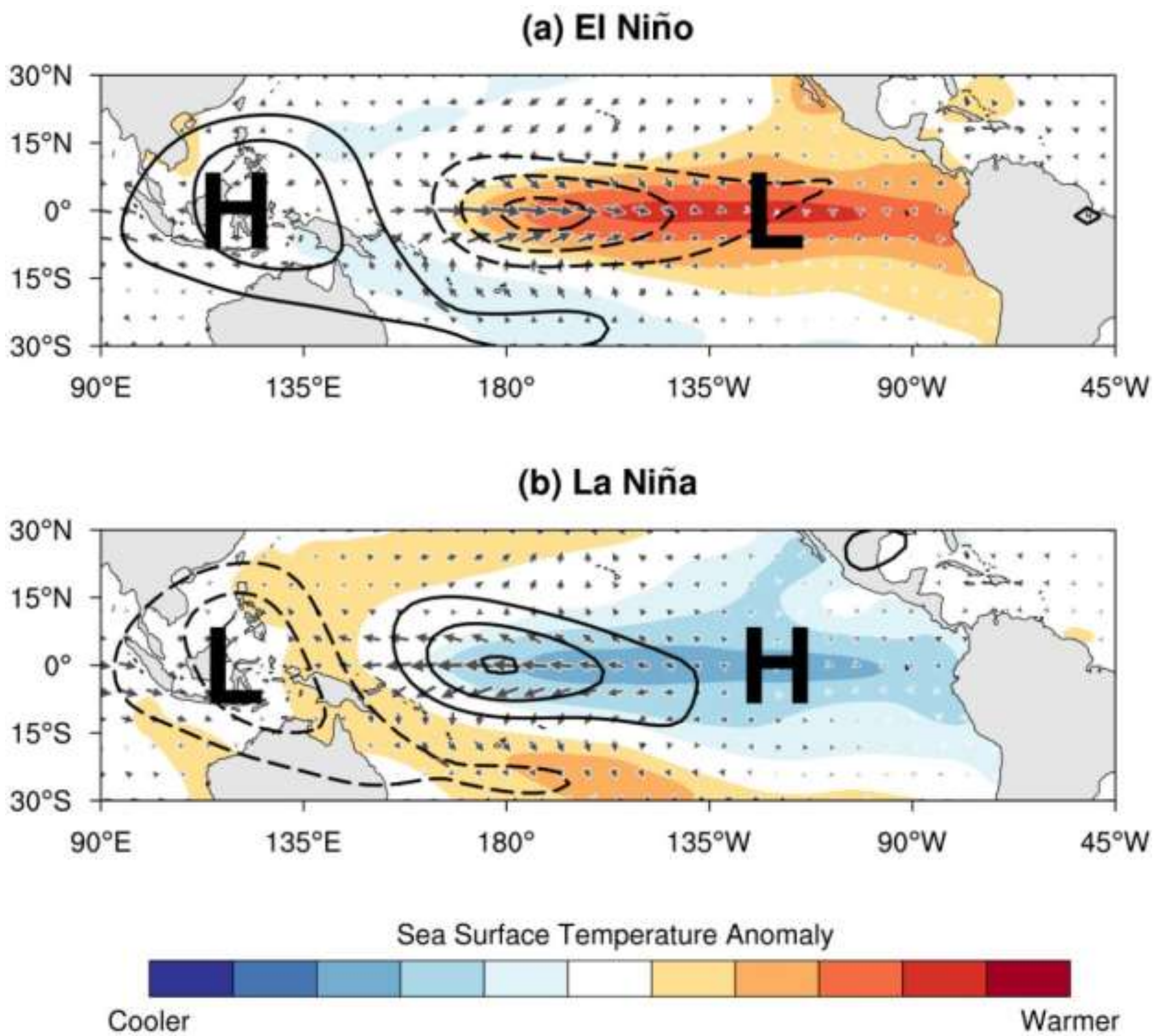


Figure 41. Diagram showing the physical mechanisms by which the SST (shaded), OLR (contours), surface zonal and meridional winds (vectors), and sea level pressure (represented by "H" and "L") determine the wintertime Multivariate ENSO Index (MEI) during (a) El Niño and (b) La Niña events" (from NOAA, 2019)

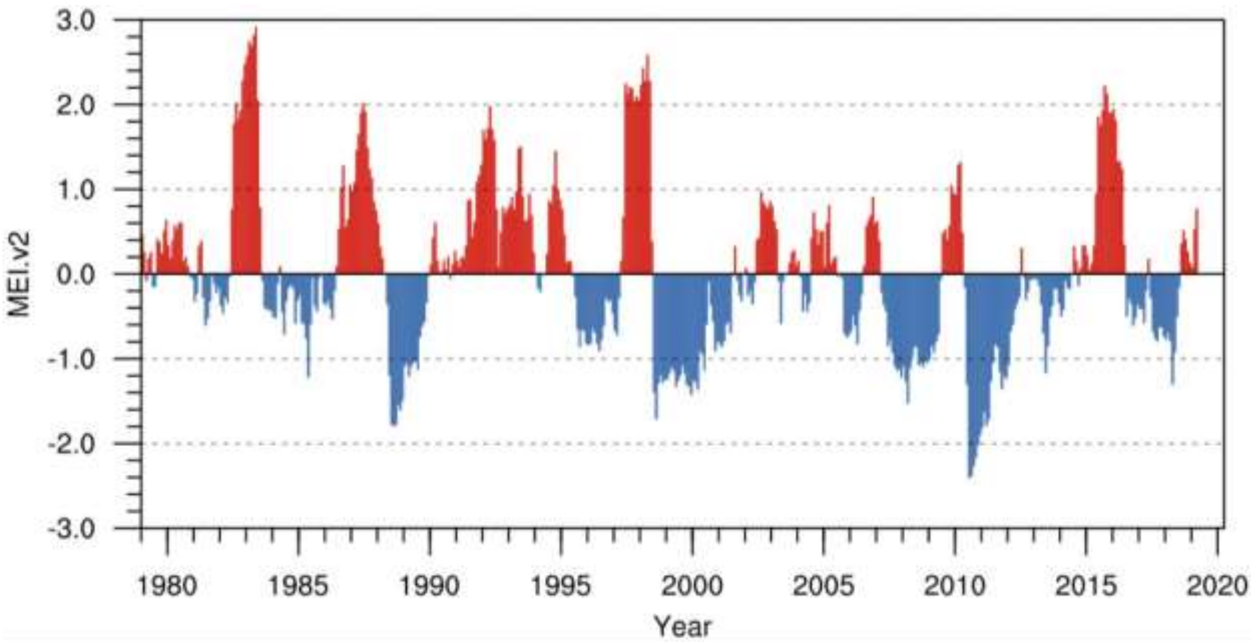


Figure 42. Time series of the Multivariate ENSO Index (MEI) v2 from 1980 to present

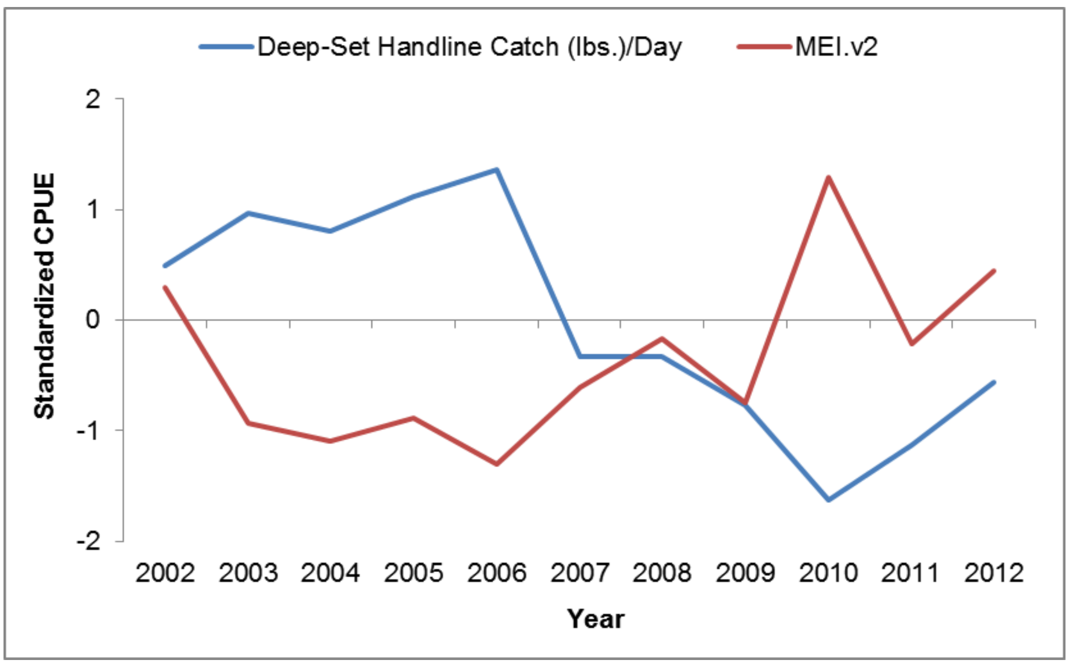


Figure 43. Comparison of standardized MHI Deep-Set Handline CPUE and MEI.v2 with a phase lag of two years from 2002-2012 (*r* = -0.729)

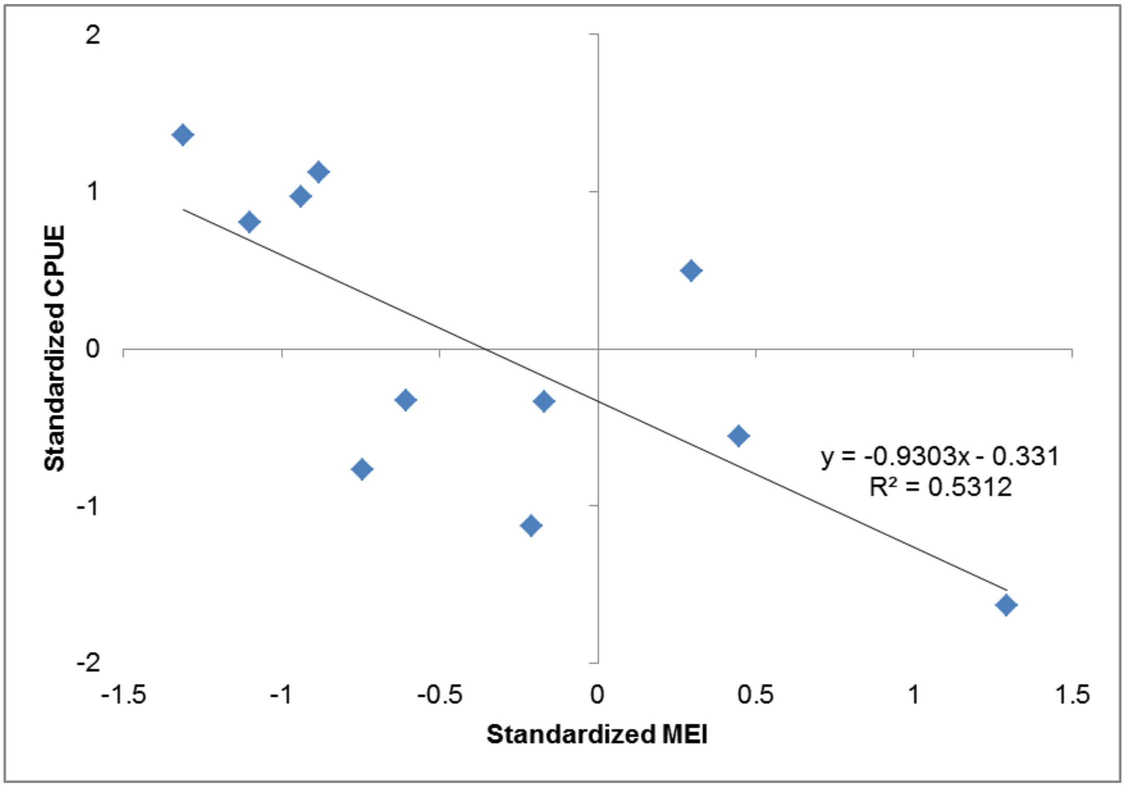


Figure 44. Standardized CPUE for uku from the MHI from 2002-2012 plotted against standardized MEI.v2 with a phase lag of two years

3.3 SURFACE ZONAL CURRENTS

The surface circulation in the tropical Pacific Ocean is complex and undergoes a large amount of short- and long-term variability due to both shifts in major winds as well as thermohaline structure of surrounding water masses (Wyriki, 1965). It has been suggested in the past that the current flow near the MHI are responsible for the variability in larval assemblages and distribution in the area (Miller, 1974). Given the vital role zonal flow plays in vorticity, it was inferred that the parameter itself may possess some sort of fishery ecosystem relationship with uku, whose spawning assemblages are known to congregate in shallow waters above Penguin Banks during the summer months (Haight et al., 1993a; Haight et al., 1993b). A summary of surface zonal currents and vorticity in the waters surrounding the MHI from 2004 is depicted in Figure 45. One of the major surface currents in this region, the North Equatorial Current, was also analyzed for the purposes of this study, with moderate relationships between NEC flow with a phase lag of two years and uku CPUE (r = 0.304).

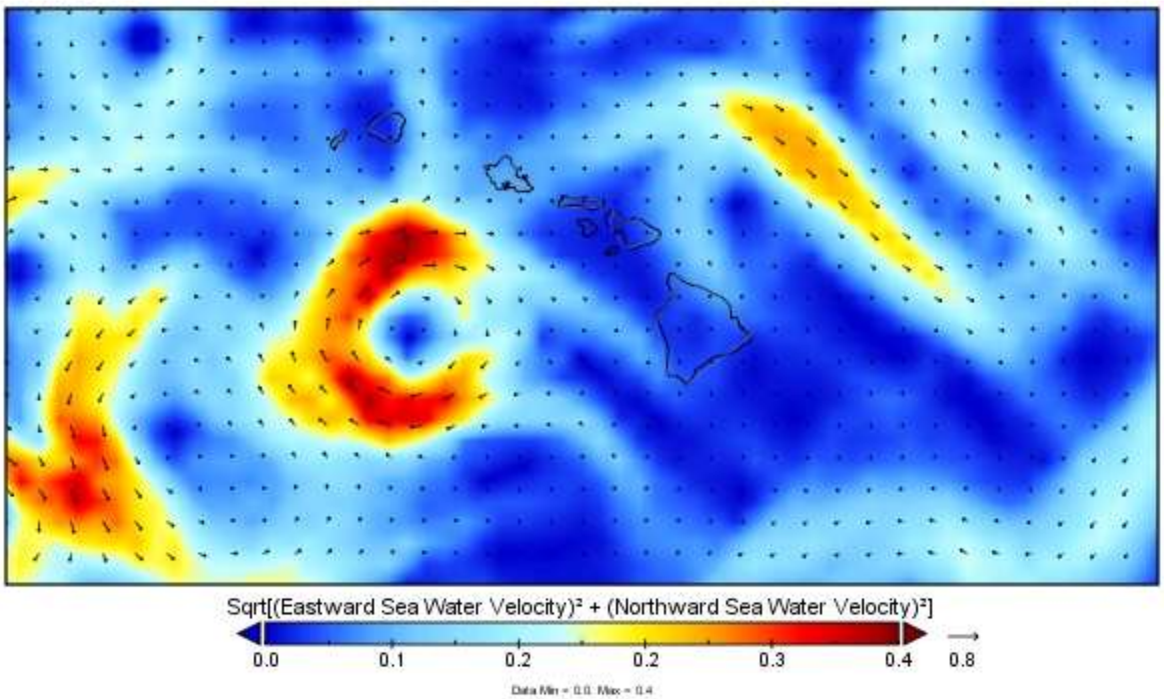


Figure 45. Example of eastward sea water current velocity around the MHI (from 2004)

Similar to comparisons with the MEI.v2, both CPUE (catch in pounds per fishing trip/day) and environmental data were standardized by both average and standard deviation so the time series would be comparable, and all covariates would have equitability. Phase lag was incorporated from one to six years. The correlation coefficient for the comparison between standardized uku CPUE from the MHI and the standardized average summertime zonal current flow in the same area was 0.748 (Figure 46) and the coefficient of determination (R^2) was approximately 0.56 (Figure 47), indicating a strong relationship between the variables. The covariates suggest that as the average summertime zonal current increases, uku CPUE in the MHI also increases.

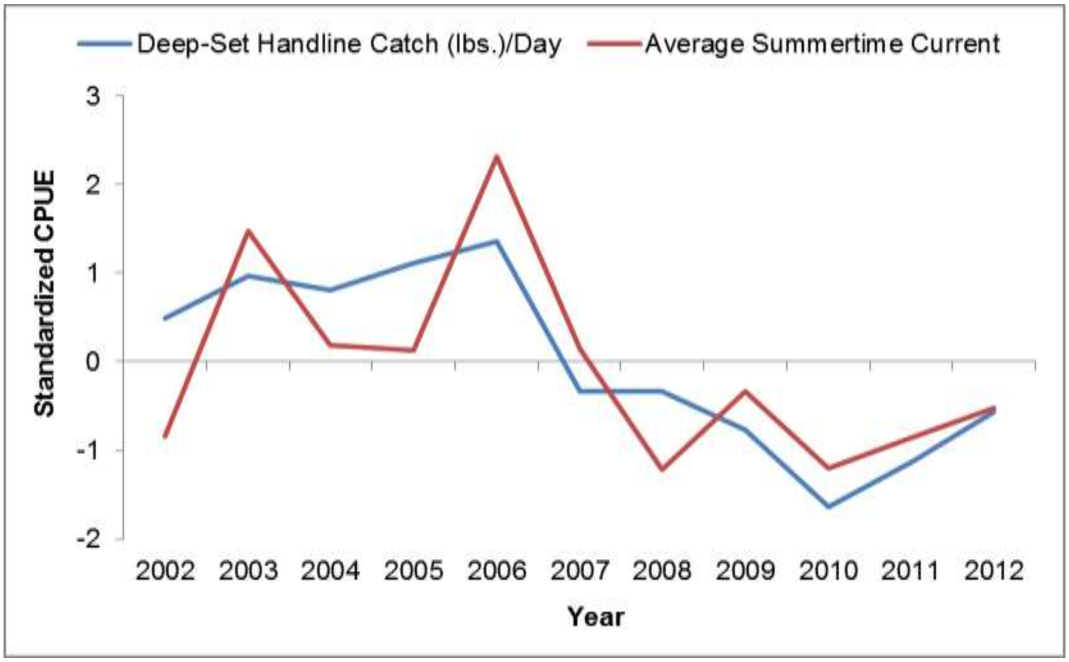


Figure 46. Comparison of standardized MHI Deep-Set Handline CPUE and the average summertime zonal current with a phase lag of two years from 2002-2012 (*r* = 0.748)

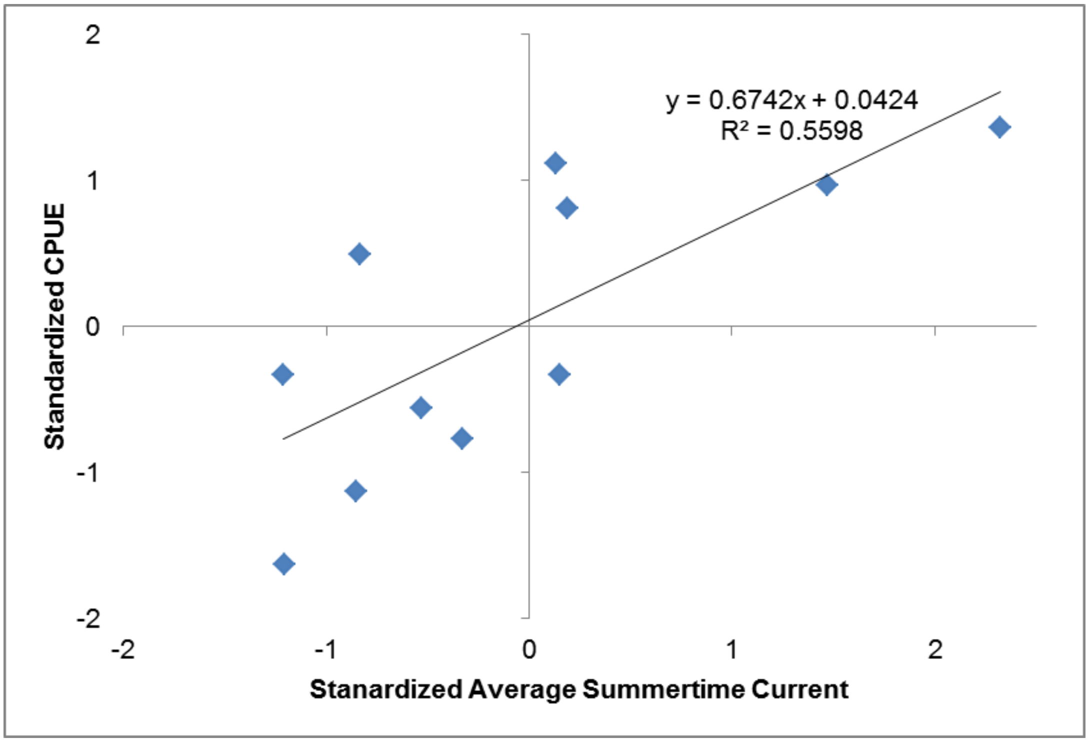


Figure 47. Standardized CPUE for uku from the MHI from 2002-2012 plotted against standardized average summertime zonal current with a phase lag of two years

3.4 RECENT RELEVANT ABSTRACTS

In this section, abstracts from primary journal articles published in 2019 and relevant to data integration are compiled. Collecting the abstracts of these articles is intended to further the goal of this chapter being used to guide adaptive management.

Asher, J., Williams, I.D., and E.S. Harvey, 2019. Is seeing believing? Diver and video-based censuses reveal inconsistencies in roving predator estimates between regions. *Marine Ecology Progress Series, 630*, pp. 115-136.

