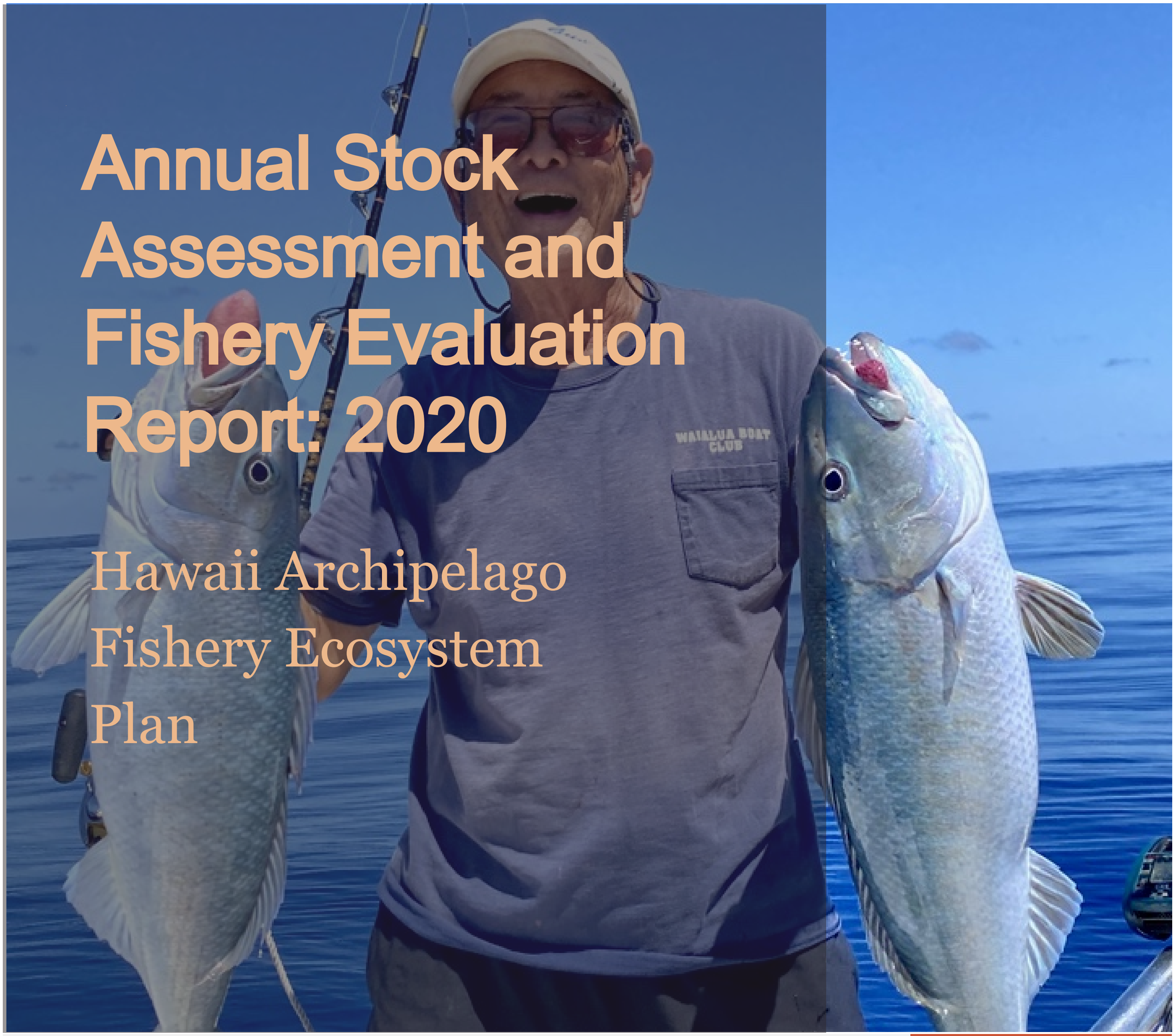
Annual Stock Assessment and Fishery Evaluation Report: 2020

Hawaii Archipelago Fishery Ecosystem Plan



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The ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT for the HAWAII ARCHIPELAGO FISHERY ECOSYSTEM 2020 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council (WPRFMC; the Council), 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.

Additionally, in 2020, there were notable impacts to fishery operations due to the 2019 novel coronavirus (COVID-19) outbreak. Impacts associated with the pandemic and its restrictions are described in Sections 1.1 through 1.3, 2.1, 2.2, and 2.5.

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v2 (7/26/2021) – added numbers for Harvest Capacity and Extent (Section 1.11); formatted the starting point of Section 1.2; revised Table 46 in Section 1.9; made abbreviation for “pounds” consistent throughout the document.

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The **Western Pacific Regional Fishery Management Council** acknowledges the valuable contributions of the following Plan Team members and others for drafting sections of this report:

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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). An amendment to the Hawaii Archipelago FEP was passed in early 2019 classifying all non-Deep 7 bottomfish except for uku, all former coral reef ecosystem MUS, several crustacean MUS, and all mollusk and limu species as ECS (84 FR 2767, February 8, 2019). Species classified as ecosystem components do not require annual catch limits (ACLs) 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 (DAR), 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 and available logbook data, status determination criteria, implemented annual catch limits, 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 2020, none of the MUS had a recent three-year average catch that exceeded their ACL, allowable biological catch (ABC) values, or overfishing limits (OFL). Data for deepwater shrimp and precious coral were not disclosed due to data confidentiality rules that prohibit reporting data from less than three licensed fishermen.

In 2020, the Main Hawaiian Islands (MHI) Deep 7 bottomfish fishery was characterized by decreasing trends in catch and effort relative to 10- and 20-year averages (i.e., short- and long-term trends, respectively). This decline can likely be attributed to decreased demand from the near complete shutdown of the hotel and restaurant industries due to COVID-19, high shark depredation, challenging environmental conditions, and atypical fish behavior. Catches of ʻōpakapaka (*Pristipomoides filamentosus*; 63,601 lb) declined over 46% relative to its 10-year average and nearly 43% compared to its 20-year average. One Deep 7 bottomfish species, gindai (*Pristipomoides zonatus*), did have increases relative to its short- and long-term trends, while ehu (*Etelis carbunculus*) and kalekale (*Pristipomoides sieboldii*) had increases of nearly 5% and

2.7%, respectively, compared to their 20-year trends. Despite general decreases for the MHI deep sea handline fishery, there was an increase of almost 5% for catch per unit effort (CPUE) compared to the 20-year average. 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 lehi (*Aphareus rutilans*) catch and overall effort.

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 (47,912 lb) was 29% lower than its 10-year average and over 24% lower than its 20-year average, likely due to difficult fishing conditions, high incidence of depredation by sharks, and the near-compete losses of the hotel and restaurant industries due to COVID-19 restrictions in 2020. While catch was lower for uku relative to its historic averages, there was an increase in the number of licenses for fishermen catching uku by trolling with bait relative to the 20-year average. Otherwise, the number of licenses, the number of trips, pounds caught, and CPUE were lower than historical averages for all gear types harvesting uku in Hawaii.

The Hawaii coral reef ecosystem component fishery in 2020 had mixed trends, though most experienced declines in participation, catch, and effort relative to their historical averages. The most harvested ECS in 2020 were akule (*Selar crumenophthalmus*) and ‘opelu (*Decapterus macarellus*) followed by menpachi (*Myripristis* spp.), parrotfish (multi-species), ta‘ape (*Lutjanus kasmira*), and palani (*Acanthurus dussumieri*). In general, all 10 prioritized ECS (as selected by DAR) had reductions in the number of licenses fishing and the number of fishing trips taken. ‘Opihi (limpets), manini (*Acanthurus triostegus*), and ta‘ape had increases in the number caught relative to historical averages, but pounds caught is typically a more useful metric in identifying fishery performance. Of these species, only ta‘ape had increases in catch relative to the 10- and 20-year trends. It is of note, however, that many ECS fisheries were largely spared from the effects of COVID-19 restrictions since many species are purchased by locals for home consumption and catch for several species increased in 2020 relative to 2019.

In 2020, 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. However, it is of note that the two fisheries differ greatly in both their operation and catch trends and combining the CMUS to analyze fishery data may not be the most practical way to make inferences about the state of the individual contributing fisheries. In general, there were decreases in licenses, trips, and pounds caught for the combined crustacean fisheries relative to their short- and long-term averages. 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). While Kona crab harvested by loop net had decreases in catch (4,201 lb) and effort (42 trips) compared to its historical averages, CPUE (100.01 lb/trip) notably increased relative to its 10- and 20-year trends because catch did not decrease at the same level as effort. Data for other gear types were unavailable to report due to data confidentiality.

In addition to reported creel survey data estimates, federal logbook catch data were added to the report for the first time this year. In Hawaii, there were two federal special coral reef ecosystem permits and one non-commercial bottomfish permit issued in 2020, but there were no permits issued for the precious coral or crustacean fisheries. None of the federal permit holders reported any catch for the year.

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. For the first time in the 2020 annual SAFE report, a section on fishermen observations was added, detailing on-the-water observations from bottomfish fishermen in the State for the year. In addition, a special section was also added describing the impacts of COVID-19 on MHI archipelagic fisheries and fishing communities.

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 (PRIA), 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. However, no surveys were conducted in 2020 due to restrictions associated with COVID-19, so no new data were added to the summaries in this year's report relative to the 2019 report.

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 families and eight bottomfish species are presented. In 2020 for the MHI, age and growth parameters for uku were finalized and the publication is in press. Age and growth for *Etelis carbunculus* were finalized and the publication is in review. Reproduction parameters for *E. coruscans* was finalized and is in press, while age and growth for the species were published. Work on sex-specific growth parameters for *Pristipomoides filamentosus* is ongoing.

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 85% of the revenue, uku comprised 15%, and crustaceans comprised just 2%. While the total number of sales from commercial marine licenses (CMLs) has continuously declined since 2014, there were 306 CMLs that reported data to DAR in 2020, down from 403 in 2019. In the Hawaii Deep 7 bottomfish fishery, there were 142,486 lb sold in 2020 at an average adjusted price of $7.23/lb. for a revenue of $1,030,834. In the uku fishery, 37,530 lb were sold at an average adjusted price of $4.82/lb. for a revenue of $180,966. There were 3,521 lb of crustacean MUS sold at an average adjusted price of $7.61/lb. for a revenue of $26,795. For the top-ten harvested ECS in Hawaii, there were 505,044 lb sold for a revenue of $1,736,904, which was slightly more than the revenue and pounds sold for the top 10 species in 2019. Priority ECS in Hawaii had 137,329 lb sold for a revenue of $525,349, which was slightly less than the revenue and pounds sold for the same species in 2019.

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. In 2020, NMFS published a proposed rule to designate critical habitat for threatened coral species in the Western Pacific region (85 FR 76262, November 27, 2020). Also in 2020, it was determined that a designation of critical habitat for the oceanic whitetip shark is not prudent, as there are no areas within US jurisdiction that meet the definition of critical habitat. Lastly, in 2020, a draft recovery plan for the MHI insular distinct population segment false killer whale, and the final recovery plan is anticipated in 2021.

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 trend of atmospheric concentration of carbon dioxide (CO_2) is increasing exponentially with a time series maximum at 414 ppm in 2020. Since 1989, the oceanic pH at Station ALOHA in Hawaii has shown a significant linear decrease of -0.043 pH units, or roughly a 9.4% increase in acidity ([H+]) and was 8.06 in 2019. The Oceanic Niño Index, which is a measure of the El Niño – Southern Oscillation (ENSO) phase, transitioned from neutral to La Niña conditions in fall 2020. The Pacific Decadal Oscillation (PDO) was negative in 2020. The Accumulated Cyclone Energy (ACE) Index ($x10^4$ kt^2) was average in Eastern North Pacific and below average in the Central North Pacific. Annual mean sea surface temperature (SST) was 26.06 ºC in 2020, and the annual anomaly was 0.51 ºC hotter than average with some intensification in the northern part of the region. The MHI experienced little coral heat stress in 2020. Annual mean chlorophyll-*a* was 0.077 mg/m^3 in 2020, with an annual anomaly that was 0.0014 mg/m^3 lower than average. Precipitation in the MHI had monthly anomalies higher than average in the beginning of the year and negative anomalies in the second half of 2020. The relative trend in sea level rise in the Hawaiian Archipelago is 1.55 mm/year, equal to 0.51 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 was included. The EFH section is also meant to address any Council directives. At its 182nd meeting in June 2020, the Council requested that NMFS work with the Council to determine "non-essential" fish habitat to look at ways to remove areas that are degraded from being considered EFH.

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 for the offshore aquaculture facility owned by Forever Oceans is in the process renewing the permit cooperatively with NMFS. 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. In December 2020, BOEM put out a new call for recommendations on environmental studies regarding offshore wind facilities, and the Hawaii State Energy Office is facilitating and providing input on studies that could be conducted to mitigate impacts on various resources, including aquatic. The Honolulu Seawater Air Conditioning project was discontinued in late 2020 due to increasing costs. The next Rim of the Pacific (RIMPAC) multinational exercise was held in August 2020, but all activities were offshore due to concerns associated with COVID-19.

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 in 2020 was a list of recent relevant abstracts from publications associated with data integration topics. Previously, in 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 (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:

Regarding the development of the non-commercial modules in the annual SAFE report, the Archipelagic Plan Team:

1. Recommends the Council requests PIFSC analyze the fishery dependent data: 1) total estimated creel catch minus commercial receipts for non-commercial catch and 2) expand the creel intended sold and unsold; and determine which approach could be used for the non-commercial estimates in the annual SAFE reports. The progress of this work will determine if an intersessional meeting of the Archipelagic Plan Team is warranted and where non-commercial estimates may be incorporated into the SAFE reports, such as incorporating into an existing module or developing an additional module.

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

- PIFSC Fisheries Research and Monitoring Division (FRMD) to consult with National Oceanic and Atmospheric Administration (NOAA) General Counsel on the application of the data confidentiality rule on data that are expanded (i.e., in reference to the confidential nature of the Guam commercial data).
- PIFSC Stock Assessment Program and FRMD staff to work with DFW to investigate the effects of their staff turn-over on trends in fishery statistics.
- In finalizing the annual SAFE reports, the Annual SAFE Report Coordinator to incorporate the fishermen observations as a separate section of the Ecosystem Considerations chapter for each archipelago and explicitly note the source of the information.
- DAWR Plan Team members to note the months with missing catch interviews in 2020 due to COVID restrictions when finalizing the narrative for the Guam fishery performance section in the annual SAFE report. State and territorial management agencies to add caveats in terms of the limitations in the data for 2020 in their respective narratives. PIFSC FRMD will provide technical support for the individual agencies.
- The Plan Team to provide clarification on what it means and how to manage ECS.
- PIFSC FRMD and Socioeconomics Program to work with the territorial management agencies in documenting the COVID impacts to the fishery performance data and fishing communities for inclusion in the new special COVID section of the annual SAFE reports.
- Council and Pacific Islands Regional Office staff to continue to work with the PIFSC FRMD, the State of Hawaii, and territories to ensure that the bycatch summaries in the annual SAFE reports are consistent with standardized bycatch reporting methodology.

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

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
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
CMUS	Crustacean Management Unit Species
CNMI	Commonwealth of the Northern Mariana Islands
CO-OPS	Ctr for Operational Oceanographic Products and Services
Council	Western Pacific Regional Fishery Management Council
CPC	Climate Prediction Center
CPI	Consumer Price Index
CPUE	Catch per Unit Effort
CRED	Coral Reef Ecosystem Division
CREP	Coral Reef Ecosystem Program
CREMUS	Coral Reef Ecosystem Management Unit Species
CRW	Coral Reef Watch
CSF	Community Supported Fishery
DLNR	Department of Land and Natural Resources (Hawaii)
DAR	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
F	Fishing Mortality
FL	Fork Length
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
FR	Federal Register
FRMD	Fisheries Research and Monitoring Division
FRS	Fishing Report System
FTP	File Transfer Protocol
Fund	Western Pacific Sustainable Fisheries Fund
GAM	Generalized Additive Model
GIS	Geographic Information System
GLM	General Linear Modeling
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
H	Harvest
HAPC	Habitat Area of Particular Concern
HDAR	Hawaii Division of Aquatic Resources
HMRFS	Hawaii Marine Recreational Fishing Survey
HOT	Hawaii Ocean Time Series (UH)
HSEMA	Hancock Seamounts Ecosystem Management Area
HSTT	Hawaii-Southern California Training and Testing
HURL	Hawaii Undersea Research Laboratory
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

Acronym	Meaning
MFMT	Maximum Fishing Mortality Threshold
MHI	Main Hawaiian Islands
MI	Mobile Invertebrates
MLCD	Marine Life Conservation District
MMA	Marine Managed Area
MMPA	Marine Mammal Protection Act
MODIS	Moderate Resolution Imaging Spectroradiometer
MPA	Marine Protected Area
MPCC	Marine Planning and Climate Change
MPCCC	MPCC Committee
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
$N_{L\text{-}W}$	Sample Size for Length-Weigh Regression
NA	Not Applicable
NAF	No Active Fishery
NASA	National Aeronautics and Space Administration
NCADAC	National Climate Assessment and Development Advisory Cmte
NCDC	National Climatic Data Center
NCEI	National Centers for Environmental Information
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	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
ONI	Ocean Niño Index
OPI	OLR Precipitation Index
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
PIAFA	Pacific Insular Area Fishery Agreement

Acronym	Meaning
PIBHMC	Pacific Islands Benthic Habitat Mapping Center
PIFSC	Pacific Island Fisheries Science Center
PIRCA	Pacific Islands Regional Climate Assessment
PIRO	Pacific Islands Regional Office
PK	Planktivorous
PMEL	Pacific Marine Environmental Laboratory
PMUS	Pelagic Management Unit Species
POES	Polar Operational Environmental Satellite
PRIA	Pacific Remote Island Areas
RAMP	Reef Assessment and Monitoring Program
RIMPAC	Rim of the Pacific
ROD	Record of Decision
ROMS	Regional Ocean Modeling System
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
SDM	Species Distribution Model
Secretary	Secretary of Commerce
SEEM	Social, Economic, Ecological, Management (Uncertainty)
SEIS	Supplemental Environmental Impact Statement
SFD	Sustainable Fisheries Division
SLP	Sea Level Pressure
SOEST	School of Ocean and Earth Science and Technology
SPC	Stationary Point Count
SPR	Spawning Potential Ratio
SSC	Scientific and Statistical Committee
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

Acronym	Meaning
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 (DLNR), Division of Aquatic Resources (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 deepwater bottomfish: ʻōpakapaka (*Pristipomoides filamentosus*; pink snapper), onaga (*Etelis coruscans*; longtail snapper), ehu (*Etelis carbunculus*; ruby snapper), hapuʻupuʻu (*Epinephelus quernus*; Hawaiian grouper), kalekale (*Pristipomoides sieboldii*; Von Siebold's snapper), gindai (*Pristipomoides zonatus*; oblique-banded snapper), and lehi (*Aphareus rutilans*; silverjaw snapper).

The Deep-7 fishery is driven in large part by the traditional consumption of a whole red fish during the holiday season. Though Asian in origin, this practice is commonplace in local households of all ethnicities and seen by many as an essential element of gatherings during the holiday season. Local families will commonly consume red fish on both New Year's Day and Christmas. As a result, market price and demand both increase markedly around this time.

Management of the Deep-7 fishery is performed jointly by DAR, NMFS, and the Council. DAR collects the fishery information, NMFS analyzes this information, and the Council, working with DAR, proposes the management scheme. Lastly, NMFS implements the scheme into federal regulations before DAR 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 species complex occurs in both State and federal waters. The information in this report is largely based on DAR-collected data.

1.1.2 Dashboard Statistics

The collection of commercial MHI 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). Since federal management of the Deep-7 bottomfish fishery began in 2007, bottomfish landings have been collected on three types of fishing reports. Initially, bottomfish fishermen 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, after which bottomfish fishers were required to submit the trip report within five days of the trip end date. DAR implemented the OFR online website in February 2010.

Paper fishing reports received via mail 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 DAR. An 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 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 DAR 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.

1.1.2.1 Historical Summary

In 2020, all Deep-7 BMUS annual fishing parameters, including number of licenses, number of trips, number caught, and pounds caught, were below corresponding 10- and 20-year averages. In the DAR fishing report data, "caught" refers to all fish kept, whether for the purpose of commercial sale or personal consumption. It does not include releases or losses to depredation.

Table 1. Annual fishing parameters for the 2020 fishing year in the MHI Deep 7 bottomfish fishery compared with short-term (10-year) and long-term (20-year) averages

Fishery	Parameter	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep 7 BMUS	No. Licenses	334	↓ 15.4%	↓ 15.0%
	Trips	1,841	↓ 30.2%	↓ 32.4%
	No. Caught	45,860	↓ 33.2%	↓ 27.5%
	Lb Caught	161,437	↓ 33.8%	↓ 31.0%

1.1.2.2 Species Summary

For the deep-sea handline gear type, the number of licenses, number of trips, and pounds caught in 2020 were all below 10- and 20-year averages. Gear type CPUE was below the 10-year average, but above the 20-year average. Lehi was the only BMUS caught with deep-sea handline gear and had its 2020 catch higher than the 10-year average. Ehu, kalekale, and gindai catch in 2020 was higher than their 20-year averages.

For non-deep-sea handline gears, the number of licenses, pounds caught, and CPUE in 2020 were below their 10- and 20-year averages. Non-deep-sea handline trips in 2020 were above both the 10- and 20-year averages. In terms of species catch, lehi catch was above both its 10- and 20-year averages. All other species were either below average or their data could not be included to uphold fisher confidentiality.

Table 2. Annual fishing parameters by gear and species for the 2020 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	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep-Sea Handline	ʻŌpakapaka	63,601 lb	↓ 46.2%	↓ 42.8%
	Onaga	41,208 lb	↓ 33.7%	↓ 37.0%
	Ehu	24,954 lb	↓ 8.49%	↑ 4.89%
	Hapuʻupuʻu	5,592 lb	↓ 36.6%	↓ 36.4%
	Kalekale	11,041 lb	↓ 13.2%	↑ 2.65%
	Gindai	5,123 lb	↑ 60.2%	↑ 81.5%
	Lehi	7,338 lb	↓ 13.3%	↓ 13.3%
	No. Lic.	320	↓ 15.3%	↓ 14.0%
	No. Trips	1,696	↓ 32.9%	↓ 35.2%
	Lb Caught	158,856 lb	↓34.0%	↓ 31.3%
	CPUE	93.67 lb/trip	↓ 3.10%	↑ 4.73%
Non-Deep-Sea Handline Methods	ʻŌpakapaka	1,015 lb	↓ 30.0%	↓ 24.1%
	Onaga	103	-	↓ 21.4%
	Ehu	21	↓ 80.2%	↓ 87.5%
	Hapuʻupuʻu	n.d.	-	-
	Kalekale	25 lb	↓ 64.3%	↓ 75.7%
	Gindai	NULL	-	-
	Lehi	1,365 lb	↑ 34.0%	↑ 54.8%
	No. Lic.	26	↓ 21.2%	↓ 31.6%
	No. Trips	146	↑ 28.1%	↑ 33.9%
	Lb Caught	2,581 lb	↓ 8.70%	↓ 7.82%
	CPUE	17.68 lb/trip	↓ 29.0%	↓ 29.3%

NULL = no available data; n.d. = non-disclosure due to data confidentiality.

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. 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, the Deep-7 fishery was dominated by a relatively low number of highliners that consistently produced large landings. Prior to the ubiquity of small, relatively affordable watercraft and modern electronics, the fishery required both a high degree of seamanship and a large, well-equipped vessel at that time rarely owned by part-time or non-commercial fishers. In 1965, only 84 licensed fishers participated in this fishery. As the availability of modernized fishing boats increased in the 1970s and 1980s, so too did the number of fishers. In 1986, fishery participation peaked at 610 registered CML holders. With the expansion of the small vessel fleet, effort and landings increased accordingly and, in 1987, peaked at 596,255 pounds. In June 1993, concerns regarding the sustainability of the fishery prompted the State to establish bottomfish regulations including: bottomfish restricted fishing areas (BRFAs), vessel registration identification, and non-commercial bag limits. Since the implementation of federal Deep-7 bottomfish management, landings have been limited by an annual catch limit (ACL). 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 bottomfish fishing.

Following the peak and subsequent decline in catch in the late 1980s, the Deep-7 fishery had another brief increase in catch peaking in 2014. There are multiple likely causes of this recent increase in catch including the closure of the Northwest Hawaiian Islands (NWHI) in 2009, which resulted both in certain fishers moving effort into the MHI, and increased market demand to fill the void. Economic downturn and high unemployment rate associated with the recession during that period may have also led some to enter the fishery or increase effort to offset economic losses. In 2020, BMUS catch was well-below 10- and 20-year averages. COVID-19 did not affect the period of peak holiday demand as lockdown restrictions did not occur until March 2020. The near complete shutdown of the hotel and restaurant industries did however decrease demand drastically following the initial lockdown. Additionally, ongoing reports of high shark depredation, challenging environmental conditions, and atypical fish behavior likely contributed to the lowered catch.

Table 3. Time series of commercial fishing reports for Deep 7 BMUS reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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	12,945	195,039
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

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
1975	247	2,096	904	24,165	222,114
1976	308	2,321	1,011	26,364	258,852
1977	338	2,722	1,173	26,880	274,308
1978	434	2,657	1,539	41,381	307,628
1979	447	2,256	1,517	32,312	273,841
1980	461	2,861	1,435	35,098	244,075
1981	486	3,770	1,637	45,086	308,306
1982	450	3,909	1,630	46,873	329,436
1983	538	4,880	1,892	61,889	409,453
1984	555	4,483	1,806	55,952	345,326
1985	556	5,812	2,065	93,799	507,639
1986	610	5,823	2,285	101,469	524,726
1987	586	5,591	2,194	133,023	596,255
1988	553	6,058	2,135	138,109	575,345
1989	569	6,327	2,252	122,033	575,616
1990	531	5,258	1,948	90,745	459,215
1991	499	4,216	1,770	67,666	331,144
1992	488	4,511	1,845	84,427	362,517
1993.1	450	3,538	1,492	62,434	260,350
1993.2	120	373	167	7,280	28,519
1994	522	3,893	1,705	85,112	317,989
1995	526	3,919	1,711	77,776	319,940
1996	518	3,980	1,745	81,391	287,138
1997	500	4,181	1,760	81,594	297,678
1998	522	4,118	1,735	83,482	288,315
1999	433	3,012	1,431	56,755	214,180
2000	498	3,935	1,700	83,429	308,128
2001	458	3,570	1,550	70,812	262,874
2002	393	2,920	1,355	56,438	217,231
2003	364	2,959	1,255	63,311	248,463
2004	333	2,669	1,145	57,588	209,475
2005	352	2,705	1,200	61,406	241,173
2006	352	2,287	1,053	46,154	193,191
2007	357	2,553	1,148	50,008	204,862
2008	351	2,354	1,027	49,397	196,347
2009	478	3,283	1,479	67,065	259,356
2010	461	2,804	1,229	56,942	209,277
2011	474	3,490	1,432	74,886	274,571
2012	480	3,108	1,529	68,024	227,971
2013	459	2,990	1,501	68,441	239,010

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
2014	423	3,182	1,496	90,296	311,209
2015	411	2,890	1,415	90,790	307,014
2016	372	2,348	1,194	74,536	260,732
2017	340	2,351	1,162	66,483	237,879
2018	341	2,169	1,102	59,332	236,119
2019	318	2,021	1,043	47,837	180,859
2020	334	1,841	1,000	45,860	161,437
10-year avg.	**395**	**2,639**	**1,287**	**68,649**	**243,680**
20-year avg.	**393**	**2,725**	**1,266**	**63,280**	**233,953**

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

1.1.4 Preferred Targets by Gear Type

1.1.4.1 Deep-Sea Handline

Typically, almost all (~99%) of Deep-7 BMUS are caught using deep-sea handline gear. ‘Ōpakapaka is the most caught species, and typically makes up approximately 50% of all catch. Onaga, though a more valuable fish at market, is more difficult to catch than ‘ōpakapaka and usually makes up approximately 25% of the catch. Ehu, prized during the holiday season for its bright red color like onaga, is the third most caught species at approximately 10% of catch. Kalekale, gindai, hapu‘upu‘u, and lehi each typically make up less than 6% of the total Deep-7 catch.

Deep-7 species composition in 2020 varied slightly from the average with a relatively low (40%) contribution from ‘ōpakapaka. This is likely in part due to the challenges reported by fishers in 2020, which included difficulty in locating normal ‘ōpakapaka aggregations and poor bite. Conversely, the lesser caught ehu, kalekale, gindai, and lehi all increased in the proportion of catch in 2020. Most notably, gindai catch, which is typically less than 1% of the total catch, rose to 3.2% in 2020.

Table 4a. DAR 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 1994-2020

Year	‘Ōpakapaka		Onaga		Ehu		Hapu‘upu‘u	
	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb 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	19,871	58	11,304
1969	115	85,663	48	53,839	68	16,088	60	10,881
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

Year	ʻŌpakapaka		Onaga		Ehu		Hapuʻupuʻu	
	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught
1974	220	134,838	86	43,607	113	21,113	117	14,444
1975	199	114,571	94	45,016	115	21,705	108	23,078
1976	224	101,718	118	78,684	152	28,069	140	21,236
1977	255	98,398	100	82,049	144	32,530	130	26,769
1978	345	149,538	135	66,124	191	34,385	197	27,366
1979	306	140,303	133	51,601	190	20,859	184	28,053
1980	344	147,341	161	29,889	183	15,828	182	16,984
1981	386	193,944	153	42,659	207	20,754	188	16,056
1982	369	173,764	176	65,235	232	24,088	189	20,854
1983	421	226,614	240	71,687	277	27,482	209	31,849
1984	396	153,925	240	84,615	282	35,430	208	29,010
1985	442	202,822	297	172,774	310	43,928	253	33,098
1986	481	180,087	346	195,675	371	60,969	245	27,238
1987	459	263,468	291	175,365	323	45,963	180	32,699
1988	448	301,053	275	159,975	299	43,234	197	11,094
1989	440	309,112	305	147,724	322	42,916	187	15,442
1990	419	210,224	307	143,003	312	37,720	176	14,203
1991	384	136,764	276	104,294	300	31,943	168	16,528
1992	374	173,118	253	91,813	310	31,907	167	15,136
1993.1	346	138,613	194	52,634	256	23,926	167	13,180
1993.2	85	14,511	51	5,707	60	3,059	34	1,971
1994	393	176,151	243	71,564	290	22,903	191	10,766
1995	426	178,302	236	66,199	288	26,109	228	14,932
1996	415	147,093	244	67,985	276	28,892	220	10,110
1997	377	157,591	216	59,587	263	26,598	213	13,740
1998	386	145,776	250	68,926	299	25,154	215	11,933
1999	326	101,875	199	60,611	233	19,548	179	9,737
2000	386	166,747	251	70,984	282	26,804	209	13,084
2001	339	126,788	253	63,089	272	25,603	202	15,531
2002	291	105,788	200	60,699	223	17,029	167	8,844
2003	254	127,628	188	70,487	212	15,740	142	9,483
2004	233	88,099	186	76,519	193	20,571	130	8,255
2005	249	102,303	202	87,832	208	21,890	131	10,121
2006	245	76,968	203	75,063	206	17,980	123	7,442
2007	271	82,489	201	80,747	224	17,713	117	5,967
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	325	101,986	251	57,011	297	24,061	165	7,960

Year	ʻŌpakapaka		Onaga		Ehu		Hapuʻupuʻu	
	No. License	**Lb Caught**	**No. License**	**Lb Caught**	**No. License**	**Lb Caught**	**No. License**	**Lb Caught**
2011	369	147,813	258	67,652	306	24,191	176	7,973
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	151,223	228	78,006	271	33,080	138	9,934
2016	285	133,770	203	62,411	234	30,844	122	9,718
2017	266	133,898	173	46,100	223	24,226	127	7,714
2018	258	114,413	183	66,252	220	21,483	129	9,593
2019	210	67,226	158	60,266	218	24,918	107	6,328
2020	235	63,601	158	41,208	219	24,954	104	5,592
10-yr avg.	**293**	**118,226**	**210**	**62,151**	**260**	**27,270**	**138**	**8,825**
20-yr avg.	**288**	**111,094**	**211**	**65,430**	**247**	**23,790**	**143**	**8,793**

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

Table 4b. DAR 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 1994-2020

Year	Kalekale		Gindai		Lehi	
	No. License	**Lb Caught**	**No. License**	**Lb Caught**	**No. License**	**Lb 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	1,076	84	9,846
1977	96	7,590	66	1,143	81	6,644
1978	150	8,823	103	2,308	116	8,623
1979	126	6,602	89	2,505	114	10,076
1980	142	6,294	87	2,089	123	16,836
1981	152	7,377	108	1,654	143	19,282
1982	158	7,735	102	1,473	139	29,500

Year	Kalekale		Gindai		Lehi	
	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught
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	283	25,059	195	3,756	185	26,548
1987	263	28,154	144	3,328	214	37,503
1988	228	18,130	121	2,075	186	37,970
1989	219	11,053	132	1,830	230	45,170
1990	248	15,482	178	2,785	207	34,944
1991	245	18,874	189	3,644	166	18,970
1992	252	28,002	190	5,120	158	17,254
1993.1	245	16,954	153	3,765	154	11,177
1993.2	48	1,908	28	652	19	658
1994	236	20,252	176	4,062	129	11,987
1995	239	17,284	187	3,721	171	13,087
1996	266	19,561	156	3,159	134	9,523
1997	224	22,634	141	2,837	142	11,866
1998	239	23,084	176	3,260	150	8,701
1999	174	11,113	130	2,182	109	7,687
2000	217	15,973	170	3,215	149	10,654
2001	187	15,371	155	3,740	142	12,251
2002	155	11,036	134	2,308	114	10,896
2003	151	12,523	108	2,131	97	8,296
2004	127	7,584	96	2,085	73	3,779
2005	133	7,846	98	2,028	85	6,800
2006	139	5,262	97	1,516	74	5,643
2007	146	5,646	106	2,010	80	6,851
2008	126	5,320	119	2,424	106	9,748
2009	209	9,382	169	3,557	153	15,159
2010	211	7,926	157	2,677	104	5,270
2011	213	9,804	178	2,947	115	11,058
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	2,882	130	11,338
2016	177	12,832	125	1,843	97	7,591
2017	169	10,782	121	2,130	111	8,332
2018	174	11,882	118	2,611	102	7,329
2019	169	10,184	129	3,452	79	5,799

Year	Kalekale		Gindai		Lehi	
	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught
2020	194	11,041	155	5,123	81	7,338
10-yr avg.	**199**	**12,722**	**148**	**3,198**	**104**	**8,464**
20-yr avg.	**179**	**10,756**	**136**	**2,823**	**103**	**8,466**

1993.1 = Fiscal Year 1993; 1993.2 = July-August 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 occasionally harvest Deep-7 BMUS though they are typically not their primary targets. The inshore handline gear is intended to be a lighter tackle than the deep-sea handline. Though it is possible to catch Deep-7 with inshore handline gear, it is likely that some of the landings were made with the heavier tackle gear but were reported incorrectly as inshore handline. Palu ahi is a tuna handline gear primarily used during the day with a drop stone or weight and chum. The target species are ahi, which include yellowfin and bigeye tuna. Deep-7 BMUS are common bycatch for Hawaiʻi Island fishers that regularly use the palu ahi method. Some of the landings may have been taken by bottomfish fishermen who used deep-sea handline tackle but reported it as palu ahi because of the gear definition, which also involves weights and chum on a handline. In the event that DAR personnel suspect that incorrect gear types may have been recorded, fishers are contacted for verification. The fishing reports are not amended if the fisher does not respond.