Coral reef research programs in Hawaii primarily use diver-based underwater visual censuses in ≤30 m depths to assess roving predator populations between the Main (MHI) and Northwestern Hawaiian Islands (NWHI). As a probable consequence of survey biases, results from some methods imply remarkably top-heavy trophic pyramids that potentially inflate the scale of differences between remote and populated regions. Other limitations include the absence of predator information in >30 m depths. To better understand regional differences, we compared shallow-water roving predator abundances and estimated predator length-frequencies between 2 diver-based visual assessment methods (stationary point count [‘SPC’] and towed-diver) and 2 video sampling techniques (unbaited and baited remote underwater stereo-video systems: RUVS and BRUVS). We also surveyed 30-100 m (‘mesophotic’) roving predators using RUVS and BRUVS. As with diver-based assessments, RUVS and BRUVS sampled considerably more roving predators in the NWHI versus the MHI, with patterns remaining consistent between methods. However, the NWHI:MHI scales of difference for RUVS and BRUVS tended to be substantially lower than for diver surveys. The largest discrepancies were recorded for the giant trevally *Caranx ignobilis*, where NWHI:MHI abundance ratios varied by >2 orders of magnitude between diver SPC and all other methods. Although our results corroborate substantially higher roving predator densities in the NWHI, this study demonstrates that the application of different methods can result in strikingly dissimilar predator estimates. Continued assessments among survey techniques, coupled with the inclusion of mesophotic surveys, remain vital to improving understanding of predator populations, providing information that is properly aligned with management and conservation needs.

Chung, A.E., Wedding, L.M., Meadows, A. et al., 2019. Prioritizing reef resilience through spatial planning following a mass coral bleaching event. *Coral Reefs, 38*, pp. 837-850.

Following the recent 2014–2017 global coral bleaching event, managers are seeking interventions to promote long-term resilience beyond monitoring coral decline. Here, we applied a spatial approach to investigate one potential intervention, mapping areas where local management could build coral reef resilience using herbivore management. Although herbivore management is a top recommendation in resilience-based management, site-specific attributes are thought to affect its success, and thus strategizing placement and design of these areas are crucial. Using Marxan, we mapped and prioritized potential Herbivore Management Areas (HMAs), where herbivores are protected but other types of fishing are allowed, in the main Hawaiian Islands. Through four scenarios, we found multiple hotspots along the west coast of Hawaiʻi Island and around the islands of Molokaʻi, Lanaʻi, Maui, and Kahoʻolawe where HMAs may have the best chance for success based on habitat, ecologically critical areas, life history, and social considerations. We further analyzed top results and found that a subset of characteristics including habitat types, biomass of herbivore functional groups, and temperature variability were significantly different from surrounding areas and thus contain potential drivers for selection. This unique approach can serve as an example for coral reef management in Hawaiʻi, on other Pacific Islands, and beyond, as it provides practical guidance on how to apply a resilience-building tool at a local level, incorporating site-specific biological and socioeconomic considerations.

Darling, E.S., McClanahan, T.R., Maina, J. et al., 2019. Social–environmental drivers inform strategic management of coral reefs in the Anthropocene. *Natural Ecology and Evolution*, *3*, pp. 1341-1350

Without drastic efforts to reduce carbon emissions and mitigate globalized stressors, tropical coral reefs are in jeopardy. Strategic conservation and management requires identification of the environmental and socioeconomic factors driving the persistence of scleractinian coral assemblages—the foundation species of coral reef ecosystems. Here, we compiled coral abundance data from 2,584 Indo-Pacific reefs to evaluate the influence of 21 climate, social and environmental drivers on the ecology of reef coral assemblages. Higher abundances of framework-building corals were typically associated with: weaker thermal disturbances and longer intervals for potential recovery; slower human population growth; reduced access by human settlements and markets; and less nearby agriculture. We therefore propose a framework of three management strategies (protect, recover or transform) by considering: (1) if reefs were above or below a proposed threshold of >10% cover of the coral taxa important for structural complexity and carbonate production; and (2) reef exposure to severe thermal stress during the 2014–2017 global coral bleaching event. Our findings can guide urgent management efforts for coral reefs, by identifying key threats across multiple scales and strategic policy priorities that might sustain a network of functioning reefs in the Indo-Pacific to avoid ecosystem collapse.

Gove, J.M., Whitney, J.L., McManus, M.A. et al., 2019. Prey-size plastics are invading larval fish nurseries. *Proceedings of the National Academy of Sciences of the United States of America, 116*(48). Pp. 24143-24149.

Life for many of the world's marine fish begins at the ocean surface. Ocean conditions dictate food availability and govern survivorship, yet little is known about the habitat preferences of larval fish during this highly vulnerable life-history stage. Here we show that surface slicks, a ubiquitous coastal ocean convergence feature, are important nurseries for larval fish from many ocean habitats at ecosystem scales. Slicks had higher densities of marine phytoplankton (1.7-fold), zooplankton (larval fish prey; 3.7-fold), and larval fish (8.1-fold) than nearby ambient waters across our study region in Hawaiʻi. Slicks contained larger, more well-developed individuals with competent swimming abilities compared to ambient waters, suggesting a physiological benefit to increased prey resources. Slicks also disproportionately accumulated prey-size plastics, resulting in a 60-fold higher ratio of plastics to larval fish prey than nearby waters. Dissections of hundreds of larval fish found that 8.6% of individuals in slicks had ingested plastics, a 2.3-fold higher occurrence than larval fish from ambient waters. Plastics were found in 7 of 8 families dissected, including swordfish (Xiphiidae), a commercially targeted species, and flying fish (Exocoetidae), a principal prey item for tuna and seabirds. Scaling up across an ~1,000 km^2 coastal ecosystem in Hawaiʻi revealed slicks occupied only 8.3% of ocean surface habitat but contained 42.3% of all neustonic larval fish and 91.8% of all floating plastics.

The ingestion of plastics by larval fish could reduce survivorship, compounding threats to fisheries productivity posed by overfishing, climate change, and habitat loss.

Heenan, A., Williams, G.J., and I.D. Williams, 2019. Natural variation in coral reef trophic structure across environmental gradients. *Frontiers in Ecology and the Environment, 18*(2), pp. 69-75.

Policies designed to address current challenges to the sustainability of fisheries generally use an ecosystem-based approach – one that incorporates interactions between fishes, fishers, and the environment. Fishing alters the trophic structure among coral reef fish but properly assessing those impacts requires an understanding of how and why that structure varies naturally across scales. Using a combination of small- and large-scale surveys, we generated biomass pyramids for 20 uninhabited Pacific islands, and found that (1) the distribution of reef fish biomass across trophic levels is highly scale dependent: trophic structures that appear top-heavy at small scales can take a variety of different states when data are integrated across the broader seascape; (2) reefs can have the greatest biomass at intermediate consumer levels, which we describe as "middle-driven" systems; and (3) in unfished coral reef systems, trophic structure is strongly predicted by energy into the base and middle of the food web, as well as by the interacting effect of water temperature.

Jouffray, J.B., Wedding, L.M., Norström, A.V., Donovan, M.K., Williams, G.J., Crowder, L.B., Erickson, A.L., Friedlander, A.M., Graham, N.A.J., Jamison M. Gove, J.M., Kappel, C.V., Kittinger, J.N., Lecky, J., Oleson, K.L.L., Kimberly A. Selkoe, K.A., Crow White, C., Ivor D. Williams, I.D. and M. Nyström, 2019. Parsing human and biophysical drivers of coral reef regimes. *Proceedings of the Royal Society B., 286*, 20182544.

Coral reefs worldwide face unprecedented cumulative anthropogenic effects of interacting local human pressures, global climate change and distal social processes. Reefs are also bound by the natural biophysical environment within which they exist. In this context, a key challenge for effective management is understanding how anthropogenic and biophysical conditions interact to drive distinct coral reef configurations. Here, we use machine learning to conduct explanatory predictions on reef ecosystems defined by both fish and benthic communities. Drawing on the most spatially extensive dataset available across the Hawaiian archipelago—20 anthropogenic and biophysical predictors over 620 survey sites—we model the occurrence of four distinct reef regimes and provide a novel approach to quantify the relative influence of human and environmental variables in shaping reef ecosystems. Our findings highlight the nuances of what underpins different coral reef regimes, the overwhelming importance of biophysical predictors and how a reef's natural setting may either expand or narrow the opportunity space for management interventions. The methods developed through this study can help inform reef practitioners and hold promises for replication across a broad range of ecosystems.

Kamikawa, K.T., Humphreys Jr., R.L., Bowen, B.W., and A.M. Friedlander, 2019. Recruitment dynamics and fishery characteristics of juvenile goatfishes *Mulloidichthys* spp. in Hawaii. *Journal of Fish Biology, 95,* pp. 1086-1093.

The most common goatfishes in Hawaiʻi, *Mulloidichthys flavolineatus* and *M. vanicolensis*, comprise a unique resource due to their cultural, ecological and biological significance. These species exhibit pulse-type recruitment to nearshore areas during the summer months. Such pulses of juvenile fishes provide prey for pelagic and nearshore fishes and support a popular directed fishery. However, limited scientific information exists on juvenile stages of these fishes, known locally as oama, despite their contribution to coastal ecology and the extensive nearshore fisheries. Here we resolve growth rates, habitat preferences, hatching dates, size and age structure, as well as fishing catch rates based on new recruits in 2014 and 2015. We sampled 257 *M. flavolineatus* and 204 *M. vanicolensis* to compare ecological and fisheries characteristics between species and years. Both show strong habitat segregation, with *M. vanicolensis* found almost exclusively on hard and *M. flavolineatus* on soft substrates. Oama recruited in anomalously high numbers in 2014, a trend reflected in a higher catch per unit effort. In contrast, 2015 recruits grew faster, were heavier on average and hatched later than during 2014. Both species have calculated hatch dates in March to July, with *M. vanicolensis* hatching earlier, recruiting earlier and being consistently larger than *M. flavolineatus*. This baseline information regarding recruitment and early life-history characteristics can enhance management for other data-limited species that comprise a substantial component of nearshore fisheries in Hawai‘i.

McClanahan, T.R., Schroeder, R.E., Friedlander, A.M., Vigliola, L. et al., 2019. Global baselines and benchmarks for fish biomass: comparing remote reefs and fisheries closures. *Marine Ecology Progress Series*, *612*, pp. 167-192.

Baselines and benchmarks (B&Bs) are needed to evaluate the ecological status and fisheries potential of coral reefs. B&Bs may depend on habitat features and energetic limitations that constrain biomass within the natural variability of the environment and fish behaviors. To evaluate if broad B&Bs exist, we compiled data on the biomass of fishes in ~1000 reefs with no recent history of fishing in 19 ecoregions. These reefs spanned the full longitude and latitude of Indian and Pacific Ocean reefs and included older high-compliance fisheries closures (>15 yr closure) and remote reef areas (>9 h travel time from fisheries markets). There was no significant change in biomass over the 15 to 48 yr closure period but closures had only ~40% of the biomass (740 kg ha^{-1}, lower confidence interval [LCI] = 660 kg ha-1, upper confidence interval [UCI] = 810 kg ha^{-1}, n = 157) of remote tropical reefs (1870 [1730, 2000] kg ha^{-1}, n = 503). Remote subtropical reefs had lower biomass (950 [860, 1040] kg ha^{-1}, n = 329) than tropical reefs. Closures and remote reef fish biomass responded differently to environmental variables of coral cover, net primary productivity, and light, indicating that remote reefs are more limited by productivity and habitat than closures. Closures in fished seascapes are unlikely to achieve the biomass and community composition of remote reefs, which suggests fisheries benchmarks will differ substantially from wilderness baselines. A fishery benchmark (B_0) of ~1000 kg ha^{-1} adjusted for geography is suggested for fisheries purposes. For ecological purposes, a wilderness baseline of ~1900 kg ha^{-1} is appropriate for including large and mobile species not well protected by closures.

Mejía-Mercado, B.E., Mundy, B., and A.R. Baco, 2019. Variation in the structure of the deep-sea fish assemblages on Necker Island, Northwestern Hawaiian Islands. *Deep Sea Research Part I: Oceanographic Research Papers*, *152*, 103086.

Evidence is accumulating that within any given seamount, the abundance and diversity of fauna may vary strongly with environmental variability. Necker Island, located in the Northwestern Hawaiian Islands, has not been subject to commercial trawl fisheries and is currently protected from fishing activities as part of the Papahānaumokuākea Marine National Monument. The relatively pristine nature of this seamount makes it an excellent location to assess the abundance and diversity of the deep-sea fish fauna of a seamount and their variability relative to environmental parameters, with minimal confounding of natural patterns by human impacts. Using 51,988 AUV photos that showed 18,478 fishes, 92 species were identified from three study sites on different slopes of Necker Island at depths of 200–700 m. The deep-sea fish assemblages were dominated by Stomiiformes, Gadiformes, Myctophiformes, Aulopiformes, and Perciformes. From 250 to 700 m, relative abundance of fishes was significantly different among study sites, with the NE side having the lowest abundance. Species richness and rarefaction estimates of the expected species richness showed significant differences by study site, depth, and their interaction. The NE slope of the island had the lowest estimated richness. By depth, species richness showed two peaks, one at 350 m and the highest at 500 m, in which diversity was also very high with low dominance. The highest values of dominance were observed at 250 and 700 m. Community structure was significantly different by study site, depth, and their interaction. Variation by depth was observed in the NMDS plot, with three assemblages characterized by different dominant species. Fish assemblage structure was correlated with dissolved oxygen, salinity, percentage of sand, rugosity, slope, POC, and current vectors u and v. These results support significant variability in deep-sea fish abundance, diversity, and assemblage structure on seamounts over relatively narrow depth ranges and among sides of a seamount at the same depth. This variability should be considered in future ecological studies of seamounts as well as in the management and conservation of seamounts.

Taylor, B.M., Choat, J.H., DeMartini, E.E., Hoey, A.S., Marshell, A., Priest, M.A., Rhodes, K.L., and M.G Meekan, 2019. *Journal of Animal Ecology*, *88*(12), pp. 1888-1900.

Variation in life-history characteristics is evident within and across animal populations. Such variation is mediated by environmental gradients and reflects metabolic constraints or tradeoffs that enhance reproductive outputs. While generalizations of life-history relationships across species provide a framework for predicting vulnerability to overexploitation, deciphering patterns of intraspecific variation may also enable recognition of peculiar features of populations that facilitate ecological resilience. This study combines age-based biological data from geographically disparate populations of bluespine unicornfish (*Naso unicornis*) - the most commercially-valuable reef-associated species in the insular Indo-Pacific - to explore the magnitude and drivers of variation in life span and examine the mechanism s enabling peculiar mortality schedules. Longevity and mortality schedules were investigated across eleven locations encompassing a range of latitudes and exploitation levels. The presence of different growth types was examined using back-calculated growth histories from otoliths. Growth-type dependent mortality (mortality rates associated with particular growth trajectories) was corroborated using population models that incorporated size-dependent competition. We found a threefold geographic variation in life span that was strongly linked to temperature, but not to anthropogenic pressure or ocean productivity. All populations consistently displayed a two - phase mortality schedule, with higher than expected natural mortality rates in earlier stages of post-settlement life. Reconstructed growth histories and population models demonstrated that variable growth types within populations can yield this peculiar biphasic mortality schedule, where fast growers enjoy early reproductive outputs at the expense of greater mortality, and benefit s for slow growers derive from extended reproductive outputs over a greater number of annual cycles. This promotes population resilience because individuals can take advantage of cycles of environmental change operating at both short and long-term scales. Our results highlight a prevailing, fundamental misperception when comparing the life histories of long - lived tropical ectotherms: the seemingly incongruent combination of extended life spans with high mortality rates was enabled by coexistence of variable growth types in a population. Thus a demographic profile incorporating contrasting growth and mortality strategies obscures the demographic effects of harvest across space or time in *N. unicornis* and possibly other ectotherms with the combination of longevity and asymptotic growth.

Venegas, R.M., Oliver, T., Liu, G., Heron, S.F., Clark, J., Pomeroy, N., Young, C., Eakin, M., and R.E. Brainard, 2019. The Rarity of Depth Refugia from Coral Bleaching Heat Stress in the Western and Central Pacific Islands. *Scientific Reports*, *9*, 19710.

Some researchers have suggested that corals living in deeper reefs may escape heat stress experienced by shallow corals. We evaluated the potential of deep coral reef refugia from bleaching stress by leveraging a long record of satellite-derived sea surface temperature data with a temporal, spatial, and depth precision of *in situ* temperature records. We calculated an *in situ* stress metric using a depth bias-adjusted threshold for 457 coral reef sites among 49 islands in the western and central Pacific Ocean over the period 2001–2017. Analysis of 1,453 heating events found no meaningful depth refuge from heat stress down to 38 m, and no significant association between depth and subsurface heat stress. Further, the surface metric underestimated subsurface stress by an average of 39.3%, across all depths. Combining satellite and *in situ* temperature data can provide bleaching-relevant heat stress results to avoid misrepresentation of heat stress exposure at shallow reefs.

Weijerman, M., Grüss, A., Dove, D., Asher, J., Williams, I.D., Kelley, C., and J.T.C. Drazen, 2019. Shining a light on the composition and distribution patterns of mesophotic and subphotic fish communities in Hawai‘i. *Marine Ecology Progress Series*, *630*, pp. 161-182.

As agencies shift from single-species management to ecosystem-based fisheries management, ecosystem models are gaining interest for understanding species dynamics in relation to oceanographic and ecological processes and human marine uses. However, information on community structure or distribution of many species that occupy deep (>30 m) waters is largely unavailable. We amassed a total of 24686 fish observations of 523 species/taxa for the 30-410 m depth areas surrounding the main Hawaiian Islands (MHI). We also obtained estimates of geomorphological variables, including substrate type, slope, rugosity, and ridge-like features. Using these 2 data sources, we (1) identified distinct fish communities along the 30-410 m depth gradient, and (2) generated relative biomass maps for fish functional groups. We showed that the mesophotic zone ranges between 30 and 129 m, with a fish faunal break at 60 m. Beyond this zone, 4 subphotic zones were identified: upper rariphotic (130-169 m), mid-rariphotic (170-239 m), lower rariphotic (240-319 m), and upper bathyal (320-410 m). We assigned fish species to functional groups partly based on identified depth ranges and fitted general additive models (GAMs) integrating geomorphological covariates to the functional group relative biomass estimates to determine the environmental variables that best predict the probability of encounter and relative biomass of each fish functional group. Finally, GAM predictions were employed to map functional group relative biomass distributions. These distribution maps showed a high relative biomass of many groups in the center of the MHI chain. This study contributes to a better understanding of fish community structure around the MHI and will inform ecosystem model parameterization.

Williams, I.D., Kindinger, T.L., Couch, C.S., Walsh, W.J., Dwayne, M., and T.A. Oliver, 2019. Can Herbivore Management Increase the Persistence of Indo-Pacific Coral Reefs? *Frontiers in Marine Science*, *6*, p. 557.

Due to climate change, coral reefs have experienced mass bleaching, and mortality events in recent years. Although coral reefs are unlikely to persist in their current form unless climate change can be addressed, local management can have a role to play by extending the time frame over which there are functional reef systems capable of recovery. Here we consider the potential application of one form of local management – management of herbivorous fishes. The premise behind this approach is that increased herbivory could shift reef algal assemblages to states that are benign or beneficial for corals, thereby increasing corals' ability to recover from destructive events such as bleaching and to thrive in periods between events. With a focus on Indo-Pacific coral reefs, we review what is known about the underlying processes of herbivory and coral-algal competition that ultimately affect the ability of corals to grow, persist, and replenish themselves. We then critically assess evidence of effectiveness or otherwise of herbivore management within marine protected areas (MPAs) to better understand why many MPAs have not improved outcomes for corals, and more importantly to identify the circumstances in which that form of management would be most likely to be effective. Herbivore management is not a panacea, but has the potential to enhance coral reef persistence in the right circumstances. Those include that: (i) absent management, there is an "algal problem" – i.e., insufficient herbivory to maintain algae in states that are benign or beneficial for corals; and (ii) management actions are able to increase net herbivory. As increased corallivory is a potentially widespread negative consequence of management, we consider some of the circumstances in which that is most likely to be a problem as well as potential solutions. Because the negative effects of certain algae are greatest for coral settlement and early survivorship, it may be that maintaining sufficient herbivory is particularly important in promoting recovery from destructive events such as mass bleaching. Thus, herbivore management can have a role to play as part of a wider strategy to manage and reduce the threats that currently imperil coral reefs.

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APPENDIX A: LIST OF SPECIES

HAWAII MANAGEMENT UNIT SPECIES

1. MHI Deep 7 Bottomfish Multi-Species Stock Complex (FSSI)

HDAR Species Code	Species Name	Scientific Name
19	pink snapper (opakapaka)	*Pristipomoides filamentosus*
22	longtail snapper (onaga)	*Etelis coruscans*
21	squirrelfish snapper (ehu)	*Etelis carbunculus*
15	sea bass (hapuupuu)	*Epinephelus quernus*
97	snapper (gindai)	*Pristipomoides zonatus*
17	pink snapper (kalekale)	*Pristipomoides seiboldii*
58	silver jaw jobfish (lehi)	*Aphareus rutilans*

2. MHI Non-Deep 7 Bottomfish Multi-Species Stock Complex (non-FSSI)

HDAR Species Code	Species Name	Scientific Name
20	gray jobfish (uku)	*Aprion virescens*

3. Seamount groundfish Complex (non-FSSI)

HDAR Species Code	Species Name	Scientific Name
140	Armorhead	*Pentaceros wheeleri*
141	Alfonsin	*Beryx splendens*
None	Ratfish/butterfish	*Hyperoglyphe japonica*

4. Crustacean deep-water shrimp Complex (non-FSSI)

HDAR Species Code	Species Name	Scientific Name
708	deepwater shrimp	*Heterocarpus* spp.

709	deepwater shrimp (ensifer)	*Heterocarpus* spp.

5. Crustacean Kona crab Complex (non-FSSI)

HDAR Species Code	**Species Name**	**Scientific Name**
701	Kona crab	*Ranina*

6. Auau Channel Black coral Complex (non-FSSI)

HDAR Species Code	**Species Name**	**Scientific Name**
860	Black Coral	*Antipathes griggi*
860	Black Coral	*Antipathes grandis*
860	Black Coral	*Myriopathes ulex*

7. Precious corals on identified and exploratory beds (non-FSSI)

HDAR Species Code	**Species Name**	**Scientific Name**
871	Pink coral	*Pleurocorallium secundum*
873	Red coral	*Hemicorallium laauense*
881	Gold Coral	*Kulamanamana haumeaae* (prev. *Gerardia* spp.)
892	Bamboo coral	*Acanella* spp.

MONITORED ECOSYSTEM COMPONENT SPECIES

1. Species Selected for Monitoring by DLNR-DAR

HDAR Species Code	**Species Name**	**Scientific Name**
18	bluefin trevally (omilu)	*Caranx melampygus*
47	whitemargin unicornfish (kala)	*Naso annulatus*
52	whitesaddle goatfish (kumu)	*Parupeneus porphyus*
64	convict tang (manini)	*Acanthurus triostegus*

HDAR Species Code	Species Name	Scientific Name
74	brown chub (nenue)	*Kyphosus bigibbus*
87/88/96	parrotfish (uhu)	Scaridae
114	bluestripe snapper (taape)	*Lutjanus kasmira*
716/717/718	lobster	Miscellaneous
724	limpets (opihi)	*Cellana* spp.
726	day octopus (day tako)	*Octopus cyanea*

2. Species Monitored by Tropic, Taxonomic, and Functional Groups

The species presented in Section 2.1 are displayed according to both trophic level and functional group as an effort to foster continued monitoring of ecosystem component species that are no longer categorized as management unit species. These species are monitored according to their ecosystem function as opposed to individually. Monitoring based on these factors allows for a broader outlook on the ecological composition of fish communities in areas of the Western Pacific. For trophic groupings, "H" stands for "Herbivore", "Cor" stands for "Corallivore", "PK" stands for "Planktivore", "MI" stands for "Mobile Invertebrate Feeder", "SI" stands for "Sessile-Invertebrate Feeder, "Om" stands for "Omnivore", and "Pisc" stands for "Piscovore".

Family	Scientific Name	Trophic Group	Functional Group
Acanthuridae	*Naso lituratus*	H	Browsing Surgeons
Acanthuridae	*Naso tonganus*	H	Browsing Surgeons
Acanthuridae	*Naso unicornis*	H	Browsing Surgeons
Acanthuridae	*Naso brachycentron*	H	Browsing Surgeons
Acanthuridae	*Ctenochaetus cyanocheilus*	H	Mid-Large Target Surgeons
Acanthuridae	*Ctenochaetus strigosus*	H	Mid-Large Target Surgeons
Acanthuridae	*Acanthurus nigroris*	H	Mid-Large Target Surgeons
Acanthuridae	*Ctenochaetus hawaiiensis*	H	Mid-Large Target Surgeons
Acanthuridae	*Ctenochaetus striatus*	H	Mid-Large Target Surgeons
Acanthuridae	*Ctenochaetus marginatus*	H	Mid-Large Target Surgeons
Acanthuridae	*Acanthurus lineatus*	H	Mid-Large Target Surgeons
Acanthuridae	*Acanthurus blochii*	H	Mid-Large Target Surgeons
Acanthuridae	*Acanthurus dussumieri*	H	Mid-Large Target Surgeons
Acanthuridae	*Acanthurus xanthopterus*	H	Mid-Large Target Surgeons
Chaetodontidae	*Chaetodon flavocoronatus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon multicinctus*	Cor	Non-PK Butterflyfish

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Chaetodontidae	*Chaetodon punctatofasciatus*	MI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon mertensii*	H	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon citrinellus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon pelewensis*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon lunulatus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon melannotus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon rafflesii*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon ulietensis*	MI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon fremblii*	SI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon quadrimaculatus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon meyeri*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon reticulatus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon trifascialis*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Heniochus chrysostomus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon bennetti*	MI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon tinkeri*	SI	Non-PK Butterflyfish
Chaetodontidae	*Heniochus varius*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon ornatissimus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon unimaculatus*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon lunula*	SI	Non-PK Butterflyfish
Chaetodontidae	*Forcipiger longirostris*	MI	Non-PK Butterflyfish
Chaetodontidae	*Forcipiger flavissimus*	SI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon ephippium*	MI	Non-PK Butterflyfish
Chaetodontidae	*Heniochus monoceros*	MI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon auriga*	SI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon vagabundus*	SI	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon semeion*	H	Non-PK Butterflyfish
Chaetodontidae	*Chaetodontidae*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Heniochus singularius*	Cor	Non-PK Butterflyfish
Chaetodontidae	*Chaetodon lineolatus*	SI	Non-PK Butterflyfish
Caracanthidae	*Caracanthus typicus*	MI	No Group
Gobiidae	*Eviota* sp.	MI	No Group
Pomacentridae	*Chrysiptera traceyi*	H	No Group
Apogonidae	*Ostorhinchus luteus*	Pk	No Group
Caracanthidae	*Caracanthus maculatus*	MI	No Group
Pseudochromidae	*Pseudochromis jamesi*	MI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Pomacentridae	*Chromis acares*	Pk	No Group
Serranidae	*Luzonichthys whitleyi*	Pk	No Group
Pomacentridae	*Pomachromis guamensis*	Pk	No Group
Pomacentridae	*Pomachromis richardsoni*	Pk	No Group
Gobiidae	*Fusigobius duospilus*	MI	No Group
Pomacentridae	*Plectroglyphidodon imparipennis*	MI	No Group
Microdesmidae	*Nemateleotris helfrichi*	Pk	No Group
Pomacentridae	*Chromis leucura*	Pk	No Group
Syngnathidae	*Doryrhamphus excisus*	Pk	No Group
Pomacentridae	*Pomacentrus coelestis*	Pk	No Group
Clupeidae	*Spratelloides delicatulus*	Pk	No Group
Pomacentridae	*Chrysiptera biocellata*	H	No Group
Pseudochromidae	*Pictichromis porphyreus*	MI	No Group
Pomacanthidae	*Centropyge fisheri*	H	No Group
Cirrhitidae	*Cirrhitops hubbardi*	MI	No Group
Gobiidae	*Amblyeleotris fasciata*	Pk	No Group
Pomacentridae	*Chromis lepidolepis*	Pk	No Group
Pomacentridae	*Chromis margaritifer*	Pk	No Group
Pomacentridae	*Chromis ternatensis*	Pk	No Group
Pomacentridae	*Chromis viridis*	Pk	No Group
Pomacentridae	*Chrysiptera cyanea*	Pk	No Group
Pomacentridae	*Dascyllus aruanus*	Pk	No Group
Pomacentridae	*Dascyllus reticulatus*	Pk	No Group
Engraulidae	*Encrasicholina purpurea*	Pk	No Group
Pomacentridae	*Neopomacentrus metallicus*	Pk	No Group
Pomacentridae	*Chromis amboinensis*	H	No Group
Pomacentridae	*Chromis iomelas*	H	No Group
Pomacentridae	*Chrysiptera glauca*	H	No Group
Pomacentridae	*Chrysiptera taupou*	H	No Group
Labridae	*Labroides pectoralis*	MI	No Group
Labridae	*Pseudocheilinus hexataenia*	MI	No Group
Labridae	*Pseudocheilinus tetrataenia*	MI	No Group
Scorpaenidae	*Sebastapistes cyanostigma*	MI	No Group
Labridae	*Wetmorella nigropinnata*	MI	No Group
Pseudochromidae	*Pseudochromis* sp.	MI	No Group
Monacanthidae	*Pervagor marginalis*	Om	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Pomacentridae	*Chromis alpha*	Pk	No Group
Pomacentridae	*Plectroglyphidodon phoenixensis*	H	No Group
Gobiidae	*Amblyeleotris guttata*	Pk	No Group
Atherinidae	*Atherinomorus insularum*	Pk	No Group
Pomacentridae	*Chromis caudalis*	Pk	No Group
Pomacentridae	*Chromis hanui*	Pk	No Group
Labridae	*Cirrhilabrus katherinae*	Pk	No Group
Microdesmidae	*Nemateleotris magnifica*	Pk	No Group
Apogonidae	*Ostorhinchus angustatus*	Pk	No Group
Serranidae	*Pseudanthias bartlettorum*	Pk	No Group
Tetraodontidae	*Canthigaster jactator*	H	No Group
Tetraodontidae	*Canthigaster janthinoptera*	H	No Group
Tetraodontidae	*Canthigaster valentini*	H	No Group
Pomacanthidae	*Centropyge shepardi*	H	No Group
Pomacentridae	*Chrysiptera brownriggii*	H	No Group
Monacanthidae	*Oxymonacanthus longirostris*	Cor	No Group
Cirrhitidae	*Amblycirrhitus bimacula*	MI	No Group
Cirrhitidae	*Cirrhitichthys falco*	MI	No Group
Labridae	*Labroides rubrolabiatus*	MI	No Group
Cirrhitidae	*Neocirrhites armatus*	MI	No Group
Labridae	*Pseudojuloides splendens*	MI	No Group
Apogonidae	*Ostorhinchus novemfasciatus*	Pk	No Group
Labridae	*Pteragogus cryptus*	MI	No Group
Scorpaenidae	*Sebastapistes* sp.	Pisc	No Group
Scorpaenidae	*Taenianotus triacanthus*	Pisc	No Group
Pomacentridae	*Amphiprion perideraion*	Pk	No Group
Pomacentridae	*Chromis fumea*	Pk	No Group
Labridae	*Cirrhilabrus jordani*	Pk	No Group
Blenniidae	*Ecsenius bicolor*	Pk	No Group
Blenniidae	*Ecsenius midas*	Pk	No Group
Blenniidae	*Ecsenius opsifrontalis*	Pk	No Group
Pomacentridae	*Lepidozygus tapeinosoma*	Pk	No Group
Blenniidae	*Meiacanthus atrodorsalis*	Pk	No Group
Apogonidae	*Ostorhinchus apogonoides*	Pk	No Group

Family	Scientific Name	Trophic Group	Functional Group
Pomacentridae	*Plectroglyphidodon lacrymatus*	Pk	No Group
Pomacentridae	*Pomacentrus brachialis*	Pk	No Group
Pomacentridae	*Pomacentrus nigriradiatus*	Pk	No Group
Pomacentridae	*Pomacentrus philippinus*	Pk	No Group
Pomacentridae	*Pomacentrus vaiuli*	Pk	No Group
Serranidae	*Pseudanthias dispar*	Pk	No Group
Serranidae	*Pseudanthias hawaiiensis*	Pk	No Group
Tetraodontidae	*Canthigaster bennetti*	H	No Group
Pomacanthidae	*Centropyge bispinosa*	H	No Group
Pomacanthidae	*Centropyge heraldi*	H	No Group
Pomacanthidae	*Centropyge loricula*	H	No Group
Blenniidae	*Cirripectes obscurus*	H	No Group
Blenniidae	*Cirripectes polyzona*	H	No Group
Blenniidae	*Cirripectes* sp.	H	No Group
Blenniidae	*Cirripectes springeri*	H	No Group
Blenniidae	*Cirripectes stigmaticus*	H	No Group
Blenniidae	*Cirripectes variolosus*	H	No Group
Callionymidae	*Callionymidae*	MI	No Group
Labridae	*Labroides phthirophagus*	MI	No Group
Pomacanthidae	*Paracentropyge multifasciata*	MI	No Group
Blenniidae	*Plagiotremus ewaensis*	MI	No Group
Blenniidae	*Plagiotremus goslinei*	MI	No Group
Scorpaenidae	*Sebastapistes coniorta*	MI	No Group
Monacanthidae	*Pervagor melanocephalus*	Om	No Group
Blenniidae	*Plagiotremus laudandus*	Par	No Group
Blenniidae	*Plagiotremus rhinorhynchos*	Par	No Group
Blenniidae	*Plagiotremus tapeinosoma*	Par	No Group
Labridae	*Pseudocheilinus ocellatus*	MI	No Group
Pomacanthidae	*Centropyge flavissima* & *vroliki*	H	No Group
Pomacentridae	*Amblyglyphidodon curacao*	Om	No Group
Pomacentridae	*Amphiprion melanopus*	Pk	No Group
Pomacentridae	*Chromis agilis*	Pk	No Group
Gobiidae	*Istigobius* sp.	Pk	No Group
Pomacentridae	*Pomacentrus pavo*	Pk	No Group