The two Deep-7 species most caught with non-deep-sea handline gears are ʻōpakapaka and lehi, both of which are known to be found in relatively shallower waters. ʻŌpakapaka are also the most targeted of the Deep-7 species. It is likely that some of the ʻōpakapaka caught with non-deep-sea handline gears are actually being targeted either with non-deep-sea handline gears or incorrectly reported deep-sea handline gear. Non-deep-sea handline gears in the past 20 years make up approximately 1% of all Deep-7 catch. Though there has been some increase in the catch of Deep-7 using these gears, it does not appear that another dominant method is gaining popularity.

Table 5a. DAR 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 1994-2020

Year	ʻŌpakapaka		Onaga		Ehu		Hapuʻupuʻu	
	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught
1965	18	662	n.d.	n.d.	11	222	3	37
1966	7	756	n.d.	n.d.	7	537	NULL	NULL
1967	3	263	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.

Year	ʻŌpakapaka		Onaga		Ehu		Hapuʻupuʻu	
	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught
1970	3	152	NULL	NULL	NULL	NULL	n.d.	n.d.
1971	7	108	6	57	5	26	n.d.	n.d.
1972	5	428	n.d.	n.d.	3	26	5	72
1973	7	159	n.d.	n.d.	3	37	4	17
1974	8	375	NULL	NULL	n.d.	n.d.	6	181
1975	23	1,613	3	38	6	214	10	123
1976	41	3,771	18	1,550	40	3,210	38	1,163
1977	77	7,927	21	2,704	41	3,218	36	3,345
1978	68	5,104	14	381	42	1,319	29	1,241
1979	106	5,708	21	1,426	63	1,632	61	1,503
1980	54	3,715	32	1,455	36	1,170	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	5,382	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	3	45	NULL	NULL	NULL	NULL	8	144
1996	7	262	NULL	NULL	n.d.	n.d.	10	129
1997	12	360	3	20	5	576	7	785
1998	12	799	n.d.	n.d.	3	37	7	68
1999	10	164	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2000	10	148	NULL	NULL	n.d.	n.d.	3	19
2001	10	110	3	37	5	104	4	53
2002	7	200	n.d.	n.d.	3	71	3	62
2003	27	1,025	4	136	8	220	7	100
2004	30	1,283	6	100	11	129	8	188
2005	22	938	3	200	8	255	5	132
2006	21	1,787	4	344	6	121	4	93

Year	ʻŌpakapaka		Onaga		Ehu		Hapuʻupuʻu	
	No. License	**Lb Caught**	**No. License**	**Lb Caught**	**No. License**	**Lb Caught**	**No. License**	**Lb Caught**
2007	23	1,459	5	169	6	447	3	468
2008	20	2,118	3	62	4	412	4	370
2009	29	2,581	8	260	13	270	7	209
2010	35	757	5	201	20	271	10	203
2011	28	1,634	4	125	14	318	8	260
2012	23	540	NULL	NULL	3	59	n.d.	n.d.
2013	26	1,417	n.d.	n.d.	3	141	3	63
2014	25	1,262	3	35	5	30	n.d.	n.d.
2015	22	1,647	3	62	5	183	n.d.	n.d.
2016	16	954	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
2020	17	1,015	4	103	3	21	n.d.	n.d.
10-yr avg.	**22**	**1,449**	**n.d.**	**n.d.**	**5**	**106**	**3**	**87**
20-yr avg.	**22**	**1,337**	**3**	**131**	**7**	**168**	**4**	**137**

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

Table 5b. DAR 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 1994-2020

Year	Kalekale		Gindai		Lehi	
	No. License	**Lb Caught**	**No. License**	**Lb Caught**	**No. License**	**Lb 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	3	19
1968	n.d.	n.d.	NULL	NULL	NULL	NULL
1969	3	26	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	3	22
1973	7	13	n.d.	n.d.	3	32
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

Year	Kalekale		Gindai		Lehi	
	No. License	Lb Caught	No. License	Lb Caught	No. License	Lb Caught
1978	36	1,003	34	245	43	1,168
1979	71	1,152	33	378	58	2,043
1980	25	753	27	305	33	690
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	3	4	18	1,158
1987	13	402	3	18	16	1,193
1988	8	129	3	6	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	3	22	NULL	NULL	n.d.	n.d.
1995	n.d.	n.d.	NULL	NULL	6	92
1996	5	32	3	62	13	253
1997	7	650	5	91	22	345
1998	5	205	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	3	79	4	34
2002	5	113	n.d.	n.d.	6	159
2003	6	110	4	40	18	545
2004	7	51	3	66	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	3	404	20	1,295
2009	12	316	6	90	32	1,748
2010	15	160	12	64	24	731
2011	11	185	10	153	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

Year	Kalekale		Gindai		Lehi	
	No. License	**Lb Caught**	**No. License**	**Lb Caught**	**No. License**	**Lb Caught**
2015	7	35	3	18	20	948
2016	n.d.	n.d.	n.d.	n.d.	12	597
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.	25	1,154
2020	3	25	NULL	NULL	15	1,365
10-year avg.	**6**	**70**	**3**	**29**	**19**	**1,019**
20- year avg.	**7**	**103**	**4**	**65**	**19**	**882**

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

1.1.5 Catch Parameters by Gear Type

Deep-sea handline CPUE has decreased markedly since the expansion of the small boat fleet in the 1970s and 1980s. During that period, the number of fishers and trips using deep-sea handline gear increased rapidly as new technology and availability of reliable fishing vessels increased. Despite the boom in participation and effort, new entrants into the fishery were not as savvy as the established full-time highliners and caught far fewer fish per trip. Following the expansion of the small boat fleet, deep-sea handline CPUE has remained relatively stable with a slight increase between 1998 and 2020.

Non-deep-sea handline catch parameters have stayed relatively consistent throughout the time series compared to those of deep-sea handline gear. Licenses, trips, and pounds caught showed the most notable increases coinciding with the expansion of the small boat fleet in the 1970s and 1980s. Presumably, this was due to the rapid increase in fishers using other methods like tuna handline that often catch Deep-7 incidentally. CPUE for non-deep-sea handline gears has fluctuated over the time series while staying consistently below that of deep-sea handline.

Table 6. DAR MHI annual Deep 7 CPUE (lb/trip) by dominant fishing methods reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2020

Year	Deep-Sea Handline				Non-Deep-Sea Handline Gears			
	No. Lic.	**No. trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lb 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	194,682	167.11	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

Year	Deep-Sea Handline				Non-Deep-Sea Handline Gears			
	No. Lic.	No. trips	Lb Caught	CPUE	No. Lic.	No. trips	Lb Caught	CPUE
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	2,040	219,663	107.68	39	62	2,451	39.53
1976	272	2,062	248,191	120.36	92	269	10,661	39.63
1977	290	2,263	255,123	112.74	105	461	19,185	41.62
1978	392	2,365	297,167	125.65	145	351	10,461	29.80
1979	379	1,901	259,999	136.77	187	380	13,842	36.43
1980	412	2,594	235,261	90.69	123	304	8,814	28.99
1981	456	3,459	301,726	87.23	105	342	6,580	19.24
1982	428	3,680	322,649	87.68	97	276	6,787	24.59
1983	500	4,574	401,799	87.84	142	363	7,654	21.09
1984	505	4,176	334,097	80.00	161	383	11,229	29.32
1985	538	5,682	504,875	88.86	44	138	2,764	20.03
1986	587	5,638	519,332	92.11	99	203	5,394	26.57
1987	567	5,431	586,480	107.99	65	164	9,775	59.60
1988	537	5,980	573,531	95.91	50	85	1,814	21.34
1989	541	6,229	573,247	92.03	68	107	2,369	22.14
1990	526	5,239	458,361	87.49	8	19	854	44.95
1991	492	4,198	331,017	78.85	11	21	127	6.05
1992	483	4,488	362,350	80.74	7	23	167	7.26
1993.1	445	3,525	260,249	73.83	8	13	101	7.77
1993.2	119	371	28,466	76.73	n.d.	n.d.	n.d.	n.d.
1994	515	3,871	317,685	82.07	13	25	304	12.16
1995	517	3,895	319,634	82.06	17	24	306	12.75
1996	504	3,930	286,321	72.86	34	55	816	14.84
1997	481	4,111	294,852	71.72	44	83	2,826	34.05
1998	506	4,049	286,833	70.84	35	79	1,482	18.75
1999	416	2,919	212,752	72.89	36	101	1,428	14.14
2000	492	3,886	307,460	79.12	28	50	668	13.35
2001	446	3,529	262,372	74.35	25	45	503	11.17
2002	384	2,885	216,599	75.08	22	38	632	16.63
2003	344	2,855	246,288	86.27	45	107	2,174	20.32
2004	303	2,550	206,893	81.13	48	122	2,582	21.16
2005	319	2,595	238,820	92.03	51	111	2,353	21.20
2006	323	2,176	189,873	87.26	43	111	3,318	29.89
2007	335	2,438	201,422	82.62	40	118	3,440	29.15
2008	329	2,250	191,475	85.10	34	104	4,872	46.84

Year	Deep-Sea Handline				Non-Deep-Sea Handline Gears			
	No. Lic.	No. trips	Lb Caught	CPUE	No. Lic.	No. trips	Lb Caught	CPUE
2009	450	3,133	253,883	81.04	61	153	5,474	35.78
2010	422	2,679	206,891	77.23	67	128	2,386	18.64
2011	450	3,387	271,438	80.14	47	104	3,133	30.13
2012	465	3,007	226,219	75.23	32	102	1,752	17.17
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	304,085	109.30	33	109	2,929	26.87
2016	360	2,266	259,009	114.30	23	82	1,723	21.01
2017	325	2,226	233,181	104.75	34	126	4,698	37.28
2018	328	2,075	233,562	112.56	25	94	2,557	27.21
2019	299	1,898	178,173	93.87	38	125	2,686	21.49
2020	320	1,696	158,856	93.67	26	146	2,581	17.68
10-year avg.	**378**	**2,526**	**240,853**	**96.67**	**33**	**114**	**2,827**	**24.90**
20- year avg.	**372**	**2,618**	**231,152**	**89.44**	**38**	**109**	**2,800**	**24.99**

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

1.1.6 Bycatch Summary

Bycatch for BMUS is generally low due to no restrictions on size (statewide) or daily bag limit (for commercial catch). The increase in percent bycatch beginning in 2007 and peaking in 2013 is due primarily to tagging efforts by the Pacific Islands Fisheries Science Center (PIFSC) and Pacific Islands Fisheries Group (PIFG) during that time. Tagging was performed by local fishers with CMLs, so all catch including Deep-7 caught and released for research purposes was included in their reports. In 2020, percent bycatch for the Deep-7 fishery is below 10- and 20-year averages due primarily to a decrease in the amount of tagging activity reported by CML holders.

Table 7. Time series of commercial fishing bycatch for Deep 7 BMUS reported by Fishing Year from 2002-2020

Year	No. Lic.	No. Trips	No. Reports	No. Caught	No. Released	Percent Bycatch
2002	393	2,920	1,355	56,438	3	0.0053
2003	364	2,959	1,255	63,311	217	0.3416
2004	333	2,669	1,145	57,588	117	0.2028
2005	352	2,705	1,200	61,406	156	0.2534
2006	352	2,287	1,053	46,154	55	0.1190
2007	357	2,553	1,148	50,008	535	1.0585
2008	351	2,354	1,027	49,397	542	1.0853
2009	478	3,283	1,479	67,065	507	0.7503
2010	461	2,802	1,229	56,942	1,102	1.8986

Year	No. Lic.	No. Trips	No. Reports	No. Caught	No. Released	Percent Bycatch
2011	474	3,456	1,432	74,886	2,098	2.7252
2012	480	3,108	1,529	68,024	1,420	2.0448
2013	459	2,990	1,501	68,441	2,010	2.8530
2014	423	3,182	1,496	90,296	1,474	1.6062
2015	411	2,890	1,415	90,790	1,378	1.4951
2016	372	2,348	1,194	74,536	733	0.9738
2017	340	2,351	1,162	66,483	411	0.6144
2018	341	2,169	1,102	59,332	440	0.7361
2019	318	2,021	1,043	47,837	630	1.2999
2020	334	1,841	1,000	45,860	206	0.4472
10-year avg.	**395**	**2,636**	**1,287**	**68,649**	**1,080**	**1.4796**
20-year avg.	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

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

1.2.1 Fishery Descriptions

The uku (*Aprion virescens*), or green jobfish, is a valued food fish in Hawaii and prized by both commercial and non-commercial fishers. Once a member of the non-Deep-7 BMUS complex, uku were previously grouped with the white/giant ulua (*Caranx ignobilis*), gunkan/black ulua (*Caranx lugubris*), butaguchi/pig-lip ulua (*Pseudocaranx dentex*), and yellowtail kalekale (*Pristipomoides auricilla*) before being removed due to the recent ecosystem component species (ECS) amendment to the Hawaii FEP in 2019 (84 FR 2767, February 8, 2019).

As a food fish, uku are regarded similarly as ʻōpakapaka, onaga, and other Deep-7 for their firm and flavorful white meat. Unlike Deep-7, uku are not typically used to fill the seasonal demand for whole fish during the holiday season due to a preference for red color. Outside of the holiday demand, uku are commonly consumed by the hotel and restaurant industries that take advantage of the low-price alternative to Deep-7 BMUS. Uku can be found across a wide range of depths and are commonly caught with a diverse array of fishing gears. Uku are typically targeted most heavily in May and June of each year, though some fishers catch them year-round in relatively high numbers.

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 fishery, 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 calendar 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 8. Annual fishing parameters for 2020 in the MHI uku fishery compared with short-term (10-year) and long-term (20-year) averages

Fishery	Parameter	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Uku	No. License	252	↓ 29.0%	↓ 24.3%
	Trips	1,024	↓ 36.2%	↓ 29.6%
	No. Caught	5,937	↓ 52.5%	↓ 43.7%
	Lb Caught	47,912	↓ 52.6%	↓ 45.2%

1.2.2.2 Gear Summary

Excluding the number of CMLs using the Troll with Bait gear type, all other parameters were below their 10- and 20-year average values in 2020.

Table 9. Annual fishing parameters for 2020 in the MHI uku fishery compared with short-term (10-year) and long-term (20-year) averages

Method	Species/ Fishery Indicator	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep-Sea Handline	No. Lic.	120	↓ 30.2%	↓ 30.2%
	No. Trips	400	↓ 44.3%	↓ 44.4%
	Lb Caught	26,361 lb	↓ 57.3%	↓ 53.6%
	CPUE	65.90 lb/trip	↓ 23.3%	↓ 15.1%
Inshore Handline	No. Lic.	32	↓ 47.5%	↓ 55.6%
	No. Trips	218	↓ 30.6%	↓ 27.3%
	Lb Caught	7,927 lb	↓ 47.8%	↓ 38.7%
	CPUE	36.36 lb/trip	↓ 25.1%	↓ 14.7%
Troll with Bait	No. Lic.	29	↓ 19.4%	↑ 7.41%
	No. Trips	108	↓ 32.5%	↓ 12.9%
	Lb Caught	4,132 lb	↓ 45.5%	↓ 38.8%
	CPUE	38.26 lb/trip	↓ 18.8%	↓ 30.9%
All Other Gears	No. Lic.	107	↓ 29.6%	↓ 11.6%
	No. Trips	298	↓ 30.2%	↓ 6.58%
	Lb Caught	9,492 lb	↓42.5%	↓ 16.3%
	CPUE	31.85 lb/trip	↓ 17.9%	↓ 5.52%

1.2.3 Time Series Statistics

1.2.3.1 Commercial Fishing Parameters

Uku catch spiked drastically in 1989. Though effort and participation also increased during the same time, local fishers have reported that the increase in catch was due to a sudden appearance of abundant adult uku into Hawaiian waters. Following the 1989 peak, catch quickly decreased to a low in 1996. Between 2003 and 2017, uku catch increased steadily likely due to multiple factors. Prior to 2010, a large proportion (occasionally the majority) of all uku landed annually in the State were caught in the NWHI. Following the NWHI closure 2009, some fishers moved effort down into the MHI. MHI fishers also likely took advantage of the high market demand left by the void in catch. After multiple initial closures of the Deep-7 fishery due to exceedance of the ACL, some Deep-7 bottomfish fishermen switched to targeting uku as an alternative, further developing the fishery. Increasing market demand, especially to supply the hotel and restaurants, has also been suggested as a cause of the recent increase in catch. Between 2003 and 2018, average price per pound (adjusted for inflation) offered by registered dealers showed persistent increase. Lastly, economic downturn and increased unemployment caused by the recession starting in 2007 may have influenced new entrants into the fishery and/or more effort by existing fishers in attempts to offset economic losses. Between 2018 and 2020 however, uku catch broke from the upward trend. In 2020, the number of licenses, trips, number of reports, number caught, and pounds caught were all below 10- and 20-year averages. Difficult fishing conditions, high incidence of depredation by sharks, and the near-compete losses of the hotel and restaurant industries due to COVID-19 restrictions in 2020 are thought to the primary contributing factors to the recent decline in catch.

Table 10. Time series of commercial fishing reports for uku by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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	245	1,093	612	2,643	47,094
1978	376	1,569	1,038	4,460	94,798
1979	381	1,346	1,037	4,832	82,747
1980	362	1,488	902	5,150	63,714
1981	392	2,117	1,107	7,950	95,027
1982	384	1,994	1,107	7,664	92,871
1983	410	2,653	1,321	10,853	121,498
1984	423	2,389	1,202	12,471	141,601
1985	387	1,878	1,017	8,867	96,014
1986	307	1,346	741	4,767	67,695
1987	326	1,353	776	7,275	87,805
1988	423	2,454	1,157	14,100	185,689
1989	477	3,032	1,523	27,108	314,285
1990	454	2,205	1,267	11,720	139,387
1991	403	1,824	1,081	9,596	117,084
1992	384	1,702	1,003	8,640	93,561
1993.1	336	1,327	798	6,080	65,925
1993.2	230	696	420	2,816	34,463
1994	355	1,457	867	5,960	73,286
1995	339	1,304	789	6,131	60,128
1996	360	1,320	887	6,234	53,346

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
1997	420	1,705	1,006	8,099	68,003
1998	366	1,455	890	6,992	61,147
1999	379	1,493	908	11,129	90,992
2000	383	1,546	923	10,820	83,341
2001	303	1,197	768	6,749	59,095
2002	276	1,040	671	6,788	59,347
2003	282	1,028	670	5,446	46,440
2004	319	1,291	772	8,751	76,338
2005	302	1,170	741	7,891	65,242
2006	259	1,186	673	6,852	61,152
2007	280	1,265	717	8,390	69,105
2008	318	1,486	812	11,298	92,576
2009	371	1,479	906	10,091	88,196
2010	407	1,924	1,075	13,660	121,046
2011	383	1,700	986	13,048	109,432
2012	407	1,754	1,075	13,600	116,395
2013	395	1,814	1,054	14,052	121,476
2014	379	1,679	1,004	11,687	97,003
2015	417	1,846	1,085	12,882	101,897
2016	378	1,915	1,051	15,133	118,622
2017	363	1,775	1,018	17,503	132,710
2018	286	1,235	746	10,145	75,250
2019	286	1,295	793	11,106	90,016
2020	252	1,024	622	5,937	47,912
10-year avg.	**355**	**1,604**	**943**	**12,509**	**101,071**
20-year avg.	**333**	**1,455**	**862**	**10,550**	**87,463**

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

1.2.4 Catch Parameters by Gear

The dominant gear type used to target uku is the deep-sea handline. However, since 1965 proportional catch using deep-sea handline gear has decreased as other gears become more commonly reported. This may be indicative of a shift away from uku being caught primarily as incidental catch by the Deep-7 fishery, which uses almost entirely the deep-sea handline gear type, to a species being targeted intentionally. Fishers moving to target uku specifically have in some cases modified their gears and techniques, and as a result some have chosen to report as different methods. While some fishers have chosen to redefine their gear as inshore handline to reflect lighter gear weight, others have chosen to move away from the handline designation entirely and report instead with other gears, most notably casting (included in the below table as "All Other Gear Types").

Despite changes in how fishers define their gear, CPUE for all major gear types has been increasing since the late 1970s and early 1980s. This again may be an indication of uku shifting from a largely incidentally caught species to one that is commonly targeted with specialized gears and techniques. CPUE in recent years, including 2020, has been low for all predominant gears, again likely due to adverse fishing condition, shark depredation, and COVID-19 restrictions.

Table 11. Time series of uku CPUE (lb/trip) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	Deep-Sea Handline				Inshore Handline				Troll with Bait				All Other Gear Types			
	No. Lic.	No. Trips	Lb Caught	CPUE	No. Lic.	No. Trips	Lb Caught	CPUE	No. Lic.	No. Trips	Lb Caught	CPUE	No. Lic.	No. Trips	Lb 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	12.5	NULL	NULL	NULL	NULL	6	53	408	7.7
1967	101	683	63,303	92.68	4	5	554	110.8	NULL	NULL	NULL	NULL	9	46	358	7.78
1968	104	510	51,715	101.4	8	13	345	26.54	NULL	NULL	NULL	NULL	8	48	302	6.29
1969	107	615	52,824	85.89	3	3	24	8	NULL	NULL	NULL	NULL	11	98	1,291	13.17
1970	115	633	48,645	76.85	3	4	20	5	NULL	NULL	NULL	NULL	10	94	1,129	12.01
1971	133	548	48,038	87.66	3	4	25	6.25	NULL	NULL	NULL	NULL	5	56	355	6.34
1972	154	663	53,336	80.45	3	3	12	4	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	8.6
1974	216	969	72,132	74.44	7	10	158	15.8	NULL	NULL	NULL	NULL	21	61	665	10.9
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	187	716	36,177	50.53	60	211	7,792	36.93	NULL	NULL	NULL	NULL	49	166	3,125	18.83
1978	303	1,097	75,501	68.82	134	298	14,348	48.15	NULL	NULL	NULL	NULL	49	181	4,949	27.34
1979	248	857	67,218	78.43	211	431	12,673	29.4	NULL	NULL	NULL	NULL	26	70	2,856	40.8
1980	290	1,196	57,753	48.29	71	113	1,836	16.25	NULL	NULL	NULL	NULL	78	181	4,125	22.79
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	354	1,752	88,334	50.42	43	64	582	9.09	NULL	NULL	NULL	NULL	40	180	3,955	21.97
1983	368	2,451	115,347	47.06	46	67	581	8.67	NULL	NULL	NULL	NULL	56	141	5,570	39.5
1984	381	2,152	134,986	62.73	53	76	1,169	15.38	NULL	NULL	NULL	NULL	69	166	5,446	32.81
1985	361	1,785	94,464	52.92	4	4	207	51.75	NULL	NULL	NULL	NULL	33	89	1,343	15.09
1986	270	1,220	63,788	52.29	22	52	2,323	44.67	NULL	NULL	NULL	NULL	47	75	1,584	21.12
1987	247	988	61,460	62.21	91	245	11,695	47.73	NULL	NULL	NULL	NULL	53	120	14,650	122.08
1988	350	2,091	167,959	80.32	91	186	10,401	55.92	NULL	NULL	NULL	NULL	59	177	7,329	41.41

Year	Deep-Sea Handline				Inshore Handline				Troll with Bait				All Other Gear Types			
	No. Lic.	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**
1989	424	2,667	298,435	111.9	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	189	14,031	74.24
1991	322	1,427	103,311	72.4	106	236	4,719	20	NULL	NULL	NULL	NULL	75	165	9,054	54.87
1992	281	1,119	68,813	61.5	127	441	18,850	42.74	NULL	NULL	NULL	NULL	73	144	5,898	40.96
1993.1	222	808	54,507	67.46	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	1,026	59,416	57.91	93	275	11,415	41.51	NULL	NULL	NULL	NULL	74	158	2,455	15.54
1995	249	931	52,322	56.2	76	222	4,836	21.78	NULL	NULL	NULL	NULL	78	152	2,970	19.54
1996	223	743	41,024	55.21	140	400	8,612	21.53	NULL	NULL	NULL	NULL	87	179	3,710	20.73
1997	231	912	47,676	52.28	189	634	17,575	27.72	NULL	NULL	NULL	NULL	87	161	2,752	17.09
1998	224	771	44,129	57.24	146	550	14,049	25.54	NULL	NULL	NULL	NULL	69	134	2,970	22.16
1999	236	836	76,039	90.96	153	508	11,700	23.03	NULL	NULL	NULL	NULL	61	150	3,253	21.69
2000	246	914	67,280	73.61	143	485	12,948	26.7	NULL	NULL	NULL	NULL	71	148	3,113	21.03
2001	185	700	38,547	55.07	115	356	15,369	43.17	NULL	NULL	NULL	NULL	62	143	5,179	36.22
2002	176	618	44,885	72.63	81	279	9,765	35	9	17	404	23.74	69	127	4,294	33.81
2003	141	576	31,930	55.43	78	209	6,454	30.88	17	67	4,674	69.75	86	177	3,382	19.11
2004	155	721	56,942	78.98	94	307	7,871	25.64	23	93	7,395	79.52	86	170	4,130	24.3
2005	164	655	46,370	70.79	71	217	5,378	24.78	18	90	6,768	75.2	89	209	6,726	32.18
2006	147	665	39,997	60.15	51	230	9,554	41.54	12	76	6,171	81.2	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	40.7	17	123	10,962	89.12	95	220	5,480	24.91
2009	205	845	66,618	78.84	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	367	17,152	46.74	31	118	5,890	49.92	135	373	14,370	38.53
2011	206	868	76,826	88.51	96	401	18,232	45.47	28	114	4,076	35.75	140	319	10,298	32.28
2012	206	767	75,310	98.19	90	409	19,789	48.38	32	146	5,778	39.57	144	435	15,518	35.67
2013	184	799	76,271	95.46	80	332	18,964	57.12	44	218	7,945	36.44	169	470	18,297	38.93

Year	Deep-Sea Handline				Inshore Handline				Troll with Bait				All Other Gear Types			
	No. Lic.	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**
2014	163	715	56,801	79.44	67	276	12,156	44.04	45	196	8,259	42.14	167	492	19,788	40.22
2015	178	779	65,083	83.55	64	346	12,591	36.39	49	172	6,344	36.88	200	550	17,879	32.51
2016	181	823	73,387	89.17	59	308	11,518	37.39	33	222	12,721	57.3	173	565	20,997	37.16
2017	201	900	85,542	95.05	45	318	16,954	53.32	35	151	13,717	90.84	153	409	16,496	40.33
2018	138	469	34,014	72.52	34	273	17,363	63.6	27	132	7,404	56.09	140	363	16,469	45.37
2019	145	529	48,327	91.36	38	259	16,460	63.55	41	142	5,390	37.95	131	370	19,840	53.62
2020	120	400	26,361	65.9	32	218	7,927	36.36	29	108	4,132	38.26	107	298	9,492	31.85
10-yr avg.	**172**	**705**	**61,792**	**85.92**	**61**	**314**	**15,195**	**48.56**	**36**	**160**	**7,577**	**47.12**	**152**	**427**	**16,507**	**38.79**
20-yr avg.	**172**	**720**	**56,778**	**77.62**	**72**	**300**	**12,932**	**42.62**	**27**	**124**	**6,754**	**55.39**	**121**	**319**	**11,336**	**33.71**

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.

1.2.5 Bycatch Summary

Uku bycatch is relatively low since the only regulation limiting commercial catch is a one-pound minimum size. Uku less than one pound can be retained for personal consumption. Percent bycatch since 2002 has seen steady increase through 2020. One possible explanation for this is the increase in the use of inshore handline gear. In the past ten years, inshore handline gear made about 16% of the total uku catch. In terms of releases though, inshore handline gear produced a disproportionately high average of about 51% of all uku releases over the same period. Potentially due to the lighter gear being used in inshore waters where small or undersized uku are more prevalent, the increase in percent bycatch may be linked to the increase in inshore handline use. Peak uku bycatch in 2020 is likely also the result of COVID-19 restrictions limiting market demand. Individual fishers have noted that during the heaviest periods of lockdown, local dealers were drastically limiting the amount of uku they were willing to purchase per day.

Table 12. Time series of commercial fishing bycatch for uku reported by Calendar Year from 2002-2020

Year	No. Lic.	No. Trips	No. Reports	No. Caught	No. Released	Percent Bycatch
2002	276	1,040	671	6,788	12	0.1765
2003	282	1,028	670	5,446	2	0.0367
2004	319	1,291	772	8,751	44	0.5003
2005	302	1,170	741	7,891	12	0.1518
2006	259	1,186	673	6,852	27	0.3925
2007	280	1,265	717	8,390	13	0.1547
2008	318	1,486	812	11,298	27	0.2384
2009	371	1,479	906	10,091	52	0.5127
2010	407	1,924	1,075	13,660	81	0.5895
2011	383	1,695	986	13,048	148	1.1216
2012	407	1,753	1,075	13,600	132	0.9613
2013	395	1,811	1,054	14,052	134	0.9446
2014	379	1,678	1,004	11,687	169	1.4254
2015	417	1,844	1,085	12,882	208	1.5890
2016	378	1,909	1,051	15,133	154	1.0074
2017	363	1,770	1,018	17,503	100	0.5681
2018	286	1,222	746	10,145	119	1.1594
2019	286	1,283	793	11,106	171	1.5164
2020	252	1,019	622	5,937	144	2.3680
10-year avg.	**355**	**1,598**	**943**	**12,509**	**148**	**1.2661**
20-year avg.	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

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, February 8, 2019). This amendment reduced 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.

Representing continued effort to monitor ECS, a one-year reflection of the top ten harvested ECS (by weight) is included in this report. Additionally, DAR selected ten species reclassified as ECS that are still of priority to the State for regular monitoring. These prioritized ECS species are ʻopihi (*Cellana* spp.; limpet), ula (*Panulirus* spp.; spiny lobster), kūmū (*Parupeneus porphyreus*; whitesaddle goatfish), omilu (*Caranx melampygus;* bluefin trevally), uhu (family Scaridae; parrotfish), he’e (*Octopus cyanea*; day tako), kala (*Naso* spp.; horned unicornfish), nenue (*Kyphosus* spp.; chubs), manini (*Acanthurus triostegus*; convict tang), and taʻape (*Lutjanus kasmira*; bluestripe snapper). Time series of commercial fishing reports for these species are included in this report. 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), which 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. DAR can also use fisheries independent data (e.g., in-water surveys) to obtain density and abundance estimates for these ten species and other ECS.

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 calendar 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.

In terms of catch parameters (pieces and pounds), the reliability of each can vary depending on the size, quantity, and collection techniques associated each species. Pieces caught is generally seen as less accurate of a measure of catch in that some fishers have a practice of providing only a rough estimate of number or occasionally omit this information altogether. This is especially common in species that are small in size and/or caught in large quantities. Whereas counting small and/or numerous catches is time consuming, weighing is simple and ensures that dealer records (which rely on weight as a primary measure of purchase) will be similar to what is reported on fishing reports. In most cases, DAR recommends using weight over pieces as a measure of catch.

1.3.2.1 2020 Most Harvested ECS

As usual, akule dominated 2020 ECS fisheries. Akule are consistently the top species harvested in the MHI due to their ability to be caught in large quantities with net gear types and the persistent high demand from local markets. Between years, the top-10 ECS ranking commonly changes in composition as fishing activity, including the activity of specific highliners, changes. This is exemplified by the recent appearance of kahala in the top-10 ECS in the past five years. Kahala catch, which primarily occurs incidentally using deep-sea handline gear, has been relatively consistent over the past 10 years in comparison to many inshore net-based fisheries, which have seen decline during the same period. In this case, kahala has moved into the top-10 because of a shift away from other inshore fisheries, not an increase in catch.