Family	Scientific Name	Trophic Group	Functional Group
Apogonidae	*Pristiapogon fraenatus*	Pk	No Group
Tetraodontidae	*Canthigaster epilampra*	H	No Group
Tetraodontidae	*Canthigaster solandri*	H	No Group
Blenniidae	*Cirripectes vanderbilti*	H	No Group
Pomacentridae	*Stegastes albifasciatus*	H	No Group
Pomacentridae	*Stegastes aureus*	H	No Group
Pomacentridae	*Stegastes marginatus*	H	No Group
Pomacentridae	*Plectroglyphidodon dickii*	Cor	No Group
Cirrhitidae	*Paracirrhites xanthus*	MI	No Group
Monacanthidae	*Paraluteres prionurus*	MI	No Group
Microdesmidae	*Microdesmidae*	Pk	No Group
Scorpaenidae	*Sebastapistes ballieui*	MI	No Group
Apogonidae	*Apogon kallopterus*	Pk	No Group
Pomacentridae	*Chromis weberi*	Pk	No Group
Labridae	*Cirrhilabrus exquisitus*	Pk	No Group
Syngnathidae	*Corythoichthys flavofasciatus*	Pk	No Group
Pomacentridae	*Dascyllus albisella*	Pk	No Group
Microdesmidae	*Gunnellichthys curiosus*	Pk	No Group
Apogonidae	*Pristiapogon kallopterus*	Pk	No Group
Serranidae	*Pseudanthias olivaceus*	Pk	No Group
Ptereleotridae	*Ptereleotris heteroptera*	Pk	No Group
Ptereleotridae	*Ptereleotris zebra*	Pk	No Group
Pomacanthidae	*Centropyge vrolikii*	H	No Group
Pomacentridae	*Plectroglyphidodon leucozonus*	H	No Group
Pomacentridae	*Plectroglyphidodon johnstonianus*	Cor	No Group
Labridae	*Anampses melanurus*	MI	No Group
Apogonidae	*Cheilodipterus quinquelineatus*	MI	No Group
Cirrhitidae	*Cirrhitichthys oxycephalus*	MI	No Group
Cirrhitidae	*Cirrhitops fasciatus*	MI	No Group
Labridae	*Halichoeres biocellatus*	MI	No Group
Labridae	*Labroides dimidiatus*	MI	No Group
Labridae	*Labropsis micronesica*	MI	No Group
Labridae	*Macropharyngodon negrosensis*	MI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Labridae	*Pseudojuloides cerasinus*	MI	No Group
Labridae	*Pseudojuloides polynesica*	MI	No Group
Blenniidae	*Aspidontus taeniatus*	Par	No Group
Tetraodontidae	*Torquigener randalli*	MI	No Group
Pomacentridae	*Plectroglyphidodon sindonis*	H	No Group
Pomacanthidae	*Centropyge potteri*	H	No Group
Cirrhitidae	*Oxycirrhites typus*	Pk	No Group
Serranidae	*Pseudanthias bicolor*	Pk	No Group
Ptereleotridae	*Ptereleotris microlepis*	Pk	No Group
Pomacentridae	*Stegastes lividus*	H	No Group
Labridae	*Cirrhilabrus punctatus*	MI	No Group
Labridae	*Halichoeres margaritaceus*	MI	No Group
Labridae	*Pseudojuloides atavai*	MI	No Group
Holocentridae	*Sargocentron punctatissimum*	MI	No Group
Monacanthidae	*Pervagor janthinosoma*	Om	No Group
Pomacentridae	*Amphiprion clarkii*	Pk	No Group
Serranidae	*Anthias* sp.	Pk	No Group
Blenniidae	*Blenniella chrysospilos*	Pk	No Group
Chaetodontidae	*Chaetodon kleinii*	Pk	No Group
Pomacentridae	*Dascyllus trimaculatus*	Pk	No Group
Apogonidae	*Ostorhinchus maculiferus*	Pk	No Group
Serranidae	*Pseudanthias cooperi*	Pk	No Group
Gobiidae	*Amblygobius phalaena*	H	No Group
Tetraodontidae	*Canthigaster amboinensis*	H	No Group
Tetraodontidae	*Canthigaster coronata*	H	No Group
Pomacanthidae	*Centropyge flavissima*	H	No Group
Pomacentridae	*Stegastes nigricans*	H	No Group
Labridae	*Halichoeres melanurus*	MI	No Group
Labridae	*Halichoeres melasmapomus*	MI	No Group
Labridae	*Labroides bicolor*	MI	No Group
Labridae	*Labropsis xanthonota*	MI	No Group
Cirrhitidae	*Paracirrhites arcatus*	MI	No Group
Labridae	*Pseudocheilinus evanidus*	MI	No Group
Labridae	*Pseudocheilinus octotaenia*	MI	No Group
Monacanthidae	*Pervagor aspricaudus*	Om	No Group
Ostraciidae	*Lactoria fornasini*	SI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Labridae	*Pseudojuloides* sp.	MI	No Group
Pomacentridae	*Abudefduf sexfasciatus*	Pk	No Group
Pomacentridae	*Chromis vanderbilti*	Pk	No Group
Pomacentridae	*Chromis xanthura*	Pk	No Group
Labridae	*Cirrhilabrus* sp.	Pk	No Group
Pomacanthidae	*Genicanthus watanabei*	Pk	No Group
Labridae	*Thalassoma amblycephalum*	Pk	No Group
Pomacanthidae	*Centropyge bicolor*	H	No Group
Serranidae	*Belonoperca chabanaudi*	MI	No Group
Labridae	*Coris centralis*	MI	No Group
Labridae	*Halichoeres ornatissimus*	MI	No Group
Malacanthidae	*Hoplolatilus starcki*	MI	No Group
Labridae	*Macropharyngodon meleagris*	MI	No Group
Labridae	*Oxycheilinus bimaculatus*	MI	No Group
Labridae	*Pteragogus enneacanthus*	MI	No Group
Labridae	*Stethojulis balteata*	MI	No Group
Labridae	*Stethojulis strigiventer*	MI	No Group
Labridae	*Stethojulis trilineata*	MI	No Group
Pomacentridae	*Stegastes* sp.	H	No Group
Apogonidae	*Apogon* sp.	Pk	No Group
Apogonidae	*Apogonidae*	Pk	No Group
Chaetodontidae	*Chaetodon miliaris*	Pk	No Group
Pomacentridae	*Dascyllus auripinnis*	Pk	No Group
Labridae	*Pseudocoris yamashiroi*	Pk	No Group
Labridae	*Stethojulis bandanensis*	Pk	No Group
Monacanthidae	*Cantherhines verecundus*	H	No Group
Pomacanthidae	*Centropyge interrupta*	H	No Group
Pomacentridae	*Stegastes fasciolatus*	H	No Group
Blenniidae	*Exallias brevis*	Cor	No Group
Labridae	*Labrichthys unilineatus*	Cor	No Group
Labridae	*Halichoeres prosopeion*	MI	No Group
Labridae	*Macropharyngodon geoffroy*	MI	No Group
Gobiidae	*Valenciennea strigata*	MI	No Group
Ostraciidae	*Ostracion whitleyi*	SI	No Group
Scorpaenidae	*Dendrochirus barberi*	MI	No Group
Blenniidae	*Blenniidae*	Pk	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Synodontidae	*Synodus binotatus*	Pisc	No Group
Pomacentridae	*Amphiprion chrysopterus*	Pk	No Group
Serranidae	*Pseudanthias pascalus*	Pk	No Group
Acanthuridae	*Ctenochaetus flavicauda*	H	No Group
Labridae	*Cheilinus oxycephalus*	MI	No Group
Holocentridae	*Sargocentron diadema*	MI	No Group
Holocentridae	*Sargocentron xantherythrum*	MI	No Group
Labridae	*Thalassoma quinquevittatum*	MI	No Group
Labridae	*Iniistius umbrilatus*	MI	No Group
Labridae	*Thalassoma* sp.	MI	No Group
Pomacentridae	*Pomacentridae*	Om	No Group
Pomacentridae	*Abudefduf notatus*	Pk	No Group
Chaetodontidae	*Hemitaurichthys polylepis*	Pk	No Group
Ptereleotridae	*Ptereleotris evides*	Pk	No Group
Labridae	*Anampses twistii*	MI	No Group
Apogonidae	*Cheilodipterus* sp.	MI	No Group
Labridae	*Cymolutes lecluse*	MI	No Group
Labridae	*Halichoeres hartzfeldii*	MI	No Group
Labridae	*Halichoeres marginatus*	MI	No Group
Pinguipedidae	*Parapercis clathrata*	MI	No Group
Pinguipedidae	*Parapercis schauinslandii*	MI	No Group
Labridae	*Choerodon jordani*	Om	No Group
Monacanthidae	*Pervagor* sp.	Om	No Group
Monacanthidae	*Pervagor spilosoma*	Om	No Group
Pomacanthidae	*Apolemichthys arcuatus*	SI	No Group
Holocentridae	*Neoniphon argenteus*	MI	No Group
Apogonidae	*Cheilodipterus artus*	MI	No Group
Pomacentridae	*Chromis ovalis*	Pk	No Group
Labridae	*Bodianus mesothorax*	MI	No Group
Pinguipedidae	*Parapercis millepunctata*	MI	No Group
Labridae	*Halichoeres* sp.	MI	No Group
Serranidae	*Cephalopholis leopardus*	Pisc	No Group
Apogonidae	*Cheilodipterus macrodon*	Pisc	No Group
Pomacentridae	*Abudefduf vaigiensis*	Pk	No Group
Chaetodontidae	*Heniochus diphreutes*	Pk	No Group
Holocentridae	*Myripristis vittata*	Pk	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Caesionidae	*Pterocaesio trilineata*	Pk	No Group
Labridae	*Thalassoma hardwicke*	Pk	No Group
Monacanthidae	*Cantherhines sandwichiensis*	H	No Group
Tetraodontidae	*Canthigaster rivulata*	H	No Group
Acanthuridae	*Zebrasoma flavescens*	H	No Group
Acanthuridae	*Zebrasoma scopas*	H	No Group
Monacanthidae	*Amanses scopas*	Cor	No Group
Labridae	*Anampses chrysocephalus*	MI	No Group
Labridae	*Anampses* sp.	MI	No Group
Labridae	*Bodianus axillaris*	MI	No Group
Labridae	*Bodianus prognathus*	MI	No Group
Labridae	*Coris dorsomacula*	MI	No Group
Labridae	*Coris venusta*	MI	No Group
Labridae	*Cymolutes praetextatus*	MI	No Group
Labridae	*Pseudocoris aurantiofasciata*	MI	No Group
Labridae	*Pseudocoris heteroptera*	MI	No Group
Scorpaenidae	*Pterois antennata*	MI	No Group
Holocentridae	*Sargocentron microstoma*	MI	No Group
Labridae	*Thalassoma jansenii*	MI	No Group
Nemipteridae	*Scolopsis lineata*	Om	No Group
Zanclidae	*Zanclus cornutus*	SI	No Group
Labridae	*Bodianus anthioides*	Pk	No Group
Chaetodontidae	*Hemitaurichthys thompsoni*	Pk	No Group
Acanthuridae	*Zebrasoma rostratum*	H	No Group
Kuhliidae	*Kuhlia sandvicensis*	Pk	No Group
Scorpaenidae	*Pterois sphex*	Pisc	No Group
Synodontidae	*Synodontidae*	Pisc	No Group
Pomacentridae	*Chromis verater*	Pk	No Group
Pempheridae	*Pempheridae*	Pk	No Group
Serranidae	*Pseudanthias thompsoni*	Pk	No Group
Balistidae	*Xanthichthys auromarginatus*	Pk	No Group
Acanthuridae	*Ctenochaetus binotatus*	H	No Group
Labridae	*Anampses meleagrides*	MI	No Group
Labridae	*Iniistius aneitensis*	MI	No Group
Mullidae	*Parupeneus chrysonemus*	MI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Balistidae	*Sufflamen chrysopterum*	MI	No Group
Cirrhitidae	*Paracirrhites forsteri*	Pisc	No Group
Synodontidae	*Saurida gracilis*	Pisc	No Group
Holocentridae	*Myripristis kuntee*	Pk	No Group
Pempheridae	*Pempheris oualensis*	Pk	No Group
Pomacentridae	*Abudefduf septemfasciatus*	H	No Group
Acanthuridae	*Acanthurus nigricans*	H	No Group
Acanthuridae	*Acanthurus nigrofuscus*	H	No Group
Holocentridae	*Neoniphon aurolineatus*	MI	No Group
Pinguipedidae	*Parapercis* sp.	MI	No Group
Labridae	*Bodianus sanguineus*	Om	No Group
Synodontidae	*Synodus dermatogenys*	Pisc	No Group
Synodontidae	*Synodus variegatus*	Pisc	No Group
Pomacentridae	*Abudefduf sordidus*	H	No Group
Holocentridae	*Myripristis earlei*	MI	No Group
Pomacentridae	*Abudefduf abdominalis*	Pk	No Group
Pomacanthidae	*Genicanthus personatus*	Pk	No Group
Chaetodontidae	*Heniochus acuminatus*	Pk	No Group
Holocentridae	*Myripristis chryseres*	Pk	No Group
Holocentridae	*Myripristis woodsi*	Pk	No Group
Labridae	*Thalassoma lunare*	Pk	No Group
Acanthuridae	*Acanthurus achilles*	H	No Group
Acanthuridae	*Acanthurus achilles* & *nigricans*	H	No Group
Acanthuridae	*Acanthurus leucopareius*	H	No Group
Acanthuridae	*Acanthurus pyroferus*	H	No Group
Monacanthidae	*Cantherhines pardalis*	H	No Group
Labridae	*Bodianus diana*	MI	No Group
Balistidae	*Rhinecanthus rectangulus*	MI	No Group
Holocentridae	*Sargocentron caudimaculatum*	MI	No Group
Holocentridae	*Sargocentron ensifer*	MI	No Group
Labridae	*Thalassoma duperrey* & *quinquevittatum*	MI	No Group
Labridae	*Thalassoma lutescens*	MI	No Group
Pomacanthidae	*Apolemichthys griffisi*	SI	No Group
Pomacanthidae	*Apolemichthys trimaculatus*	SI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Pomacanthidae	*Apolemichthys xanthopunctatus*	SI	No Group
Pomacanthidae	*Pygoplites diacanthus*	SI	No Group
Serranidae	*Epinephelus hexagonatus*	Pisc	No Group
Acanthuridae	*Acanthurus nubilus*	Pk	No Group
Muraenidae	*Gymnothorax melatremus*	MI	No Group
Labridae	*Pseudodax moluccanus*	MI	No Group
Labridae	*Thalassoma duperrey*	MI	No Group
Acanthuridae	*Acanthurus triostegus*	H	No Group
Serranidae	*Grammistes sexlineatus*	MI	No Group
Labridae	*Halichoeres hortulanus*	MI	No Group
Labridae	*Halichoeres trimaculatus*	MI	No Group
Serranidae	*Cephalopholis urodeta*	Pisc	No Group
Cirrhitidae	*Paracirrhites hemistictus*	Pisc	No Group
Acanthuridae	*Acanthurus thompsoni*	Pk	No Group
Siganidae	*Siganus spinus*	H	No Group
Balistidae	*Rhinecanthus lunula*	MI	No Group
Balistidae	*Sufflamen bursa*	MI	No Group
Ostraciidae	*Ostracion meleagris*	SI	No Group
Acanthuridae	*Acanthurus guttatus*	H	No Group
Cirrhitidae	*Cirrhitidae*	MI	No Group
Serranidae	*Cephalopholis spiloparaea*	Pisc	No Group
Labridae	*Oxycheilinus digramma*	Pisc	No Group
Scorpaenidae	*Scorpaenopsis diabolus*	Pisc	No Group
Scorpaenidae	*Scorpaenopsis* sp.	Pisc	No Group
Synodontidae	*Synodus ulae*	Pisc	No Group
Caesionidae	*Caesio lunaris*	Pk	No Group
Balistidae	*Canthidermis maculata*	Pk	No Group
Hemiramphidae	*Hyporhamphus acutus*	Pk	No Group
Caesionidae	*Pterocaesio lativittata*	Pk	No Group
Caesionidae	*Pterocaesio tile*	Pk	No Group
Carangidae	*Selar crumenophthalmus*	Pk	No Group
Balistidae	*Xanthichthys mento*	Pk	No Group
Acanthuridae	*Ctenochaetus sp*	H	No Group
Acanthuridae	*Naso thynnoides*	H	No Group
Balistidae	*Balistapus undulatus*	MI	No Group
Cirrhitidae	*Cirrhitus pinnulatus*	MI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Labridae	*Coris ballieui*	MI	No Group
Lethrinidae	*Gnathodentex aureolineatus*	MI	No Group
Malacanthidae	*Malacanthus brevirostris*	MI	No Group
Mullidae	*Mulloidichthys mimicus*	MI	No Group
Holocentridae	*Myripristis violacea*	MI	No Group
Labridae	*Novaculichthys taeniourus*	MI	No Group
Balistidae	*Rhinecanthus aculeatus*	MI	No Group
Synodontidae	*Saurida flamma*	Pisc	No Group
Acanthuridae	*Paracanthurus hepatus*	Pk	No Group
Caesionidae	*Caesionidae*	Pk	No Group
Holocentridae	*Holocentridae*	MI	No Group
Priacanthidae	*Heteropriacanthus carolinus*	Pk	No Group
Holocentridae	*Myripristis adusta*	Pk	No Group
Holocentridae	*Myripristis amaena*	Pk	No Group
Labridae	*Cheilinus chlorourus*	MI	No Group
Labridae	*Gomphosus varius*	MI	No Group
Lethrinidae	*Lethrinus harak*	MI	No Group
Holocentridae	*Neoniphon sammara*	MI	No Group
Serranidae	*Epinephelus melanostigma*	Pisc	No Group
Serranidae	*Epinephelus merra*	Pisc	No Group
Holocentridae	*Myripristis berndti*	Pk	No Group
Priacanthidae	*Priacanthus hamrur*	Pk	No Group
Priacanthidae	*Priacanthus meeki*	Pk	No Group
Acanthuridae	*Acanthurus albipectoralis*	H	No Group
Tetraodontidae	*Arothron nigropunctatus*	Cor	No Group
Mullidae	*Parupeneus insularis*	MI	No Group
Mullidae	*Parupeneus pleurostigma*	MI	No Group
Holocentridae	*Sargocentron tiere*	MI	No Group
Labridae	*Thalassoma trilobatum*	MI	No Group
Mullidae	*Upeneus taeniopterus*	MI	No Group
Balistidae	*Melichthys vidua*	H	No Group
Serranidae	*Epinephelus spilotoceps*	Pisc	No Group
Lutjanidae	*Lutjanus semicinctus*	Pisc	No Group
Serranidae	*Pogonoperca punctata*	Pisc	No Group
Caesionidae	*Caesio caerulaurea*	Pk	No Group
Carangidae	*Decapterus macarellus*	Pk	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Holocentridae	*Myripristinae*	Pk	No Group
Caesionidae	*Pterocaesio marri*	Pk	No Group
Balistidae	*Xanthichthys caeruleolineatus*	Pk	No Group
Labridae	*Iniistius pavo*	MI	No Group
Holocentridae	*Neoniphon opercularis*	MI	No Group
Holocentridae	*Neoniphon* sp.	MI	No Group
Mullidae	*Parupeneus crassilabris*	MI	No Group
Labridae	*Anampses cuvier*	MI	No Group
Labridae	*Cheilinus fasciatus*	MI	No Group
Siganidae	*Siganus punctatus*	H	No Group
Gobiidae	*Gobiidae*	MI	No Group
Scorpaenidae	*Pterois volitans*	Pisc	No Group
Balistidae	*Melichthys niger*	Pk	No Group
Priacanthidae	*Priacanthus* sp.	Pk	No Group
Monacanthidae	*Monacanthidae*	H	No Group
Siganidae	*Siganidae*	H	No Group
Diodontidae	*Diodon holocanthus*	MI	No Group
Mullidae	*Mulloidichthys vanicolensis*	MI	No Group
Mullidae	*Parupeneus multifasciatus*	MI	No Group
Balistidae	*Sufflamen fraenatum*	MI	No Group
Monacanthidae	*Cantherhines dumerilii*	Om	No Group
Pomacanthidae	*Pomacanthus imperator*	SI	No Group
Lethrinidae	*Lethrinus rubrioperculatus*	MI	No Group
Caesionidae	*Caesio teres*	Pk	No Group
Balistidae	*Odonus niger*	Pk	No Group
Acanthuridae	*Acanthurus nigricauda*	H	No Group
Acanthuridae	*Acanthurus olivaceus*	H	No Group
Acanthuridae	*Zebrasoma veliferum*	H	No Group
Labridae	*Bodianus loxozonus*	MI	No Group
Labridae	*Coris gaimard*	MI	No Group
Labridae	*Hologymnosus annulatus*	MI	No Group
Labridae	*Hologymnosus doliatus*	MI	No Group
Mullidae	*Mulloidichthys flavolineatus*	MI	No Group
Acanthuridae	*Acanthurus maculiceps*	H	No Group
Kyphosidae	*Kyphosus hawaiiensis*	H	No Group
Cheilodactylidae	*Cheilodactylus vittatus*	SI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Ostraciidae	*Ostraciidae*	SI	No Group
Siganidae	*Siganus argenteus*	H	No Group
Labridae	*Anampses caeruleopunctatus*	MI	No Group
Serranidae	*Epinephelus fasciatus*	Pisc	No Group
Labridae	*Thalassoma ballieui*	MI	No Group
Labridae	*Thalassoma purpureum*	MI	No Group
Serranidae	*Cephalopholis miniata*	Pisc	No Group
Hemiramphidae	*Hemiramphidae*	Pk	No Group
Acanthuridae	*Acanthurus leucocheilus*	H	No Group
Ostraciidae	*Ostracion cubicus*	H	No Group
Bothidae	*Bothus mancus*	MI	No Group
Labridae	*Cheilinus* sp.	MI	No Group
Labridae	*Cheilinus trilobatus*	MI	No Group
Malacanthidae	*Malacanthus latovittatus*	MI	No Group
Labridae	*Oxycheilinus unifasciatus*	Pisc	No Group
Labridae	*Oxycheilinus* sp.	MI	No Group
Serranidae	*Epinephelus retouti*	Pisc	No Group
Mullidae	*Mulloidichthys pfluegeri*	MI	No Group
Serranidae	*Cephalopholis sexmaculata*	Pisc	No Group
Serranidae	*Cephalopholis sonnerati*	Pisc	No Group
Serranidae	*Gracila albomarginata*	Pisc	No Group
Mullidae	*Parupeneus cyclostomus*	Pisc	No Group
Belonidae	*Platybelone argalus*	Pisc	No Group
Acanthuridae	*Acanthurus mata*	Pk	No Group
Tetraodontidae	*Arothron meleagris*	Cor	No Group
Balistidae	*Balistoides conspicillum*	MI	No Group
Labridae	*Hemigymnus fasciatus*	MI	No Group
Lethrinidae	*Lethrinus obsoletus*	MI	No Group
Mullidae	*Mullidae*	MI	No Group
Mullidae	*Parupeneus barberinus*	MI	No Group
Holocentridae	*Sargocentron* sp.	MI	No Group
Ephippidae	*Platax orbicularis*	Om	No Group
Serranidae	*Epinephelus macrospilos*	Pisc	No Group
Scorpaenidae	*Scorpaenopsis cacopsis*	Pisc	No Group
Kyphosidae	*Kyphosus cinerascens*	H	No Group
Labridae	*Cheilio inermis*	MI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Mullidae	*Parupeneus porphyreus*	MI	No Group
Serranidae	*Epinephelus socialis*	Pisc	No Group
Tetraodontidae	*Arothron hispidus*	MI	No Group
Holocentridae	*Sargocentron spiniferum*	MI	No Group
Carangidae	*Trachinotus baillonii*	Pisc	No Group
Labridae	*Epibulus insidiator*	MI	No Group
Serranidae	*Epinephelus howlandi*	Pisc	No Group
Labridae	*Bodianus albotaeniatus*	MI	No Group
Labridae	*Bodianus bilunulatus*	MI	No Group
Acanthuridae	*Acanthurus* sp.	H	No Group
Serranidae	*Aethaloperca rogaa*	Pisc	No Group
Serranidae	*Anyperodon leucogrammicus*	Pisc	No Group
Serranidae	*Cephalopholis argus*	Pisc	No Group
Serranidae	*Cephalopholis* sp.	Pisc	No Group
Serranidae	*Epinephelus maculatus*	Pisc	No Group
Holocentridae	*Myripristis murdjan*	Pk	No Group
Acanthuridae	*Naso brevirostris*	Pk	No Group
Acanthuridae	*Naso maculatus*	Pk	No Group
Acanthuridae	*Naso vlamingii*	Pk	No Group
Kyphosidae	*Kyphosus vaigiensis*	H	No Group
Muraenidae	*Gymnothorax eurostus*	MI	No Group
Labridae	*Hemigymnus melapterus*	MI	No Group
Balistidae	*Pseudobalistes flavimarginatus*	MI	No Group
Lethrinidae	*Lethrinus xanthochilus*	Pisc	No Group
Acanthuridae	*Naso caesius*	Pk	No Group
Lethrinidae	*Monotaxis grandoculis*	MI	No Group
Serranidae	*Variola albimarginata*	Pisc	No Group
Labridae	*Coris flavovittata*	MI	No Group
Tetraodontidae	*Arothron mappa*	Om	No Group
Carangidae	*Carangoides ferdau*	Pisc	No Group
Carangidae	*Carangoides orthogrammus*	Pisc	No Group
Carangidae	*Scomberoides lysan*	Pisc	No Group
Acanthuridae	*Acanthuridae*	H	No Group
Lethrinidae	*Lethrinus amboinensis*	MI	No Group
Lethrinidae	*Lethrinus erythracanthus*	MI	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Ephippidae	*Platax teira*	Om	No Group
Serranidae	*Plectropomus areolatus*	Pisc	No Group
Carangidae	*Gnathanodon speciosus*	Pisc	No Group
Serranidae	*Epinephelus polyphekadion*	Pisc	No Group
Serranidae	*Epinephelus tauvina*	Pisc	No Group
Muraenidae	*Gymnothorax breedeni*	Pisc	No Group
Acanthuridae	*Naso hexacanthus*	Pk	No Group
Acanthuridae	*Naso* sp.	Pk	No Group
Kyphosidae	*Kyphosus sandwicensis*	H	No Group
Kyphosidae	*Kyphosus* sp.	H	No Group
Balistidae	*Balistidae*	MI	No Group
Balistidae	*Balistoides viridescens*	MI	No Group
Muraenidae	*Echidna nebulosa*	MI	No Group
Haemulidae	*Plectorhinchus gibbosus*	MI	No Group
Balistidae	*Balistes polylepis*	MI	No Group
Tetraodontidae	*Tetraodontidae*	MI	No Group
Monacanthidae	*Aluterus scriptus*	Om	No Group
Ophichthidae	*Myrichthys magnificus*	MI	No Group
Aulostomidae	*Aulostomus chinensis*	Pisc	No Group
Muraenidae	*Enchelycore pardalis*	Pisc	No Group
Sphyraenidae	*Sphyraena helleri*	Pisc	No Group
Muraenidae	*Gymnothorax rueppelliae*	MI	No Group
Oplegnathidae	*Oplegnathus fasciatus*	MI	No Group
Serranidae	*Variola louti*	Pisc	No Group
Haemulidae	*Plectorhinchus picus*	MI	No Group
Haemulidae	*Plectorhinchus vittatus*	MI	No Group
Lethrinidae	*Lethrinidae*	MI	No Group
Lethrinidae	*Lethrinus* sp.	MI	No Group
Oplegnathidae	*Oplegnathus punctatus*	MI	No Group
Carangidae	*Caranx papuensis*	Pisc	No Group
Muraenidae	*Gymnothorax steindachneri*	Pisc	No Group
Diodontidae	*Diodon hystrix*	MI	No Group
Labridae	*Labridae*	MI	No Group
Belonidae	*Belonidae*	Pisc	No Group
Carangidae	*Caranx lugubris*	Pisc	No Group
Carangidae	*Caranx sexfasciatus*	Pisc	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Scombridae	*Euthynnus affinis*	Pisc	No Group
Scombridae	*Grammatorcynus bilineatus*	Pisc	No Group
Lethrinidae	*Lethrinus olivaceus*	Pisc	No Group
Acanthuridae	*Naso annulatus*	Pk	No Group
Ophidiidae	*Brotula multibarbata*	MI	No Group
Dasyatidae	*Urogymnus granulatus*	MI	No Group
Scombridae	*Sarda orientalis*	Pisc	No Group
Congridae	*Congridae*	Pisc	No Group
Congridae	*Heterocongrinae*	Pisc	No Group
Scombridae	*Katsuwonus pelamis*	Pisc	No Group
Echeneidae	*Echeneis naucrates*	Pk	No Group
Carangidae	*Trachinotus blochii*	MI	No Group
Carangidae	*Caranx melampygus*	Pisc	No Group
Muraenidae	*Gymnothorax meleagris*	Pisc	No Group
Tetraodontidae	*Arothron stellatus*	Cor	No Group
Labridae	*Coris aygula*	MI	No Group
Carangidae	*Pseudocaranx dentex*	Pisc	No Group
Muraenidae	*Scuticaria tigrina*	Pisc	No Group
Serranidae	*Plectropomus laevis*	Pisc	No Group
Serranidae	*Epinephelus* sp.	Pisc	No Group
Serranidae	*Serranidae*	Pisc	No Group
Belonidae	*Tylosurus crocodilus*	Pisc	No Group
Carangidae	*Alectis ciliaris*	Pisc	No Group
Muraenidae	*Enchelynassa canina*	Pisc	No Group
Muraenidae	*Gymnothorax undulatus*	Pisc	No Group
Muraenidae	*Gymnomuraena zebra*	MI	No Group
Carangidae	*Carangidae*	Pisc	No Group
Fistulariidae	*Fistularia commersonii*	Pisc	No Group
Carangidae	*Caranx ignobilis*	Pisc	No Group
Carangidae	*Caranx* sp.	Pisc	No Group
Sphyraenidae	*Sphyraena qenie*	Pisc	No Group
Carangidae	*Elagatis bipinnulata*	Pisc	No Group
Chanidae	*Chanos chanos*	H	No Group
Dasyatidae	*Taeniurops meyeni*	MI	No Group
Dasyatidae	*Dasyatidae*	MI	No Group
Carangidae	*Seriola dumerili*	Pisc	No Group

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Carcharhinidae	*Carcharhinus melanopterus*	Pisc	No Group
Sphyraenidae	*Sphyraena barracuda*	Pisc	No Group
Scombridae	*Thunnus albacares*	Pisc	No Group
Carcharhinidae	*Triaenodon obesus*	Pisc	No Group
Labridae	*Cheilinus undulatus*	MI	No Group
Carcharhinidae	*Carcharhinus amblyrhynchos*	Pisc	No Group
Muraenidae	*Gymnothorax flavimarginatus*	Pisc	No Group
Scombridae	*Scombridae*	Pisc	No Group
Scombridae	*Gymnosarda unicolor*	Pisc	No Group
Muraenidae	*Muraenidae*	Pisc	No Group
Carcharhinidae	*Carcharhinus limbatus*	Pisc	No Group
Muraenidae	*Gymnothorax javanicus*	Pisc	No Group
Muraenidae	*Gymnothorax* sp.	Pisc	No Group
Ginglymostomatidae	*Nebrius ferrugineus*	Pisc	No Group
Myliobatidae	*Aetobatus ocellatus*	MI	No Group
Carcharhinidae	*Carcharhinus galapagensis*	Pisc	No Group
Sphyrnidae	*Sphyrna lewini*	Pisc	No Group
Sphyrnidae	*Sphyrnidae*	Pisc	No Group
Myliobatidae	*Mobula* sp.	Pk	No Group
Scaridae	*Scarus fuscocaudalis*	H	Parrotfish
Scaridae	*Calotomus zonarchus*	H	Parrotfish
Scaridae	*Chlorurus japanensis*	H	Parrotfish
Scaridae	*Scarus globiceps*	H	Parrotfish
Scaridae	*Scarus spinus*	H	Parrotfish
Scaridae	*Scarus psittacus*	H	Parrotfish
Scaridae	*Scarus dubius*	H	Parrotfish
Scaridae	*Scarus oviceps*	H	Parrotfish
Scaridae	*Scarus schlegeli*	H	Parrotfish
Scaridae	*Chlorurus spilurus*	H	Parrotfish
Scaridae	*Scarus niger*	H	Parrotfish
Scaridae	*Scarus festivus*	H	Parrotfish
Scaridae	*Scarus frenatus*	H	Parrotfish
Scaridae	*Chlorurus frontalis*	H	Parrotfish
Scaridae	*Scarus dimidiatus*	H	Parrotfish
Scaridae	*Calotomus carolinus*	H	Parrotfish

Family	**Scientific Name**	**Trophic Group**	**Functional Group**
Scaridae	*Scarus forsteni*	H	Parrotfish
Scaridae	*Scarus tricolor*	H	Parrotfish
Scaridae	*Scarus xanthopleura*	H	Parrotfish
Scaridae	*Hipposcarus longiceps*	H	Parrotfish
Scaridae	*Scarus altipinnis*	H	Parrotfish
Scaridae	*Chlorurus perspicillatus*	H	Parrotfish
Scaridae	*Scaridae*	H	Parrotfish
Scaridae	*Scarus rubroviolaceus*	H	Parrotfish
Scaridae	*Chlorurus microrhinos*	H	Parrotfish
Scaridae	*Cetoscarus ocellatus*	H	Parrotfish
Scaridae	*Scarus ghobban*	H	Parrotfish
Scaridae	*Chlorurus* sp.	H	Parrotfish
Scaridae	*Scarus* sp.	H	Parrotfish
Scaridae	*Bolbometopon muricatum*	Cor	Parrotfish
Lutjanidae	*Lutjanus fulvus*	MI	Snappers
Lutjanidae	*Lutjanus kasmira*	MI	Snappers
Lutjanidae	*Lutjanus gibbus*	MI	Snappers
Lutjanidae	*Lutjanus monostigma*	Pisc	Snappers
Lutjanidae	*Macolor macularis*	Pk	Snappers
Lutjanidae	*Aphareus furca*	Pisc	Snappers
Lutjanidae	*Macolor niger*	Pk	Snappers
Lutjanidae	*Macolor* sp.	Pk	Snappers
Lutjanidae	*Lutjanus bohar*	Pisc	Snappers
Lutjanidae	*Lutjanus argentimaculatus*	MI	Snappers
Lutjanidae	*Aprion virescens*	Pisc	Snappers

APPENDIX B: LIST OF PROTECTED SPECIES AND DESIGNATED CRITICAL HABITAT

Table B-1. Protected species found or reasonably believed to be found near or in Hawai`i shallow-set longline waters

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Seabirds					
Laysan Albatross	*Phoebastria immutabilis*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Black-Footed Albatross	*Phoebastria nigripes*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Short-Tailed Albatross	*Phoebastria albatrus*	Endangered	N/A	Breeding visitor in the NWHI	35 FR 8495, 65 FR 46643, Pyle & Pyle 2009
Northern Fulmar	*Fulmarus glacialis*	Not Listed	N/A	Winter resident	Pyle & Pyle 2009
Kermadec Petrel	*Pterodroma neglecta*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Herald Petrel	*Pterodroma arminjoniana*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Murphy's Petrel	*Pterodroma ultima*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Mottled Petrel	*Pterodroma inexpectata*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Juan Fernandez Petrel	*Pterodroma externa*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Hawaiian Petrel	*Pterodroma sandwichensis (Pterodroma phaeopygia sandwichensis)*	Endangered	N/A	Breeding visitor in the MHI	32 FR 4001, Pyle & Pyle 2009
White-Necked Petrel	*Pterodroma cervicalis*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Bonin Petrel	*Pterodroma hypoleuca*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
Black-Winged Petrel	*Pterodroma nigripennis*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Cook Petrel	*Pterodroma cookii*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Stejneger Petrel	*Pterodroma longirostris*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Pycroft Petrel	*Pterodroma pycrofti*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Bulwer Petrel	*Bulweria bulwerii*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Flesh-Footed Shearwater	*Ardenna carneipes*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Wedge-Tailed Shearwater	*Ardenna pacifica*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Buller's Shearwater	*Ardenna bulleri*	Not Listed	N/A	Migrant	Pyle & Pyle 2009

Common name	**Scientific name**	**ESA listing status**	**MMPA status**	**Occurrence**	**References**
Sooty Shearwater	*Ardenna grisea*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Short-Tailed Shearwater	*Ardenna tenuirostris*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Christmas Shearwater	*Puffinus nativitatis*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Newell's Shearwater	*Puffinus newelli (Puffinus auricularis newelli)*	Threatened	N/A	Breeding visitor	40 FR 44149, Pyle & Pyle 2009
Wilson's Storm-Petrel	*Oceanites oceanicus*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Not Listed	N/A	Winter resident	Pyle & Pyle 2009
Band-Rumped Storm-Petrel	*Oceanodroma castro*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Tristram Storm-Petrel	*Oceanodroma tristrami*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
White-Tailed Tropicbird	*Phaethon lepturus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Red-Tailed Tropicbird	*Phaethon rubricauda*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Masked Booby	*Sula dactylatra*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Brown Booby	*Sula leucogaster*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Red-Footed Booby	*Sula*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Great Frigatebird	*Fregata minor*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Lesser Frigatebird	*Fregata ariel*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Laughing Gull	*Leucophaeus atricilla*	Not Listed	N/A	Winter resident in the MHI	Pyle & Pyle 2009
Franklin Gull	*Leucophaeus pipixcan*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Ring-Billed Gull	*Larus delawarensis*	Not Listed	N/A	Winter resident in the MHI	Pyle & Pyle 2009
Herring Gull	*Larus argentatus*	Not Listed	N/A	Winter resident in the NWHI	Pyle & Pyle 2009
Slaty-Backed Gull	*Larus schistisagus*	Not Listed	N/A	Winter resident in the NWHI	Pyle & Pyle 2009
Glaucous-Winged Gull	*Larus glaucescens*	Not Listed	N/A	Winter resident	Pyle & Pyle 2009
Brown Noddy	*Anous stolidus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Black Noddy	*Anous minutus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Blue-Gray Noddy	*Procelsterna cerulea*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
White Tern	*Gygis alba*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Sooty Tern	*Onychoprion fuscatus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Gray-Backed Tern	*Onychoprion lunatus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Little Tern	*Sternula albifrons*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
Least Tern	*Sternula antillarum*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
Arctic Tern	*Sterna paradisaea*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
South Polar Skua	*Stercorarius maccormicki*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Pomarine Jaeger	*Stercorarius pomarinus*	Not Listed	N/A	Winter resident in the MHI	Pyle & Pyle 2009
Parasitic Jaeger	*Stercorarius parasiticus*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Long-Tailed Jaeger	*Stercorarius longicaudus*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Sea turtles					
Green Sea Turtle	*Chelonia mydas*	Threatened (Central North Pacific DPS)	N/A	Most common turtle in the Hawaiian Islands, much more common in nearshore state waters (foraging grounds) than offshore federal waters. Most nesting occurs on French Frigate Shoals in the NWHI. Foraging and haul out in the MHI.	43 FR 32800, 81 FR 20057, Balazs et al. 1992, Kolinski et al. 2001
Green Sea Turtle	*Chelonia mydas*	Threatened (East Pacific DPS)	N/A	Nest primarily in Mexico and the Galapagos Islands. Little known about their pelagic range west of 90°W but may range as far as the Marshall Islands. Genetic testing confirmed that they are incidentally taken in the HI DSLL fishery.	43 FR 32800, 81 FR 20057, WPRFMC 2009, Cliffton et al. 1982, Karl & Bowen 1999
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered[a]	N/A	Small population foraging around Hawai`i and low level nesting on Maui and Hawai`i Islands. Occur worldwide in tropical and subtropical waters.	35 FR 8491, NMFS & USFWS 2007, Balazs et al. 1992, Katahira et al. 1994
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered[a]	N/A	Regularly sighted in offshore waters, especially at the southeastern end of the archipelago.	35 FR 8491, NMFS & USFWS 1997

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Loggerhead Sea Turtle	*Caretta caretta*	Endangered (North Pacific DPS)	N/A	Rare in Hawai`i. Found worldwide along continental shelves, bays, estuaries, and lagoons of tropical, subtropical, and temperate waters.	43 FR 32800, 76 FR 58868, Dodd 1990, Balazs 1979
Olive Ridley Sea Turtle	*Lepidochelys olivacea*	Threatened (Entire species, except for the breeding population on the Pacific coast of Mexico, which is listed as endangered)	N/A	Rare in Hawai`i. Occurs worldwide in tropical and warm temperate ocean waters.	43 FR 32800, Pitman 1990, Balacz 1982
Marine mammals					
Blainville's Beaked Whale	*Mesoplodon densirostris*	Not Listed	Non-strategic	Found worldwide in tropical and temperate waters	Mead 1989
Blue Whale	*Balaenoptera musculus*	Endangered	Strategic	Acoustically recorded off of Oahu and Midway Atoll, small number of sightings around Hawai`i. Considered extremely rare, generally occur in winter and summer.	35 FR 18319, Bradford et al. 2013, Northrop et al. 1971, Thompson & Friedl 1982, Stafford et al. 2001
Bottlenose Dolphin	*Tursiops truncatus*	Not Listed	Non-strategic	Distributed worldwide in tropical and warm-temperate waters. Pelagic stock distinct from island-associated stocks.	Perrin et al. 2009, Martien et al. 2012
Bryde's Whale	*Balaenoptera edeni*	Not Listed	Unknown	Distributed widely across tropical and warm-temperate Pacific Ocean.	Leatherwood et al. 1982
Common Dolphin	*Delphinus delphis*	Not Listed	N/A	Found worldwide in temperate and subtropical seas.	Perrin et al. 2009
Cuvier's Beaked Whale	*Ziphius cavirostris*	Not Listed	Non-strategic	Occur year round in Hawaiian waters.	McSweeney et al. 2007
Dall's Porpoise	*Phocoenoides dalli*	Not Listed	Non-strategic	Range across the entire north Pacific Ocean.	Hall 1979
Dwarf Sperm Whale	*Kogia sima*	Not Listed	Non-strategic	Most common in waters between 500 m and 1,000 m in depth. Found worldwide in tropical and warm-temperate waters.	Nagorsen 1985, Baird et al. 2013

Common name	**Scientific name**	**ESA listing status**	**MMPA status**	**Occurrence**	**References**
False Killer Whale	*Pseudorca crassidens*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters. Pelagic stock tracked to within 11 km of Hawaiian Islands.	Stacey et al. 1994, Baird et al. 2012, Bradford et al. 2015
Fin Whale	*Balaenoptera physalus*	Endangered	Strategic	Infrequent sightings in Hawai`i waters. Considered rare in Hawai`i, though may migrate into Hawaiian waters during fall/winter based on acoustic recordings.	35 FR 18319, Hamilton et al. 2009, Thompson & Friedl 1982
Fraser's Dolphin	*Lagenodelphis hosei*	Not Listed	Non-strategic	Found worldwide in tropical waters.	Perrin et al. 2009
Guadalupe Fur Seal	*Arctocephalus townsendi*	Threatened	Strategic	Extremely rare sightings. Little known about their pelagic distribution. Breed mainly on Isla Guadalupe, Mexico.	50 FR 51252, Gallo-Reynoso et al. 2008, Fleischer 1987
Hawaiian Monk Seal	*Neomonachus schauinslandi*	Endangered[a]	Strategic	Endemic tropical seal. Occurs throughout the archipelago. MHI population spends some time foraging in federal waters during the day.	41 FR 51611, Baker at al. 2011
Humpback Whale	*Megaptera novaeangliae*	Delisted Due to Recovery (Hawai`i DPS)	Strategic	Migrate through the archipelago and breed during the winter. Common during winter months when they are generally found within the 100 m isobath.	35 FR 18319, 81 FR 62259, Childerhouse et al. 2008, Wolman & Jurasz 1976, Herman & Antinoja 1977, Rice & Wolman 1978
Killer Whale	*Orcinus orca*	Not Listed	Non-strategic	Rare in Hawai`i. Prefer colder waters within 800 km of continents.	Mitchell 1975, Baird et al. 2006
Longman's Beaked Whale	*Indopacetus pacificus*	Not Listed	Non-strategic	Found in tropical waters from the eastern Pacific westward through the Indian Ocean to the eastern coast of Africa. Rare in Hawai`i.	Dalebout 2003, Baird et al. 2013
Melon-Headed Whale	*Peponocephala electra*	Not Listed	Non-strategic	Found in tropical and warm-temperate waters worldwide, found primarily in equatorial waters. Uncommon in Hawai`i.	Perryman et al. 1994, Barlow 2006, Bradford et al. 2013

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Minke Whale	*Balaenoptera acutorostrata*	Not Listed	Non-strategic	Occur seasonally around Hawai`i	Barlow 2003, Rankin & Barlow 2005
North Pacific Right Whale	*Eubalaena japonica*	Endangered[a]	Strategic	Extremely rare in Hawai`i waters	35 FR 18319, 73 FR 12024, Rowntree et al. 1980, Herman et al. 1980
Northern Elephant Seal	*Mirounga angustirostris*	Not Listed	Non-strategic	Females migrate to central North Pacific to feed on pelagic prey.	Le Beouf et al. 2000
Northern Fur Seal	*Callorhinus ursinus*	Not Listed	Non-strategic	Occur throughout the North Pacific Ocean.	Gelatt et al. 2015
Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	Not Listed	Non-strategic	Endemic to temperate waters of North Pacific Ocean. Occur both on the high seas and along continental margins.	Brownell et al. 1999
Pantropical Spotted Dolphin	*Stenella attenuata*	Not Listed	Non-strategic	Common and abundant throughout the Hawaiian archipelago. Pelagic stock occurs outside of insular stock areas (20 km for Oahu and 4-island stocks, 65 km for Hawai`i Island stock).	Baird et al. 2013, Oleson et al. 2013
Pygmy Killer Whale	*Feresa attenuata*	Not Listed	Non-strategic	Small resident population in Hawaiian waters. Found worldwide in tropical and subtropical waters.	McSweeney et al. 2009, Ross & Leatherwood 1994
Pygmy Sperm Whale	*Kogia breviceps*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Caldwell & Caldwell 1989
Risso's Dolphin	*Grampus griseus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide.	Perrin et al. 2009
Rough-Toothed Dolphin	*Steno bredanensis*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Occasionally found offshore of Hawai`i.	Perrin et al. 2009, Baird et al. 2013, Barlow 2006, Bradford et al. 2013
Sei Whale	*Balaenoptera borealis*	Endangered	Strategic	Rare in Hawai`i. Generally found in offshore temperate waters.	35 FR 18319, Barlow 2003, Bradford et al. 2013

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Commonly observed around MHI and present around NWHI.	Shallenberger 1981, Baird et al. 2013, Bradford et al. 2013
Sperm Whale	*Physeter macrocephalus*	Endangered	Strategic	Found in tropical to polar waters worldwide, most abundant cetaceans in the region. Sighted off the NWHI and the MHI.	35 FR 18319, Rice 1960, Lee 1993, Barlow 2006, Mobley et al. 2000, Shallenberger 1981
Spinner Dolphin	*Stenella longirostris*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters. Pelagic stock found outside of island-associated boundaries (10 nm).	Perrin et al. 2009
Striped Dolphin	*Stenella coeruleoalba*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters throughout the world.	Perrin et al. 2009
Elasmobranchs					
Giant manta ray	*Manta birostris*	Threatened	N/A	Found worldwide in tropical, subtropical, and temperate waters. Commonly found in upwelling zones, oceanic island groups, offshore pinnacles and seamounts, and on shallow reefs.	Dewar et al. 2008, Marshall et al. 2009, Marshall et al. 2011.
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	N/A	Found worldwide in open ocean waters from the surface to 152 m depth. It is most commonly found in waters > 20°C	Bonfil et al. 2008, Backus et al, 1956, Strasburg 1958, Compagno 1984
Scalloped hammerhead shark	*Sphyrna lewini*	Endangered (Eastern Pacific DPS)	N/A	Found in coastal areas from southern California to Peru.	Compagno 1984, Baum et al. 2007, Bester 2011
Scalloped hammerhead	*Sphyrna lewini*	Threatened (Indo-West Pacific DPS)	N/A	Occur over continental and insular shelves, and adjacent deep waters, but rarely found in waters < 22°C. Range from the intertidal and surface to depths up to 450–512 m.	Compagno 1984, Schulze-Haugen & Kohler 2003, Sanches 1991, Klimley 1993
Corals					

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
N/A	*Acropora globiceps*	Threatened	N/A	Not confirmed in Hawai`i waters. Occur on upper reef slopes, reef flats, and adjacent habitats in depths ranging from 0 to 8 m	Veron 2014
N/A	*Acropora jacquelineae*	Threatened	N/A	Not confirmed in Hawai`i waters. Found in numerous subtidal reef slope and back-reef habitats, including but not limited to, lower reef slopes, walls and ledges, mid-slopes, and upper reef slopes protected from wave action, and depth range is 10 to 35 m.	Veron 2014
N/A	*Acropora retusa*	Threatened	N/A	Not confirmed in Hawai`i waters. Occur in shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons, and depth range is 1 to 5 m.	Veron 2014
N/A	*Acropora speciosa*	Threatened	N/A	Not confirmed in Hawai`i waters. Found in protected environments with clear water and high diversity of *Acropora* and steep slopes or deep, shaded waters. Depth range is 12 to 40 meters and have been found in mesophotic habitat (40-150 m).	Veron 2014
N/A	*Euphyllia paradivisa*	Threatened	N/A	Not confirmed in Hawai`i waters. Found in environments protected from wave action on at least upper reef slopes, mid-slope terraces, and lagoons in depths ranging from 2 to 25 m depth.	Veron 2014
N/A	*Isopora crateriformis*	Threatened	N/A	Not confirmed in Hawai`i waters. Found in shallow, high-wave energy environments, from low tide to at least 12 meters deep, and have been reported from mesophotic depths (less than 50 m depth).	Veron 2014

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
N/A	*Seriatopora aculeata*	Threatened	N/A	Not confirmed in Hawai`i waters. Found in broad range of habitats including, but not limited to, upper reef slopes, mid-slope terraces, lower reef slopes, reef flats, and lagoons, and depth ranges from 3 to 40 m.	Veron 2014
Invertebrates					
Chambered nautilus	*Nautilus pompilius*	Threatened	N/A	Found in small, isolated populations throughout the Indo-Pacific on steep-sloped forereefs with sandy, silty, or muddy bottom substrates from depths of 100 m to 500 m.	83 FR 48948, CITES 2016

[a] These species have critical habitat designated under the ESA. See Table B-4.

Table B-2. Protected species found or reasonably believed to be found near or in Hawai`i deep-set longline waters

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Seabirds					
Laysan Albatross	*Phoebastria immutabilis*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Black-Footed Albatross	*Phoebastria nigripes*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Short-Tailed Albatross	*Phoebastria albatrus*	Endangered	N/A	Breeding visitor in the NWHI	35 FR 8495, 65 FR 46643, Pyle & Pyle 2009
Northern Fulmar	*Fulmarus glacialis*	Not Listed	N/A	Winter resident	Pyle & Pyle 2009
Kermadec Petrel	*Pterodroma neglecta*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Herald Petrel	*Pterodroma arminjoniana*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Murphy's Petrel	*Pterodroma ultima*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Mottled Petrel	*Pterodroma inexpectata*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Juan Fernandez Petrel	*Pterodroma externa*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Hawaiian Petrel	*Pterodroma sandwichensis (Pterodroma phaeopygia sandwichensis)*	Endangered	N/A	Breeding visitor in the MHI	32 FR 4001, Pyle & Pyle 2009
White-Necked Petrel	*Pterodroma cervicalis*	Not Listed	N/A	Migrant	Pyle & Pyle 2009

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Bonin Petrel	*Pterodroma hypoleuca*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
Black-Winged Petrel	*Pterodroma nigripennis*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Cook Petrel	*Pterodroma cookii*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Stejneger Petrel	*Pterodroma longirostris*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Pycroft Petrel	*Pterodroma pycrofti*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Bulwer Petrel	*Bulweria bulwerii*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Wedge-Tailed Shearwater	*Ardenna pacifica*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Buller's Shearwater	*Ardenna bulleri*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Sooty Shearwater	*Ardenna grisea*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Short-Tailed Shearwater	*Ardenna tenuirostris*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Christmas Shearwater	*Puffinus nativitatis*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Newell's Shearwater	*Puffinus newelli (Puffinus auricularis newelli)*	Threatened	N/A	Breeding visitor	40 FR 44149, Pyle & Pyle 2009
Wilson's Storm-Petrel	*Oceanites oceanicus*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Not Listed	N/A	Winter resident	Pyle & Pyle 2009
Band-Rumped Storm-Petrel	*Oceanodroma castro*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Tristram Storm-Petrel	*Oceanodroma tristrami*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
White-Tailed Tropicbird	*Phaethon lepturus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Red-Tailed Tropicbird	*Phaethon rubricauda*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Masked Booby	*Sula dactylatra*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Nazca Booby	*Sula granti*	Not Listed	N/A	Vagrant	Pyle & Pyle 2009
Brown Booby	*Sula leucogaster*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Red-Footed Booby	*Sula*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Great Frigatebird	*Fregata minor*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Lesser Frigatebird	*Fregata ariel*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Laughing Gull	*Leucophaeus atricilla*	Not Listed	N/A	Winter resident in the MHI	Pyle & Pyle 2009