Table 13. Top ten landed species (lb) in Hawaii ECS fisheries in 2020

Species	No. Licenses	No. Trips	Catch (lb)
Selar crumenophthalmus (akule)	210	1,558	267,551
Decapterus macarellus (‘opelu)	115	1,082	70,774
Myripristis spp. (menpachi)	163	862	60,518
Parrotfish species (uhu)	50	514	38,100
Lutjanus kasmira (ta‘ape)	178	756	37,787
Acanthurus dussumieri (palani)	47	384	26,442
Mulloidichthys vanicolensis (red weke)	50	191	20,615
Cellana spp. (‘opihi)	11	205	16,558
Seriola dumerili (kahala)	146	495	14,624
Acanthurus triostegus (manini)	34	304	12,103

1.3.2.2 Prioritized Species Summary

Ta‘ape was the only species in 2020 to show improved catch (pieces and pounds) in comparison to its 10-and 20-year averages. ‘Opihi and manini showed increased pieces reported but decreases in pounds landed. For these species, catch may have declined given that weight is seen as a more reliable measure of catch for these small species. Number of licenses and number of trips in 2020 was below corresponding 10- and 20-year averages for all ten species.

Table 14. Annual fishing parameters for 2020 for prioritized MHI ECS designated by DAR compared with short-term (10-year) and long-term (20-year) averages

Species	Fishery Indicator	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
‘Opihi	No. Lic.	11	↓ 45.0%	↓ 47.6%
	No. Trips	205	↓ 16.7%	↓ 19.9%
	No. Caught	108,529	↑ 153%	↑ 331%

Species	Fishery Indicator	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
	Lb Caught	16,558 lb	↓ 4.77%	↓ 14.7%
Lobster	No. Lic.	10	↓ 37.5%	-
	No. Trips	135	↓ 29.0%	-
	No. Caught	1,993	↓ 42.6%	-
	Lb Caught	3,713 lb	↓ 47.6%	-
Kūmū	No. Lic.	35	↓ 50.7%	↓ 55.1%
	No. Trips	123	↓ 64.8%	↓ 68.7%
	No. Caught	624	↓ 75.1%	↓ 70.3%
	Lb Caught	864 lb	↓ 77.2%	↓ 76.9%
Omilu	No. Lic.	115	↓ 4.17%	↓ 2.54%
	No. Trips	311	↓ 16.8%	↓ 13.9%
	No. Caught	772	↓ 31.5%	↓ 29.8%
	Lb Caught	4,749 lb	↓ 26.4%	↓ 26.6%
Uhu	No. Lic.	50	↓ 35.9%	↓ 42.5%
	No. Trips	514	↓ 39.4%	↓ 41.7%
	No. Caught	8,314	↓ 30.7%	↓ 21.3%
	Lb Caught	38,100 lb	↓ 28.3%	↓ 17.6%
He‘e (Day tako)	No. Lic.	41	↓ 40.6%	-
	No. Trips	206	↓ 70.8%	-
	No. Caught	1,521	↓ 81.6%	-
	Lb Caught	4,360 lb	↓ 81.9%	-
Kala	No. Lic.	31	↓ 36.7%	↓ 45.6%
	No. Trips	172	↓ 53.8%	↓ 53.4%
	No. Caught	3,109	↓ 40.0%	↓ 36.9%
	Lb Caught	11,150 lb	↓ 49.2%	↓ 49.8%
Nenue	No. Lic.	32	↓ 48.4%	↓ 52.2%
	No. Trips	199	↓ 41.5%	↓ 41.0%
	No. Caught	3,626	↓ 28.0%	↓ 42.4%
	Lb Caught	9,147 lb	↓ 44.6%	↓ 52.6%
Manini	No. Lic.	34	↓ 39.3%	↓ 46.0%
	No. Trips	304	↓ 43.3%	↓ 47.8%
	No. Caught	25,273	↑ 5.15%	↑ 5.41%
	Lb Caught	12,103 lb	↓ 1.16%	↓ 5.10%
Ta‘ape	No. Lic.	178	↓ 23.9%	↓ 21.9%
	No. Trips	756	↓ 33.0%	↓ 35.9%
	No. Caught	72,703	↑ 58.0%	↑ 72.6%
	Lb Caught	37,787 lb	↑ 14.1%	↑ 3.70%

1.3.3 Prioritized Species Statistics

A common catch trend among inshore species in the past 20 years is a peak occurring between 2010 and 2015. This trend can be seen in a diverse array of fisheries including those using handpick, net, hook and line, and spearfishing gear types. This may be in part due to the economic downturn that occurred concurrently. In times of economic downturn and high unemployment, an increase in the number of individuals participating in these fisheries is common as some turn to commercial fishing to supplement their incomes or replace lost jobs. For many of these species, catch tracks similarly with statewide rates of unemployment. Unlike offshore boat-based fisheries, the targeting of inshore species requires minimal initial investment and therefore the greatest ease of entry. Accordingly, it is likely that the decreasing employment rates post-2011 influenced the catch in many of these fisheries.

Many ECS fisheries may have been largely spared from the effects of COVID-19 restrictions since many species are purchased by locals for home consumption. Some ECS fisheries like ‘opihi, kūmū, kala, manini, and ta‘ape saw increases in catch between 2019 and 2020. Job loss and economic insecurity may have driven some of this increase, though its total impact is unknown.

Of the prioritized ECS, the uhu or parrotfish fishery is of particular interest to DAR. Catch of uhu has shown relatively persistent increase since 1965. The noticeable increase in uhu catch is mainly the result of increases in spearfishing activity. Whereas other gears including nets and fish traps once made up a significant proportion of methods used to target uhu, the fishery has been increasingly dominated by spearfishing. In 2020, approximately 96% of all uhu were caught via spearing. Spearfishing as a gear type has changed as well, as fishers more commonly employ the use of SCUBA and rebreathers to target deeper areas. Uhu are a prized food fish in Hawaii, important to non-commercial fisheries, and play a key role in reef ecosystems.

Unlike uhu, it is decreasing he’e catch that warrants attention. He’e catch in recent years has dropped precipitously from a recent high of 39,206 lb in 2013 to just 4,360 lb in 2020. The he’e fishery is unique in that a large proportion of catch is sold to fishing stores for bait. Because of this, low catch in 2020 is especially surprising give the increase in recreational fishing during COVID-19 restrictions. A large proportion of this decrease in catch can be attributed to losses of known highliners during the period. The fishery in general has also decreased in effort and participation. CPUE, though affected by the lack of prominent highliners, has not decreased to the extent of catch.

Table 15. Time series of commercial fishing reports for all ‘opihi (*Cellana* spp.; limpet) species reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
1965	14	239	66	-	16,651
1966	13	171	61	-	13,989
1967	40	779	176	-	36,000
1968	26	450	112	-	23,185
1969	36	413	127	-	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

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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	-	14,146
1980	49	230	119	28	10,617
1981	36	218	87	30	7,889
1982	36	190	82	1	7,725
1983	37	190	78	-	6,675
1984	40	181	95	61	8,548
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	11,685
1990	56	179	110	-	7,848
1991	58	212	114	-	7,680
1992	55	315	130	-	9,271
1993.1	39	194	87	-	5,672
1993.2	26	138	55	-	4,628
1994	42	435	137	-	11,444
1995	56	461	151	-	13,098
1996	41	371	115	-	12,079
1997	51	299	125	1,106	10,979
1998	50	289	128	110	13,936
1999	43	406	112	-	10,774
2000	31	415	103	-	9,950
2001	24	356	96	710	12,938
2002	32	427	105	11,300	13,373
2003	23	341	106	9,980	11,714
2004	15	193	57	2,234	8,087
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	289	96	8,750	18,377
2013	18	362	86	6,893	25,816
2014	27	333	91	10,419	22,417

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
2015	17	248	82	14,126	14,211
2016	16	156	77	39,166	9,125
2017	16	198	80	72,820	11,131
2018	17	229	93	76,541	13,336
2019	20	182	91	50,631	11,018
2020	11	205	67	108,529	16,558
10-year avg.	**20**	**246**	**84**	**42,925**	**15,804**
20-year avg.	**21**	**256**	**80**	**25,212**	**14,438**

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

Table 16. Time series of commercial fishing reports for all lobster species from reported by Calendar Year from 2003-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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	250	57	5,091	10,949
2014	19	228	54	4,887	10,526
2015	14	141	41	2,941	5,922
2016	14	160	43	2,249	4,521
2017	15	185	49	2,817	5,578
2018	8	157	36	2,585	5,015
2019	10	128	32	2,120	4,213
2020	10	135	29	1,993	3,713
10-year avg.	**16**	**190**	**49**	**3,471**	**7,089**
20-year avg.	**NA**	**NA**	**NA**	**NA**	**NA**

Table 17. Time series of commercial fishing reports for kūmū (*Parupeneus porphyreus*; white saddle goatfish) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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
1978	168	897	519	3,731	15,435
1979	163	620	488	3,133	15,429
1980	149	810	439	2,544	13,978
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	7,150
1985	134	941	396	2,015	10,866
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	6,628
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	131	637	367	1,127	5,118
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	558	283	1,266	3,917
2003	91	364	223	1,218	2,585
2004	82	380	231	1,255	2,233
2005	71	295	181	958	2,585
2006	56	228	148	673	1,471

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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	5,503	9,832
2011	96	665	305	6,144	9,564
2012	106	679	333	6,216	8,451
2013	102	571	287	4,499	7,179
2014	91	438	236	2,945	4,418
2015	70	276	177	1,668	2,708
2016	59	291	160	1,114	2,069
2017	61	205	133	951	1,371
2018	45	144	105	538	751
2019	43	99	75	357	553
2020	35	123	93	624	864
10-year avg.	**71**	**349**	**190**	**2,506**	**3,793**
20-year avg.	**78**	**393**	**214**	**2,104**	**3,733**

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

Table 18. Time series of commercial fishing reports for omilu (*Caranx melampygus*; bluefin trevally) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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	84	247	157	717	5,135
1984	108	316	195	1,879	16,501

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
1985	117	333	212	850	7,341
1986	115	368	205	1,317	8,145
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	159	405	289	1,414	9,786
1992	59	135	108	343	4,530
1993.1	58	120	94	224	1,960
1993.2	39	64	54	114	1,319
1994	64	123	93	302	2,717
1995	70	122	104	159	1,836
1996	58	145	111	301	3,141
1997	64	128	109	277	2,422
1998	56	103	88	168	1,572
1999	47	93	71	194	1,251
2000	61	137	108	282	2,418
2001	70	154	117	354	2,504
2002	89	180	140	429	3,085
2003	102	342	231	1,321	7,590
2004	124	360	243	1,213	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	150	456	328	1,472	7,697
2010	143	505	342	1,660	9,082
2011	146	442	302	1,074	6,857
2012	135	508	328	1,273	8,282
2013	123	400	274	965	6,470
2014	130	378	267	1,262	7,627
2015	113	356	253	1,563	6,243
2016	113	363	257	992	5,961
2017	127	396	276	1,472	8,274
2018	100	294	200	1,172	5,262
2019	96	289	203	725	4,784
2020	115	311	218	772	4,749
10-year avg.	**120**	**374**	**258**	**1,127**	**6,451**
20-year avg.	**118**	**361**	**251**	**1,099**	**6,469**

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

Table 19. Time series of commercial fishing reports for uhu (*Scaridae* spp.; parrotfish) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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
1974	60	263	151	541	5,215
1975	39	243	123	295	3,624
1976	59	272	159	406	9,633
1977	76	393	228	427	6,418
1978	124	598	369	955	19,775
1979	125	437	364	1,004	19,718
1980	119	586	333	1,425	22,509
1981	116	740	344	1,519	21,487
1982	96	633	316	1,099	16,782
1983	107	568	293	3,103	25,782
1984	117	620	315	3,423	27,694
1985	110	763	337	1,428	27,697
1986	124	823	359	1,991	35,171
1987	134	853	388	3,289	41,016
1988	122	865	356	3,104	44,689
1989	114	759	313	2,044	31,511
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	26,499
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

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
2002	111	885	391	4,324	31,324
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	1,441	450	17,483	71,028
2011	96	1,190	409	17,687	72,347
2012	117	1,399	462	20,301	84,442
2013	96	1,197	399	17,689	76,813
2014	89	934	348	14,190	69,929
2015	75	642	274	7,461	33,661
2016	66	585	254	6,411	26,204
2017	70	668	276	7,939	32,572
2018	57	747	248	10,488	51,621
2019	62	605	209	9,834	45,606
2020	50	514	186	8,341	38,100
10-year avg.	**78**	**848**	**307**	**12,034**	**53,130**
20-year avg.	**87**	**882**	**335**	**10,592**	**46,235**

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

Table 20. Time series of commercial fishing reports for he'e (*Octopus cyanea*; day tako) reported by Calendar Year from 2003-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
2003	77	666	221	6,128	17,592
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	1,176	392	11,216	34,089
2011	95	996	351	10,735	30,142
2012	92	1,191	405	11,969	34,602
2013	88	1,155	413	13,436	39,206
2014	86	866	311	10,422	33,637
2015	68	737	243	10,607	32,713
2016	56	588	184	8,158	22,938
2017	60	523	205	7,265	19,895

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
2018	57	431	198	4,512	12,642
2019	49	367	167	4,070	11,082
2020	41	206	122	1,521	4,360
10-year avg.	**69**	**706**	**260**	**8,270**	**24,122**
20-year avg.	**NA**	**NA**	**NA**	**NA**	**NA**

Table 21. Time series of commercial fishing reports for kala (*Naso* spp.; bluespine unicornfish, short-nosed unicornfish, whitemargin unicornfish) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
1965	27	251	93	823	30,278
1966	20	220	60	174	26,115
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	90	223	174	807	10,397
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	11,560
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	7,805
1993.2	50	174	90	325	4,445

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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	516	253	2,993	20,243
2003	67	449	187	4,169	21,218
2004	59	419	177	5,074	21,855
2005	51	330	140	5,447	22,502
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	8,182	33,955
2011	68	514	216	7,303	29,724
2012	69	688	247	8,559	42,464
2013	66	534	241	6,946	32,580
2014	61	480	198	6,624	30,216
2015	48	363	174	4,717	21,917
2016	41	305	140	4,056	12,665
2017	42	301	152	5,433	19,620
2018	33	208	117	2,731	10,078
2019	32	154	100	2,323	8,843
2020	31	172	108	3,109	11,150
10-year avg.	**49**	**372**	**169**	**5,180**	**21,926**
20-year avg.	**57**	**394**	**183**	**4,928**	**22,196**

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

Table 22. Time series of commercial fishing reports for nenue (*Kyphosus* spp.; chubs) from reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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	8,780
1980	84	258	177	810	13,104
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
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	8,430
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	7,378
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	84	376	223	2,018	22,627
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	450	240	14,399	31,690

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
2011	82	506	220	9,901	27,755
2012	91	571	239	7,442	31,238
2013	78	425	225	5,685	27,473
2014	84	418	221	4,664	16,638
2015	56	279	157	3,697	17,443
2016	55	258	153	3,290	10,465
2017	57	256	147	2,677	6,901
2018	44	267	129	5,135	9,677
2019	37	216	105	4,274	10,199
2020	32	199	105	3,626	9,247
10-year avg.	**62**	**340**	**170**	**5,039**	**16,704**
20-year avg.	**67**	**337**	**184**	**6,294**	**19,505**

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

Table 23. Time series of commercial fishing reports for manini (*Acanthurus triostegus*; convict tang) reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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	86	452	253	2,294	11,091
1984	98	471	266	2,320	9,505
1985	97	533	275	1,737	9,472
1986	98	549	274	4,226	6,971
1987	94	654	299	5,374	11,042

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
1988	94	670	319	7,739	9,037
1989	101	705	330	8,126	12,637
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
2001	78	543	233	10,555	11,919
2002	79	591	255	18,103	15,912
2003	61	560	213	38,573	20,008
2004	61	614	230	20,445	10,057
2005	63	481	220	27,947	12,312
2006	69	539	207	20,059	9,109
2007	66	715	258	26,578	11,398
2008	70	623	272	20,623	11,602
2009	79	718	300	25,386	12,793
2010	85	895	332	30,925	17,496
2011	76	872	296	33,450	17,746
2012	79	768	297	23,949	14,039
2013	66	744	280	28,089	15,896
2014	59	593	247	25,475	11,609
2015	65	406	205	14,261	9,152
2016	47	445	187	18,675	8,957
2017	47	406	181	23,423	10,441
2018	42	469	174	29,252	13,777
2019	40	355	149	18,498	8,725
2020	34	304	137	25,273	12,103
10-year avg.	**56**	**536**	**215**	**24,035**	**12,245**
20-year avg.	**63**	**582**	**234**	**23,977**	**12,753**

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

Table 24. Time series of commercial fishing reports for ta'ape (*Lutjanus kasmira*; bluestripe snapper) reported by Fiscal Year from 1970-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
1970	5	26	11	-	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	1,089	741	14,524	50,933
1979	320	972	845	25,672	58,175
1980	331	1,153	762	17,912	56,056
1981	299	1,448	756	20,295	80,498
1982	298	1,451	782	20,871	71,101
1983	308	1,508	799	11,078	69,225
1984	335	1,485	798	13,861	43,747
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	417	1,908	1,037	16,970	50,894
1989	389	1,629	957	15,746	36,211
1990	400	1,635	954	17,099	43,888
1991	426	1,768	1,048	17,041	62,487
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	1,690	882	16,459	59,773
1995	365	1,783	951	14,943	71,781
1996	352	1,538	904	14,415	44,195
1997	365	1,983	979	23,281	85,497
1998	365	1,754	933	20,894	74,851
1999	297	1,821	841	31,734	70,073
2000	280	1,926	817	27,267	55,041
2001	240	1,593	666	17,328	47,550
2002	234	1,202	635	14,403	41,147
2003	211	1,068	541	28,194	42,130
2004	210	1,149	554	62,451	45,718
2005	176	1,033	487	45,580	39,479

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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	1,518	767	56,918	43,538
2011	265	1,369	693	56,221	41,261
2012	297	1,394	800	37,849	33,003
2013	269	1,394	734	38,888	33,451
2014	261	1,233	658	35,159	30,271
2015	227	1,074	582	31,077	25,823
2016	221	1,107	590	39,258	33,902
2017	241	1,247	669	60,647	37,200
2018	199	871	499	43,388	28,835
2019	178	831	465	44,856	29,583
2020	178	756	433	72,703	37,787
10-year avg.	**234**	**1,128**	**612**	**46,005**	**33,112**
20-year avg.	**228**	**1,179**	**605**	**42,131**	**36,439**

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

1.3.4 Bycatch Summary

Bycatch in 2020 was below both the 10- and 20-year average values. Bycatch for non-MUS has been decreasing overall since a peak in 2007. This trend in non-MUS bycatch can be attributed almost entirely to the akule and ‘opelu fisheries, which since 2002 typically make up approximately 69% of all non-MUS caught each year. High reported releases by akule and ‘opelu fishers using net gear types, in particular pelagic purse seine, seine, and gill nets, have a disproportionately large influence on the total released of non-MUS. Because akule and ‘opelu are caught in large numbers with these gears, a single release event can result in up to 90,000 pieces reported as released. While annual releases of akule and ‘opelu have ranged between 0.04% to 20.3% of catch, total bycatch rates of other non-MUS are more stable, ranging between 2.1% and 9.0%.

Table 25. Time series of commercial fishing bycatch for non-MUS reported by Calendar Year from 2002-2020

Year	No. Lic.	No. Trips	No. Reports	No. Caught	No. Released	Percent Bycatch
2002	997	12,060	3,897	794,750	44,156	5.2635
2003	888	11,718	3,608	1,352,457	100,021	6.8862
2004	875	11,865	3,539	1,249,356	57,736	4.4171
2005	862	10,081	3,155	1,068,289	167,912	13.5829
2006	761	9,446	2,891	1,193,618	133,748	10.0762
2007	824	10,792	3,262	2,217,897	369,774	14.2898

2008	963	11,463	3,662	1,877,246	237,940	11.2491
2009	1,116	13,789	4,377	1,788,814	230,382	11.4096
2010	1,102	14,387	4,538	1,702,132	135,766	7.3870
2011	1,027	12,629	4,083	1,735,860	99,615	5.4272
2012	1,032	12,591	4,219	1,511,833	17,225	1.1265
2013	980	12,225	4,077	1,503,004	43,129	2.7895
2014	951	10,901	3,848	1,559,658	32,191	2.0222
2015	915	10,127	3,641	1,433,792	21,683	1.4898
2016	792	8,879	3,209	1,502,188	97,984	6.1233
2017	801	8,717	3,259	1,417,472	21,228	1.4755
2018	720	7,519	2,830	1,303,904	28,208	2.1175
2019	678	7,057	2,737	1,197,643	22,769	1.8657
2020	650	6,180	2,482	1,228,677	24,942	1.9896
10-year avg.	**855**	**9,683**	**3,439**	**1,439,403**	**40,897**	**2.6427**
20-year avg.	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

1.4 CRUSTACEAN

1.4.1 Fishery Descriptions

This species group of crustacean management unit species (CMUS) is comprised of the *Heterocarpus* deepwater shrimps (*H. laevigatus* and *H. ensifer*) and Kona crab (*Ranina ranina*). The main gear types used are shrimp traps and Kona crab 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 calendar 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

CMUS catch, number of licenses, and number of trips in 2020 were all below 10- and 20-year averages.

Table 26. Annual fishing parameters for 2020 in the MHI crustacean fishery compared with short-term (10-year) and long-term (20-year) averages

Fishery	Parameters	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Crustacean	No. License	14	↓ 54.8%	↓ 65.0%
	Trips	168	↓ 32.0%	↓ 32.5%
	No. Caught	4,810	↓ 94.7%	↓ 90.9%
	Lb Caught	13,256 lb	↓ 40.1%	↓ 49.4%

1.4.2.2 Species Summary

Shrimp trap and all other gear parameters could not be reported due to fewer than three distinct CML holders reporting CMUS catch using them. The number of licenses and trips using the Kona crab net gear type in 2020 were below both 10- and 20-year averages. Pounds caught using Kona crab nets was also below 10-and 20-year averages, but to a lesser degree than the 2020 decrease in trips. As a result, CPUE for the Kona crab net gear type in 2020 increased in comparison to 10- and 20-year averages.

Table 27. Annual fishing parameters for 2020 in the MHI crustacean fishery compared with short-term (10-year) and long-term (20-year) averages

Methods	Fishery Indicator	2020 Value	2020 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Shrimp Trap	*H. laevigatus* *H. ensifer*	n.d. n.d.	- -	- -
	No. Lic. No. Trips Lb Caught CPUE	n.d. n.d. n.d. n.d.	- - - -	- - - -
Kona Crab Net	Kona crab	4,201 lb	↓ 11.1%	↓ 44.5%
	No. Lic. No. Trips Lb Caught CPUE	12 42 4,201 lb 100.01 lb/trip	↓ 53.9% ↓ 43.2% ↓ 11.1% ↑ 62.9%	↓ 65.7% ↓ 65.9% ↓ 44.5% ↑ 64.0%
All Other Gears	No. Lic. No. Trips Lb Caught CPUE	n.d. n.d. n.d. n.d.	- - - -	- - - -

n.d. = non-disclosure due to data confidentiality.

1.4.3 Time Series Statistics

CMUS catch (weight) has been highly variable since 1965 and is currently in a state of decline. Catch in terms of pieces is likely unreliable for CMUS due to limited deepwater shrimp count data. CMUS fishery licenses and reports both peaked in 1998 and have been declining steadily since then. Like catch, effort has been variable over the time series with multiple distinct peaks in annual number of trips occurring since 1965. It is important to note that the two fisheries included in CMUS (deepwater shrimp trap fishery and Kona crab net fishery) are very different in both their operation and catch trends. Because of those differences (further detailed in Sections 1.4.4.1 and 1.4.4.2), care must be taken when using combined CMUS data to make inferences about the state of the individual contributing fisheries.

1.4.3.1 Commercial Fishing Parameters

Table 28. Time series of commercial fishermen reports for the CMUS fishery reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Trips	No. Reports	No. Caught	Lb 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

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
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	50	157	103	6,717	17,858
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	148	63	916	60,726
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	340	165	3,114	105,179
1995	88	467	200	4,992	98,478
1996	92	401	180	5,291	62,662
1997	90	346	169	8,119	50,913
1998	102	438	207	7,966	213,067
1999	86	298	170	5,810	52,506
2000	65	199	113	4,075	14,970
2001	64	243	130	3,771	20,209
2002	66	248	134	6,593	17,032
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

Year	No. License	Trips	No. Reports	No. Caught	Lb Caught
2010	48	243	96	15,377	13,481
2011	51	272	114	55,352	19,076
2012	40	272	97	115,257	20,106
2013	43	310	101	105,954	26,807
2014	34	398	94	372,676	50,808
2015	32	271	86	150,530	31,693
2016	22	161	53	30,034	17,961
2017	22	142	49	10,207	8,761
2018	25	194	56	33,956	14,551
2019	26	282	67	23,079	18,429
2020	14	168	39	4,810	13,256
10-year avg.	**31**	**247**	**76**	**90,186**	**22,145**
20-year avg.	**40**	**249**	**88**	**52,900**	**26,176**

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 1986. Prior to then, all trap activities were reported under miscellaneous traps. The principal species taken by shrimp traps are the deepwater *Heterocarpus* shrimp. Of the two species commonly caught, *Heterocarpus laevigatus* is preferred over *Heterocarpus ensifer* due to their larger size and superior food quality. Deepwater shrimp catch has pulsed multiple times since the early 1980s, resulting from a small number of large mainland-based vessels periodically entering the fishery primarily for the purpose of export to out of State markets. Fishing by these mainland-based vessels has not occurred since 2006, notably reducing catch.

Despite the potential for high catch, the deepwater shrimp trap fishery is characterized by low participation even in years when mainland-based vessels were active. Peak CMLs active in the fishery occurred in 2013 with ten fishers reporting catch. Since the peak, participation has declined to three or fewer fishers per year. Though seemingly low, this is typical for the fishery. Catch (weight) has also declined primarily because of the loss of notable mainland-based and to a lesser extent a few Hawaii-based highliners. Catch and participation for the shrimp trap gear type in 2020 could not be presented in this report to due to fewer than three licensed fishers reporting during the year.

Table 29. DAR MHI annual crustacean catch summary by species for shrimp traps reported by Fiscal Year from 1987-1993 and by Calendar Year from 1994-2020

Year	*Heterocarpus laevigatus*		*Heterocarpus ensifer*	
	No. License	Lb Caught	No. License	Lb Caught
1987	3	1,796	n.d.	n.d.
1988	n.d.	n.d.	3	1,568

Year	*Heterocarpus laevigatus*		*Heterocarpus ensifer*	
	No. License	Lb Caught	No. License	Lb Caught
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	3	35,631	NULL	NULL
1993.2	3	15,627	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	3	1,521
1999	5	33,585	n.d.	n.d.
2000	n.d.	n.d.	n.d.	n.d.
2001	4	9,225	n.d.	n.d.
2002	3	3,779	n.d.	n.d.
2003	3	5,166	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	18,977	4	406
2014	9	48,050	4	657
2015	6	28,766	n.d.	n.d.
2016	5	17,158	n.d.	n.d.
2017	3	5,964	n.d.	n.d.
2018	3	11,588	n.d.	n.d.
2019	3	12,630	n.d.	n.d.
2020	n.d.	n.d.	n.d.	n.d.
10-year avg.	**5**	**16,997**	**n.d.**	**n.d.**
20-year avg.	**4**	**17,652**	**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 Kona Crab Net

Also referred to as loop nets, Kona crab nets are specifically designed to capture the Kona crab species. They are characterized by a single or double layer of thin taught cotton or nylon mesh over a metal hoop. Kona crab are caught in the net when their joints become entangled in the thin mesh.

A challenge to Kona crab fishing is the suite of regulations currently in place including size (4" minimum carapace), sex (no-take of females), seasonal (May-August closed season), and gear-type (no spearing) restrictions. Though a previous stock assessment indicated that the population may be at risk from fishing, the 2018 stock assessment has deemed the MHI population not overfished or experiencing overfishing. As a result, DAR is currently taking steps to allow the take of female Kona crab, which should provide fishers with improved opportunities for retention.

Fishing effort and landings have been in a state of overall decline since the late 1990s. The downward trend in catch is due in part to the progressively decreasing activity and the eventual loss of a prominent Kona crab highliner. The primary fishing areas used are changing as well. Whereas the fishery once primarily targeted larger and more numerous Kona crab in federal waters, fishing in State waters has been increasingly dominant over time and now makes up the majority of all effort. Kona crab catch in recent years continues to show improvement in comparison to the all-time low in 2016. It remains unclear what future interest in the fishery will be, though it seems likely that the removal of the no-take of females will result in some increased effort and new intrants into the fishery. However, without the emergence of dedicated highliners, the fishery may struggle to return to its previous levels of catch.

Table 30. DAR MHI annual crustacean catch summary for loop net catching Kona crab reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	No. License	Lb 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	Lb 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	19,472
1995	84	27,741
1996	83	27,603
1997	82	27,931
1998	91	30,639
1999	81	18,698
2000	62	14,143
2001	59	10,763
2002	63	12,830
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	10,876
2012	35	7,980
2013	33	7,330
2014	24	2,029
2015	26	2,902
2016	16	745
2017	19	2,753
2018	20	2,769
2019	24	5,688
2020	12	4,201

Year	No. License	Lb Caught
10-year avg.	**26**	**4,727**
20-year avg.	**35**	**7,564**

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

1.4.5 Catch Parameters by Gear

Shrimp trap CPUE over time has, like catch, spiked periodically as a small number of mainland-based vessels returned to Hawaii to catch deepwater shrimp. In years in which those vessels were active, CPUE saw a marked increase due to the high number of gears that the larger and more well-equipped mainland vessels could handle. The 1984 peak in CMUS CPUE using "All Other Gear Types" is due to the lack of a specific shrimp trap gear code offered at that time. Deepwater shrimp fishers prior to 1986 used the "Miscellaneous Trap" gear code in lieu of a dedicated shrimp trap code.

Kona crab net CPUE spiked in the early 1970s. High CPUE during that time is primarily attributed to a specific highliner. The majority of fishers during that period, including the dominant highliner, fished primarily in federal waters, which were known to hold larger, more abundant crabs. Over time, highliner activity has decreased and the fishery progressively moved to occurring predominantly in State waters. As a result, CPUE has declined. The introduction of regulations, especially the 2006 ban on the take of females also likely played a role in the persistently low CPUE in comparison to historic levels.

Table 31. Time series of crustacean CPUE (lb/trip) in the MHI reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2020

Year	Shrimp Trap				Kona Crab Net (Loop)				All Other Gear Types			
	No. Lic.	No. Trips	Lb Caught	CPUE	No. Lic.	No. Trips	Lb Caught	CPUE	No. Lic.	No. Trips	Lb 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	3	12	1,431	119.25
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	3	14	4,037	288.36
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	8	14	5,756	411.14

Year	Shrimp Trap				Kona Crab Net (Loop)				All Other Gear Types			
	No. Lic.	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lb Caught**	**CPUE**
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	3	44	12,934	293.95	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	3,943.7	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	3	86	35,631	414.31	66	309	25,305	81.89	n.d.	n.d.	n.d.	n.d.
1993.2	3	36	16,531	459.19	50	151	15,464	102.41	NULL	NULL	NULL	NULL
1994	5	86	85,657	996.01	69	253	19,472	76.96	n.d.	n.d.	n.d.	n.d.
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	3	4	86	21.5
1997	6	51	22,792	446.9	82	288	27,931	96.98	3	7	190	27.14
1998	7	129	181,912	1410.17	91	299	30,639	102.47	4	10	516	51.6
1999	5	75	33,644	448.59	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	3	4	133	33.25
2002	3	50	3,989	79.78	63	196	12,830	65.46	n.d.	n.d.	n.d.	n.d.
2003	3	56	5,420	96.79	49	158	11,841	74.94	3	3	370	123.33
2004	n.d.	n.d.	n.d.	n.d.	48	167	12,164	72.84	3	30	133	4.43
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	3	26	172	6.62
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	3	38	325	8.55
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	172	10,876	63.23	5	39	103	2.65
2012	5	143	11,894	83.18	35	121	7,980	65.95	3	8	232	29
2013	10	205	19,383	94.55	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	3	16	72	4.53
2015	6	200	28,775	143.87	26	62	2,902	46.81	n.d.	n.d.	n.d.	n.d.
2016	5	133	17,203	129.35	16	25	745	29.8	n.d.	n.d.	n.d.	n.d.
2017	3	80	5,984	74.8	19	53	2,753	51.95	n.d.	n.d.	n.d.	n.d.
2018	3	131	11,598	88.53	20	52	2,769	53.25	3	12	184	15.35

Year	Shrimp Trap				Kona Crab Net (Loop)				All Other Gear Types			
	No. Lic.	No. Trips	Lb Caught	CPUE	No. Lic.	No. Trips	Lb Caught	CPUE	No. Lic.	No. Trips	Lb Caught	CPUE
2019	3	196	12,692	64.76	24	71	5,688	80.11	n.d.	n.d.	n.d.	n.d.
2020	n.d.	n.d.	n.d.	n.d.	12	42	4,201	100.01	n.d.	n.d.	n.d.	n.d.
10-yr avg.	**5**	**159**	**17,333**	**105.24**	**26**	**74**	**4,727**	**61.38**	**n.d.**	**n.d.**	**n.d.**	**n.d.**
20-yr avg.	**4**	**108**	**18,450**	**144.90**	**35**	**123**	**7,564**	**60.97**	**3**	**20**	**163**	**21.31**

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.

1.4.6 Bycatch Summary

CMUS percent bycatch in 2020 at 83.5% was much higher than corresponding 10- and 20-year averages, both of which were less than 25%. Releases of Kona crab have been increasing in recent years, with a growing proportion being reported as released due to being undersized. While there were reports of unusually small crab being caught in 2020, it is unclear if Kona crab encountered statewide are smaller than average presently or if more fishers are opting to distinguish their reason for release instead of reporting as a general release. A growing number of fishers may also be correctly reporting releases (i.e., reporting releases at all). The chance of having to release Kona crab is high, given both size and sex restrictions that commonly result in less than 50% of crab being fit for legal retention. The decreasing number of trips in which Kona grab were caught but none were released suggests fishers are beginning to more accurately self-report.