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Franklin Gull	*Leucophaeus pipixcan*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Ring-Billed Gull	*Larus delawarensis*	Not Listed	N/A	Winter resident in the MHI	Pyle & Pyle 2009
Herring Gull	*Larus argentatus*	Not Listed	N/A	Winter resident in the NWHI	Pyle & Pyle 2009
Slaty-Backed Gull	*Larus schistisagus*	Not Listed	N/A	Winter resident in the NWHI	Pyle & Pyle 2009
Glaucous-Winged Gull	*Larus glaucescens*	Not Listed	N/A	Winter resident	Pyle & Pyle 2009
Brown Noddy	*Anous stolidus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Black Noddy	*Anous minutus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Blue-Gray Noddy	*Procelsterna cerulea*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
White Tern	*Gygis alba*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Sooty Tern	*Onychoprion fuscatus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Gray-Backed Tern	*Onychoprion lunatus*	Not Listed	N/A	Breeding visitor	Pyle & Pyle 2009
Little Tern	*Sternula albifrons*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
Least Tern	*Sternula antillarum*	Not Listed	N/A	Breeding visitor in the NWHI	Pyle & Pyle 2009
Arctic Tern	*Sterna paradisaea*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
South Polar Skua	*Stercorarius maccormicki*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Pomarine Jaeger	*Stercorarius pomarinus*	Not Listed	N/A	Winter resident in the MHI	Pyle & Pyle 2009
Parasitic Jaeger	*Stercorarius parasiticus*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Long-Tailed Jaeger	*Stercorarius longicaudus*	Not Listed	N/A	Migrant	Pyle & Pyle 2009
Sea turtles					
Green Sea Turtle	*Chelonia mydas*	Threatened (Central North Pacific DPS)	N/A	Most common turtle in the Hawaiian Islands, much more common in nearshore state waters (foraging grounds) than offshore federal waters. Most nesting occurs on French Frigate Shoals in the NWHI. Foraging and haulout in the MHI.	43 FR 32800, 81 FR 20057, Balazs et al. 1992, Kolinski et al. 2001

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Green Sea Turtle	*Chelonia mydas*	Threatened (East Pacific DPS)	N/A	Nest primarily in Mexico and the Galapagos Islands. Little known about their pelagic range west of 90°W but may range as far as the Marshall Islands. Genetic testing confirmed that they are incidentally taken in the HI DSLL fishery.	43 FR 32800, 81 FR 20057, WPRFMC 2009, Cliffton et al. 1982, Karl & Bowen 1999
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered[a]	N/A	Small population foraging around Hawai`i and low level nesting on Maui and Hawai`i Islands. Occur worldwide in tropical and subtropical waters.	35 FR 8491, NMFS & USFWS 2007, Balazs et al. 1992, Katahira et al. 1994
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered[a]	N/A	Regularly sighted in offshore waters, especially at the southeastern end of the archipelago.	35 FR 8491, NMFS & USFWS 1997
Loggerhead Sea Turtle	*Caretta*	Endangered (North Pacific DPS)	N/A	Rare in Hawai`i. Found worldwide along continental shelves, bays, estuaries and lagoons of tropical, subtropical, and temperate waters.	43 FR 32800, 76 FR 58868, Dodd 1990, Balazs 1979
Olive Ridley Sea Turtle	*Lepidochelys olivacea*	Threatened (Entire species, except for the breeding population on the Pacific coast of Mexico, which is listed as endangered)	N/A	Rare in Hawai`i. Occurs worldwide in tropical and warm temperate ocean waters.	43 FR 32800, Pitman 1990, Balacz 1982
Marine mammals					
Blainville's Beaked Whale	*Mesoplodon densirostris*	Not Listed	Non-strategic	Found worldwide in tropical and temperate waters	Mead 1989
Blue Whale	*Balaenoptera musculus*	Endangered	Strategic	Acoustically recorded off of Oahu and Midway Atoll, small number of sightings around Hawai`i. Considered extremely rare, generally occur in winter and summer.	35 FR 18319, Bradford et al. 2013, Northrop et al. 1971, Thompson & Friedl 1982, Stafford et al. 2001

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Bottlenose Dolphin	*Tursiops truncatus*	Not Listed	Non-strategic	Distributed worldwide in tropical and warm-temperate waters. Pelagic stock distinct from island-associated stocks.	Perrin et al. 2009, Martien et al. 2012
Bryde's Whale	*Balaenoptera edeni*	Not Listed	Unknown	Distributed widely across tropical and warm-temperate Pacific Ocean.	Leatherwood et al. 1982
Common Dolphin	*Delphinus delphis*	Not Listed	N/A	Found worldwide in temperate and subtropical seas.	Perrin et al. 2009
Cuvier's Beaked Whale	*Ziphius cavirostris*	Not Listed	Non-strategic	Occur year round in Hawaiian waters.	McSweeney et al. 2007
Dall's Porpoise	*Phocoenoides dalli*	Not Listed	Non-strategic	Range across the entire north Pacific Ocean.	Hall 1979
Dwarf Sperm Whale	*Kogia sima*	Not Listed	Non-strategic	Most common in waters between 500 m and 1,000 m in depth. Found worldwide in tropical and warm-temperate waters.	Nagorsen 1985, Baird et al. 2013
False Killer Whale	*Pseudorca crassidens*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters. Pelagic stock tracked to within 11 km of Hawaiian Islands.	Stacey et al. 1994, Baird et al. 2012, Bradford et al. 2015
Fin Whale	*Balaenoptera physalus*	Endangered	Strategic	Infrequent sightings in Hawai`i waters. Considered rare in Hawai`i, though may migrate into Hawaiian waters during fall/winter based on acoustic recordings.	35 FR 18319, Hamilton et al. 2009, Thompson & Friedl 1982
Fraser's Dolphin	*Lagenodelphis hosei*	Not Listed	Non-strategic	Found worldwide in tropical waters.	Perrin et al. 2009
Guadalupe Fur Seal	*Arctocephalus townsendi*	Threatened	Strategic	Rare sightings. Little known about their pelagic distribution. Breed mainly on Isla Guadalupe, Mexico.	50 FR 51252, Gallo-Reynoso et al. 2008, Fleischer 1987
Hawaiian Monk Seal	*Neomonachus schauinslandi*	Endangered[a]	Strategic	Endemic tropical seal. Occurs throughout the archipelago. MHI population spends some time foraging in federal waters during the day.	41 FR 51611, Baker at al. 2011

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Humpback Whale	*Megaptera novaeangliae*	Delisted Due to Recovery (Hawai`i DPS)	Strategic	Migrate through the archipelago and breed during the winter. Common during winter months when they are generally found within the 100 m isobath.	35 FR 18319, 81 FR 62259, Childerhouse et al. 2008, Wolman & Jurasz 1976, Herman & Antinoja 1977, Rice & Wolman 1978
Killer Whale	*Orcinus orca*	Not Listed	Non-strategic	Rare in Hawai`i. Prefer colder waters within 800 km of continents.	Mitchell 1975, Baird et al. 2006
Longman's Beaked Whale	*Indopacetus pacificus*	Not Listed	Non-strategic	Found in tropical waters from the eastern Pacific westward through the Indian Ocean to the eastern coast of Africa. Rare in Hawai`i.	Dalebout 2003, Baird et al. 2013
Melon-Headed Whale	*Peponocephala electra*	Not Listed	Non-strategic	Found in tropical and warm-temperate waters worldwide, found primarily in equatorial waters. Uncommon in Hawai`i.	Perryman et al. 1994, Barlow 2006, Bradford et al. 2013
Minke Whale	*Balaenoptera acutorostrata*	Not Listed	Non-strategic	Occur seasonally around Hawai`i	Barlow 2003, Rankin & Barlow 2005
North Pacific Right Whale	*Eubalaena japonica*	Endangered[a]	Strategic	Extremely rare in Hawai`i waters	35 FR 18319, 73 FR 12024, Rowntree et al. 1980, Herman et al. 1980
Northern Elephant Seal	*Mirounga angustirostris*	Not Listed	Non-strategic	Females migrate to central North Pacific to feed on pelagic prey	Le Beouf et al. 2000
Northern Fur Seal	*Callorhinus ursinus*	Not Listed	Non-strategic	Range across the north Pacific Ocean.	Gelatt et al. 2015
Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	Not Listed	Non-strategic	Endemic to temperate waters of North Pacific Ocean. Occur both on the high seas and along continental margins.	Brownell et al. 1999
Pantropical Spotted Dolphin	*Stenella attenuata*	Not Listed	Non-strategic	Common and abundant throughout the Hawaiian archipelago. Pelagic stock occurs outside of insular stock areas (20 km for Oahu and 4-island stocks, 65 km for Hawai`i Island stock)	Baird et al. 2013, Oleson et al. 2013

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Pygmy Killer Whale	*Feresa attenuata*	Not Listed	Non-strategic	Small resident population in Hawaiian waters. Found worldwide in tropical and subtropical waters.	McSweeney et al. 2009, Ross & Leatherwood 1994
Pygmy Sperm Whale	*Kogia breviceps*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Caldwell & Caldwell 1989
Risso's Dolphin	*Grampus griseus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide.	Perrin et al. 2009
Rough-Toothed Dolphin	*Steno bredanensis*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Occasionally found offshore of Hawai`i.	Perrin et al. 2009, Bradford et al. 2013, Barlow 2006, Baird et al. 2013
Sei Whale	*Balaenoptera borealis*	Endangered	Strategic	Rare in Hawai`i. Generally found in offshore temperate waters.	35 FR 18319, Barlow 2003, Bradford et al. 2013
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Commonly observed around MHI and present around NWHI.	Shallenberger 1981, Baird et al. 2013, Bradford et al. 2013
Sperm Whale	*Physeter macrocephalus*	Endangered	Strategic	Found in tropical to polar waters worldwide, most abundant cetaceans in the region. Sighted off the NWHI and the MHI.	35 FR 18319, Rice 1960, Lee 1993, Barlow 2006, Mobley et al. 2000, Shallenberger 1981
Spinner Dolphin	*Stenella longirostris*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters. Pelagic stock found outside of island-associated boundaries (10 nm)	Perrin et al. 2009
Striped Dolphin	*Stenella coeruleoalba*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters throughout the world	Perrin et al. 2009
Elasmobranchs					

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Giant manta ray	*Manta birostris*	Threatened	N/A	Found worldwide in tropical, subtropical, and temperate waters. Commonly found in upwelling zones, oceanic island groups, offshore pinnacles and seamounts, and on shallow reefs.	Dewar et al. 2008, Marshall et al. 2009, Marshall et al. 2011.
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	N/A	Found worldwide in open ocean waters from the surface to 152 m depth. It is most commonly found in waters > 20°C	Bonfil et al. 2008, Backus et al, 1956, Strasburg 1958, Compagno 1984
Scalloped hammerhead shark	*Sphyrna lewini*	Endangered (Eastern Pacific DPS)	N/A	Found in coastal areas from southern California to Peru.	Compagno 1984, Baum et al. 2007, Bester 2011
Scalloped hammerhead shark	*Sphyrna lewini*	Threatened (Indo-West Pacific DPS)	N/A	Occur over continental and insular shelves, and adjacent deep waters, but rarely found in waters < 22°C. Range from the intertidal and surface to depths up to 450–512 m.	Compagno 1984, Schulze-Haugen & Kohler 2003, Sanches 1991, Klimley 1993
Corals					
N/A	*Acropora globiceps*	Threatened	N/A	Occur on upper reef slopes, reef flats, and adjacent habitats in depths ranging from 0 to 8 m.	Veron 2014
N/A	*Acropora jacquelineae*	Threatened	N/A	Found in numerous subtidal reef slope and back-reef habitats, including but not limited to, lower reef slopes, walls and ledges, mid-slopes, and upper reef slopes protected from wave action, and depth range is 10 to 35 m.	Veron 2014
N/A	*Acropora retusa*	Threatened	N/A	Occur in shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons, and depth range is 1 to 5 m.	Veron 2014

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
N/A	*Acropora speciosa*	Threatened	N/A	Found in protected environments with clear water and high diversity of *Acropora* and steep slopes or deep, shaded waters. Depth range is 12 to 40 meters, and it has been found in mesophotic habitat (40-150 m).	Veron 2014
N/A	*Euphyllia paradivisa*	Threatened	N/A	Found in environments protected from wave action on at least upper reef slopes, mid-slope terraces, and lagoons in depths ranging from 2 to 25 m depth.	Veron 2014
N/A	*Isopora crateriformis*	Threatened	N/A	Found in shallow, high-wave energy environments, from low tide to at least 12 m deep, and have been reported from mesophotic depths (less than 50 m depth).	Veron 2014
N/A	*Seriatopora aculeata*	Threatened	N/A	Found in broad range of habitats including, but not limited to, upper reef slopes, mid-slope terraces, lower reef slopes, reef flats, and lagoons, and depth ranges from 3 to 40 m.	Veron 2014
Invertebrates					
Chambered nautilus	*Nautilus pompilius*	Threatened	N/A	Found in small, isolated populations throughout the Indo-Pacific on steep-sloped forereefs with sandy, silty, or muddy bottom substrates from depths of 100 m to 500 m.	83 FR 48948, CITES 2016

[a] These species have critical habitat designated under the ESA. See Table B-4.

Table B-3. Protected species found or reasonably believed to be found near or in American Samoa longline waters

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Seabirds					
Audubon's Shearwater	*Puffinus lherminieri*	Not Listed	N/A	Resident	Craig 2005
Black Noddy	*Anous minutus*	Not Listed	N/A	Resident	Craig 2005

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Black-Naped Tern	*Sterna sumatrana*	Not Listed	N/A	Visitor	Craig 2005
Blue-Gray Noddy	*Procelsterna cerulea*	Not Listed	N/A	Resident	Craig 2005
Bridled Tern	*Onychoprion anaethetus*	Not Listed	N/A	Visitor	Craig 2005
Brown Booby	*Sula leucogaster*	Not Listed	N/A	Resident	Craig 2005
Brown Noddy	*Anous stolidus*	Not Listed	N/A	Resident	Craig 2005
Christmas Shearwater	*Puffinus nativitatis*	Not Listed	N/A	Resident?	Craig 2005
Collared Petrel	*Pterodroma brevipes*	Not Listed	N/A	Resident?	Craig 2005
White Tern	*Gygis alba*	Not Listed	N/A	Resident	Craig 2005
Greater Crested Tern	*Thalasseus bergii*	Not Listed	N/A	Visitor	Craig 2005
Gray-Backed Tern	*Onychoprion lunatus*	Not Listed	N/A	Resident	Craig 2005
Great Frigatebird	*Fregata minor*	Not Listed	N/A	Resident	Craig 2005
Herald Petrel	*Pterodroma heraldica*	Not Listed	N/A	Resident	Craig 2005
Laughing Gull	*Leucophaeus atricilla*	Not Listed	N/A	Visitor	Craig 2005
Lesser Frigatebird	*Fregata ariel*	Not Listed	N/A	Resident	Craig 2005
Masked Booby	*Sula dactylatra*	Not Listed	N/A	Resident	Craig 2005
Newell's Shearwater	*Puffinus auricularis newelli*	Threatened	N/A	Visitor	40 FR 44149, Craig 2005
Red-Footed Booby	*Sula*	Not Listed	N/A	Resident	Craig 2005
Red-Tailed Tropicbird	*Phaethon rubricauda*	Not Listed	N/A	Resident	Craig 2005
Short-Tailed Shearwater	*Ardenna tenuirostris*	Not Listed	N/A	Visitor	Craig 2005
Sooty Shearwater	*Ardenna grisea*	Not Listed	N/A	Visitor	Craig 2005
Sooty Tern	*Sterna fuscata*	Not Listed	N/A	Resident	Craig 2005
Tahiti Petrel	*Pterodroma rostrata*	Not Listed	N/A	Resident	Craig 2005
Wedge-Tailed Shearwater	*Ardenna pacifica*	Not Listed	N/A	Resident?	Craig 2005
White-Necked Petrel	*Pterodroma cervicalis*	Not Listed	N/A	Visitor	Craig 2005
White-Faced Storm-Petrel	*Pelagodroma marina*	Not Listed	N/A	Visitor	Craig 2005
White-Tailed Tropicbird	*Phaethon lepturus*	Not Listed	N/A	Resident	Craig 2005
White-Throated Storm-Petrel	*Nesofregetta fuliginosa*	Not Listed	N/A	Resident?	Craig 2005
Laysan Albatross	*Phoebastria immutabilis*	Not Listed	N/A	Breed mainly in Hawai`i, and range across the North Pacific Ocean.	Causey 2008

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Hawaiian Petrel	*Pterodroma sandwichensis (Pterodroma phaeopygia sandwichensis)*	Endangered	N/A	Breed in MHI, and range across the central Pacific Ocean.	32 FR 4001, Simons & Hodges 1998
Laysan Albatross	*Phoebastria immutabilis*	Not Listed	N/A	Breed mainly in Hawai`i, and range across the North Pacific Ocean.	Causey 2009
Northern Fulmar	*Fulmarus glacialis*	Not Listed	N/A	Breed and range across North Pacific Ocean.	Hatch & Nettleship 2012
Short-Tailed Albatross	*Phoebastria albatrus*	Endangered	N/A	Breed in Japan and NWHI, and range across the North Pacific Ocean.	35 FR 8495, 65 FR 46643, BirdLife International 2017
Sea turtles					
Green Sea Turtle	*Chelonia mydas*	Endangered (Central South Pacific DPS)	N/A	Frequently seen. Nest at Rose Atoll in small numbers.	43 FR 32800, 81 FR 20057, Balacz 1994
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered[a]	N/A	Frequently seen. Nest at Rose Atoll, Swain's Island, and Tutuila.	35 FR 8491, NMFS & USFWS 2013, Tuato'o-Bartley et al. 1993
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered[a]	N/A	Very rare. One juvenile recovered dead in experimental longline fishing.	35 FR 8491, Grant 1994
Loggerhead Sea Turtle	*Caretta*	Endangered (South Pacific DPS)	N/A	No known sightings. Found worldwide along continental shelves, bays, estuaries and lagoons of tropical, subtropical, and temperate waters.	43 FR 32800, 76 FR 58868, Utzurrum 2002, Dodd 1990
Olive Ridley Sea Turtle	*Lepidochelys olivacea*	Threatened (Entire species, except for the endangered breeding population on the Pacific coast of Mexico)	N/A	Rare. Three known sightings.	43 FR 32800, Utzurrum 2002
Marine mammals					
Blainville's Beaked Whale	*Mesoplodon densirostris*	Not Listed	Non-strategic	Found worldwide in tropical and temperate waters	Mead 1989
Blue Whale	*Balaenoptera musculus*	Endangered	Strategic	No known sightings. Occur worldwide and are known to be found in the western South Pacific.	35 FR 18319, Olson et al. 2015

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Bottlenose Dolphin	*Tursiops truncatus*	Not Listed	Non-strategic	Distributed worldwide in tropical and warm-temperate waters. Pelagic stock distinct from island-associated stocks.	Perrin et al. 2009, Martien et al. 2012
Bryde's Whale	*Balaenoptera edeni*	Not Listed	Unknown	Distributed widely across tropical and warm-temperate Pacific Ocean.	Leatherwood et al. 1982
Common Dolphin	*Delphinus delphis*	Not Listed	N/A	Found worldwide in temperate and subtropical seas.	Perrin et al. 2009
Cuvier's Beaked Whale	*Ziphius cavirostris*	Not Listed	Non-strategic	Occur worldwide.	Heyning 1989
Dwarf Sperm Whale	*Kogia sima*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Nagorsen 1985
False Killer Whale	*Pseudorca crassidens*	Not Listed	Unknown	Found in waters within the U.S. EEZ of A. Samoa	Bradford et al. 2015
Fin Whale	*Balaenoptera physalus*	Endangered	Strategic	No known sightings but reasonably expected to occur in A. Samoa. Found worldwide.	35 FR 18319, Hamilton et al. 2009
Fraser's Dolphin	*Lagenodelphis hosei*	Not Listed	Non-strategic	Found worldwide in tropical waters.	Perrin et al. 2009
Guadalupe Fur Seal	*Arctocephalus townsendi*	Threatened	Strategic	No known sightings. Little known about their pelagic distribution. Breed mainly on Isla Guadalupe, Mexico.	50 FR 51252, Gallo-Reynoso et al. 2008, Fleischer 1987
Humpback Whale	*Megaptera novaeangliae*	Delisted Due to Recovery (Oceania DPS)	Strategic	Migrate through the archipelago and breed during the winter in American Samoan waters.	35 FR 18319, 81 FR 62259, Guarrige et al. 2007, SPWRC 2008
Killer Whale	*Orcinus orca*	Not Listed	Non-strategic	Found worldwide. Prefer colder waters within 800 km of continents.	Leatherwood & Dalheim 1978, Mitchell 1975, Baird et al. 2006
Longman's Beaked Whale	*Indopacetus pacificus*	Not Listed	Non-strategic	Found in tropical waters from the eastern Pacific westward through the Indian Ocean to the eastern coast of Africa.	Dalebout 2003
Melon-Headed Whale	*Peponocephala electra*	Not Listed	Non-strategic	Found in tropical and warm-temperate waters worldwide, primarily found in equatorial waters.	Perryman et al. 1994

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Minke Whale	*Balaenoptera acutorostrata*	Not Listed	Non-strategic	Uncommon in this region, usually seen over continental shelves in the Pacific Ocean.	Brueggeman et al. 1990
North Pacific Right Whale	*Eubalaena japonica*	Endangered[a]	Strategic	Extremely rare.	35 FR 18319, 73 FR 12024, Childerhouse et al. 2008, Wolman & Jurasz 1976, Herman & Antinoja 1977, Rice & Wolman 1978
Northern Elephant Seal	*Mirounga angustirostris*	Not Listed	Non-strategic	Females migrate to central North Pacific to feed on pelagic prey	Le Beouf et al. 2000
Pantropical Spotted Dolphin	*Stenella attenuata*	Not Listed	Non-strategic	Found in tropical and subtropical waters worldwide.	Perrin et al. 2009
Pygmy Killer Whale	*Feresa attenuata*	Not Listed	Non-strategic	Found in tropical and subtropical waters worldwide.	Ross & Leatherwood 1994
Pygmy Sperm Whale	*Kogia breviceps*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Caldwell & Caldwell 1989
Risso's Dolphin	*Grampus griseus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide.	Perrin et al. 2009
Rough-Toothed Dolphin	*Steno bredanensis*	Not Listed	Unknown	Found in tropical to warm-temperate waters worldwide. Common in A. Samoa waters.	Perrin et al. 2009, Craig 2005
Sei Whale	*Balaenoptera borealis*	Endangered	Strategic	Generally found in offshore temperate waters.	35 FR 18319, Barlow 2003, Bradford et al. 2013
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide	Shallenberger 1981, Baird et al. 2013, Bradford et al. 2013
Sperm Whale	*Physeter macrocephalus*	Endangered	Strategic	Found in tropical to polar waters worldwide, most abundant cetaceans in the region.	35 FR 18319, Rice 1960, Barlow 2006, Lee 1993, Mobley et al. 2000, Shallenberger 1981
Spinner Dolphin	*Stenella longirostris*	Not Listed	Unknown	Common in American Samoa, found in waters with mean depth of 44 m.	Reeves et al. 1999, Johnston et al. 2008

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Striped Dolphin	*Stenella coeruleoalba*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters throughout the world	Perrin et al. 2009
Elasmobranchs					
Giant manta ray	*Manta birostris*	Threatened	N/A	Found worldwide in tropical, subtropical, and temperate waters. Commonly found in upwelling zones, oceanic island groups, offshore pinnacles and seamounts, and on shallow reefs.	Dewar et al. 2008, Marshall et al. 2009, Marshall et al. 2011.
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	N/A	Found worldwide in open ocean waters from the surface to 152 m depth. It is most commonly found in waters > 20°C.	Bonfil et al. 2008, Backus et al, 1956, Strasburg 1958, Compagno 1984
Scalloped hammerhead shark	*Sphyrna lewini*	Threatened (Indo-West Pacific DPS)	N/A	Occur over continental and insular shelves, and adjacent deep waters, but rarely found in waters < 22°C. Range from the intertidal and surface to depths up to 450–512 m.	Compagno 1984, Schulze-Haugen & Kohler 2003, Sanches 1991, Klimley 1993
Corals					
N/A	*Acropora globiceps*	Threatened	N/A	Occur on upper reef slopes, reef flats, and adjacent habitats in depths from 0 to 8 m	Veron 2014
N/A	*Acropora jacquelineae*	Threatened	N/A	Found in numerous subtidal reef slope and back-reef habitats, including but not limited to, lower reef slopes, walls and ledges, mid-slopes, and upper reef slopes protected from wave action, and its depth range is 10 to 35 m.	Veron 2014
N/A	*Acropora retusa*	Threatened	N/A	Occur in shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons. Depth range is 1 to 5 m.	Veron 2014

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
N/A	*Acropora speciosa*	Threatened	N/A	Found in protected environments with clear water and high diversity of Acropora and steep slopes or deep, shaded waters. Depth range is 12 to 40 meters and have been found in mesophotic habitat (40-150 m).	Veron 2014
N/A	*Euphyllia paradivisa*	Threatened	N/A	Found in environments protected from wave action on at least upper reef slopes, mid-slope terraces, and lagoons in depths ranging from 2 to 25 m depth.	Veron 2014
N/A	*Isopora crateriformis*	Threatened	N/A	Found in shallow, high-wave energy environments, from low tide to at least 12 meters deep, and have been reported from mesophotic depths (less than 50 m depth).	Veron 2014
Invertebrates					
Chambered nautilus	*Nautilus pompilius*	Threatened	N/A	Found in small, isolated populations throughout the Indo-Pacific on steep-sloped forereefs with sandy, silty, or muddy bottom substrates from depths of 100 m to 500 m.	83 FR 48948, CITES 2016

[a] These species have critical habitat designated under the ESA. See Table B-4.