Another contributing factor to the increase in CMUS bycatch is the recent decline in the harvest of deepwater shrimp. Unlike Kona crab, deepwater shrimp have no size or sex restrictions, resulting in little to no releases. They are also caught in comparatively high numbers. As a result, as deepwater shrimp catch decreases (as it has since 2014), total CMUS catch drops accordingly while total CMUS releases are not affected.

Table 32. Time series of commercial fishing bycatch for CMUS reported by Calendar Year from 2002-2020

Year	No. Lic.	No. Trips	No. Reports	No. Caught	No. Released	Percent Bycatch
2002	66	248	134	6,593	195	2.8727
2003	53	217	102	10,082	1,080	9.6757
2004	51	204	90	7,441	1,620	17.8788
2005	51	381	106	8,240	1,177	12.4987
2006	38	203	77	5,941	3,688	38.3010
2007	34	238	75	26,487	3,422	11.4414
2008	38	302	88	56,257	1,376	2.3875
2009	41	237	98	15,960	2,295	12.5719
2010	48	219	96	15,377	6,511	29.7469
2011	51	252	114	55,352	7,360	11.7362

2012	40	258	97	115,257	3,816	3.2048
2013	43	302	101	105,954	7,816	6.8700
2014	34	398	94	372,676	5,610	1.4830
2015	32	271	86	150,530	7,760	4.9024
2016	22	161	53	30,034	5,122	14.5693
2017	22	142	49	10,207	6,967	40.5671
2018	25	194	56	33,956	12,141	26.3379
2019	26	282	67	23,079	27,186	54.0853
2020	14	168	39	4,810	24,297	83.4748
10-year avg.	**31**	**243**	**76**	**90,186**	**10,808**	**24.7231**
20-year avg.	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**

1.5 PRECIOUS CORALS FISHERY

1.5.1 Fishery Descriptions

This species group is comprised of any coral of the genus *Corallium* (pink coral, also known as red coral, *Corallium secundum*, *C. regale*, *C. laauense*) in addition to 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*).

There are no active fisheries for precious coral in federal waters around Hawaii, as most fishing for precious coral occurs in nearshore waters managed by the State of Hawaii. The precious coral fishery in Hawaii is limited to black coral harvests in the ‘Au‘au Channel, and fishing is not currently occurring for pink, bamboo, or gold corals. Only selective gear may be used to harvest corals, and the top gears utilized for harvesting this species group are submersible and SCUBA.

1.5.2 Dashboard Statistics

Future reports will include data as resources allow (see Section 1.5.3)

1.5.3 Other Statistics

Commercial fishery statistics for recent years are unavailable due to data confidentiality restrictions, as the number of active participants has been fewer than three since the 2011-2012 fishing year. 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 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 33).

Table 33. 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 34). 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 34. 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

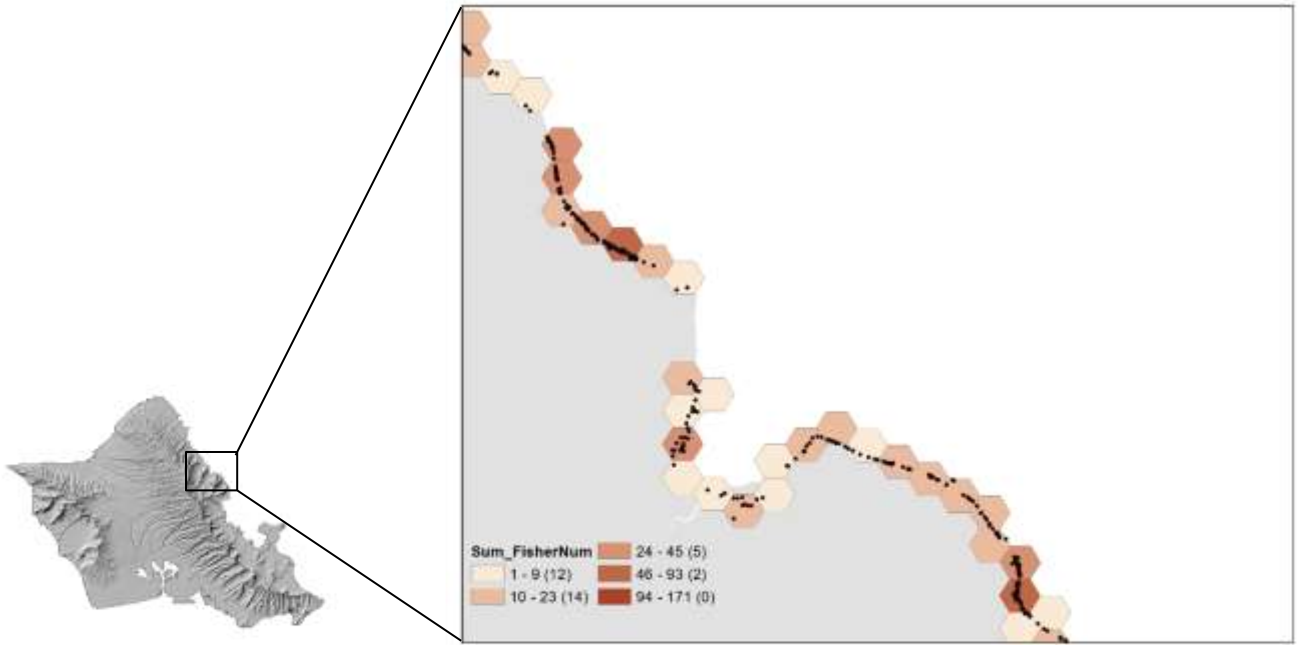

Figure 1. Example of 300 m hexagons around Kahana Bay on Oahu

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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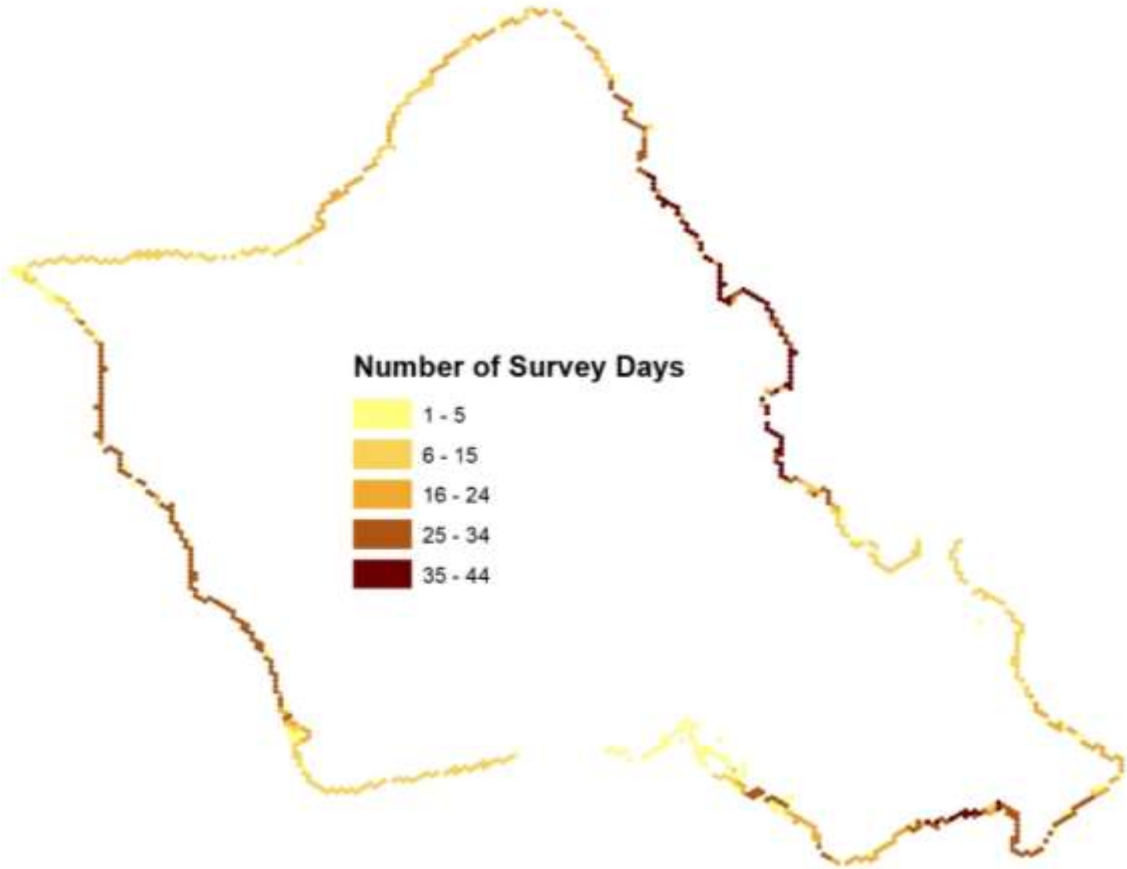

Figure 2. The total number of survey-days by area on Oahu

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 35). 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 35). Gleaning (crabbing, tako wading, paeaea pole, limu, ʻopihi, and urchin picking) was rarely observed during the survey and thus no spatial patterns were determined.

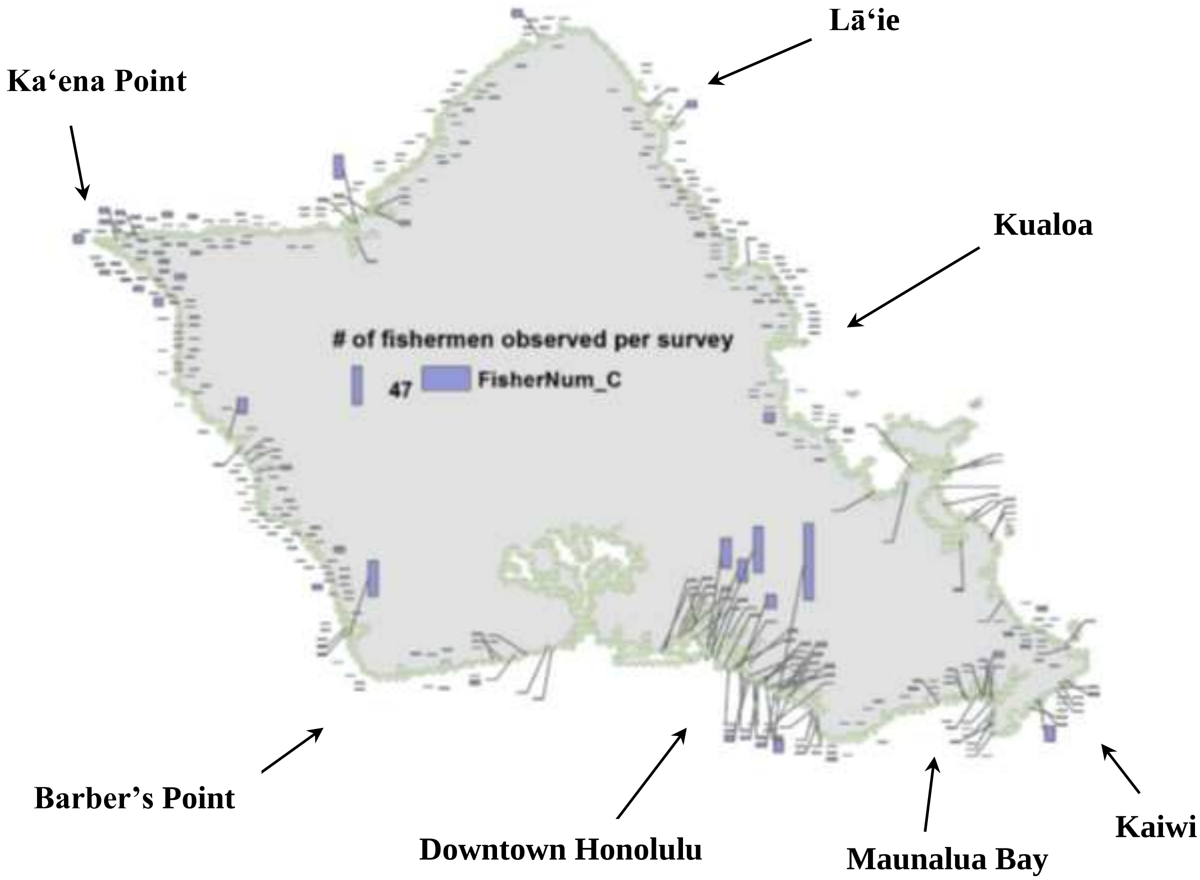

Figure 3. Average number of fishers observed per survey for each hexagon around Oahu

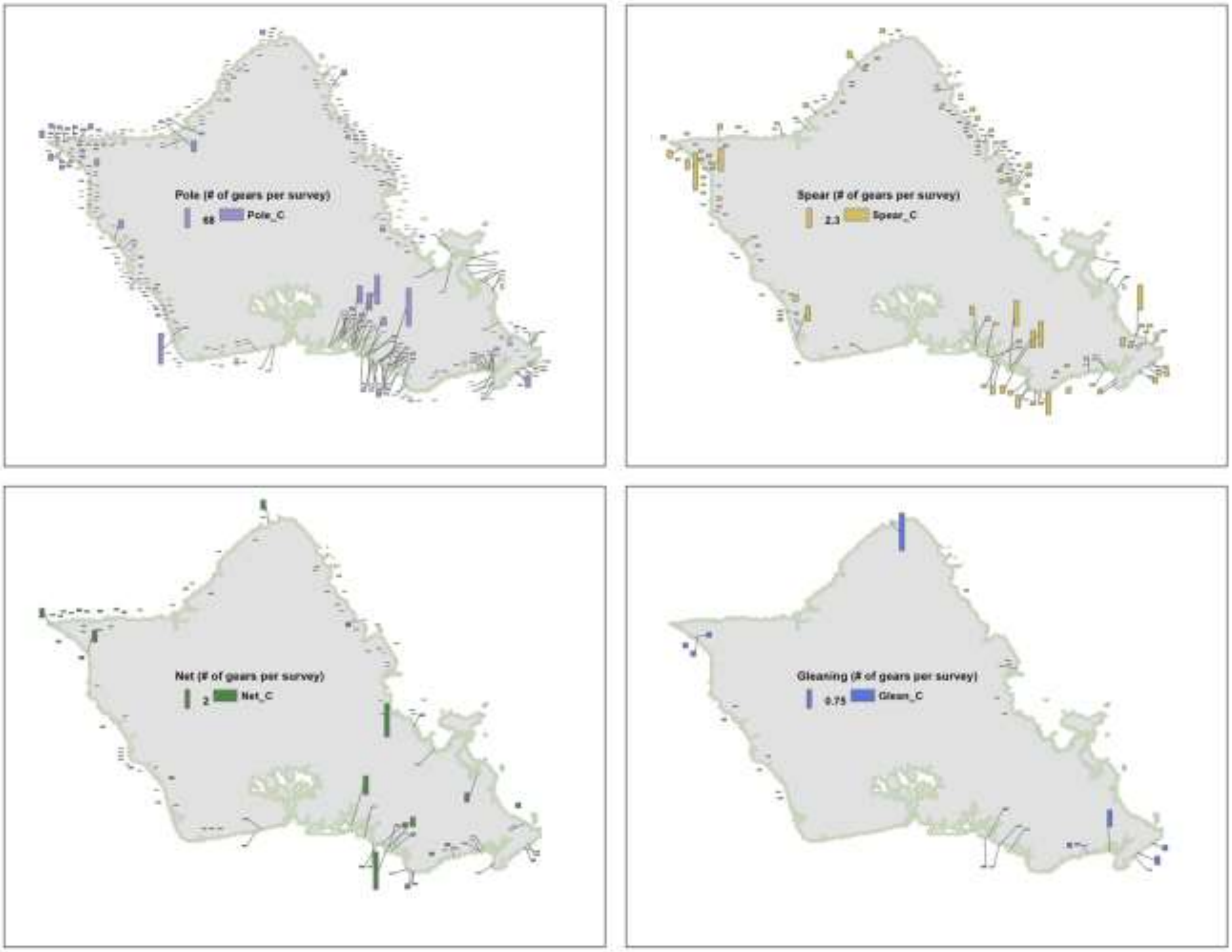

Figure 4. Fishing effort (number of gears) for each gear type observed around Oahu

Table 35. 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.

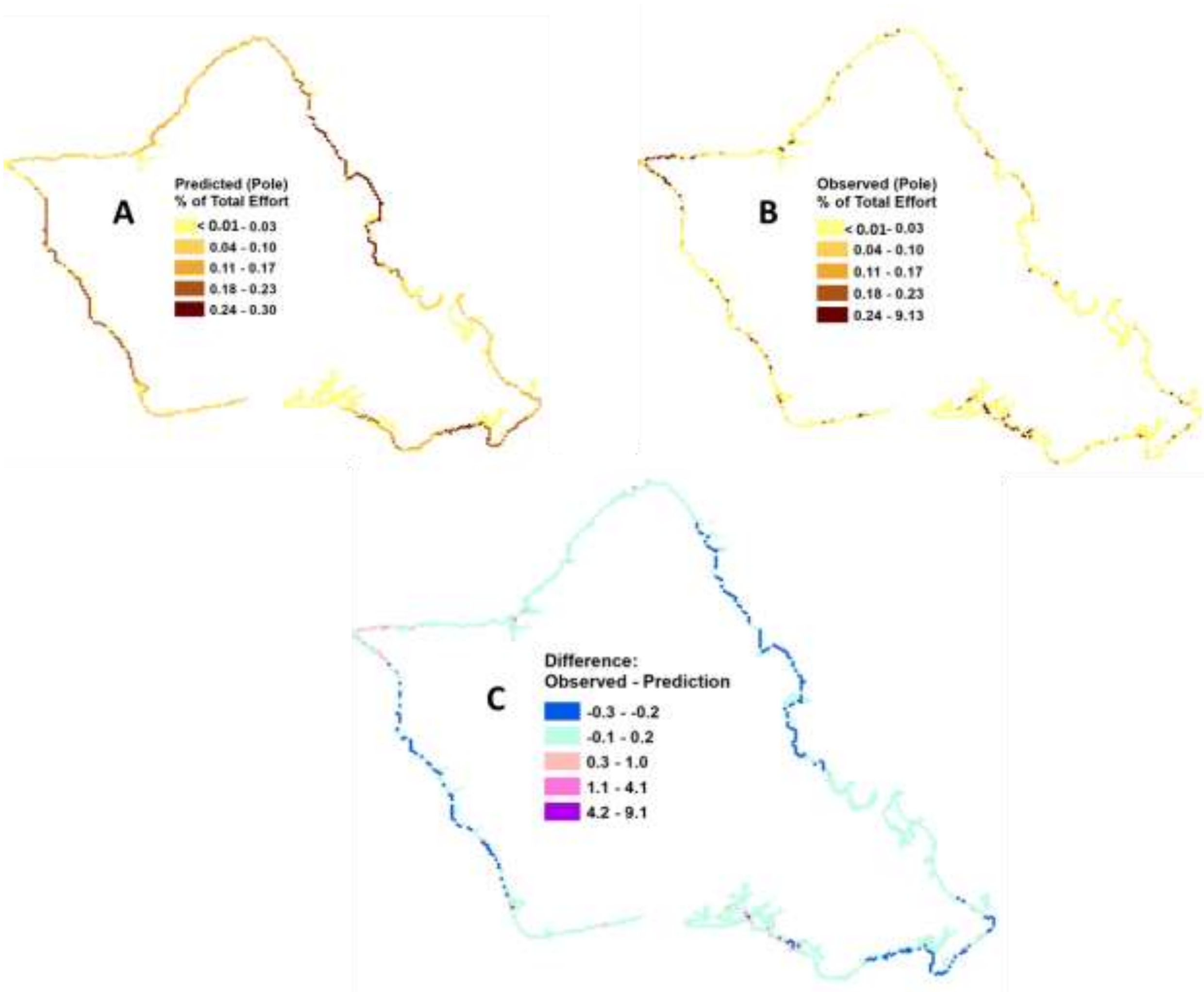

Figure 5. Comparison (C) of pole fishing effort between the prediction model (A) and observed shoreline survey data (B)

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 FEDERAL LOGBOOK DATA

1.7.1 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.

1.7.1.1 Special Coral Reef Ecosystem Permit

Regulations require the special coral reef ecosystem fishing permit for anyone fishing for coral reef 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 BMUS, CMUS or crustacean 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.

1.7.1.2 Main Hawaiian Islands Non-Commercial Bottomfish

Regulations require this permit for any person, including vessel owners, fishing for BMUS or bottomfish ECS in the EEZ around the MHI. If the participant possesses a current State of Hawaii CML, or is a charter fishing customer, he or she is not required to have this permit.

1.7.1.3 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 (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).

1.7.1.4 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 (PRIA), and in the EEZ seaward of three nautical miles of the shoreline of the CNMI.

Table 36 provides the number of permits issued to Hawaii FEP fisheries between 2011 and 2020. Data are from the PIRO Sustainable Fisheries Division (SFD) permits program.

Table 36. Number of federal permits in Hawaii FEP fisheries

Year	Special Coral Reef Ecosystem	MHI Non-Commercial Bottomfish	Precious Coral	Crustacean - Shrimp	Crustacean - Lobster
2011	1	22	2	0	0
2012	1	18	2	1	2
2013	0	10	1	2	7
2014	0	3	1	1	6

Year	Special Coral Reef Ecosystem	MHI Non-Commercial Bottomfish	Precious Coral	Crustacean - Shrimp	Crustacean - Lobster
2015	0	2	1	1	5
2016	1	0	1	2	5
2017	1	1	1	2	6
2018	1	0	1	2	6
2019	0	2	1	0	2
2020	1	2	0	0	0

Source: PIRO SFD unpublished data.

1.7.2 Summary of Catch and Effort for FEP Fisheries

The Hawaii Archipelago FEP requires fishermen to obtain a federal permit to fish for certain MUS in federal waters and to report all catch and discards. While NMFS annually issues permits for various FEP fisheries, there is currently limited available data on the level of catch or effort made by federal non-longline permit holders. Determining the level of fishing activity through the required federal logbook reporting for each fishery helps establish the level of non-longline fishing occurring in federal waters to assess whether there is a continued need for active conservation and management measures (e.g., annual catch limits) for these fisheries. For each FEP fishery, the number of federal permits issued since implementation of the federal permit and logbook reporting requirement became effective as well as available catch and effort data are presented (Table 37 through Table 39).

1.7.2.1 Precious Coral

There have been less than three permittees for the precious coral fishery in recent years (see Section 1.5.3), so any reports received are confidential.

1.7.2.2 Non-Commercial Bottomfish

Table 37. Summary of available federal logbook data for the non-commercial bottomfish fishery in Hawaii

Year	No. of Federal Bottomfish Permits Issued[1]	No. of Federal Bottomfish Permits Reporting Catch	No. of Trips in MHI EEZ	Total Reported Logbook Catch (lb)		Total Reported Logbook MUS Release/Discard (#)	
				Deep 7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year	*Non-Deep 7 Bottomfish (MUS & ECS)[2] from Jan. 1 to Dec. 31*	*Deep 7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year*	*Non-Deep 7 Bottomfish (MUS & ECS)[2] from Jan. 1 to Dec. 31*
2008-09	80	4	9	182	32	0	0
2009-10	59	4	11	309	10	0	3
2010-11	22	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2011-12	18	0					

Year	No. of Federal Bottomfish Permits Issued[1]	No. of Federal Bottomfish Permits Reporting Catch	No. of Trips in MHI EEZ	Total Reported Logbook Catch (lb)		Total Reported Logbook MUS Release/Discard (#)	
				Deep 7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year	*Non-Deep 7 Bottomfish (MUS & ECS)[2] from Jan. 1 to Dec. 31*	*Deep 7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year*	*Non-Deep 7 Bottomfish (MUS & ECS)[2] from Jan. 1 to Dec. 31*
2012-13	10	0					
2013-14	3	0					
2014-15	2	0					
2015-16	0	0					
2016-17	1	0					
2017-18	0	0					
2018-19	2	0					
2019-20	2	0					

[1] Source: PIRO SFD unpublished data.
[2] On February 8, 2019, NMFS published a final rule (84 FR 2767) to reclassify certain MUS as ecosystem component species (ECS). This rule reclassified all of the non-Deep 7 bottomfish except uku as ECS.
Notes: Federal non-commercial bottomfish permit and reporting requirements became effective on August 8, 2008 (73 FR 41296, July 18, 2008). The fishing year for "Deep 7 bottomfish" begins September 1 and ends August 31 the following year. For example, data for 2008 should include information from September 1, 2008, through August 31, 2009. The fishing year for "non-Deep 7 bottomfish" is the calendar year. n.d. = Not available due to confidentiality.

1.7.2.3 Spiny and Slipper Lobster

Table 38. Summary of available federal logbook data for the lobster fisheries in Hawaii

Year	No. of Federal Lobster Permits Issued[1]	No. of Federal Lobster Permits Reporting Catch in MHI	No. of Trips in MHI EEZ	Total Reported Logbook Catch (lb)		Total Reported Logbook Release/Discard (lb)	
				Spiny lobster MUS	*Slipper lobster MUS*	*Spiny lobster MUS*	*Slipper lobster MUS*
2004	0						
2005	0						
2006	0						
2007	2	0					
2008	2	0					
2009	3	0					
2010	0						
2011	0						
2012	1	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2013	2	0					

Year	No. of Federal Lobster Permits Issued[1]	No. of Federal Lobster Permits Reporting Catch in MHI	No. of Trips in MHI EEZ	Total Reported Logbook Catch (lb)		Total Reported Logbook Release/Discard (lb)	
				Spiny lobster MUS	*Slipper lobster MUS*	*Spiny lobster MUS*	*Slipper lobster MUS*
2014	1	0					
2015	1	0					
2016	2	0					
2017	2	0					
2018	2	0					
2019	0	0					
2020	0	0					

[1] Source: PIRO SFD unpublished data.
Note: n.d. = Not available due to confidentiality.

1.7.2.4 Deepwater Shrimp

Table 39. Summary of available federal logbook data for the deepwater shrimp fishery in Hawaii

Year	No. of Federal Shrimp Permits Issued[1]	No. of Federal Shrimp Permits Reporting Catch[2]	No. of Trips in MHI EEZ	Total Reported Logbook Shrimp MUS Catch (lb)	Total Reported Logbook Shrimp MUS Release/Discard (lb)
2009	0				
2010	0				
2011	0				
2012	2	n.d.	n.d.	n.d.	n.d.
2013	7	6	80	10,520	113
2014	6	6	61	11,676	212
2015	5	3	24	13,020	261
2016	5	3	123	39,781	7,257
2017	6	4	27	5,529	74
2018	6	n.d.	n.d.	n.d.	n.d.
2019	2	3	192	23,939	0
2020	0	n.d.	n.d.	n.d.	n.d.

[1] Source: PIRO SFD unpublished data.
[2] Permits are valid for one year from the date issued, so permits issued in 2018 may be valid for a part of 2019. The number of permits reporting catch can therefore be greater than the number issued that year.
Notes: Federal permit and reporting requirements for deepwater shrimp fisheries became effective on June 29, 2009 (74 FR 25650, May 29, 2009). n.d. = Not available due to confidentiality. Shrimp MUS = *H. laevigatus* and *H. ensifer*. No. of trips in MHI EEZ used permit number, gear set date to determine unique trips. Total catch and discard include both within the MHI EEZ and outside of the EEZ.

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 (F) 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. 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 is not specified in this section. The latest estimate published annually in the annual 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 40. Note that the MFMT listed here only applies to Hawaiian bottomfish.

Table 40. Overfishing threshold specifications for Hawaiian bottomfish and NWHI lobsters

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

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 ($SSBP_t$) 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 $SSBPR_{MIN}$. These two reference points and their associated recruitment overfishing control rule, which prescribe a target fishing mortality rate ($F_{RO-REBUILD}$) as a function of the SSBPR, are specified as indicated in Table 41. Again, E_{MSY} is used as a proxy for F_{MSY}.

Table 41. Recruitment overfishing control rule specifications for the BMUS in Hawaii

$F_{RO-REBUILD}$	$SSBPR_{MIN}$	$SSBPR_{TARGET}$
$F(SSBPR) = 0$ for $SSBPR \le 0.10$ $F(SSBPR) = 0.2\,F_{MSY}$ for $0.10 < SSBPR \le SSBPR_{MIN}$ $F(SSBPR) = 0.4\,F_{MSY}$ for $SSBPR_{MIN} < SSBPR \le SSBPR_{TARGET}$	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 MHI 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 42). A stock assessment update for MHI Deep 7 BMUS will be completed in 2021.

Table 42. 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 lb	
MSY for reported catch	509,000 ± 233,000	Mean ± std. error, units in lb	
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 lb	
B_{MSY}	15.4 ± 4.9	Mean ± std. error, units in million lb	
B/B_{MSY}	1.31		Not overfished

1.8.2.2 Uku

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

In 2016, 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 MUS. Results from the uku assessment are presented in Table 43.

Table 43. Results from 2016 stock assessment for MHI uku (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 MHI 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 44).

Table 44. Stock assessment parameters for the Hawaiian Kona crab stock (Kapur et al. 2019)

Parameter	Value	Notes	Status
MSY for total catch	73,069	In lb	
MSY for reported catch	25,870	In lb	
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 lb	
B_{MSY}	640,489	In lb	
B_{2016}/B_{MSY}	1.3977		Not overfished

For ACL-specification purposes, the MSY for spiny lobsters is 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 PIFSC. This method was applied to species complexes grouped by taxonomic families. The most recent MSY estimates are found in Table 45.

Table 45. Best available MSY estimates for the Crustacean MUS in Hawaii

Fishery	Management Unit Species	MSY (lb)
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 overfishing limit (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. Implemented ACL 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). NMFS can implement ACLs on an annual basis, but the Council normally recommends a multi-year specification.

The AM typically implemented Hawaii insular fisheries is post-season AM in the form of an overage adjustment. The subsequent ACL is downward adjusted with the amount of overage relative to the previous ACL based on a three-year running average. A three-year average of recent catch is utilized as recommended by the Council at its 160th meeting to avoid large fluctuations in catch due to data quality and outliers. The uku and Kona crab fisheries, however, also implemented an in-season AM where, if the catch is projected to reach the implemented ACT, the fishery will be closed in federal waters for the remainder of the fishing year. Similarly, an in-season AM for precious coral fisheries will close individual coral beds if the ACL for that bed is projected to be reached.

1.9.2 Current OFL, ABC, ACL, and Recent Catch

The most recent implementation of OFLs, ABCs, and ACLs covers fishing years 2019-2021 for the MHI Deep 7 bottomfish stock complex, 2020-2023 for Kona crab (85 FR 79928, December 11, 2020), 2019-2021 for uku, 2019-2021 for deepwater shrimp, and 2019-2021 for precious corals (85 FR 26622, May 5, 2020). 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, February 9, 2019). Note that the MHI Deep 7 stock complex operates based on fishing year and is still open. The ACT for Kona crab was newly implemented, and any projected exceedance of the ACT will result in a federal fishery closure for the species. The ACLs shown in Table 46 are the most recently implemented ACLs by NMFS. Recent average catch for the MHI Deep 7 Bottomfish stock complex (217,846 lb) accounted for 44.3% of its implemented ACL (492,000 lb; Table 46).

Table 46. Hawaii 2020 ACLs with three-year recent average catch (lb)

Fishery	Management Unit Species	OFL	ABC	ACL	ACT	Catch
Bottomfish	MHI Deep 7 stock complex	558,000	508,000	492,000	NA	161,437
	Aprion virescens (uku)	132,277	127,205	127,205	NA	71,059
Crustacean	Deepwater shrimp	N.A.	250,773	250,773	NA	n.d.
	Kona crab	33,989	30,802	30,802	25,491	4,219
Precious Coral	‘Au‘au Channel black coral	NA	7,508	5,512	NA	n.d.
	Makapu‘u Bed pink coral	NA	3,009	2,205	NA	n.d.
	Makapu‘u Bed bamboo coral	NA	571	551	NA	n.d.
	180 Fathom Bank pink coral	NA	668	489	NA	n.d.
	180 Fathom Bank bamboo coral	NA	126	123	NA	n.d.
	Brooks Bank pink coral	NA	1,338	979	NA	n.d.
	Brooks Bank bamboo coral	NA	256	245	NA	n.d.
	Ka‘ena Point Bed pink coral	NA	201	148	NA	n.d.
	Ka‘ena Point Bed bamboo coral	NA	37	37	NA	n.d.
	Keāhole Bed pink coral	NA	201	148	NA	n.d.
	Keāhole Bed bamboo coral	NA	37	37	NA	n.d.
	Hawaii Exploratory Area precious corals	NA	2,205	2,205	NA	n.d.

Notes: “n.d.” indicates that the data could not be disclosed due to issues with data confidentiality (i.e., less than three licenses reporting). “NA” indicates that there is no value for the given parameter (i.e., not estimated or implemented). Catch for the MHI Deep 7 stock complex is for the 2020 fishing year only and not a three-year average.

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, 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 lb 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 lb 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 Stock Assessment Updates

A stock assessment update for the MHI Deep 7 bottomfish complex will be completed in 2021.

1.10.1.3 Best Available Scientific Information

National Standard 2 requires that conservation and management measures be based on the BSIA 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 BSIA. This is based on the assessment passing a Western Pacific Stock Assessment Review by a three-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 MUS.

This assessment utilized a different approach compared to the existing model used for the fishing years 2015-2018 specification. It used life history information and a length-based approach to obtain stock status based on 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), 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 OFL to a 50% risk of overfishing was defined as the median of the C_{30} distribution.

1.10.2.2 Stock Assessment Updates

There are no stock assessment updates available for uku.

1.10.2.3 Best Scientific Information Available

The Nadon (2017) assessment underwent peer review starting with the Center for Independent Experts (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 BSIA for these species.

1.10.3 Crustacean Fishery

1.10.3.1 Stock Assessment Benchmark

Deep-water Shrimp: The deepwater 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 BSIA 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 47 summarizes the harvest extent and harvest capacity information for Hawaii in 2019 using three-year average catch.

Table 47. Hawaii proportion of harvest capacity and extent relative to the ACL in 2020

Fishery	Management Unit Species	ACL	Catch (lb)	Harvest Extent (%)	Harvest Capacity (%)
Bottomfish	MHI Deep 7 stock complex	492,000	161,437	32.8	67.2
	Aprion virescens (uku)	127,205	71,059	55.9	44.1
Crustacean	Deepwater shrimp	250,773	n.d.	NA	NA
	Kona crab	30,802	4,219	13.7	86.3
Precious Coral	‘Au‘au Channel black coral	5,512	n.d.	NA	NA
	Makapu‘u Bed pink coral	2,205	n.d.	NA	NA
	Makapu‘u Bed bamboo coral	551	n.d.	NA	NA
	180 Fathom Bank pink coral	489	n.d.	NA	NA
	180 Fathom Bank bamboo coral	123	n.d.	NA	NA

Fishery	Management Unit Species	ACL	Catch (lb)	Harvest Extent (%)	Harvest Capacity (%)
	Brooks Bank pink coral	979	n.d.	NA	NA
	Brooks Bank bamboo coral	245	n.d.	NA	NA
	Ka‘ena Point Bed pink coral	148	n.d.	NA	NA
	Ka‘ena Point Bed bamboo coral	37	n.d.	NA	NA
	Keāhole Bed pink coral	148	n.d.	NA	NA
	Keāhole Bed bamboo coral	37	n.d.	NA	NA
	Hawaii Exploratory Area precious corals	2,205	n.d.	NA	NA

“n.d.” indicates that the data could not be disclosed due to issues with data confidentiality (i.e., less than three licenses reporting). “NA” indicates that there is no value for the given parameter (i.e., not estimated or implemented). Each catch value represents the recent three-year average except for the MHI Deep 7 stock complex, which presents the catch value only for the 2020 fishing year.

1.12 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions NMFS implemented for insular fisheries in the Hawaiian Archipelago during calendar year 2020.

February 12, 2020. Annual harvest guideline: **2020 Northwestern Hawaiian Islands Lobster Harvest Guideline**. NMFS established the annual harvest guideline for the commercial lobster fishery in the NWHI for calendar year 2020 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 2020 at zero lobsters. Harvest of NWHI lobster resources was not allowed.

May 5, 2020. Final Rule: **2019-2021 Annual Catch Limits and Accountability Measures**. This final rule establishes ACLs and AMs in the MHI for deepwater shrimp, precious corals, and gray jobfish (uku) in 2019-2021, and for Kona crab in 2019. The fishing year for each fishery begins on January 1 and ends on December 31, except for precious coral fisheries, which begin July 1 and end on June 30 of the next year. This rule supports the long-term sustainability of Pacific Island fisheries. The final rule is applicable in fishing years 2019, 2020, and 2021 for deepwater shrimp, precious corals, and gray jobfish, and fishing year 2019 for Kona crab. The final rule is effective June 4, 2020.

October 15, 2020. Notice of Agency Decision: **Marine Conservation Plan (MCP) for Pacific Insular Areas Other Than American Samoa, Guam, and the Northern Mariana Islands; Western Pacific Sustainable Fisheries Fund**. NMFS announces approval of a MCP for Pacific Insular Areas other than American Samoa, Guam, and the Northern Mariana Islands. Section 204(e) of the MSA authorizes the Secretary of State, with the concurrence of the Secretary of Commerce (Secretary), and in consultation with the Council, to negotiate and enter into a Pacific Insular Area fishery agreement (PIAFA). Before entering into a PIAFA for the PRIA, the Council must develop and submit to the Secretary a three-year MCP that details the uses for funds collected by the Secretary under the PIAFA. The Magnuson-Stevens Act requires payments received under a PIAFA, and any funds or contributions received in support of conservation and management objectives for the MCP, to be deposited into the Western Pacific Sustainable Fisheries Fund (Fund) for use by the Council. Section 204(e)(7)(C) of the MSA also authorizes the Council to use the Fund to meet conservation and management objectives in the State of Hawaii, if funds remain available. An MCP must be consistent with the Council's FEPs. The MCP contains five conservation and management objectives that are consistent with the FEP for the PRIA and the FEP for Pelagic Fisheries of the Western Pacific. In addition, the MCP contains seven conservation and management objectives that are consistent with the FEP for the Hawaiian Archipelago. This notice announces that NMFS has reviewed the MCP and determined that it satisfies the requirements of the MSA. Accordingly, NMFS has approved the MCP for the three-year period from August 4, 2020, through August 3, 2023.

December 11, 2020. Final rule: **2020-2023 Annual Catch Limit and Accountability Measures for Hawaii Kona Crab**. In this final rule, NMFS implements an ACL of 30,802 lb (13,972 kg), and an ACT of 25,491 lb (11,563 kg), of Hawaii Kona crab for fishing years 2020-2023. The fishing year is the same as the calendar year, and catch from State and federal waters counts toward the ACL and ACT. This rule also implements as AMs, an in-season closure of the fishery if catch is projected to reach the ACT, and a post-season adjustment if catch exceeds the ACL. This action supports the long-term sustainability of the Hawaii Kona crab fishery. The final rule is applicable in fishing years 2020, 2021, 2022, and 2023. The final rule is effective January 11, 2021.

2 ECOSYSTEM CONSIDERATIONS

2.1 2020 COVID IMPACTS

This section on impacts associated with COVID-19 in the Western Pacific region was added to the annual SAFE report this year given the distinctive effects that the pandemic had on both fishing communities and fisheries in the Pacific Islands. The section is not meant to be a permanent fixture in the annual SAFE report, and it will only be included in the future as long as the impacts from COVID-19 remain relevant for the region's fisheries.

2.1.1 Social Impacts

The Pacific Islands Region has experienced a number of unique risks from COVID-19 as well as measures put in place to stop its spread. While the number of COVID-19 cases in the Pacific Island Region have been comparatively few, restrictions on travel and local restrictions on gathering and commerce have had profound effects on local economies, livelihoods, and human well-being. Since March 2020, airlines have significantly limited flights across the Pacific Islands Region, impacting the ability of people to see their loved ones, travel off island for medical treatments, as well as reshaping economies heavily reliant on tourism. Measures to limit community spread such as curfews, limitations on gatherings, and stay-at-home orders have also had a heavy impact on local businesses, and often shifted subsistence practices.

Through it all fisheries communities in the Pacific Islands Region have played a vital role in supporting local food systems, nutrition, food security, and community social cohesion. COVID-19 has amplified these critical roles of fishing in island communities and there is a shared hope for an increased understanding and value of all local fisheries to island communities, economy, and food security for the future.

2.1.2 Community Impacts

The State of Hawaii implemented numerous protective measures to prevent the spread of the novel coronavirus beginning in mid-March 2020, including social distancing (March 13), cancellation of public gatherings (March 15), a statewide stay-at-home work-at-home order (March 25), and a requirement that all persons entering Hawaii (visitors and returning residents) self-quarantine for 14 days or for the duration of their stay in Hawaii, whichever is shorter (March 26) (Department of Health 2020).

Along with many other states, these restrictions were slowly relaxed between the months of May and July 2020 as the islands staged an incremental reopening strategy. However, surges in domestic cases in June and July stopped the State from relaxing quarantine restrictions further. Initial plans were to launch a program called "Safe Travels" on August 1 that would allow travelers with pre-travel negative test results to bypass quarantine. This program was delayed because local case counts spiked in August and September; the islands returned to a strict lockdown with renewed statewide stay-at-home orders for a period of 4 weeks (August 27 – September 23) (Consillio 2020a). In mid-October, the "Safe Travels" program was finally initiated (Gomes 2020). The first COVID-19 vaccines arrived in Hawaii in mid-December (Consillio 2020b), and at that time quarantine periods were also reduced from two weeks to 10 days (O'Connor 2020).

Hawaii's largest industry, tourism, which provides high demand for the State's seafood products, remained shuttered for most of 2020, creating significant economic hardship statewide. Cumulative visitor counts for the months of April to July 2020 (53,000 visitors) were down 98.5% from this same period in 2019 (3.6 million visitors) (DBEDT 2021). August to December (537,000 visitors) saw moderate gains from April to July, however this still reflects an 87% decline relative to 2019 (4.1 million visitors). In total, the number of visitors in 2020 was down 74% relative to 2019, slightly exceeding early predictions from the State's Department of Business, Economic Development, and Tourism (DBEDT) (DBEDT 2020). Seasonally-adjusted unemployment rates in Hawaii were some of the highest in the nation between April and July. This trend continued for the remainder of 2020, with unemployment rates as high as 14.8% in September and declining to 10.2% by December, compared to national rates of 8.4% and 6.7%, respectively. The State had the highest unemployment rate in the nation between September and December 2020.

2.1.3 Fisheries Impacts

While fishing and seafood markets are classified as an "Essential Business", the Hawaii fishing and seafood industry has experienced significant economic impacts as a result of global COVID-19 spread.

The Hawaii fishing and seafood industry is an integrated food production and supply system that links fishermen to our nation's only fresh tuna auction, the fish auction buyers (mainly wholesalers), and ultimately retailers and restaurants in Hawaii and across the United States. Between March and December 2020, the COVID-19 pandemic virtually eliminated market demand for Hawaii seafood in local restaurants, which are heavily dependent on tourism, and severely restricted the mainland U.S. retail market. What remained were the local retail and direct-to-consumer markets in Hawaii. This significant reduction in market demand cascaded through market channels to the fishing sector, which faced significant reductions in fish prices, and the market struggled to balance supply with reduced demand. The economic viability of fishermen, the fish auction, and fish processors continued to be threatened by the economic effects associated with pandemic restrictions and shifts in demand.

Despite these challenges, the fishing community (i.e., commercial fishers, non-commercial fishers, seafood distributors) in the Pacific Islands region plays a vital role in supporting local food systems, nutrition, food security, and social cohesion (Allen 2013). This importance is amplified in the face of natural disasters and human health crises, and fishing communities across the Pacific Islands region have adapted to continue these crucial functions in the face of this unprecedented disruption. New markets, such as direct sales from wholesalers to the public, roadside sales, and community-supported fisheries (CSF), initially provided discounts to the community and have continued to provide alternative means to supply fresh fish directly to local populations (see Section 2.2).

Archipelagic commercial fisheries in Hawaii include small boat, spear, and nearshore fishermen targeting tunas and other highly-migratory species, as well as bottomfish, nearshore, and reef fish species. Similar to the longline fishery, these fishers faced negative pricing impacts on account of COVID-19 since they also market their fish through UFA auction, dealers/processors, restaurants, retail storefronts, and within their community. Historically low prices and statewide stay-at-home orders severely limited commercial small boat fishing effort during March.

However, as local restrictions relaxed in May and June, fishing activity was able to pick up, helping some through the difficult economic conditions. The months of October through December saw fishing activity moving closer towards baseline conditions. Many commercial small boat fishers were forced to or chose to shift to marketing their fish via social media, within community networks, and in partnerships with local CSF-style businesses. Some also developed value-added products with their catch. Pursuing these marketing channels, coupled with significant reductions in longline fishery landings, likely helped this sector realize less dramatic price declines relative to the Hawaii longline fishery. However, 2020 continued the downward trend of commercial marine licenses, and there was also a notable reduction in active seafood dealers on account of COVID-19 impacts and restrictions. Non-longline commercial fishery revenues also experienced a decline (see Section 2.5).

These fishers (along with thousands of non-commercial fishers; Ladao 2021) play vital roles in supporting local food systems, nutrition, food security, and community social cohesion (Allen 2013). This importance is amplified in the face of natural disasters and human health crises. A public Facebook group Hawaii Fishermen Feeding Families (Ramsey 2020) was established in mid-April to promote fisher contributions to local food security. During 2020, over 1,200 individual fishers had posted a cumulative estimate of over 11,275 pounds of fish that have helped to feed over 11,780 people across the State. Community members in Oahu and the Big Island reported an increase in the number of shoreline fishers. This increase was due to a mix of reasons, including fishing being a safe outdoor activity and an important source of food for those under economic hardship. There were also reports of increases in family and community sharing.

2.1.4 Data Collection Impacts

There were no significant impacts to the commercial fisheries data collection because most data are self-reported by fishermen and vendors online. When the statewide stay-at-home work-at-home order went into effect on March 25, 2020, DAR staff were able to transition to primarily work-from-home without issue. Some DAR staff were also allowed to work in-office part-time to handle the limited number of paper reports received each month. License processing was slightly hindered, but the hinderance was no significant.

HMRFS in-person sampling was discontinued on March 20, 2020 in response to State-mandated restrictions resulting from the escalating pandemic. Regular sampling then resumed on July 1, 2020. The Marine Recreational Information Program imputed data from the same time periods from past years in order to provide fishery estimates for the months when sampling was not conducted.

2.2 2020 FISHERMEN OBSERVATIONS

Hawaii fishermen met with the Council's Advisory Panel on Thursday, February 4, 2021 to discuss observations in the fishery during Calendar Year 2020. The COVID-19 pandemic was identified as a driving factor in 2020 playing a large role in fishing motivations, market loss, and ability to fish. From the lockdown of parks and the limiting of number of people allowed to gather, the restrictions in place had a large impact on fishing. On-the-water observations from fishermen in each of the Council's fisheries are provided to provide context to the fishery-dependent data provided in the fishery performance modules, and vice versa.

2.2.1 Deep 7 BMUS

Bottomfish fishing in 2020 ranged from average to good across the State but was severely hampered by the market as it dealt with the COVID-19 pandemic. Fishing that did occur for individual species, however, differed between the islands. Fishers targeting onaga (ruby snapper) on Oahu noted that fishing was poor and the worst some have ever seen. They noted that they found "blips" or "piles" of the species but usually of smaller individuals in the 1 to 3 lb size range. These small onaga were more likely to pick up hooks quicker than ehu (red snapper). Maui fishers had similar experiences with small onaga. Kauai fisherman Marvin Lum set a new State record of 34 lb 2 oz with an onaga that he caught off of Niihau.

Both Maui and Oahu noted larger individual size ehu and gindai (oblique-banded snapper) landed in 2020, with a larger abundance caught earlier in the year. The two islands also experienced a lot of what seemed to be ʻōpakapaka (pink snapper) around both islands but were mostly made up of smaller fish. Maui, which normally would catch an average of 8 lb ʻōpakapaka, saw an average of 2 to 3 lb in 2020. Oahu fishermen saw large ʻōpakapaka schools of fish less than one pound in size in December. Other schools were of mixed sizes where they usually are more stratified based on size. Others reported ʻōpakapaka missing on traditional grounds such as the Penguin Banks, Honolulu, and Lanai. Those who fished had 2 or 3 individual fish caught compared to what is normally 200 to 300 lb of fish. Oahu fishers in 2020 also saw hapuʻupuʻu (Hawaiian Grouper) in lower numbers at certain spots than in previous years.

Overall, fishers noted that the currents observed in the bottomfish fishery were running strong and in the wrong direction. The expected favorable currents at certain times in previous years were not present in 2020. On Hawaii Island, the South current has been the predominant current in the last two years, but at Ka Lae, the current was pulling straight offshore at the end of 2020. Other ecosystem observations made by fishermen in 2020 was that heavy rains contributed to mudlines that run straight offshore on Hawaii Island and the habitats for bottomfish in Maui have changed as muddy areas appear to now be hard bottom. Fishermen estimate that the grounds are moving eastward as they have changed their landmarks according to depth recorders.

From the market perspective, fishers noted that prices were stable in 2020 but would tank if too many fish were brought in. The COVID-19 pandemic caused a huge change for Oahu fishermen as the United Fishing Agency (UFA) changed policies to not receive fish afterhours in the evening. Fishermen were required to drop off their catch early the next morning if they wanted to sell their catch from the day before. This forced some fishermen skip a day of fishing in order to hold their catch to be dropped off the next day. This also led to people selling locally and exclusively peddling fish or giving it away. As a result, Oahu fishers noted that they specifically targeted smaller bottomfish for direct sales to the community. The lack of restaurants, markets, and stores open to sell the fish resulted in fish dealers and wholesalers not buying fish. Those that would typically fish uku in the summer did not go because the restaurants were closed so they had no outlet for their fish in Kona. Meanwhile, fishing supply stores did very well in 2020 and some were often sold out of supplies. As many who were unemployed or working from home turned to fishing to feed their family or for recreation and peace of mind.

2.2.2 Uku

Uku (gray jobfish) fishing in 2020 across the State was poor to terrible with the spring aggregation failing to show up in normal areas. A fisherman reported the bite (i.e., catch rate) was slow on the North Shore, and others confirmed similar experiences in other areas. The slow bite was due to two factors. First, there has been an increase in shark predation and hooked fish were usually lost to sharks. The increase in shark depredation has been noted since 2018 with silky and sandbar sharks identified as the culprits. The result of the increased depredation was that fishermen stopped targeting uku. The second reason for the poor fishing in 2020 for uku was that fishermen noted currents tended to be much stronger and pulling in different directions than normal. The currents normally running parallel along the ledges were moving perpendicular either onshore or offshore (see Section 2.2.1). They surmised that the change in currents also had an effect on water temperature and bait distribution, which resulted in less favorable conditions for the fish. The lack of restaurants, markets, and stores open to sell the fish resulted in fish dealers and wholesalers not buying fish (see Section 2.2.1). Those that would typically fish uku in the summer did not go because the restaurants were closed so they had no outlet for their fish in Kona.

2.2.3 Crustaceans

Kona crab (Spanner crab) fisheries in 2020 were average on Oahu, but fishermen noted that there were a lot of small, “sand turtle” size crabs in some areas on the North Shore, potentially indicating good recruitment. They also reported that the sandy areas on Penguin Bank that were old Kona crab fishing grounds were not there. Sandy areas/patches had apparently shifted or moved and was now hard substrate on which Kona crabs do not live. In Hilo, Kona crab catch was down and more difficult to catch in 2020, and fishermen noted that this could be because of large amounts of rain leading to coastal runoff.

2.3 CORAL REEF FISH ECOSYSTEM PARAMETERS

2.3.1 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 2020. Hard Coral cover is mean cover derived from visual estimates by divers of sites where reef fish surveys occurred. No new survey occurred in 2020 and the numbers presented here are identical to last year's report.

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 (PRIA)

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.

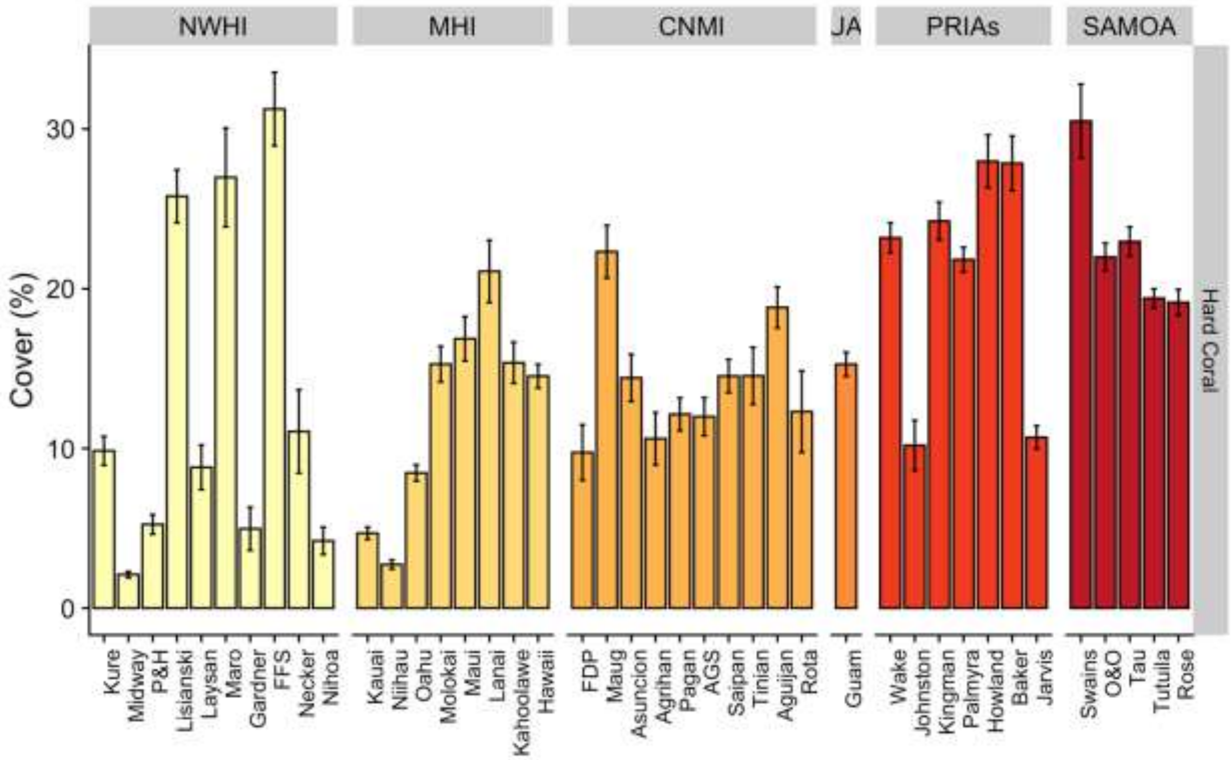

Figure 6. Mean coral cover (%) per U.S. Pacific Island averaged over the years 2010-2020 by latitude

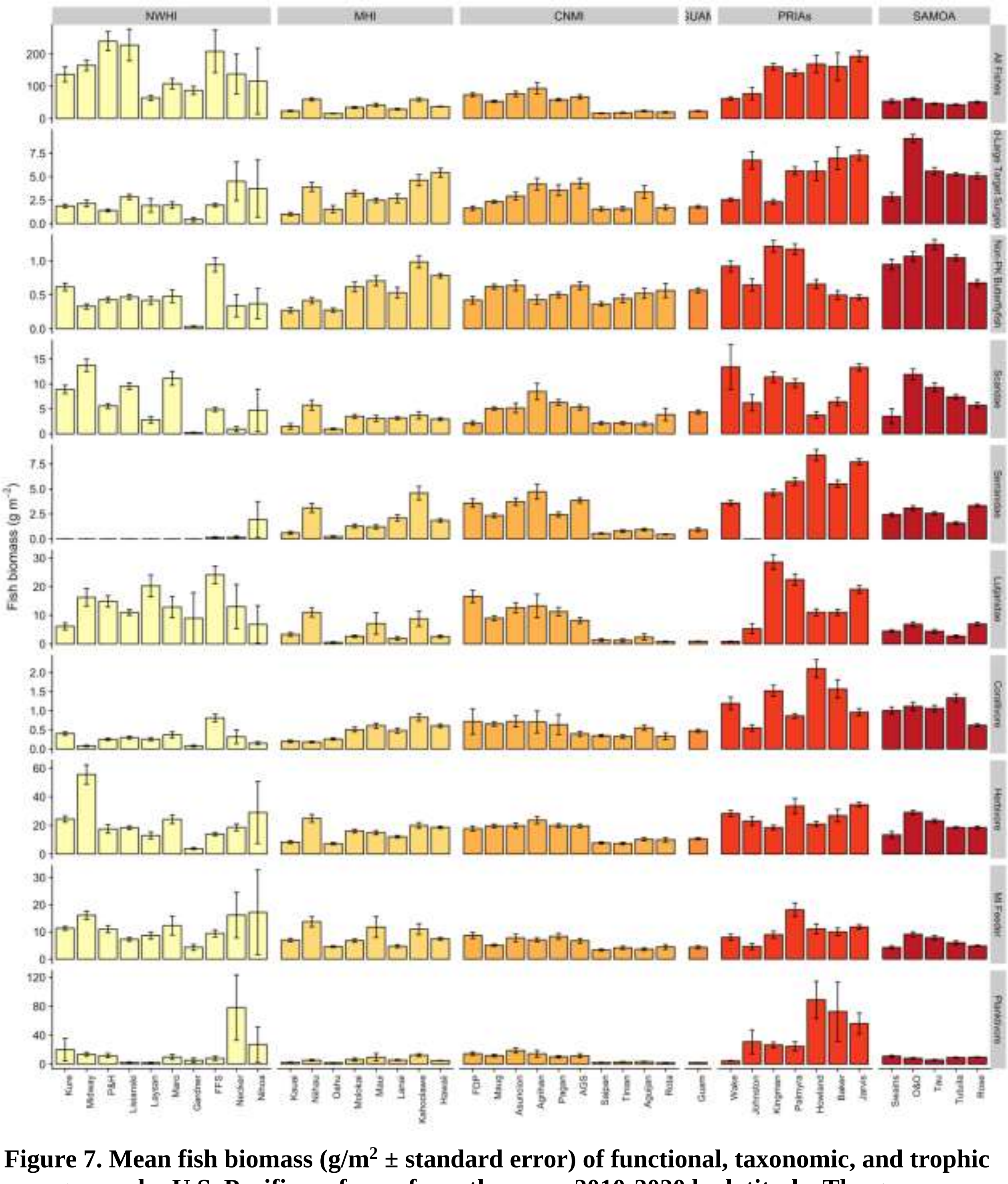

Figure 7. Mean fish biomass (g/m^2 ± standard error) of functional, taxonomic, and trophic groups by U.S. Pacific reef area from the years 2010-2020 by latitude. The group Serranidae excludes planktivorous members of that family – i.e., anthias, which can by hyper-abundant in some regions. Similarly, 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

2.3.2 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 partners, as part of the Pacific RAMP. Survey methods and sampling design, and methods to generate reef fish biomass are described in Section 2.3.1.

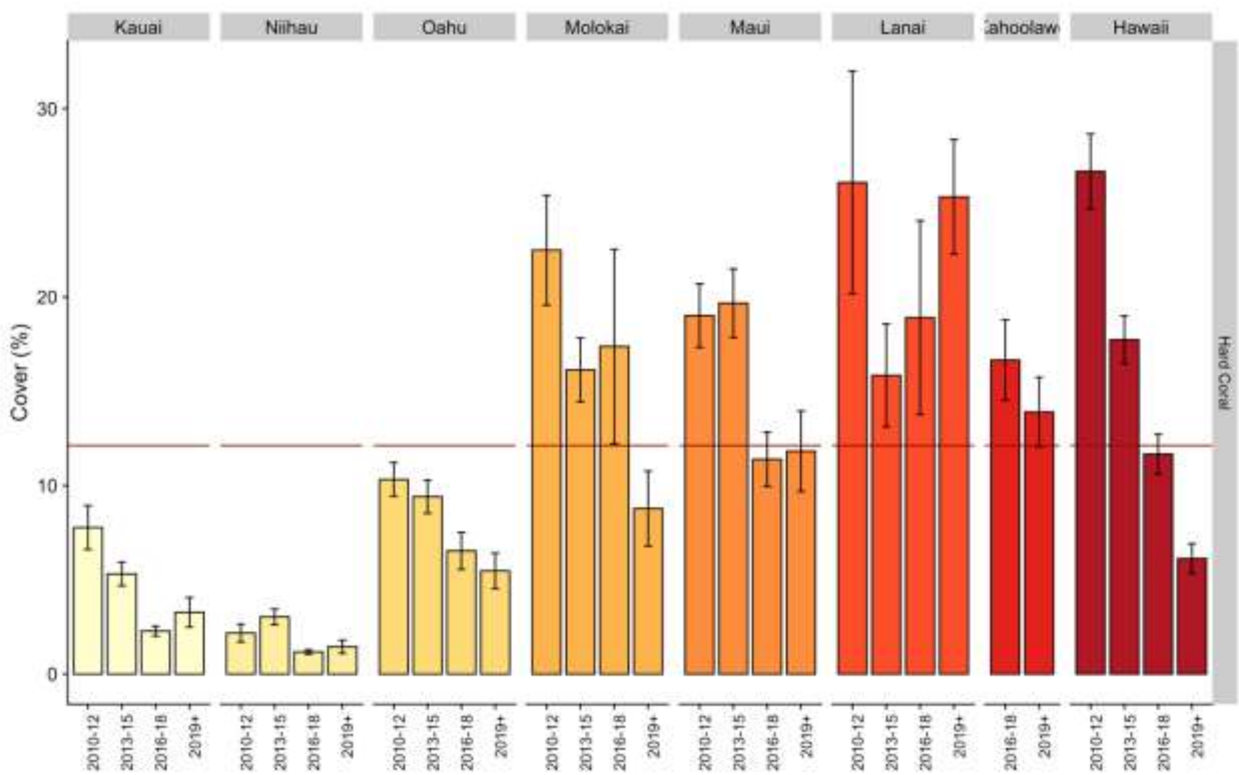

Figure 8. Mean coral cover (%) per island averaged over the years 2010-2020 by latitude with MHI mean estimates plotted for reference (red line)

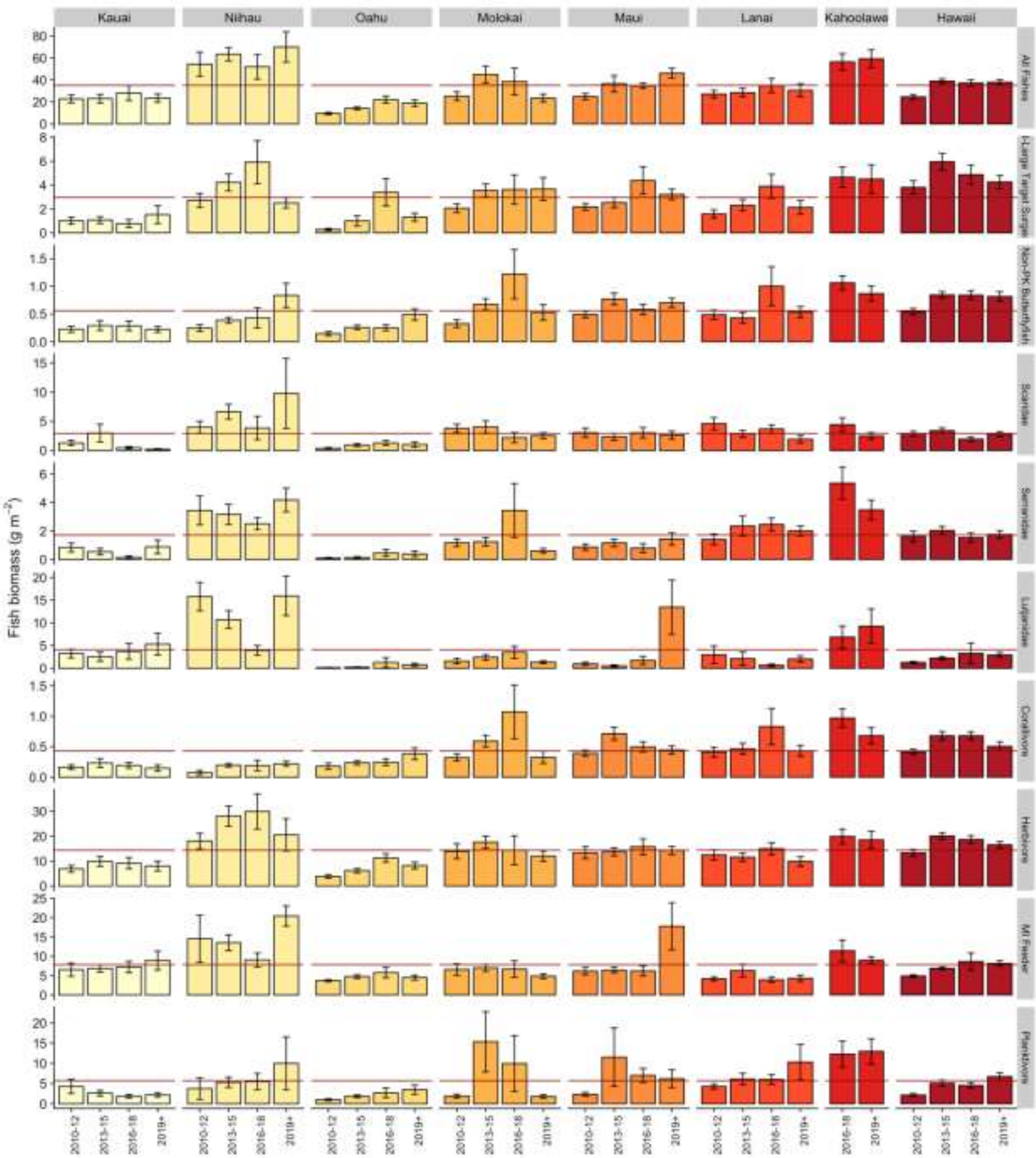

Figure 9. Mean fish biomass (g/m^2 ± standard error) of MHI functional, taxonomic, and trophic groups from the years 2010-2020 by island. The group Serranidae excludes planktivorous members of that family (i.e., anthias, which can by hyper-abundant in some regions). The group "MI Feeder" consists of fishes that primarily feed on mobile invertebrates; with MHI mean estimates plotted for reference (red line)

2.3.3 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 2020. Hard Coral cover is mean cover derived from visual estimates by divers of sites where reef fish surveys occurred. No new survey occurred in 2020 and the numbers presented here are identical to last year's report.

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 partners, as part of the Pacific RAMP. Survey methods and sampling design, and methods to generate reef fish biomass are described in Section 2.3.1.