Table B-4. ESA-listed species' critical habitat in the Pacific Ocean[a]

Common Name	Scientific Name	ESA Listing Status	Critical Habitat	References
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered	None in the Pacific Ocean.	63 FR 46693
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	Approximately 16,910 square miles (43,798 square km) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles (64,760 square km) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour.	77 FR 4170
Hawaiian Monk Seal	*Neomonachus schauinslandi*	Endangered	Ten areas in the Northwestern Hawaiian Islands (NWHI) and six in the main Hawaiian Islands (MHI). These areas contain one or a combination of habitat types: Preferred	53 FR 18988, 51 FR 16047, 80 FR 50925

			pupping and nursing areas, significant haul-out areas, and/or marine foraging areas, that will support conservation for the species.	
North Pacific Right Whale	*Eubalaena japonica*	Endangered	Two specific areas are designated, one in the Gulf of Alaska and another in the Bering Sea, comprising a total of approximately 95,200 square kilometers (36,750 square miles) of marine habitat.	73 FR 19000, 71 FR 38277

[a] For maps of critical habitat, see https://www.fisheries.noaa.gov/national/endangered-species-conservation/critical-habitat.

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APPENDIX C: REVIEW OF ESSENTIAL FISH HABITAT FOR REEF-ASSOCIATED CRUSTACEANS IN THE WESTERN PACIFIC REGION

INTRODUCTION

Essential fish habitat under the Magnuson-Stevens Fishery Conservation and Management Act is defined as:" those waters necessary to fish for spawning, breeding, or growth to maturity". Habitat Areas of Particular Concern (HAPCs) are defined as subsets of EFH that are: "rare, stressed by development, provide important ecological functions for federally managed species, and/or are especially vulnerable to anthropogenic degradation".

In 2009, the Fishery Ecosystem Plans (FEPs) for Hawaii, American Samoa, and Marianas defined EFH for all reef-associated crustacean eggs and larvae as *"In the water column from the shoreline to the outer limit of the EEZ down to a depth of 150 m (75 fm)".* EFH for juveniles and adults for all reef associated crustaceans was defined as: "*all of the bottom habitat from the shoreline to a depth of 100 m (fm)".* Additionally, the 2009 Hawaii FEP defined HAPC for reef-associated crustaceans as: *"all banks in the NWHI with summits less than or equal to 30 m (15 fathoms) from the surface."* Species specific EFH for crustaceans was not defined in the FEP.

Reef-associated crustaceans landed in the Main Hawaiian Island commercial fishery include Kona crab (*Ranina ranina*), two species of spiny lobster (*Panulirus marginatus* and *P. penicillatus*), and slipper lobster species (*Scyllarides sp*.).Total commercial landings reported for reef associated crustaceans for the Main Hawaiian Island from 1948 – 2017 was 6,010,183 lbs. with the majority coming from Penguin Bank, an extended shelf area off Maui Nui. Kona crab (*Ranina ranina*) accounts for the majority (>60%) of the reef-associated crustacean reported landings from 1948-2017 in the Main Hawaiian Islands, followed by unidentified *Panulirus spp.* (~30 %), *Panulirus penicillatus* (~6%), *Panulirus marginatus* (~1%), and *Scyllardies* sp. (Figure C-1).

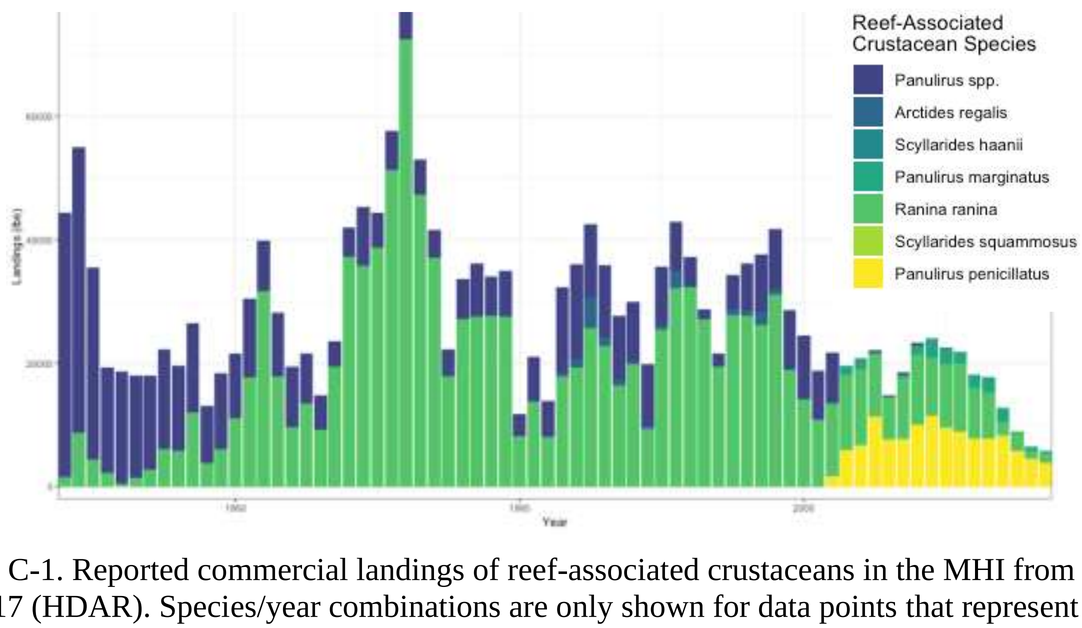

Figure C-1. Reported commercial landings of reef-associated crustaceans in the MHI from 1948 – 2017 (HDAR). Species/year combinations are only shown for data points that represent > 3 fishing licenses for confidentiality purposes.

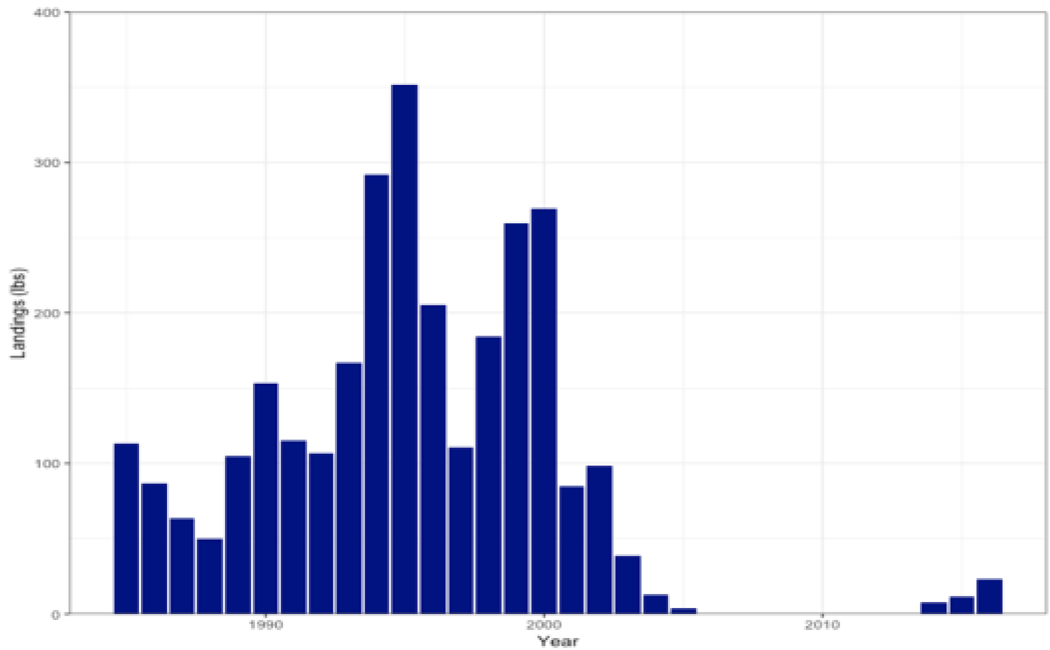

Figure C-2. Estimated landings of reef-associated crustaceans from1983-2016 (WPacFIN)

P. penicillatus accounts for over 90% of reef associated crustacean landings in Guam from 1983 -2016. Slipper lobster species account for approximately 8% of historical crustacean landings, and *P. versicolor, P. longipes,* and *P. ornatus* make up the remainder of the catch. In total, the estimated landings for reef-associated crustaceans from 1983-2016 was 3,012 lbs. (Figure C-2). The majority of reef associated crustacean catch was reported from the north east and south coasts of the island.

Sufficient data were not available to identify reef-associated crustaceans that may be present in CNMI or American Samoa's fisheries. Only two records of lobsters were available in the CNMI CFW creel survey data. The lobster in these data were not reported to the species level, but scientific literature suggests that *P. penicillatus* is the most abundant invertebrate landed in CNMI's fisheries (Coutures, 2003; Porter et al., 2005). Fishery data were not available to identify landed in American Samoa's reef-associated crustacean fishery. Literature states that a fishery for *P. penicillatus* exists in American Samoa, but no information was available on reef-associated crustaceans landed (McGinnis, 1972; Coutures, 2003; Porter et al., 2005).

The primary objectives of this project are to 1. Update the EFH definitions for reef-associated crustaceans in the Western Pacific U.S. and U.S. associated territories at each life stage and 2. Use the best available spatial data layers to map EFH for each species at each life stage. Due to the lack of information on commercial landings of reef-associated crustaceans in CNMI and American Samoa, EFH was only mapped for reef-associated crustaceans landed in the Main Hawaiian Islands and Guam. For a detailed literature review on life history and habitat requirements of reef-associated crustacean species see accompanying report titled: "A Review of Life History Characteristics and Essential Habitat for Reef-Associated Crustaceans in U.S. Associated Islands of the Western Pacific.

METHODS

Data: Description and Pre-processing

The first step in this analysis was to obtain available spatial data layers on depth and habitat for waters surrounding the Main Hawaiian Islands and Guam. Two data layers were obtained and used for each island to identify EFH for the life stage of each species: 1) 5 x 5 m resolution bathymetry data and 2) A 5 x 5 m data layer representing substrate hardness (backscatter data in MHI; substrate data in Guam), which can be utilized to differentiate between reef and sandy areas. Details on these spatial data layers used for each location are presented in Table C-1.

Table C-1. Spatial data layers used for mapping EFH of reef-associated crustaceans in the Main Hawaiian Islands and Guam

Archipelago	Data Layer	Description	Resolution	Reference
Main Hawaiian Islands (MHI)	Bathymetry (Figure C-10)	Synthesis grid of multi-beam bathymetry data	5 m	Smith et al. 2016
	Bathymetry (Figure C-11)	Synthesis grid of multi-beam bathymetry data	50 m	Smith et al. 2016
	Backscatter (Figure C-12)	Synthesis grid of multi-beam backscatter data	5 m	Smith et al. 2016
	Backscatter (Figure C-13)	Synthesis grid of multi-beam backscatter data	60 m	Smith et al. 2016
Guam	Bathymetry (Figure C-14)	Gridded multibeam bathymetry data is integrated with gridded lidar data collected from 2001 - 2008	5 m	Pacific Islands Benthic Habitat Mapping Center (PIBHMC) 2011
	Substrate data (Figure C-15)	Hard and soft bottom seafloor substrate map derived from an unsupervised classification of gridded backscatter and bathymetry derivatives	5 m	Pacific Islands Benthic Habitat Mapping Center (PIBHMC) 2008

All spatial data layers were pre-processed for analysis using the raster package (Hijmans, 2019) in R (RStudio, 2015). Data layers were projected to a WGS coordinate reference system using the projectRaster function and R's 'nearest neighbor' method. For the MHI, higher resolution data (50 m for bathymetry and 60 m backscatter) was used to fill areas not covered by the 5 m resolution data. The higher resolution data were resampled using the nearest neighbor technique to a 5 m resolution.

Spatial Habitat Mapping

Habitat descriptions for each species and life stage presented in Table C-1 were transformed to quantitative threshold values for bathymetry and substrate hardness (Table C-2). Smith et al (2016) classified values in the backscatter layer as < 140 as soft substrate and values >= 140 as hard substrate. All lobster species are associated with reef habitat, so the suitable threshold range for the backscatter data were >=140. Kona crabs are associated with soft habitat, so the backscatter threshold for Kona crab was set to < 140. Substrate thresholds were not set for the egg/larvae life stage because they are pelagic and do not require a specific benthic habitat. For each species and life stage combination, values in the bathymetry layer that fell within the species threshold were reassigned to a 1, and values falling outside of the threshold values were assigned a zero. The same process was done for the backscatter/substrate layers. This resulted in a layer of suitable depths and substrate hardness for each species and life stage. The raster layers of suitable depth and suitable substrate hardness for each species and life stage were multiplied together and the resulting raster file had cell values of 0 or 1, with cell values of 1 representing only cells that met both the bathymetry and backscatter criteria specified in Table C-2 and the EFH for the species at that life stage.

Table C-2. Depth and habitat thresholds applied to bathymetry and backscatter layers for each species/life stage/location

Location	Species	Life Stage	Bathymetry Layer	Backscatter Layer
MHI	Kona crab (*Ranina ranina*)	Egg/larvae	0 - 150 m	NA
		Juvenile/Adult	>=2m and <= 200 m	< 140 (soft bottom)
	Spiny lobster (*P. panulirus*)	Egg/larvae	0 - 150 m	NA
		Juvenile	>=1 m and <= 30 m	>=140 (hard bottom)
		Adult	>=20 m and <= 150 m	>= 140 (hard bottom)
	Spiny lobster (*P. penicillatus*)	Egg/larvae	0 - 150 m	NA
		Juvenile/Adult	=< 16 m	>=140 (hard bottom)
	Slipper lobster (*Scyllarides* sp.)	Egg/larvae	0 - 150 m	NA
		Juvenile/adult	0-120 m	>=140 (hard bottom)
Guam	Spiny lobster (*P. penicillatus*)	Egg/larvae	0 - 150 m	NA
		Juvenile/Adult	=< 16 m	2 (hard bottom)
	Slipper lobster (*Scyllarides* sp.)	Egg/larvae	0 - 150 m	NA
		Juvenile/adult	0-120 m	>=140 (hard bottom)

RESULTS

Eggs and Larvae of Reef-Associated Crustaceans

EFH of egg and larvae Kona crab is presented in Figure C-3. Egg and larvae EFH for all reef-associated crustaceans was defined as the water column between 0 and 150 m depth from the shoreline out to 200 nm, or the top 150 m of the water column for entire Main Hawaiian Island Exclusive Economic Zone. The total estimated EFH area for egg and larvae is 895,346 km^2. Only ~0.6% (5,250 km^2) includes the whole water column (where depths are 0 to 150m, depicted in dark blue in Figure C-3). The remainder is the top 150 m of the water column.

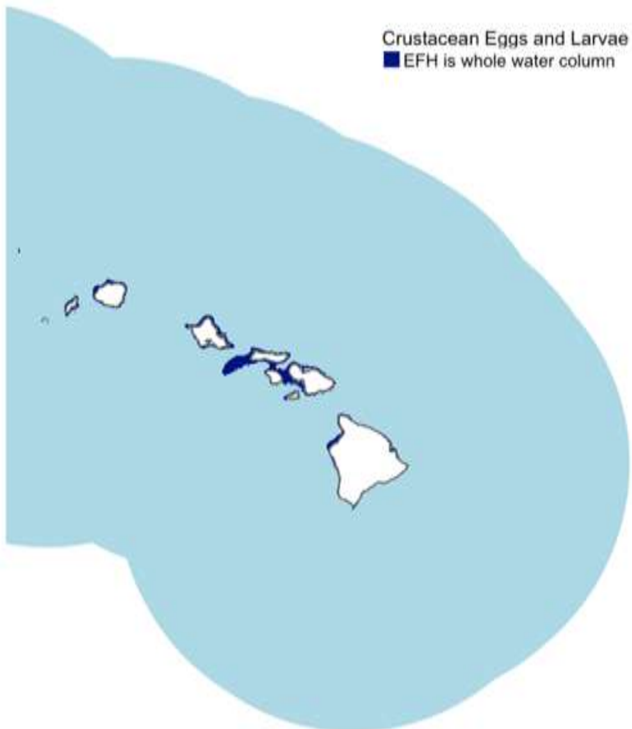

Figure C-3. EFH for eggs and larvae of reef-associated crustaceans in the MHI. Dark blue areas indicate where the entire water column is EFH (<=150 m) and light blue areas indicate where only the top 150 m of the water column is considered EFH

Kona crabs (Ranina ranina)

The estimated EFH area for juvenile and adult Kona crabs in the MHI was 3,866km^2 of benthic area (Figure C-4). EFH area for Kona crabs was defined as benthic areas in depths from 2 to 200 m with soft substrate. To help verify our results, Locations where Kona crabs were caught during a study on post release mortality of Kona crabs from Nov. 2017- April 2018 (Wiley and Pardee, 2018) were plotted over the identified EFH in Figure C-4 (navy dots). Coordinates of fishing locations all overlapped with areas we identified as EFH.

Figure C-4. EFH for juvenile and adult Kona crab (*R. ranina*) in the MHI (red) and verified Kona crab fishing locations (navy dots)

Spiny lobster (Panulirus marginatus)

The total estimated EFH for juvenile spiny lobster was 56.60 km^2 (Figure C-5a). Juvenile spiny lobster habitat was defined as benthic areas with depths from 1 to 30 m and hard substrate. The total estimated EFH area for adult spiny lobsters was 1,151.93 km^2 (Figure C-5b). Adult spiny lobster EFH was defined as benthic areas in depths from 20 to 150 m and hard substrate.

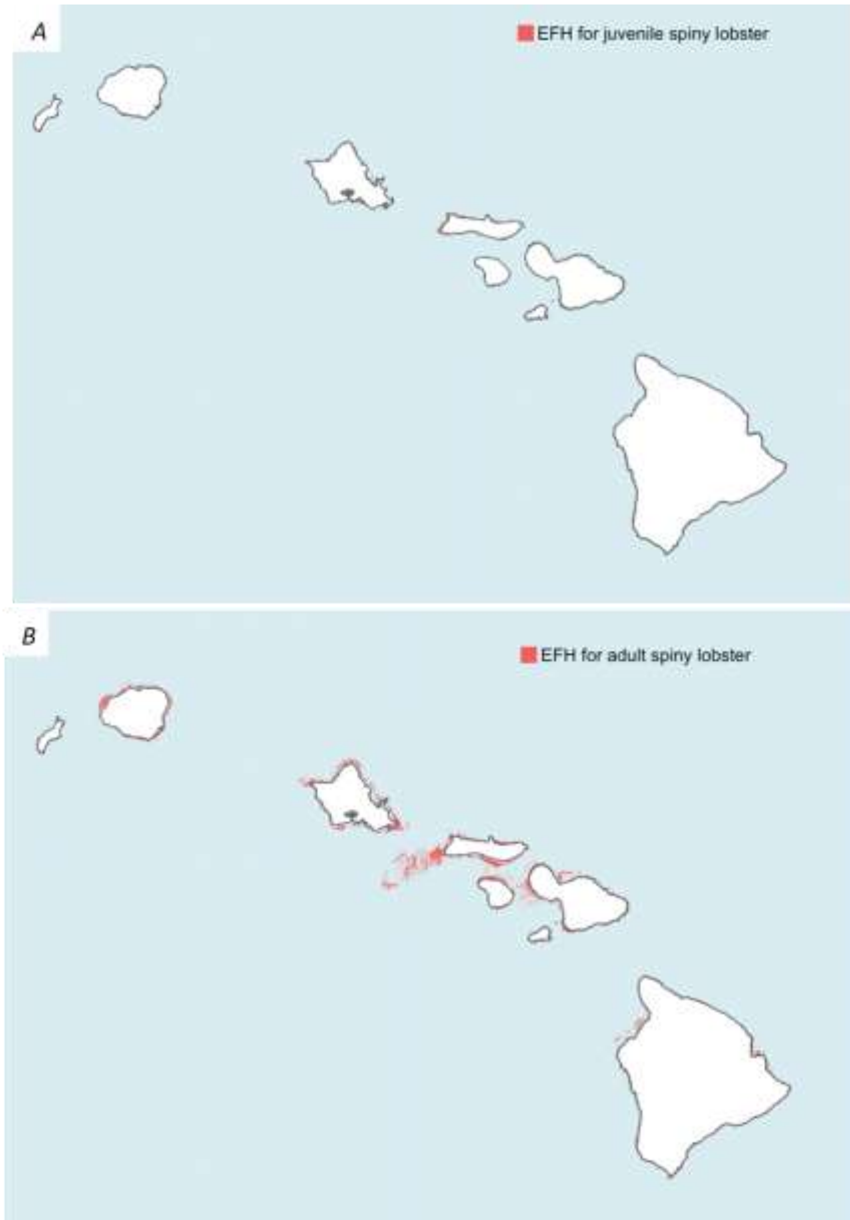

Figure C-5. EFH for juvenile (A) and adult (B) spiny lobster (*P. panulirus*) in the MHI

Pronghorn spiny lobster (Panulirus penicillatus)

The total estimated EFH area for juvenile and adult pronghorn spiny lobster was 706.95 km^2 for the Main Hawaiian Islands (Figure C-6), and 18.1 km^2 for Guam (Figure C-7). Juvenile and adult EFH for *P. penicillatus* were defined as areas in depths from 1-16 m with hard substrate.