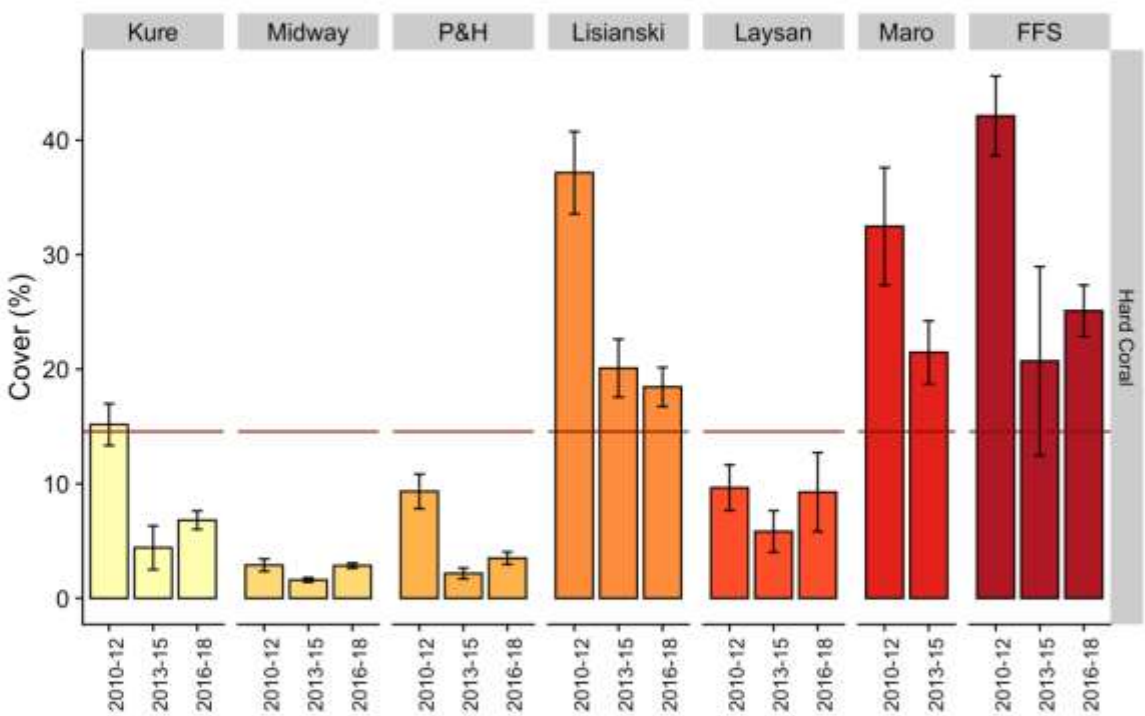

Figure 10. Mean coral cover (%) per island averaged over the years 2010-2020 by latitude with NWHI mean estimates plotted for reference (red line)

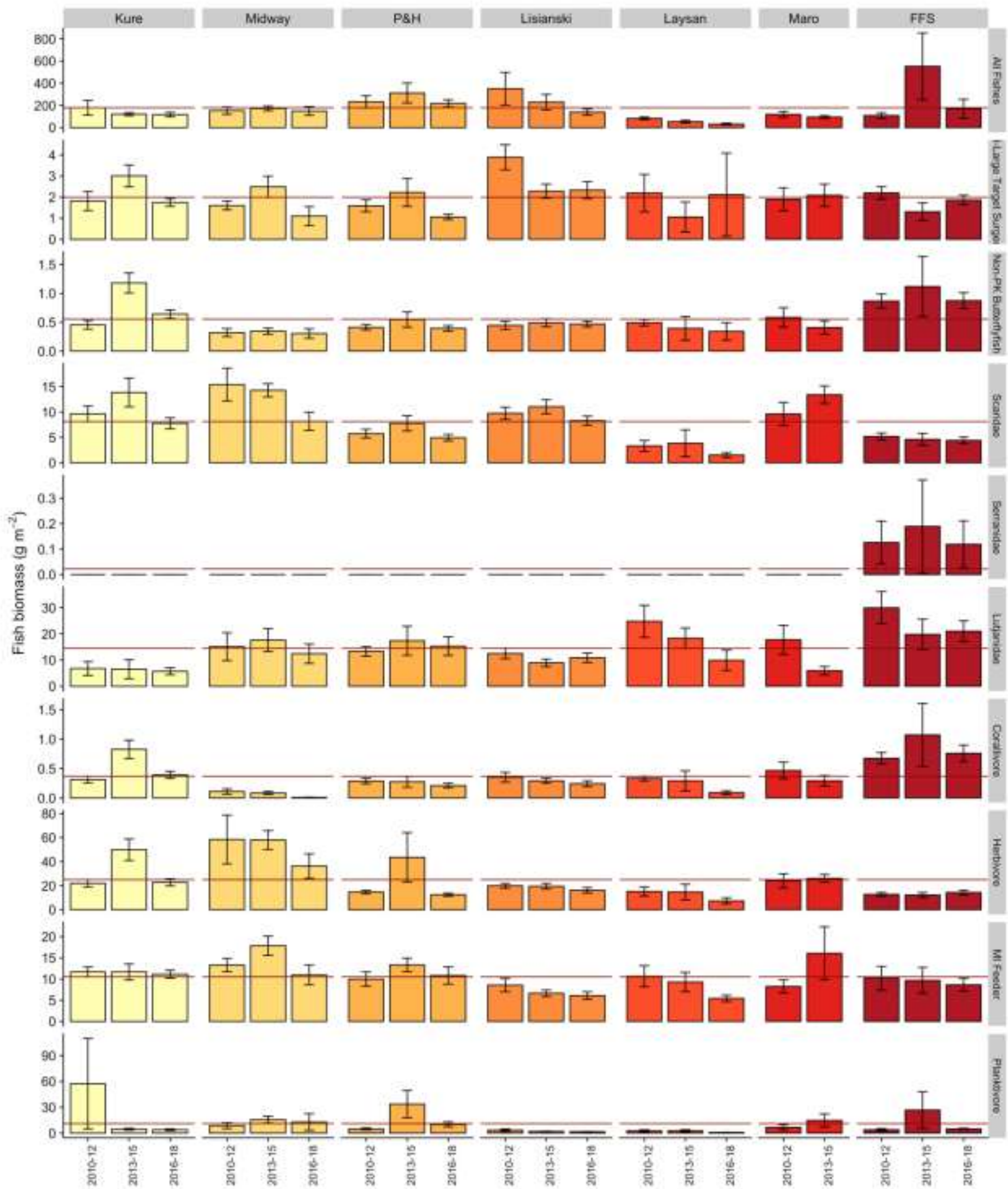

Figure 11. Mean fish biomass (g/m^2 ± standard error) of NWHI functional, taxonomic, and trophic groups from the years 2010-2019 by island. The group Serranidae excludes planktivorous members of that family (i.e., anthias, which can by hyper-abundant in some regions). The group "MI Feeder" consists of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

2.4 LIFE HISTORY AND LENGTH DERIVED PARAMETERS

2.4.1 MHI Coral Reef Ecosystem Components Life History

2.4.1.1 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 48 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 48. 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[1]		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[2]		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).
[1] *Panulirus marginatus* growth rates (k and L_∞) are from a range of locations in the NWHI for both sexes.
[2] *Scyllarides squammosus* growth rates available for Schnute growth model but not from von Bertalannfy growth model (i.e., no k or L_∞).

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 is 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.

2.4.2 MHI Bottomfish Management Unit Species Life History

2.4.2.1 Age, Growth, and Reproductive Maturity

Description: 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 49 for specific details on data sources by species.

Parameter Definitions: Identical to Section 2.4.2.1

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 is 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.

Table 49. 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	
Aprion virescens	27[d]	72.78[d]	0.31[d]		0.24[d]		NA	42.5-47.5[d]	NA	Everson et al. (1989); O'Malley et al. (in press)
Etelis carbunculus	22[c]	50.3[c]	0.07[c]				NA	23.4[d]	NA	Nichols et al. (in review); DeMartini (2016)
Etelis coruscans	f=55[d] m=51[d]	f=87.6[d] m=82.7[d]	f=0.12[d] m=0.13[d]	f=-1.02[d] m=-1.37[d]		X[a]	NA	62.2[d]	NA	Reed et al. (in press); Andrews et al. (2020)
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); Luers et al. (2017)
Pristipomoides sieboldii							NA	23.8[d]	NA	DeMartini (2016)
Pristipomoides 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).

2.5 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.

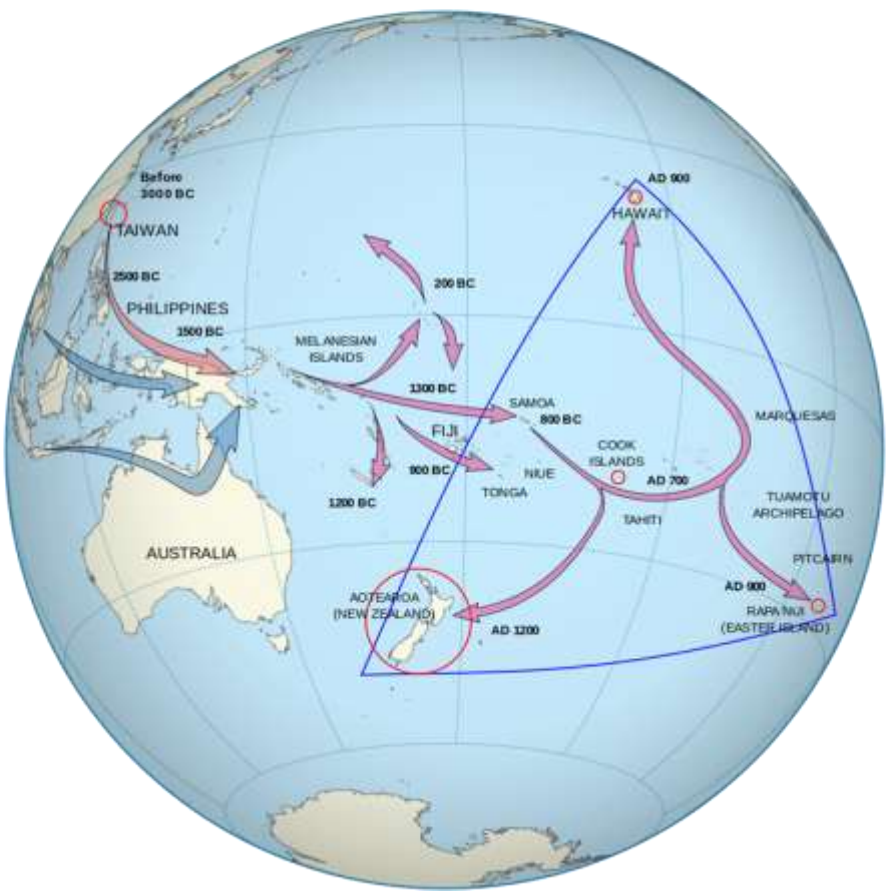

Figure 12. Settlement of the Pacific Islands, courtesy Wikimedia Commons
https://commons.wikimedia.org/wiki/File:Polynesian_Migration.svg

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.

2.5.1 Response to Previous Council Recommendations

At its 184th meeting held virtually, in December 2020 the Council encouraged NMFS to work with social scientists to better characterize potential for interactions between non-longline fisheries and insular false killer whales. PIFSC socioeconomic staff offered a willingness to support this effort in the future.

At its 182nd meeting held virtually, in June 2020 the Council directed staff to work with the NMFS 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. PIFSC socioeconomic staff coordinated with WPacFIN to ensure that data for kahala are included in the ecosystem component section of this module.

2.5.2 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 (WPRFMC 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 ahupuaʻa-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 Hawaiʻi, 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 Hawaiʻi (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 (NCRMP 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 (NCRMP 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 fishermen 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 ʻahi poke (bite-sized cubes of seasoned raw tuna) and ahi sashimi (sliced raw tuna). ʻAhi 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 Hawaiʻi'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).

Examination of the seascape of compliance across the US Pacific Island region found, that while the literature highlights the importance of enforcement, local experts emphasized barriers of capacity, governance process, and the lack of data. This suggests that non-instrumental and governance approaches can complement enforcement and should be part of an integrated compliance approach both in the region (Ayers and Leong 2020).

2.5.3 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 50.

Table 50. 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 50). 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.

2.5.3.1 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 bottomfish fishing 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. Bottomfish fishing 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 bottomfish fishing outweigh economic prospects.

2.5.3.2 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].

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

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

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.

2.5.3.3 Crustaceans

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

2.5.3.4 Precious Corals

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

2.5.4 Fishery Economic Performance

2.5.4.1 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 51 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 51. 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.

2.5.4.2 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, *H. laevigatus* 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.

2.5.4.2.1 MUS Commercial Participation, Landings, Revenues, Prices

Figure 13 shows the revenue structure of the three species groups (deep 7 bottomfish, uku, and three species of crustaceans) in the MUS and Deep 7 bottomfish are the main component of the MUS. In 2020, deep7 composed of 85% total revenue, uku 15%, and crustaceans 2%. On average of the past 10 years, deep-7 composed of 76% of the total revenue of MUS.

Figure 14 shows the number of fishers with MUS sales in 2011-2020. The number of fishers (CML from the HDAR fisher reports) with MUS landings and the number of fishers with MUS sale (CML from the HDAR dealer reports) decreased since 2014. In general, the percentage of fishers reporting MUS sales vs. the fishers reporting MUS landings has increased since 2013, except for 2020. In 2020, the number of fishers (CML) reporting MUS sales dropped 41 from 403 to 362, compared to 2019, while the number of fishers (CML) with MUS landings declined by only 4 fishers.

Figure 15 shows the pounds sold and revenue of Deep 7 of Hawaii bottomfish fishery, 2011-2020. Commercial landings of Deep 7 peaked in 2015 and has decreased in recent years. Deep 7 revenues show similar trends to commercial landings. Deep-7 revenue declined 23% in 2020 compared with 2019, while the average annual decrease during the period of 2016-2020 was 11%. The combination of lower prices and lower commercial landings, probably due to impacts associated with pandemic restrictions, resulted in the historical low revenue in 2020.

Supporting data for Figure 13, Figure 14, and Figure 15 are presented in Table 52. Please note that the commercial data (the number of fishers/CML with MUS sold, pounds sold, and revenue) were sourced from the HDAR dealer data, while 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, 2011-2020. Both Deep-7 and uku prices declined in 2020, and Deep-7 price dropped considerably, from $8.32 per pound (adj.) in 2019 to $7.23 per pound in 2020. Supporting data for Figure 16 are presented in Table 53.

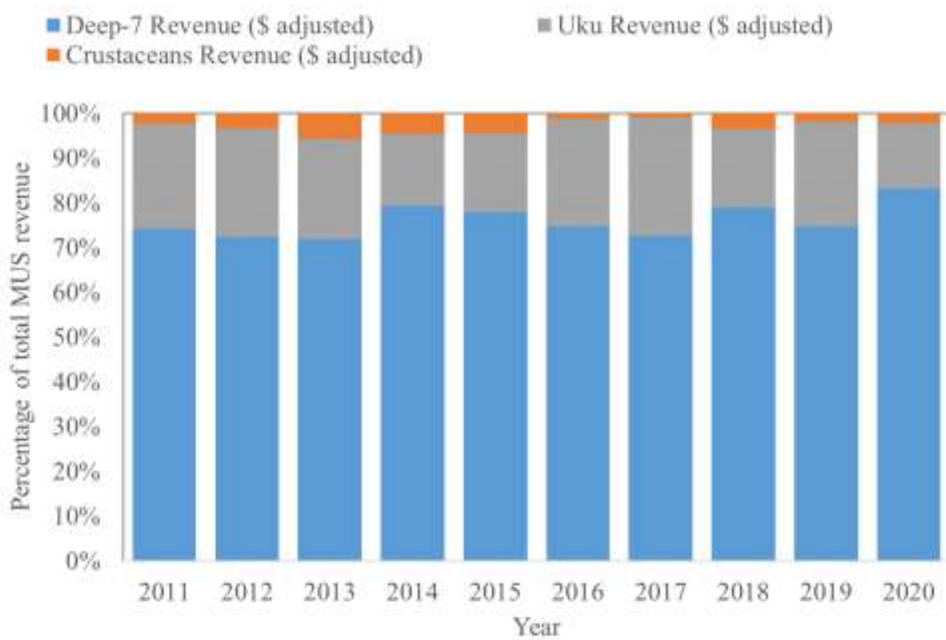

Figure 13. The revenue structure of the three species groups in the MUS, 2011-2020

Table 52. Total participants and revenue structure of the three species groups in the MUS

Year	MUS Pounds kept (lb)	MUS pounds sold (lb)	% of pounds sold	# CML (HDAR)	# of CML (Dealer reports)	MUS Rev ($)	MUS Rev adj ($)	% Deep-7 of total sold	% Uku of total sold	% Crustaceans of total sold	CPI adjustor
2011	403,079	322,633	80%	684	497	1,762,816	2,069,546	74%	24%	2%	1.174
2012	364,471	300,405	82%	708	522	1,731,964	1,984,831	72%	24%	3%	1.146
2013	387,293	316,339	82%	690	528	1,908,276	2,148,719	72%	23%	6%	1.126
2014	459,020	369,337	80%	648	517	2,276,827	2,527,278	79%	16%	5%	1.110
2015	440,605	383,238	87%	668	533	2,399,708	2,637,279	78%	18%	4%	1.099
2016	397,314	360,657	91%	581	484	2,332,979	2,514,951	75%	24%	1%	1.078
2017	379,350	349,290	92%	529	462	2,271,009	2,386,830	73%	27%	1%	1.051
2018	325,921	291,138	89%	496	419	2,110,269	2,177,798	79%	18%	4%	1.032
2019	289,303	250,814	87%	478	403	1,791,227	1,819,887	75%	23%	2%	1.016
2020	222,605	183,537	82%	472	362	1,238,594	1,238,594	83%	15%	2%	1.000

Data source: PIFSC FRMD from HDAR data.

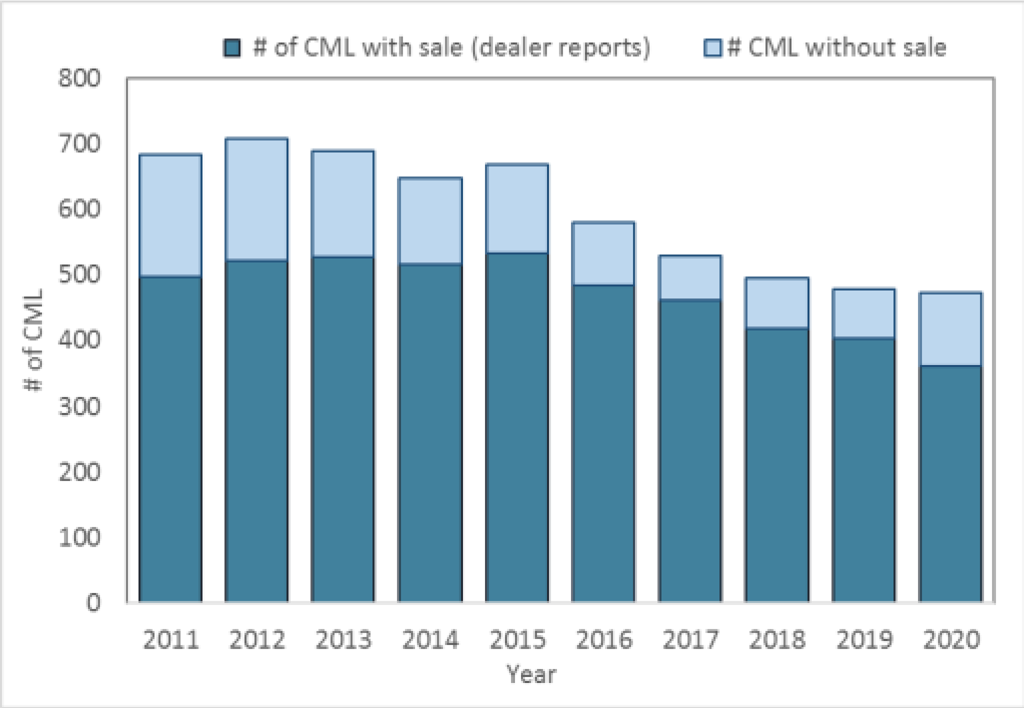

Figure 14. Total fishers in Hawaii MUS, 2011-2020

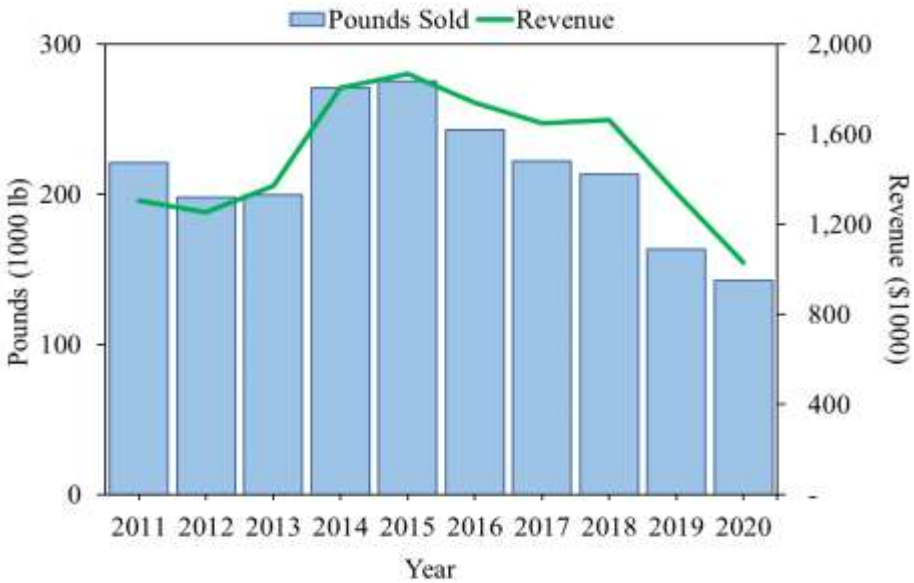

Figure 15. Pounds sold and revenue of Deep 7 of Hawaii bottomfish fishery, 2011-2020, adjusted to 2020 dollars

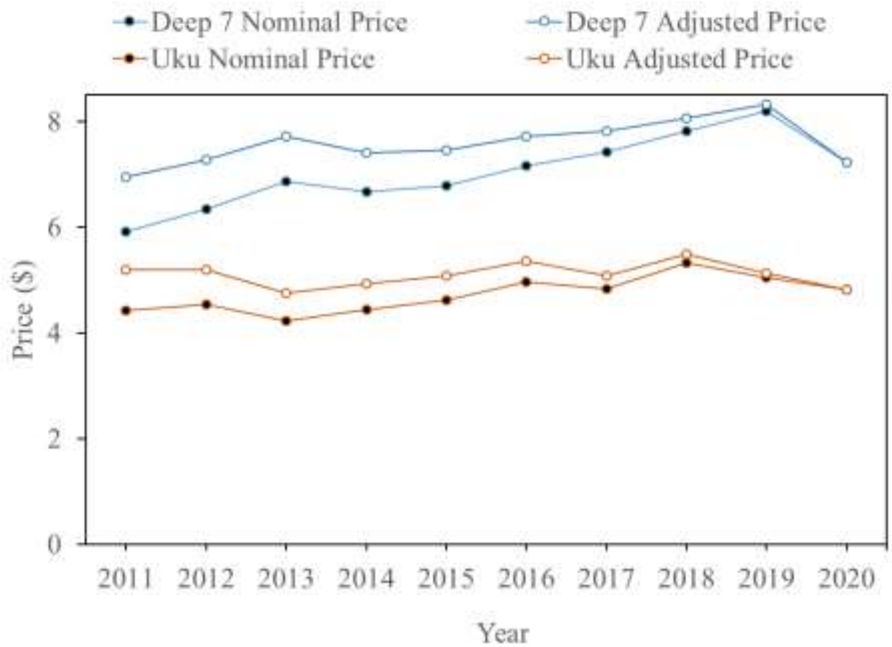

Figure 16. Fish prices of Deep 7 and Uku of Hawaii bottomfish fishery, 2011-2020

Table 53. Fish sold, revenue, and price information of MUS, 2011-2020

Year	Deep-7 pounds caught (lb)	Deep-7 pounds sold (lb)	Deep-7 Revenue ($adj.)	Deep-7 price ($/lb)	Deep-7 price adj. ($/lb)	Uku pounds sold (lb)	Uku Revenue ($adj.)	Uku price ($/lb)	Uku price adj. ($/lb)	Crustacean pounds sold (lb)	Crustaceans Revenue ($adj.)	Crustacean Price	Crustacean price adj ($/lb)	CPI adjustor
2011	274,571	220,860	1,306,006	5.91	6.94	94,056	489,137	4.43	5.20	7,717	47,158	5.21	6.12	1.174
2012	227,971	197,766	1,254,165	6.34	7.27	92,831	481,547	4.53	5.19	9,808	66,011	5.87	6.73	1.146
2013	239,010	199,747	1,370,325	6.86	7.72	102,079	484,757	4.22	4.75	14,513	120,976	7.40	8.33	1.126
2014	311,209	270,684	1,805,908	6.67	7.40	82,571	407,285	4.44	4.93	16,082	115,436	6.47	7.18	1.110
2015	307,014	275,262	1,867,947	6.79	7.46	92,063	467,416	4.62	5.08	15,913	116,991	6.69	7.35	1.099
2016	260,732	243,103	1,740,382	7.16	7.72	113,662	608,039	4.96	5.35	3,892	30,780	7.34	7.91	1.078
2017	237,879	221,988	1,648,485	7.43	7.81	124,762	633,665	4.83	5.08	2,541	20,609	7.72	8.11	1.051
2018	236,119	213,157	1,664,085	7.81	8.06	69,495	381,400	5.32	5.49	8,487	79,060	9.03	9.32	1.032
2019	180,859	163,341	1,338,295	8.19	8.32	82,756	424,630	5.05	5.13	4,717	35,549	7.42	7.54	1.016
2020	161,437	142,486	1,030,834	7.23	7.23	37,530	180,966	4.82	4.82	3,521	26,795	7.61	7.61	1

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

2.5.4.2.2 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, ʻōpakapaka, kalekale, gindai, lehi, and hapuʻupuʻu. 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. Thus, the estimated value would be different from the sale value generated from the dealer's sale value.

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). Gini coefficient 0 indicates "no different" and 1 is "extremely different". Therefore, 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. As showed in Figure 17, the average Gini coefficient in the past ten years had been steady, 0.74 on average, and it dropped slightly to 0.72 in 2020, indicating the variations of annual revenue among vessels were substantial. In 2020, the average annual revenue per vessel (CML) from all bottomfish sold was $5,816, dropped $615 from 2019.

In Figure 18, the revenue per trip included Deep-7, non-Deep-7 bottomfish species, and non-bottomfish species (such as pelagic) that were caught in the same trip, unlike Figure 17 where "fishery revenues" refers only to Deep 7 bottomfish species. Supporting data for Figure 17 and Figure 18 are provided in Table 54, where the second column to the last reflects the share of Deep 7 bottomfish in total fishing revenues (all species combined caught on Deep 7 fishing trips.

In 2020, the average annual revenue per a fishing trip from all fish sold was $1,165. As Figure 17 shows, the revenue per trip increased from 2011 to 2016 gradually and it tended to stable in recent years since 2016. However, the share of Deep-7 in the trip revenue has shown a downward trend in general, particularly in both 2019 and 2020. On average, the share of Deep-7 revenue was 76% to the total trip revenue, but it was down to 60% in 2020. This implies that a Deep-7 fishing trip caught 40% of non-Deep-7 species (in terms of estimated value).

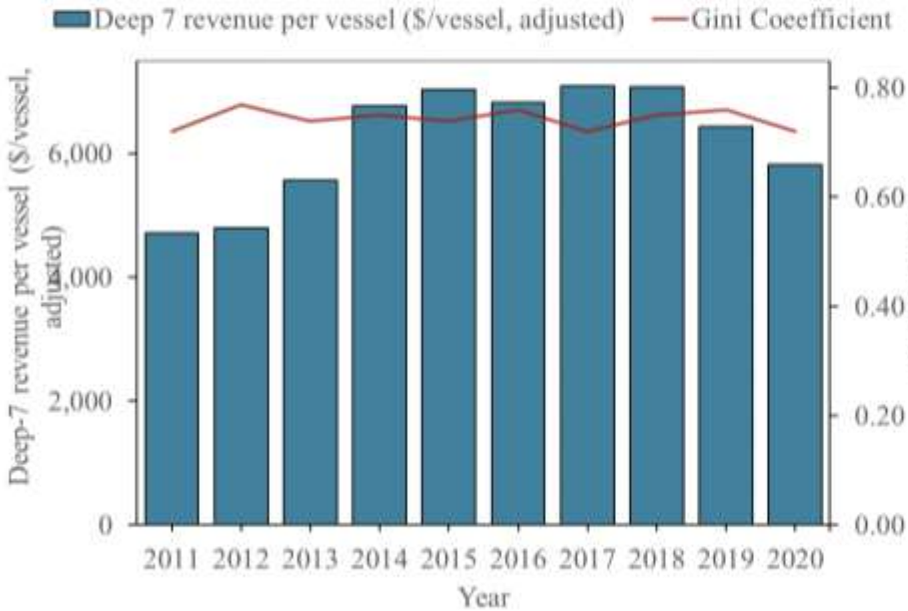

Figure 17. Trends in fishery revenue per vessel and Gini coefficient for the MHI Deep 7 Bottomfish fishery, 2011-2020

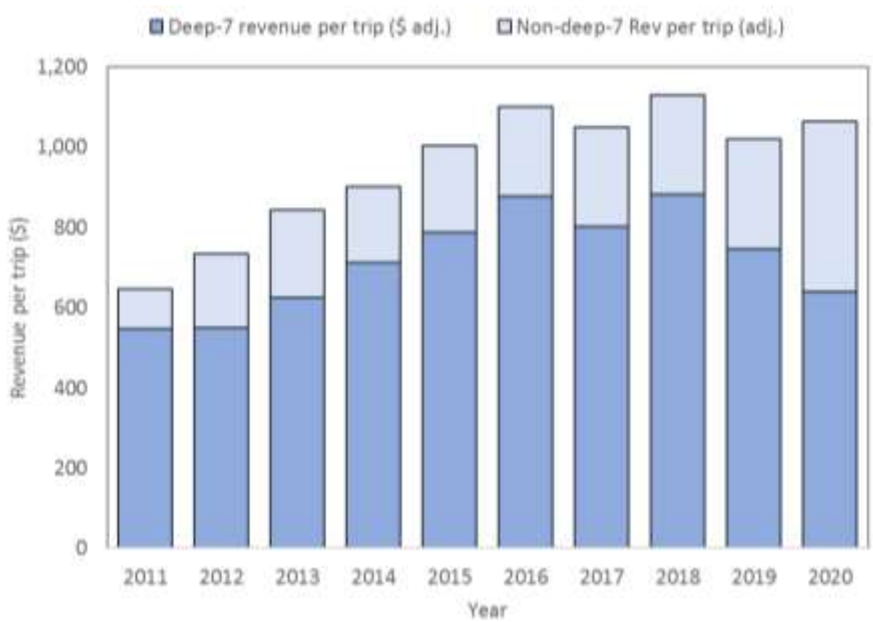

Figure 18. Trends in fishery revenue per trip and Deep 7 as a percentage of total revenues of all Bottomfish sold (2011-2020)

Table 54. MHI Deep 7 bottomfish fishery economic performance measures, 2011-2020

Year	Total revenue per vessel ($)	Total revenue per vessel adj. ($)	Gini Coeefficient	Deep-7 Rev per trip ($)	Deep-7 revenue per trip ($ adj.)	Total trip revenue (adj.)	% of deep-7 in total revenue	CPI adjustor
2011	3,930	4,712	0.72	457	548	648	85%	1.20
2012	4,152	4,800	0.77	475	549	734	75%	1.16
2013	4,926	5,561	0.74	554	625	844	74%	1.13
2014	6,105	6,771	0.75	642	712	902	79%	1.11
2015	6,430	7,028	0.74	720	787	1,003	78%	1.09
2016	6,308	6,825	0.76	812	878	1,102	80%	1.08
2017	6,687	7,095	0.72	756	802	1,050	76%	1.06
2018	6,837	7,076	0.75	853	882	1,130	78%	1.04
2019	6,333	6,434	0.76	735	747	1,020	73%	1.02
2020	5,819	5,819	0.72	641	641	1,065	60%	1.00

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

2.5.4.2.3 Hawaii Ecosystem Component Species

Based on the new guideline for the archipelagic SAFE report from the Council, this section highlights 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 55 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 over half a million dollars in 2020, slightly higher than 2019. Akule was the leading species of the top 10, which composed 48% of the total revenue of the top 10 in 2020. In addition, the ten fish species defined as the priority species (species of interest) for Hawaii are shown in Table 56. The total revenue of the 10 priority species also was also over half a million dollars in 2020, slightly higher than 2019.

Table 55. Top 10 ECS commercial landings, revenue, and price, 2019 and 2020

	2020						2019					
Local Name	# of Fishers	Pounds Kept	Pounds Sold	Revenue	%	Price $/lb	# of Fishers	Pounds Kept	Pounds Sold	Revenue (adj.)	%	Price $/lb (adj.)
Akule	210	267,551	256,245	835,961	48%	3.26	209	245,746	222,202	764,332	45%	3.44
Menpachi	163	60,518	55,648	286,236	16%	5.14	177	45,814	46,893	226,913	13%	4.84
Opelu	115	70,774	51,723	158,523	9%	3.06	122	121,984	84,646	240,767	14%	2.84
Uhu	49	36,260	30,715	144,938	8%	4.72	58	45,399	42,495	214,801	13%	5.06
Taape	178	37,787	36,931	67,037	4%	1.82	178	29,583	30,547	50,550	3%	1.66
Red Weke	50	20,615	22,132	77,559	4%	3.50	56	18,254	15,840	57,871	3%	3.66
Opihi Alinalina	11	13,547	10,755	74,222	4%	6.90						
Palani	47	26,442	28,192	52,668	3%	1.87	48	24,964	28,247	51,139	3%	1.81
Manini	34	12,103	11,019	37,005	2%	3.36						
Kahala	146	14,624	1,684	2,755	0%	1.64	154	13,998	3,197	6,225	0%	1.95
Kuahonu Crab							1	17,321	8,509	43,612	3%	5.12
He'e (Day Tako)							49	11,082	9,678	54,186	3%	5.60
Sum		560,221	505,044	1,736,904		3.44		574,145	492,254	1,710,396		3.47

Table 56. Priority ECS commercial landings, revenue, and price, 2019 and 2020

	2020						2019					
Local Name	# of Fishers	Pounds Kept	Pounds Sold	Revenue ($)	% of total rev	Price $/lb	# of Fishers	Pounds Kept	Pounds Sold	Revenue (adj.)	% of total rev	Price $/lb (adj.)
Uhu	50	38,100	44,087	218,269	42%	4.95	62	45,606	46,029	233,058	42%	5.05968
Opihi	11	16,558	14,493	101,245	19%	6.99	20	11,018	11,773	87,950	16%	7.4676
Taape	178	37,787	36,931	67,037	13%	1.82	178	29,583	30,547	50,550	9%	1.65608
Manini	34	12,103	11,019	37,005	7%	3.36	40	8,725	9,284	30,346	6%	3.27152
Kala	31	11,150	11,412	22,569	4%	1.98	32	8,843	9,348	17,638	3%	1.88976
Nenue	32	9,247	9,505	19,319	4%	2.03	37	10,199	11,145	23,287	4%	2.09296
He'e (Day tako)	41	4,360	2,960	15,034	3%	5.08	49	11,082	9,678	54,186	10%	5.59816
Kumu	35	864	1,725	18,653	4%	10.81	43	553	1,364	15,040	3%	11.0338
Lobster	10	3,713	1,598	14,657	3%	9.17	10	4,213	3,437	31,803	6%	9.25576
Omilu	115	4,749	3,599	11,561	2%	3.21	96	4,784	1,875	6,052	1%	3.23088
Total		138,631	137,329	**525,349**		3.83		134,606	134,480	**549,910**		4.09

2.5.5 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 2020. 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 57. Pacific Islands Region 2020 Commercial Fishing Economic Assessment Index

	2020 CFEAI				
	2020 Reporting Year (e.g. 1/2020-12/2020)				
	Data			Assessment	
Pacific Islands Fisheries	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	2013	2020	2016
ASam Longline	2020	2020	2016	2020	2019
HI Offshore Handline	2020	2014	2014	2019	2019
HI Small Boat (pelagic)	2020	2014	2014	2017	2019
HI Small Boat (bottomfish)	**2020**	**2014**	**2014**	**2017**	**2019**
HI Small Boat (reef)	**2020**	**2014**	**2014**	**2017**	**2019**
Guam Small boat	2020	2020	2019	2020	
CNMI Small boat	2020	2020	2019	2020	
ASam Small boat	2020	2020	2015	2020	

PIFSC also generates projections for upcoming fiscal years, and the table below provides the projected CFEAI report for 2021 (*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 2021.

Table 58. Pacific Islands Region 2021 Commercial Fishing Economic Assessment Index

	2021 Projected CFEAI				
	2021 Reporting Year (e.g. 1/2021-12/2021)				
	Data			Assessment	
Pacific Islands Fisheries	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	2021	2021	2013	2021	2016
ASam Longline	2021	2021	2016	2021	2019
HI Offshore Handline	2021	2021	2021	2019	2019
HI Small Boat (pelagic)	2021	2021	2021	2017	2019
HI Small Boat (bottomfish)	**2021**	**2021**	**2021**	**2017**	**2019**
HI Small Boat (reef)	**2021**	**2021**	**2021**	**2017**	**2019**
Guam Small boat	2021	2021	2019	2021	
CNMI Small boat	2021	2021	2019	2021	
ASam Small boat	2021	2021	2021	2021	

PIFSC had plans to field an update to the Hawaii small boat cost earnings survey (Chan and Pan 2017; Hospital et al. 2011) during calendar year 2020, however due to delays in survey approval coupled with COVID-19 restrictions, this effort was postponed to 2021. This survey will provide updated information on operating costs and fixed costs for the Hawaii bottomfish and boat-based reef fisheries, as well as numerous elements related to fishing behavior, market participation, and fishery demographics Hawaii small boat 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 environmental justice, economic vulnerability, and gentrification pressure (https://www.fisheries.noaa.gov/national/socioeconomics/social-indicators-coastal-communities).

2.5.6 Relevant PIFSC Economics and Human Dimensions Publications: 2020

Publication	MSRA Priority
Ayers AL, Leong K. 2020. Examining the Seascape of Compliance in U.S. Pacific Island fisheries. Marine Policy. 115:103820. https://doi.org/10.1016/j.marpol.2020.103820	PS1.4.2 HC3.2
Ingram RJ, Leong KM, Gove J, Wongbusarakum S. 2020. Including Human Well-Being in Resource Management with Cultural Ecosystem Services. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC112, 95 p. https://doi.org/10.25923/q8ya-8t22	IF8.1.1 HC2.1.1
Iwane MA, Leong KM, Vaughan M, Oleson KLL. 2020. Engaging Hawai'i small boat fishers to mitigate pelagic shark mortality. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-20-10, 113 p. https://doi.org/10.25923/54tf-kh65	PS1.4.2 HC3.2
Leong KM, Decker DJ. 2020. Human Dimensions Considerations in Wildlife Disease Management: U.S. Geological Survey Techniques and Methods. Book 15, chap. C8, 21 p. https://doi.org/10.3133/tm15C8	HC3.2.3 HC3.2.4
Leong KM, Gramza AR, Lepczyk CA. 2020. Understanding conflicting cultural models of outdoor cats to overcome conservation impasse. Conservation Biology. 34(5):1190-1199. https://doi.org/10.1111/cobi.13530	HC3.2.3 HC3.2.4
Leong KM, Torres A, Wise S, Hospital J. 2020. Beyond recreation: when fishing motivations are more than sport or pleasure. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-20-05, 57 p. https://doi.org/10.25923/k5hk-x319	HC1.2 HC3.1.1 HC3.2.1
Lovell S, Hilger J, Rollins E, Olsen NA, Steinbeck S. 2020. The Economic Contribution of Marine Angler Expenditures on Fishing Trips in the United States, 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFSF/SPO-201, 80 p. https://spo.nmfs.noaa.gov/content/tech-memo/economiccontribution-marine-angler-expenditures-fishing-trips-united-states-2017	HC1.2 HC1.2.1
McKenzie P, Leong K, Robinson S. 2020. What's the word on monk seals? How the endangered Hawaiian monk seal Is portrayed in the media. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-20-02, 34 p. https://doi.org/10.25923/d74y-j565	HC3.2

National Marine Fisheries Service (NMFS). 2020. NOAA Fisheries Initial Impacts Assessment of the COVID-19 Crisis on the U.S. Commercial Seafood and Recreational For-Hire/Charter Industries. 32p. https://media.fisheries.noaa.gov/2021-02/Initial-COVID-19-ImpactAssessment-webready.pdf	HC1
Oliver TA, Hospital J, Brainard RE. 2020. Spatial Prioritization under Resilience Based Management: Evaluating Trade-offs among Prioritization Strategies. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFSPIFSC-105, 47 p. https://doi.org/10.25923/xdf2-t259	HC2.1.2 HC2.2.1
Oliver TA, Kleiber D, Hospital J, Maynard J, Tracey D. 2020. Coral Reef Resilience and Social Vulnerability to Climate Change: Main Hawaiian Islands. Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-20-002a, 6 p. https://doi.org/10.25923/5xhp-5k12	HC2.1.2 HC2.2.1
Pacific Islands Fisheries Science Center. 2020. Fishery Ecosystem Analysis Tool (FEAT). https://origin-apps-pifsc.fisheries.noaa.gov/FEAT/#/	HC1.1.1 HC3.1.3
Pacific Islands Fisheries Science Center. 2020. Pacific Islands Fisheries Impacts from COVID-19: Pacific Islands Snapshot, March-July 2020. 10p. https://media.fisheries.noaa.gov/2021-02/Pacific-Islands-COVID-19-ImpactSnapshot-webready.pdf	HC1
Sterling EJ, Pascua P, Sigouin A, Gazit N, Mandle L, Betley E, Aini J, Albert S, Caillon S, Caselle JE, Wongbusarakum S, et al. 2020. Creating a space for place and multidimensional well-being: lessons learned from localizing the SDGs. Sustainability Science. 15(4):1129-47. https://doi.org/10.1007/s11625-020- 00822-w	HC2.1.1 HC2.2.2
Weijerman M, Oyafuso ZS, Leong KM, Oleson KLL, Winston M. 2020. Supporting Ecosystem-based Fisheries Management in meeting multiple objectives for sustainable use of coral reef ecosystems. ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsaa194	IF8.1.6 HC2.1.2 HC2.1.4
Wongbusarakum S, Kindinger T, Gorstein M. 2020. Assessing socio-economic indicators to improve their usefulness for resource management in the US Pacific islands. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-98, 67 p. https://doi.org/10.25923/27jh-pm07	HC1.1.7 HC1.1.9 HC2.1.2

2.6 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.

2.6.1 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.

2.6.1.1 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.

2.6.1.2 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 59).

Table 59. 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.

2.6.1.2.1 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 bottomfish fishing 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).

2.6.1.2.2 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.

2.6.1.2.3 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.

2.6.1.2.4 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.

2.6.1.3 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 2021 LOF (86 FR 3028, January 14, 2021), 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).

2.6.2 Status of Protected Species Interactions in the Hawaii FEP Fisheries

2.6.2.1 Bottomfish Fishery

2.6.2.1.1 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 bottomfish fishing 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.

2.6.2.1.2 Elasmobranch Interactions

As described in Section 2.6.1.2, 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 Enterprise Inc. 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.

2.6.2.2 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 Hawaii 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.

2.6.3 Identification of Emerging Issues

Table 60 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 60. 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.
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; recovery planning workshop planned for 2021.

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)	Draft recovery plan published 10/16/2020 (85 FR 65791), comment period closed 12/15/2020, final plan anticipated in 2021.
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)	7 populations qualify as DPS, but DPS listing not warranted due to all populations meeting existing endangered classification; no changes proposed to existing global listing (85 FR 48332, 8/10/20)	N/A	N/A	N/A
Cauliflower Coral	*Pocillopora meandrina*	Positive (83 FR 47592, 9/20/2018)	Not warranted (85 FR 40480, 7/6/20)	N/A	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

2.6.4 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.

2.7 CLIMATE AND OCEANIC INDICATORS

2.7.1 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 2020 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 Committee (MPCCC). 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. 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

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.

2.7.2 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 for the Hawaii Archipelago in 2020.

2.7.3 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).

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

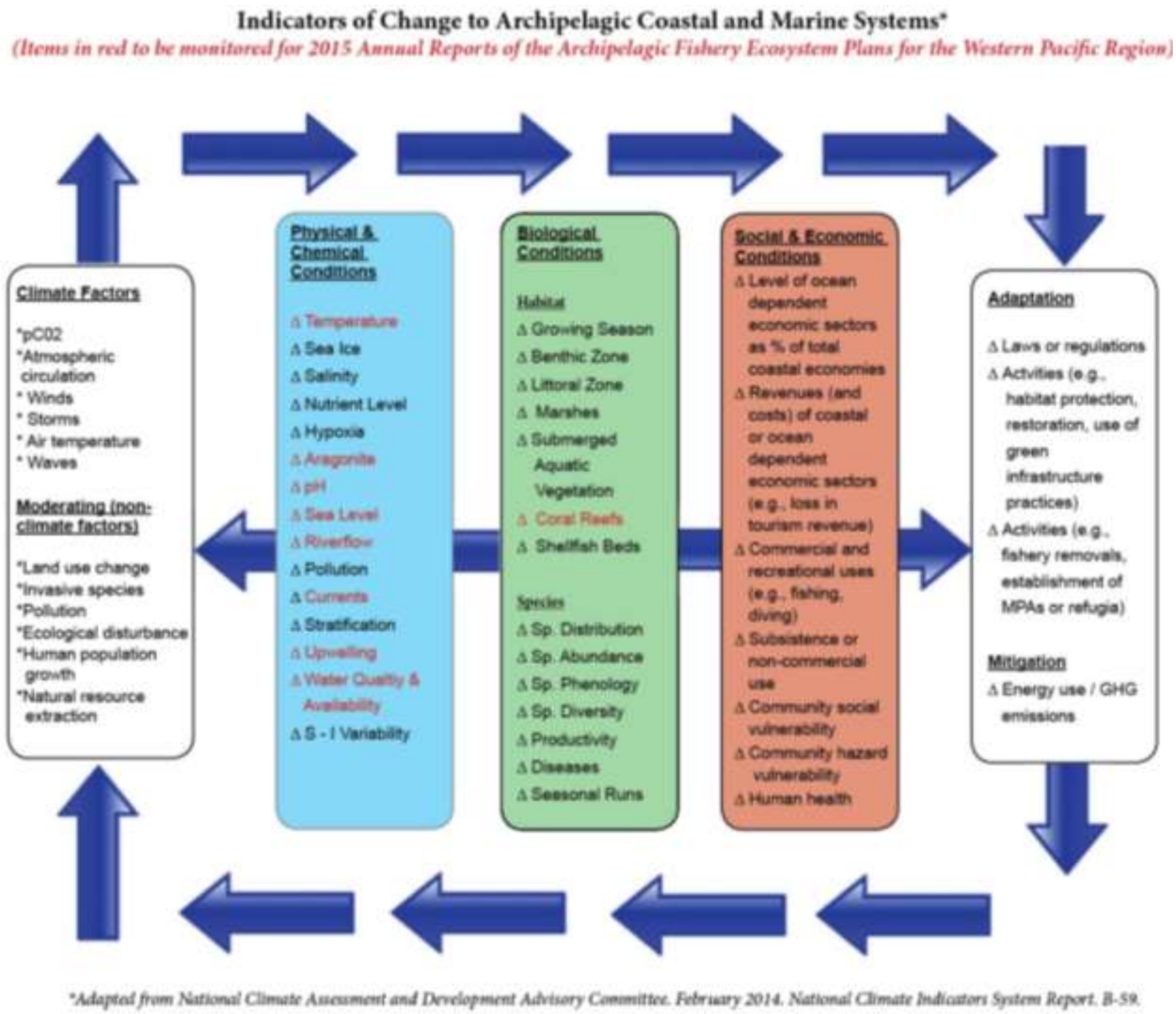

Figure 19. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability

2.7.4 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.

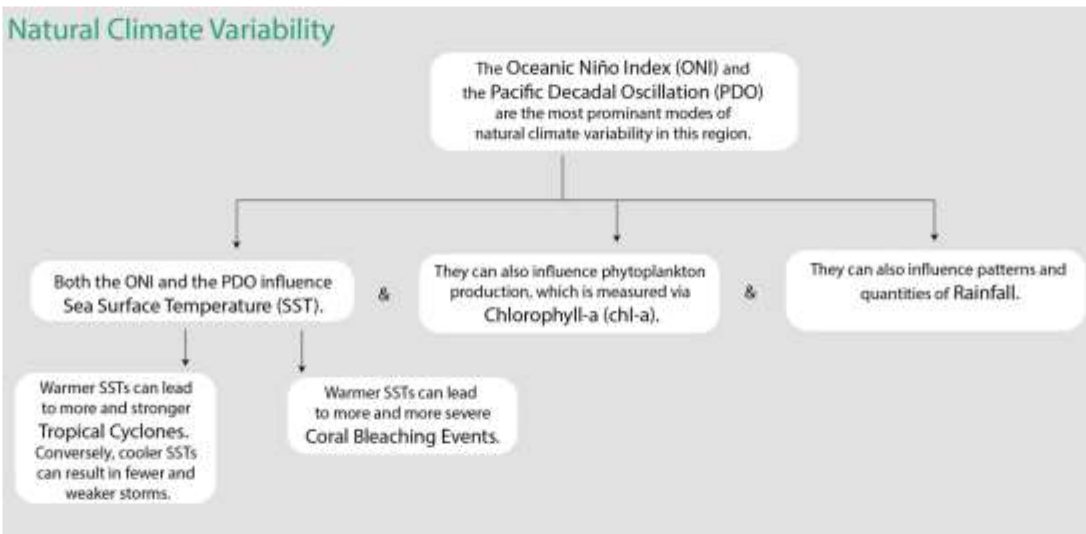

Figure 20. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability

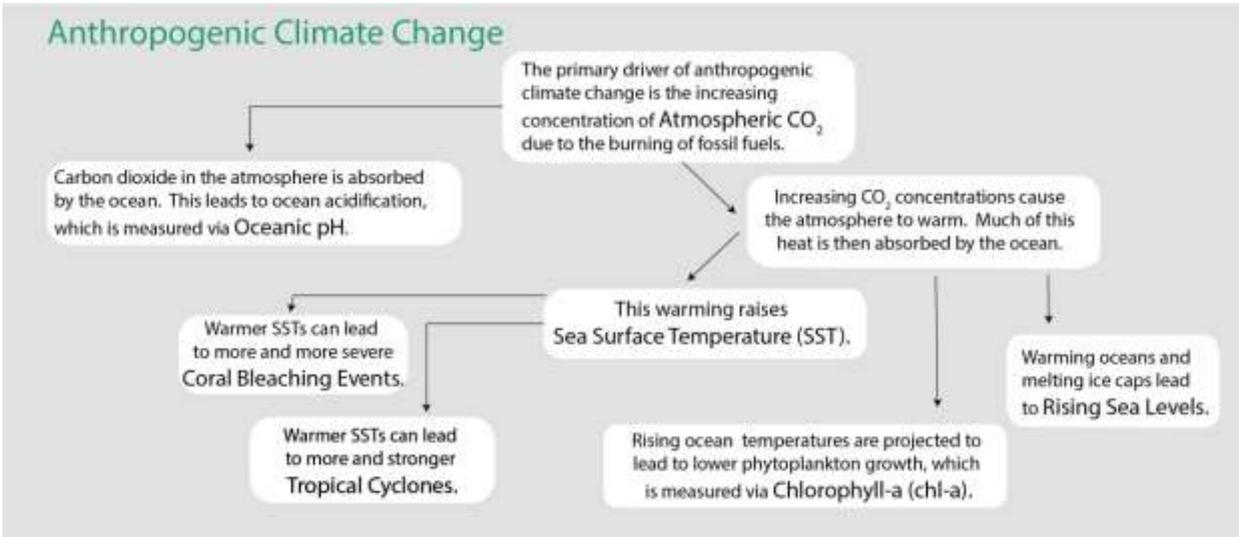

Figure 21. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of anthropogenic climate change

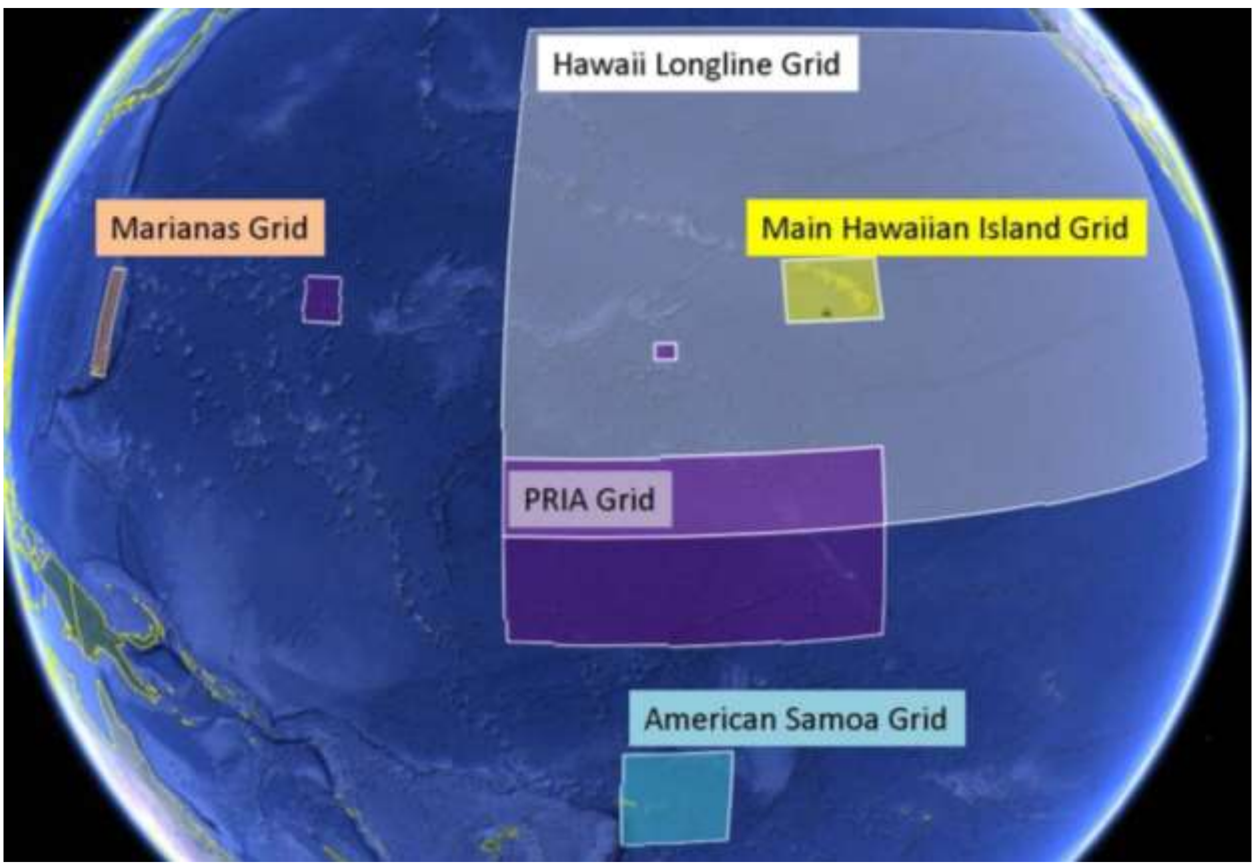

Figure 22. Regional spatial grids representing the scale of the climate change indicators being monitored

2.7.4.1 Atmospheric Concentration of Carbon Dioxide at Mauna Loa

Rationale: Atmospheric carbon dioxide (CO_2) 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 2020, the annual mean concentration of CO_2 was 414 parts per million (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.

Description: Monthly mean atmospheric carbon dioxide at Mauna Loa Observatory, Hawai‘i in 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 approximately one year. The annual variations at Mauna Loa, Hawai‘i are due to the seasonal imbalance between the photosynthesis and respiration of terrestrial plants. During the summer growing season, photosynthesis exceeds respiration, and CO_2 is removed from the atmosphere. In the winter (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 its 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 (2021a).

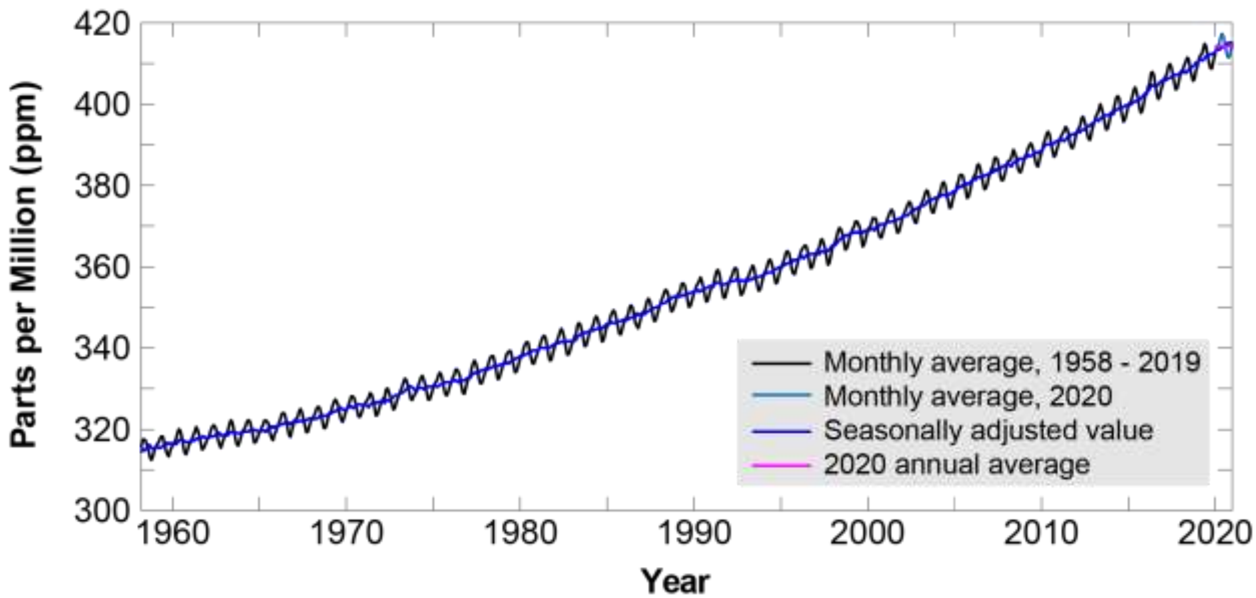

Figure 23. Monthly mean (black) and seasonally corrected (blue) atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii

2.7.4.2 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 9.4% more acidic than it was 30 years ago at the start of this time series. Over this time, pH has declined by 0.043 at a constant rate. In 2019, the most recent year for which data are available, the average pH was 8.06. Additionally, small variations seen over the course of the year are outside the range seen in the first year of the time series for the third year in a row. The highest pH value reported for the most recent year (8.077) is lower than the lowest pH value reported in the first year of the time series (8.081).

Description: Trends in surface (5 m) pH at Station ALOHA, north of Oahu (22.75°N, 158°W), collected by the Hawaiʻi Ocean Time Series (HOT) from October 1988 to 2019 (2020 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), and the Hawaii Ocean Time Series as described in Karl and Lukas (1996) and on its website (HOT 2021).

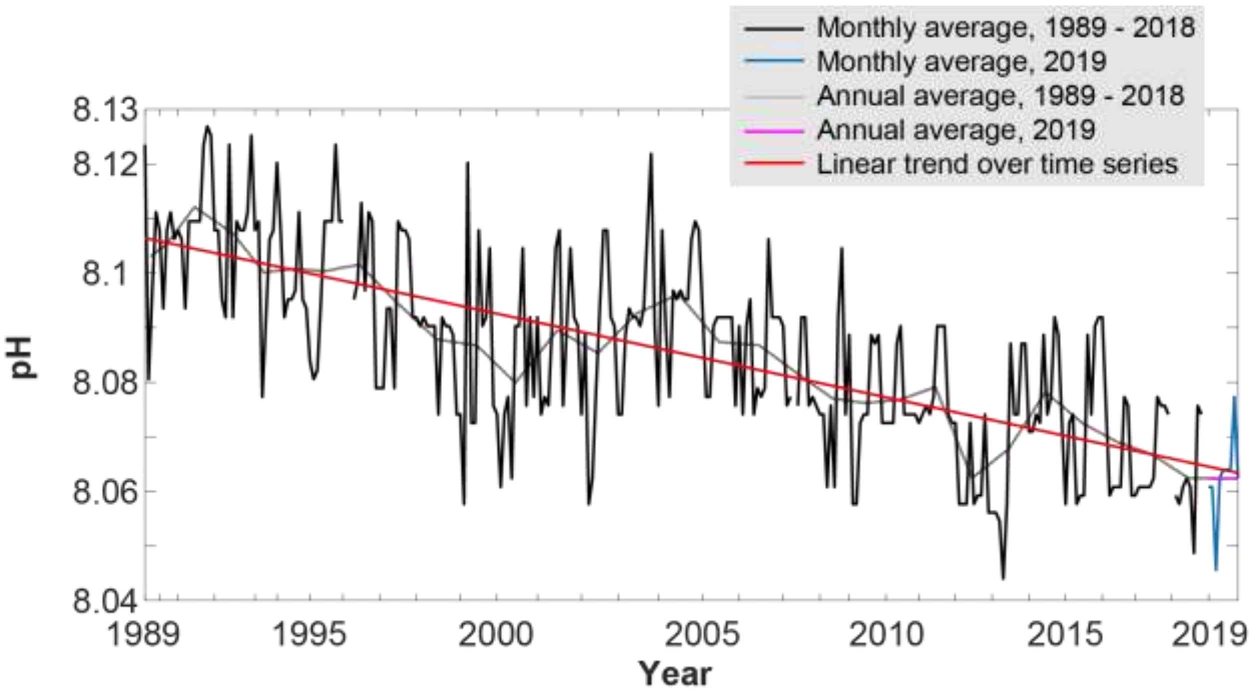

Figure 24. Time series and long-term trend of oceanic pH measured at Station ALOHA from 1989-2019

2.7.4.3 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 autumn of 2020, the ONI transitioned from neutral to La Niña conditions. Over the year, the ONI ranged from 0.5 to -1.3. This is within the range of values observed previously in the time series.

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 (2021).

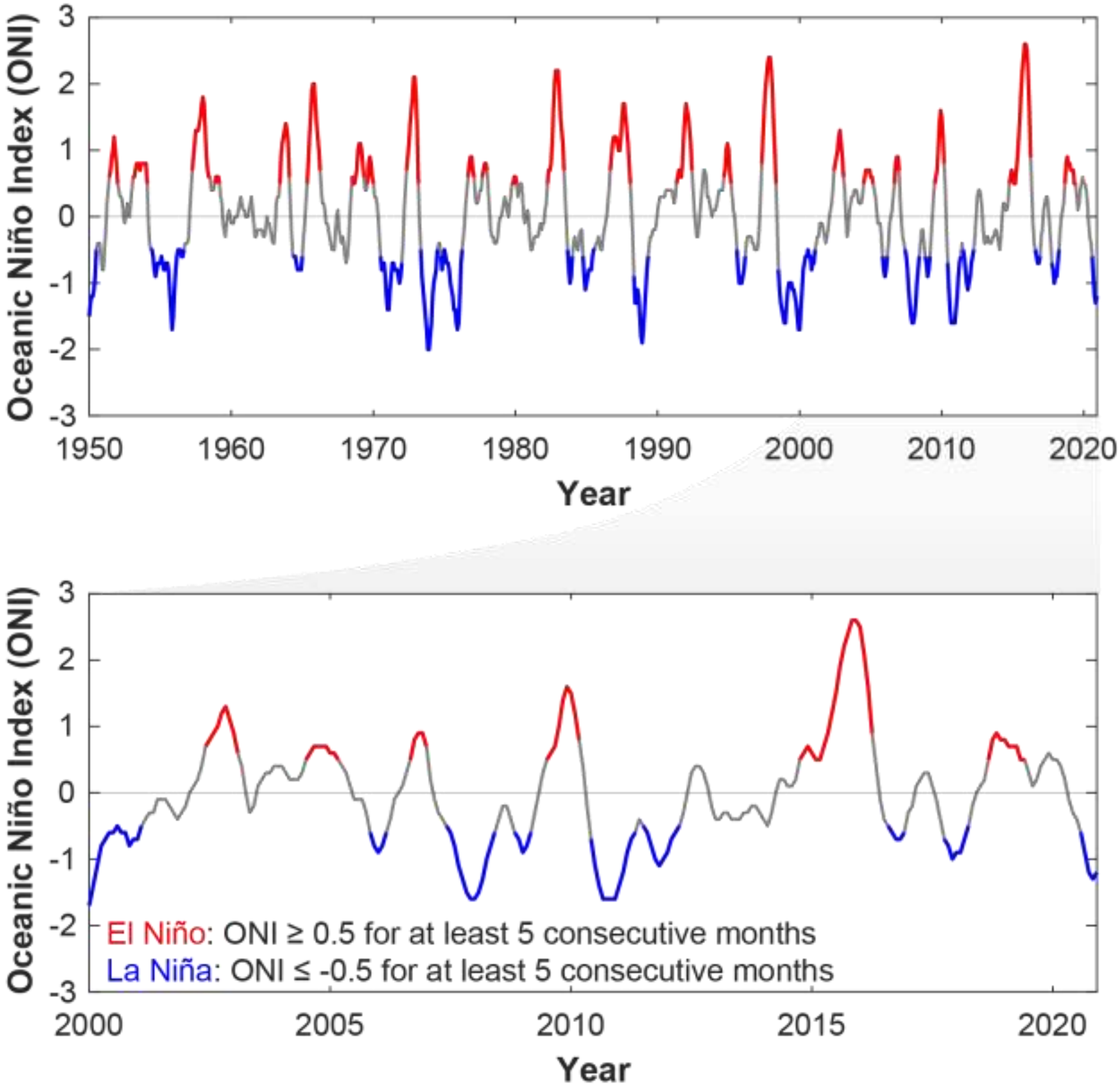

Figure 25. Oceanic Niño Index from 1950-2020 (top) and 2000–2020 (bottom) with El Niño periods in red and La Niña periods in blue

2.7.4.4 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 (2021b) and Mantua (2017).