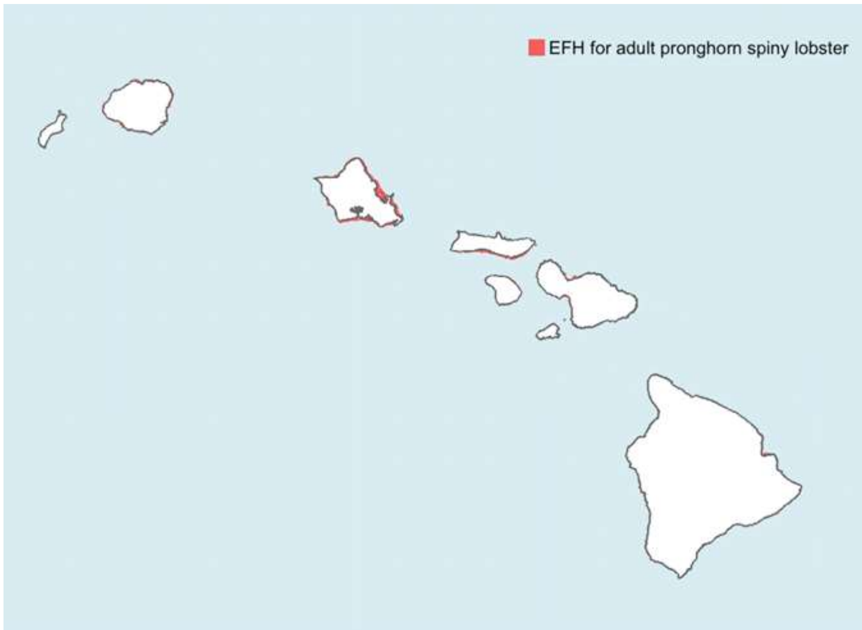

Figure C-6. EFH for juvenile and adult pronghorn spiny lobster (*P. penicillatus*) in the MHI

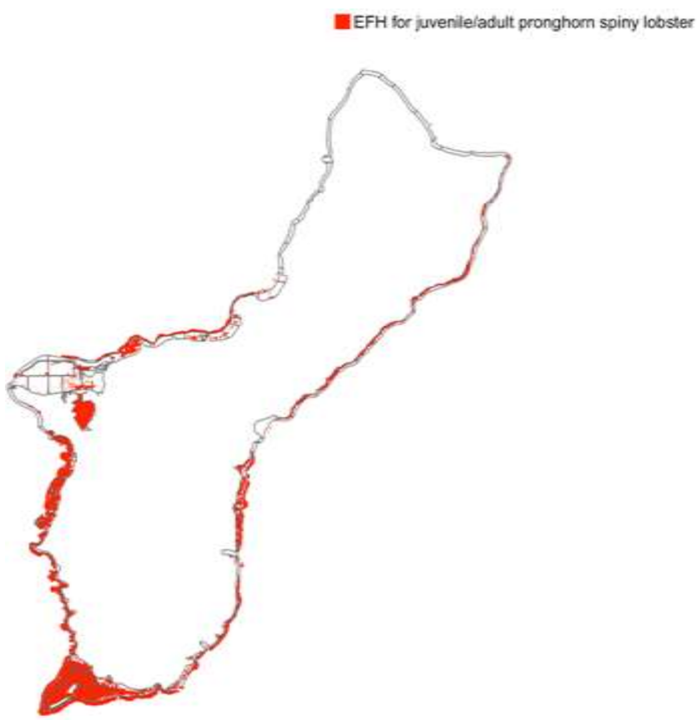

Figure C-7. EFH for juvenile and adult pronghorn spiny lobster (P. penicillatus) in Guam

Slipper lobster (Scyllarides squammosus)

The total estimated EFH area for juvenile and adult slipper lobster (*S. squammosus*) was 1,924 km^2 for the MHI (Figure C-8) and 79.75 km^2 for Guam (Figure C-9). Juvenile and adult EFH for *S. squammosus* were defined as areas in depths from 1-120 m with hard substrate.

Figure C-8. EFH for juvenile and adult slipper lobster (*S. squammosus*) in the MHI

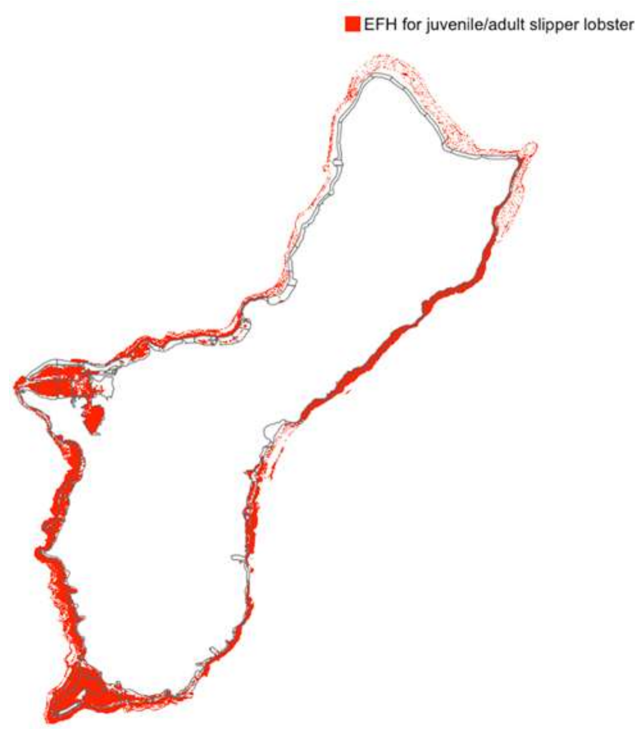

Figure C-9. EFH for juvenile and adult slipper lobster (*S. squammosus*) in Guam

APPENDIX C REFERENCES

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ADDENDUM TO APPENDIX C

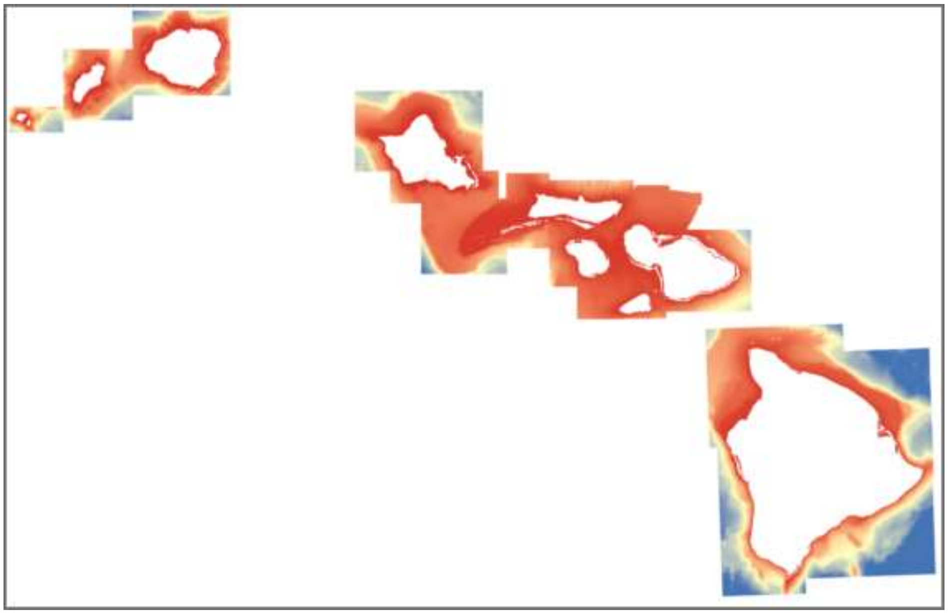

Figure C-10. Multibeam bathymetry synthesis grid (5 m) for Main Hawaiian Islands (Smith et al., 2016). Downloaded at: http://www.soest.hawaii.edu/HMRG/multibeam/bathymetry.php

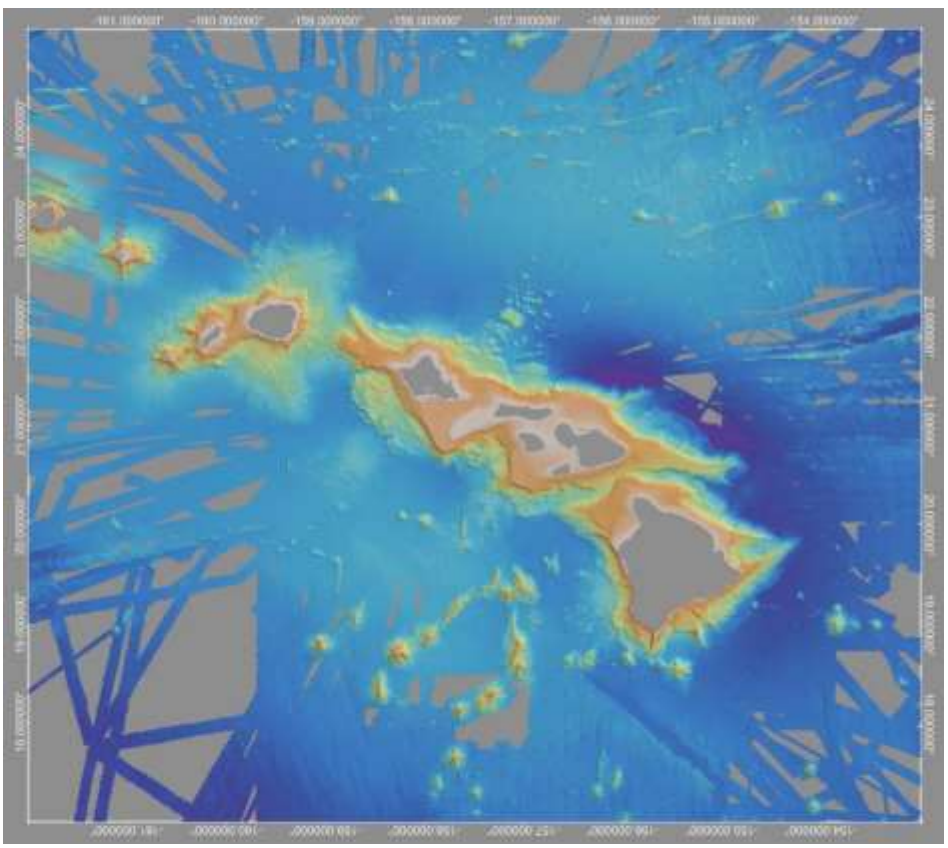

Figure C-11. Multibeam bathymetry synthesis grid (50 m) for Main Hawaiian Islands (Smith et al., 2016). Downloaded at: http://www.soest.hawaii.edu/HMRG/multibeam/bathymetry.php

Figure C-12. Backscatter synthesis grid (5 m) of substrate hardness of the Main Hawaiian Islands (Smith et al., 2016). Downloaded at: http://www.soest.hawaii.edu/HMRG/multibeam/backscatter.php

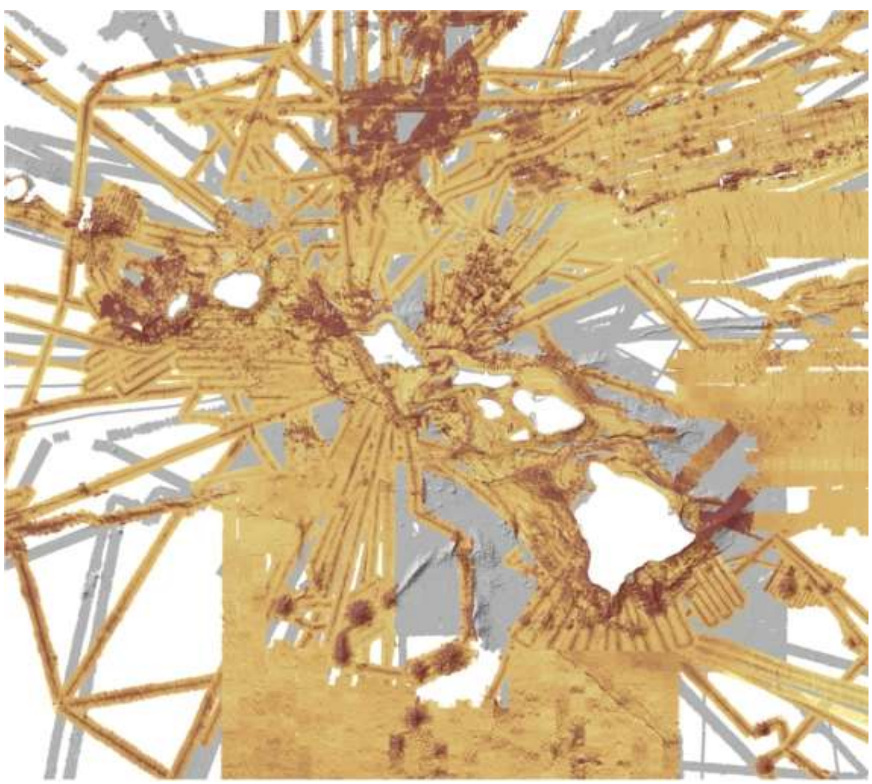

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Figure C-13. Backscatter synthesis grid (60 m) of substrate hardness of the Main Hawaiian Islands (Smith et al., 2016). Downloaded at: http://www.soest.hawaii.edu/HMRG/multibeam/backscatter.php

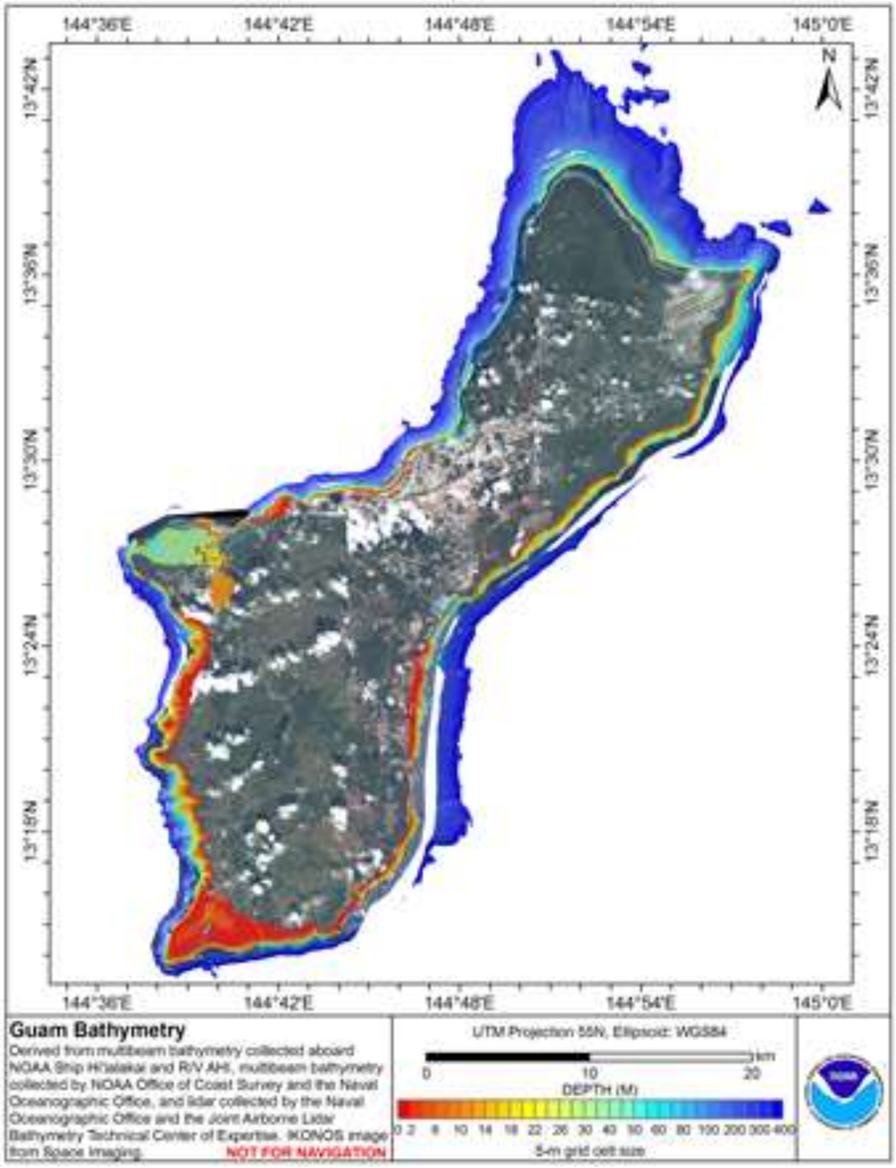

Figure C-14. Gridded (5 m) multibeam and lidar integrated bathymetry data of Guam (NOAA Pacific Islands Fisheries Science Center, and the Joint Institute for Marine and Atmospheric Research (JIMAR) University of Hawaii, 2011). Downloaded at: <http://www.soest.hawaii.edu/pibhmc/cms/data-by-location/cnmi-guam/guam-island/bathymetry/>

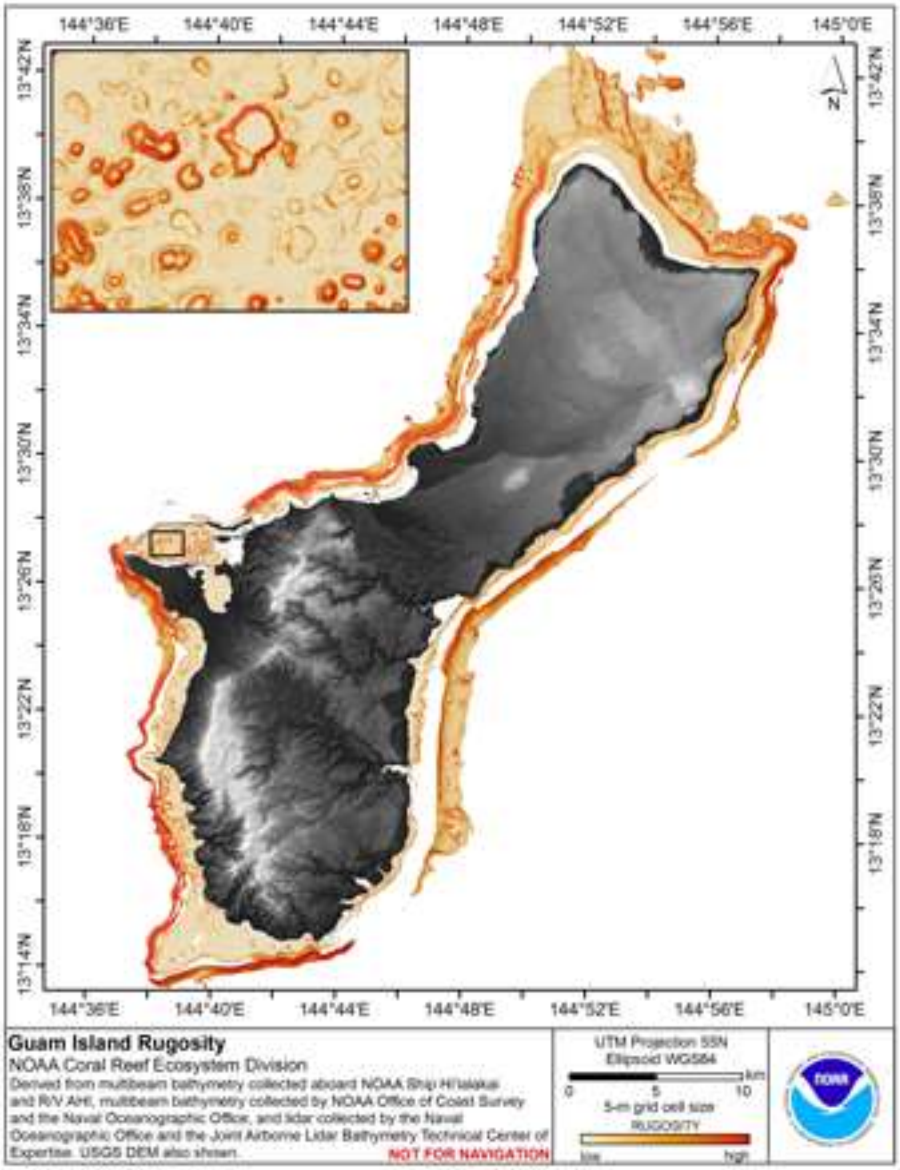

Figure C-15. Rugosity grid (5 m) derived from gridded bathymetry of the US Territory of Guam (NOAA Pacific Islands Fisheries Science Center Coral Reef Ecosystem Division Pacific Islands Benthic Habitat Mapping Center, 2011). Downloaded at: http://www.soest.hawaii.edu/pibhmc