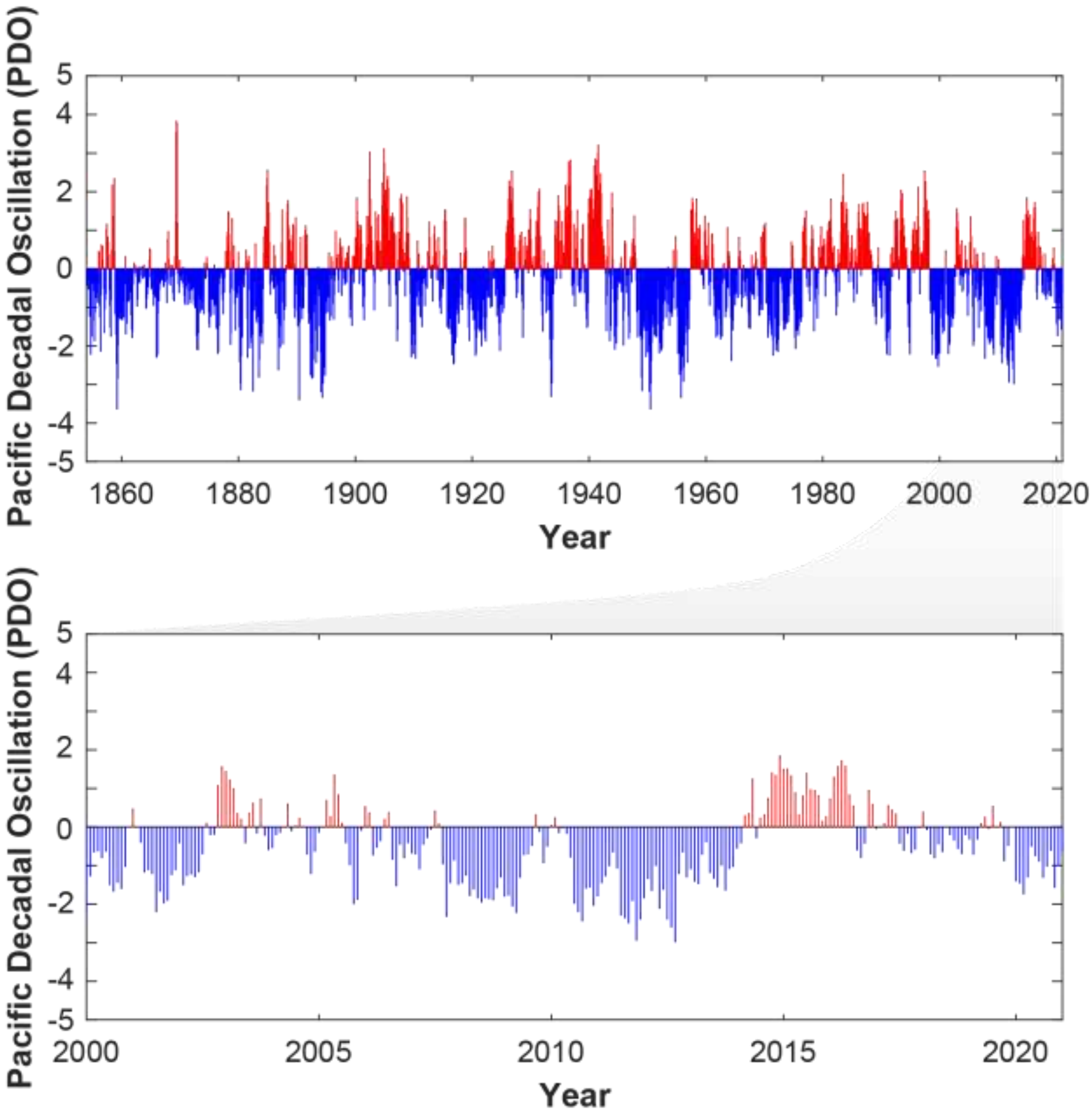

Figure 26. Pacific Decadal Oscillation from 1950–2020 (top) and 2000–2020 (bottom) with positive warm periods in red and negative cool periods in blue

2.7.4.5 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 Hawaiʻi 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 2020 eastern Pacific hurricane season featured an average number of named storms, but below average hurricane and major hurricane activity. There were sixteen named storms, of which four 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 five tropical depressions that did not reach tropical storm strength. Two tropical storms, Odalys and Polo, formed in the basin in November. Although the long-term (1981-2010) average is one tropical storm forming in the basin every second or third year, this is the third straight November with at least one named storm forming. In fact, named storms have formed in November in six of the past seven years in the basin. In terms of Accumulated Cyclone Energy (ACE), which measures the strength and duration of tropical storms and hurricanes, activity in the basin for 2020 was below normal, more than 40 percent below the long-term average. Summary inserted from https://www.nhc.noaa.gov/text/MIATWSEP.shtml.

Central North Pacific. Tropical cyclone activity in the central Pacific in 2020 was slightly below average. While there was only one named storm, which is below the 1981 – 2010 average of three, this storm was particularly noteworthy. July's hurricane Douglas reached category 4 strength, making it a major hurricane. Its intensity fell prior to its passage just north of the main Hawaiian Islands. On average, the central Pacific sees three named storms, two hurricanes, and no major hurricanes. The 2020 ACE index was about an order of magnitude below the 1981 – 2010 average.

Western North Pacific. Tropical cyclone activity was below average in the western Pacific in 2020. There were 23 named storms, compared to an average of 26. Twelve of these developed into typhoons, and seven of these typhoons were major. An average year would see 17 typhoons, nine of which would be major. The West Pacific was unusually quiet in 2020 with less than half its normal ACE (third lowest since 1981). The West Pacific did have the strongest storm of 2020, Super Typhoon Goni, which made landfall in the Philippines as a powerful category 5 storm. The initial estimates of 195-mph winds during its landfall would be the strongest on record. Portions of the summary inserted from https://www.ncdc.noaa.gov/sotc/tropical-cyclones/202013.

South Pacific. Tropical cyclone activity in the south Pacific region was roughly average in 2020. There were ten named storms, five of which developed into cyclones and one of which – Harold – was major. The long-term average in this region is nine named storms, five cyclones, and two major cyclones. The strongest cyclone of the Southern Hemisphere season was category-5 Tropical Cyclone Harold. Harold alone accounted for more than half of the Southwest Pacific's ACE for 2020 (overall, the region's ACE index was below average in 2020). It was the first category 5 storm in the Southern Hemisphere since Tropical Cyclone Gita in 2018. Harold caused widespread damage throughout the South Pacific Islands, particularly in Vanuatu where it achieved its peak intensity. Portions of the summary inserted from https://www.ncdc.noaa.gov/sotc/tropical-cyclones/202013.

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 bar 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), and NOAA (2021c).

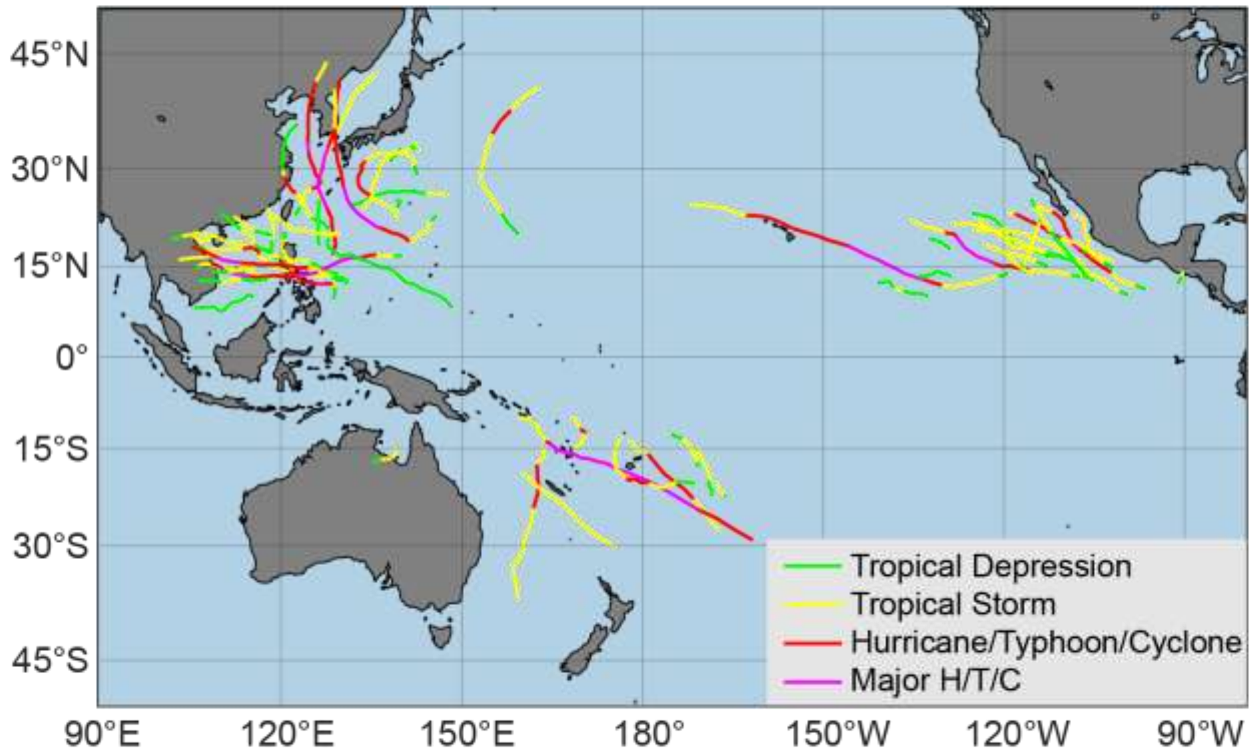

Figure 27. 2020 Pacific basin tropical cyclone tracks

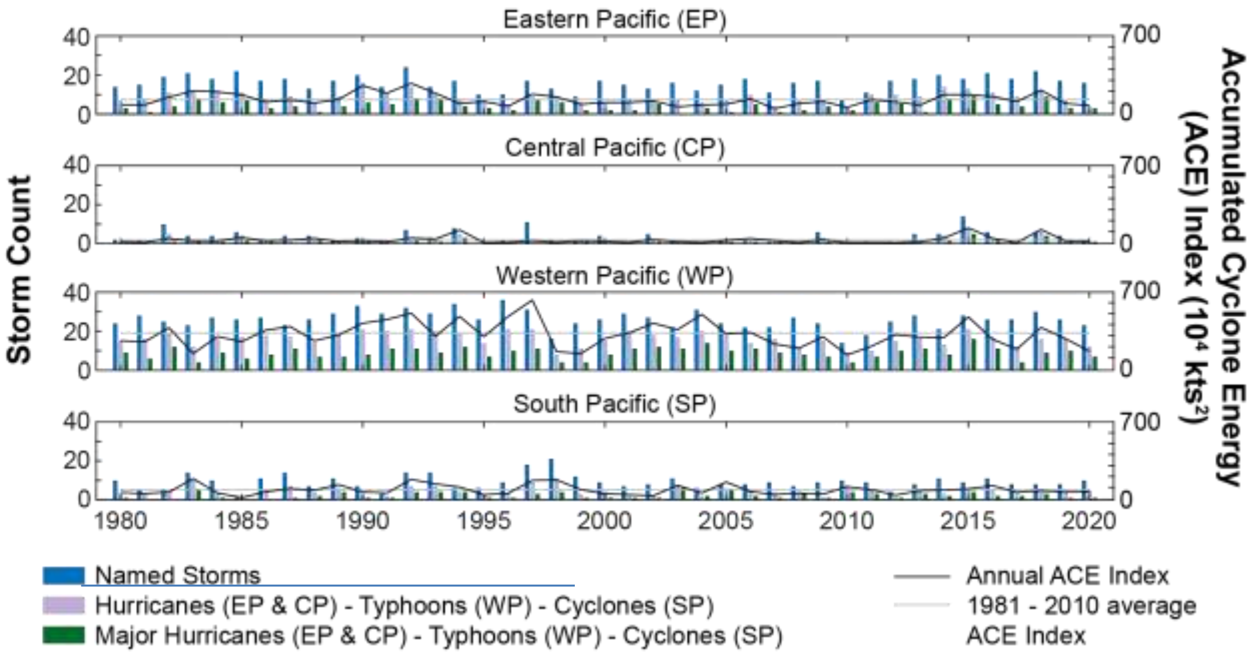

Figure 28. 2020 tropical storm totals by region

2.7.4.6 Sea Surface Temperature & Anomaly

Rationale: Sea surface temperature (SST) 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 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 26.06 ºC in 2020. Over the period of record, annual SST has increased at a rate of 0.0176 ºC yr^{-1}. Monthly SST values in 2020 ranged from 24.34 – 27.43 ºC, outside the climatological range of 23.29 – 28.48 ºC. The annual anomaly was 0.51 ºC hotter than average, with some intensification in the northern part of the region.

Note that from the top to bottom in Figure 29, panels show climatological SST (1985-2019), 2020 SST anomaly, time series of monthly mean SST, and time series of monthly SST anomaly.

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 Coral Reef Watch CoralTemp v3.1 (2021).

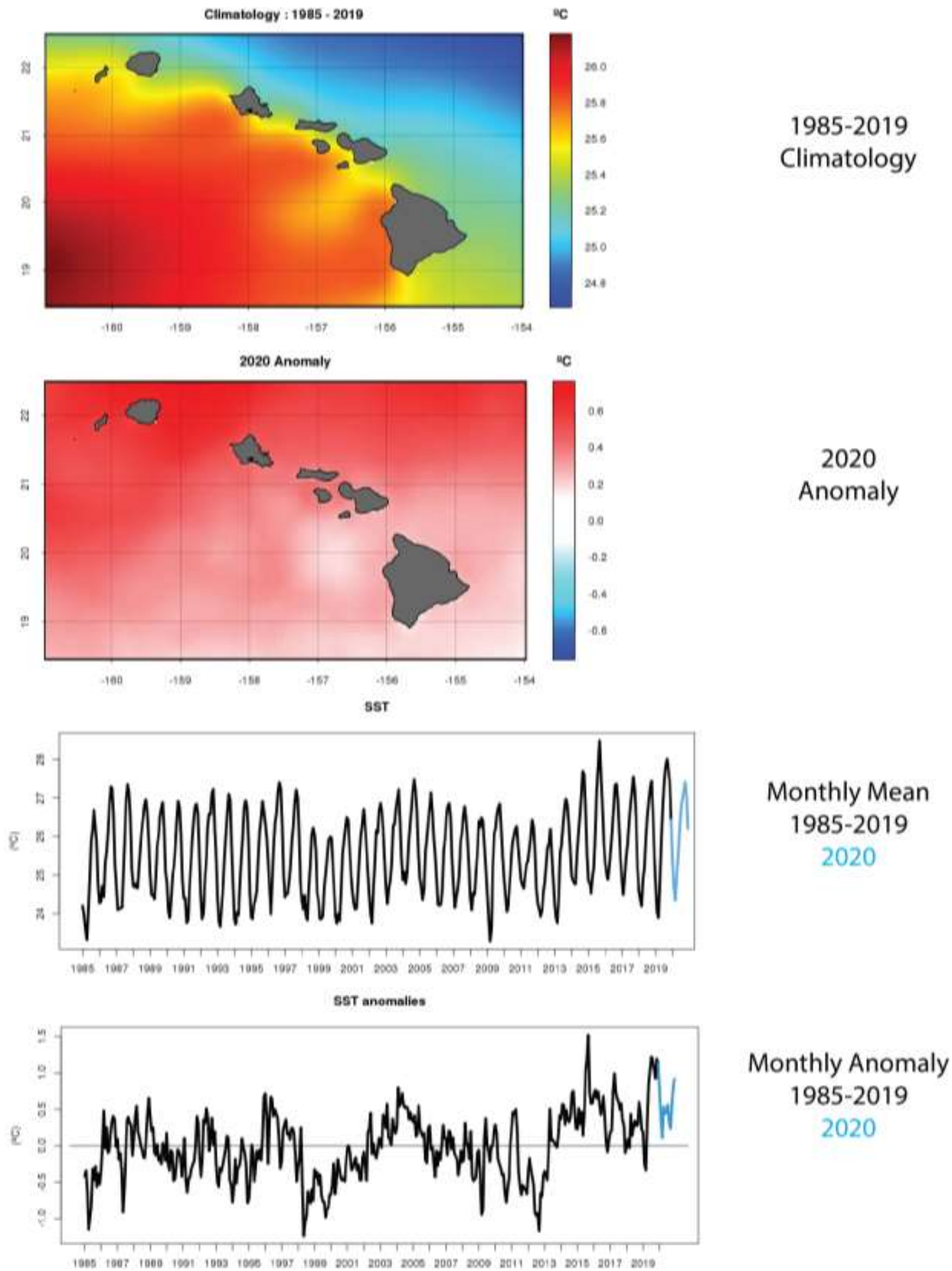

Figure 29. Sea surface temperature climatology and anomalies from 1985-2020

2.7.4.7 Coral Thermal Stress Exposure: Degree Heating Weeks

Rationale: Degree heating weeks (DHW) 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 2019, the main Hawaiian Islands experienced little coral heat stress in 2020.

Description: Here we present a metric of exposure to thermal stress that is relevant to coral bleaching. DHW measures 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 daily 5-km satellite coral bleaching 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.

Timeframe: 2014-2019, daily data.

Region/Location: Global.

Sourced from: Sourced from: NOAA Coral Reef Watch CoralTemp v3.1 (2021).

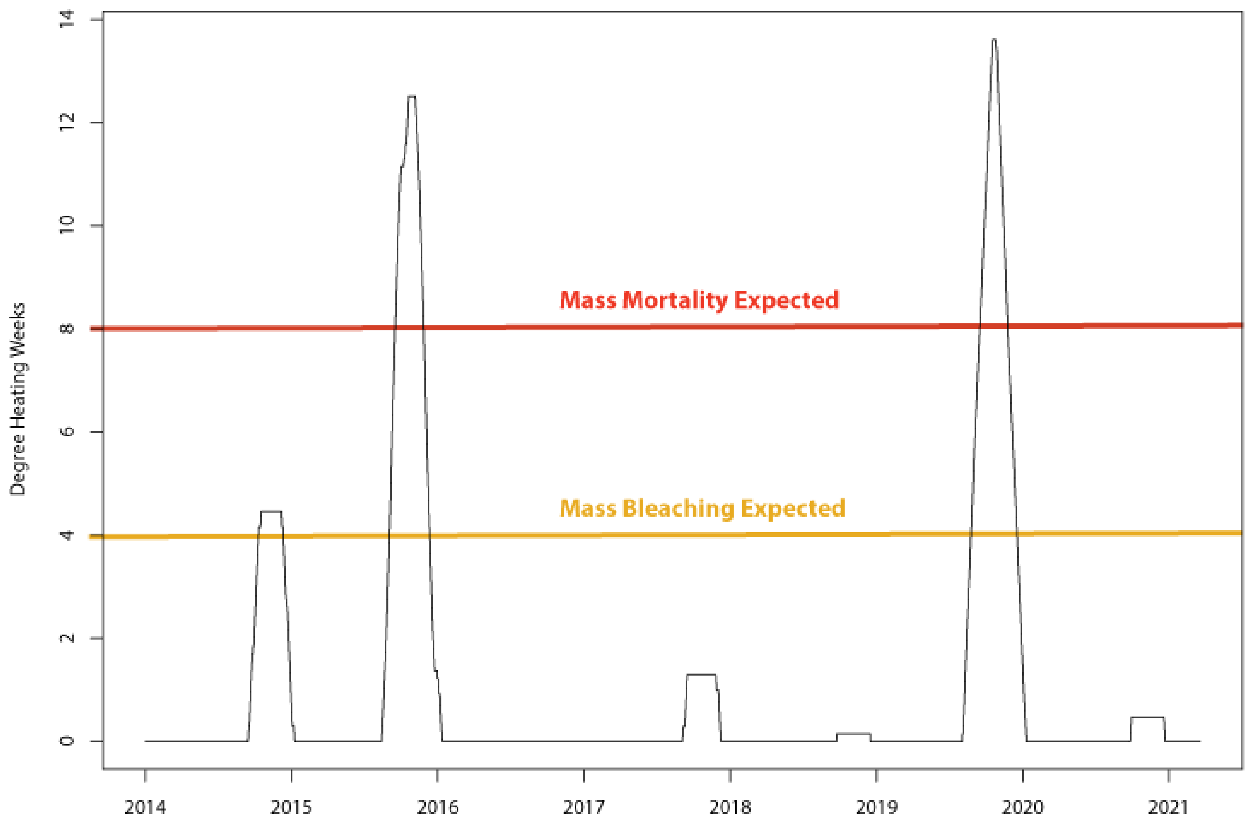

Figure 30. Coral Thermal Stress Exposure, Main Hawaiian Island Virtual Station from 2014-2020, measured in Coral Reef Watch Degree Heating Weeks

2.7.4.8 Chlorophyll-A and Anomaly

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

Status: Annual mean Chl-A was 0.077 mg/m^3 in 2020. Over the period of record, annual Chl-A has shown no significant temporal trend. Monthly Chl-A values in 2020 ranged from 0.061-0.096 mg/m^3, within the climatological range of 0.057 – 0.121 mg/m^3. The annual anomaly was 0.0014 mg/m^3 lower than average, with some intensification in the northeastern section of the region.

Description: Chl-A concentration from 1998-2020 was derived from the ESA Ocean Color Climate Change Initiative dataset, v5.0. A monthly climatology was generated across the entire period (1998-2019) to provide both a 2020 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: 1998-2020, daily data available, monthly means shown.

Region/Location: Global.

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

Sourced from: NOAA OceanWatch (2021).

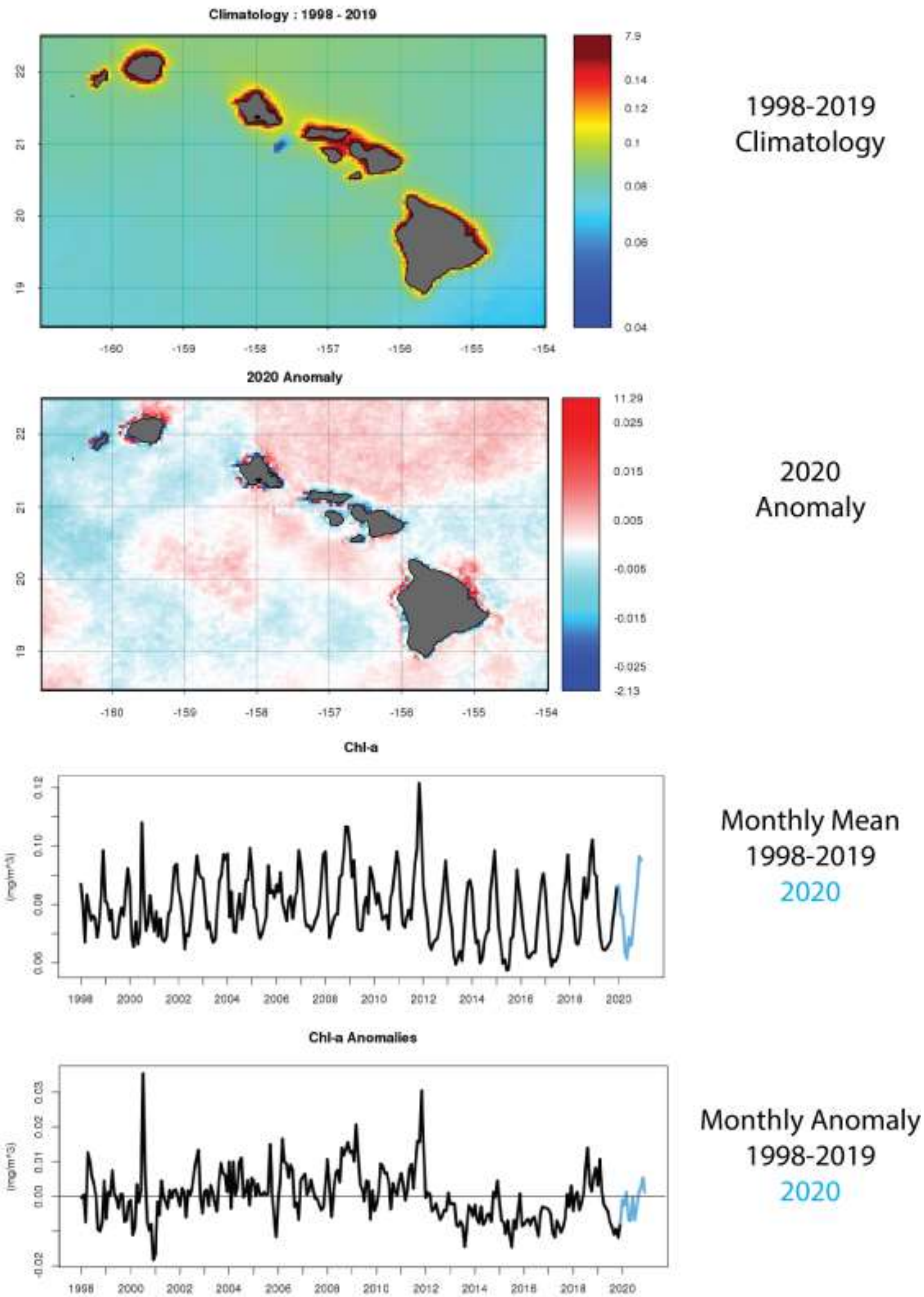

Figure 31. Chlorophyll-*a* (Chl-A) and Chl-A Anomaly from 1998-2020

2.7.4.9 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 Climate Prediction Center (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).

Text inserted from https://www.cpc.ncep.noaa.gov/products/global_precip/html/wpage.cmap.shtml.

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/; NOAA (2021d).

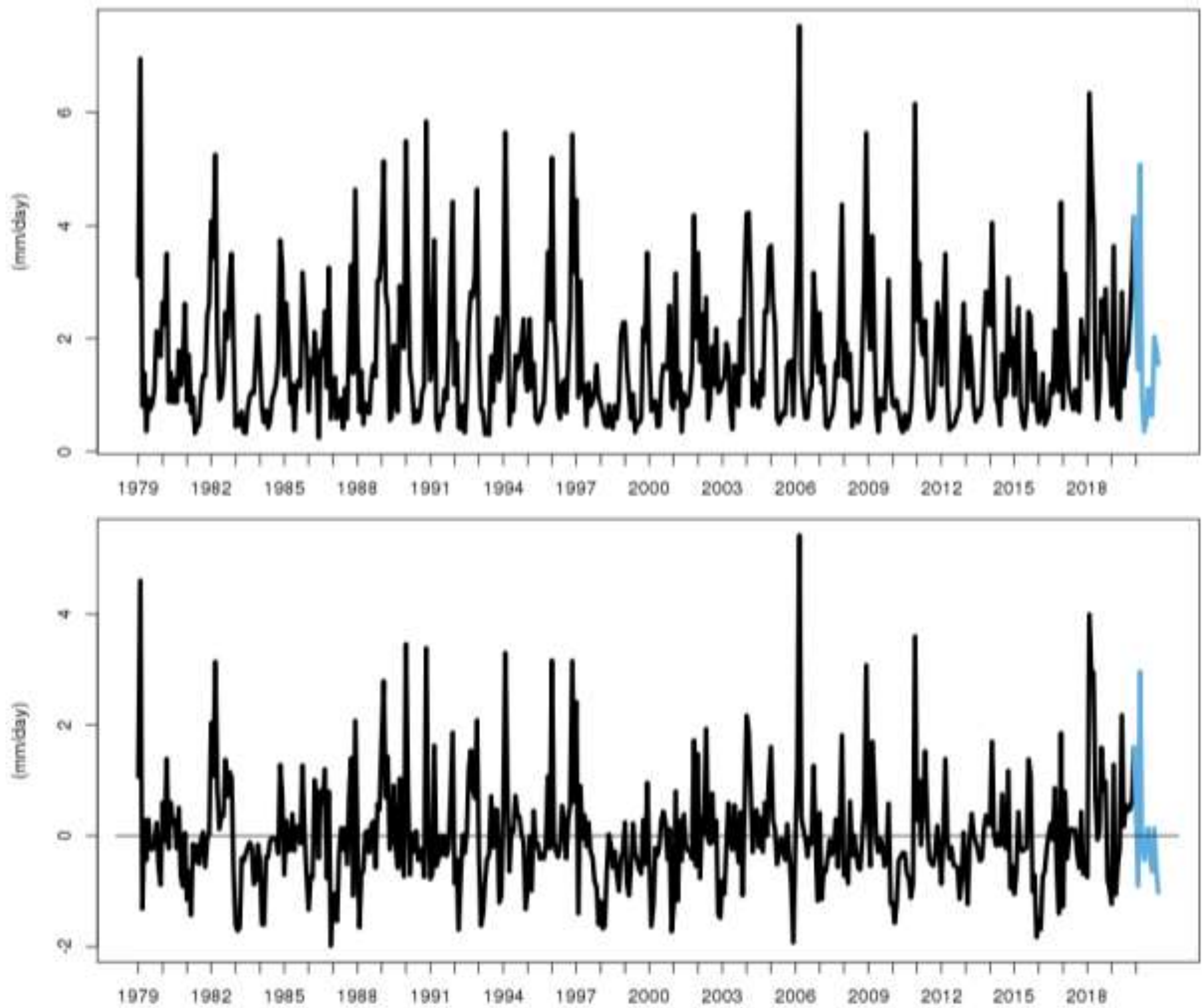

Figure 32. CMAP precipitation (top) and anomaly (bottom) across the MHI Grid with 2020 values in blue

2.7.4.10 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 (2021) and NOAA (2021e).

2.7.4.10.1 Basin-Wide Perspective

This image of the mean sea level anomaly for February 2020 compared to 1993-2013 climatology from satellite altimetry provides a glimpse into how the 2020 neutral ENSO conditions affected sea level across the Pacific Basin. The image captures the fact that sea level is slightly lower in the Western Pacific and slightly higher in the Central and Eastern Pacific (this basin-wide perspective provides a context for the location-specific sea level/sea surface height images that follow).

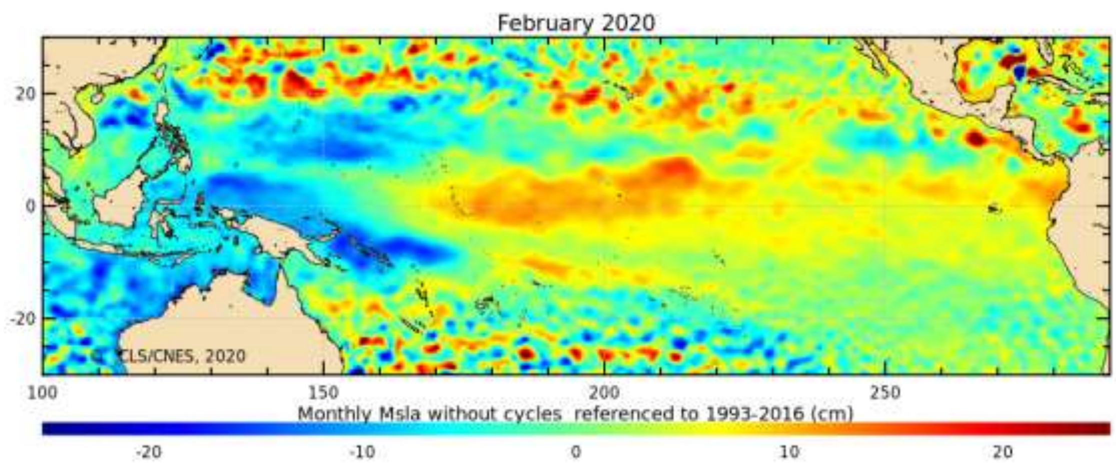

Figure 33a. Sea surface height and anomaly

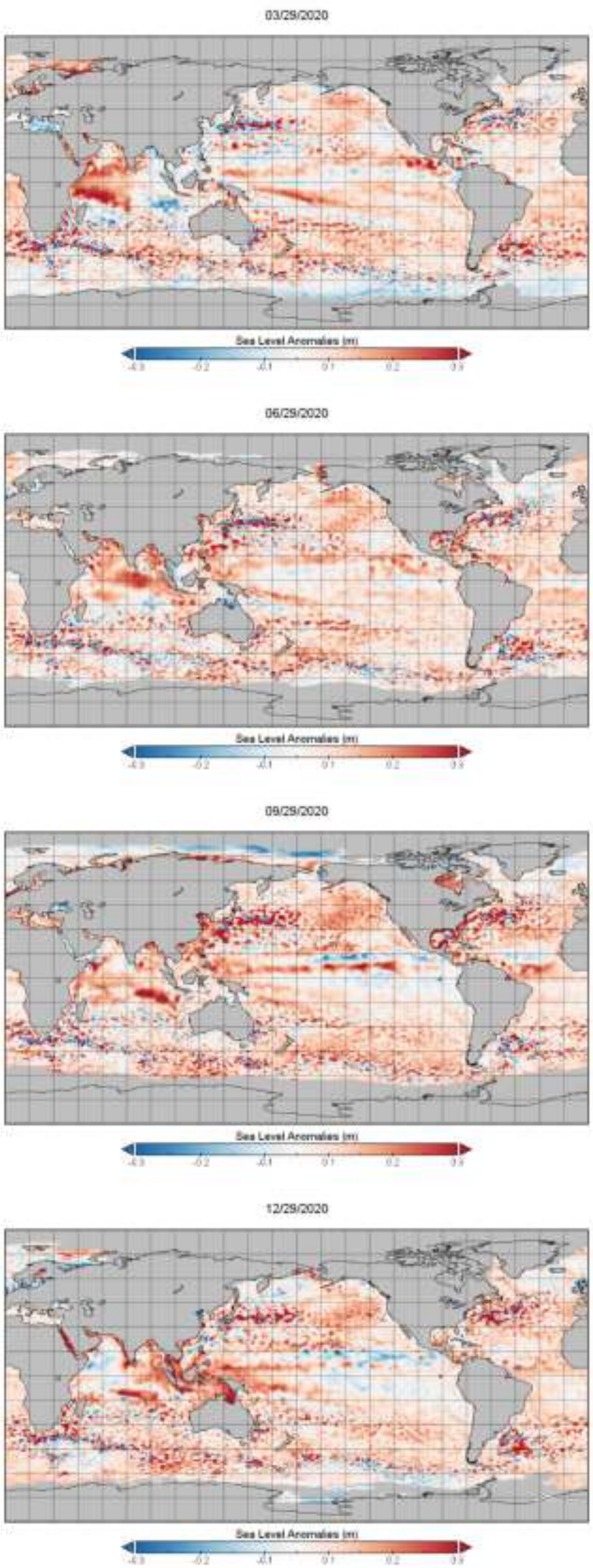

Figure 33b. Quarterly time series of mean sea level anomalies during 2020 show no pattern of El Niño throughout the year according to satellite altimetry measurements of sea level height.

Altimetry data are provided by the NOAA Laboratory for Satellite Altimetry, accessed from NOAA CoastWatch (2021).

2.7.4.10.2 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, or 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 1.55 millimeters/year with a 95% confidence interval of +/- 0.21 mm/yr based on monthly mean sea level data from 1905 to 2020 which is equivalent to a change of 0.51 feet in 100 years.

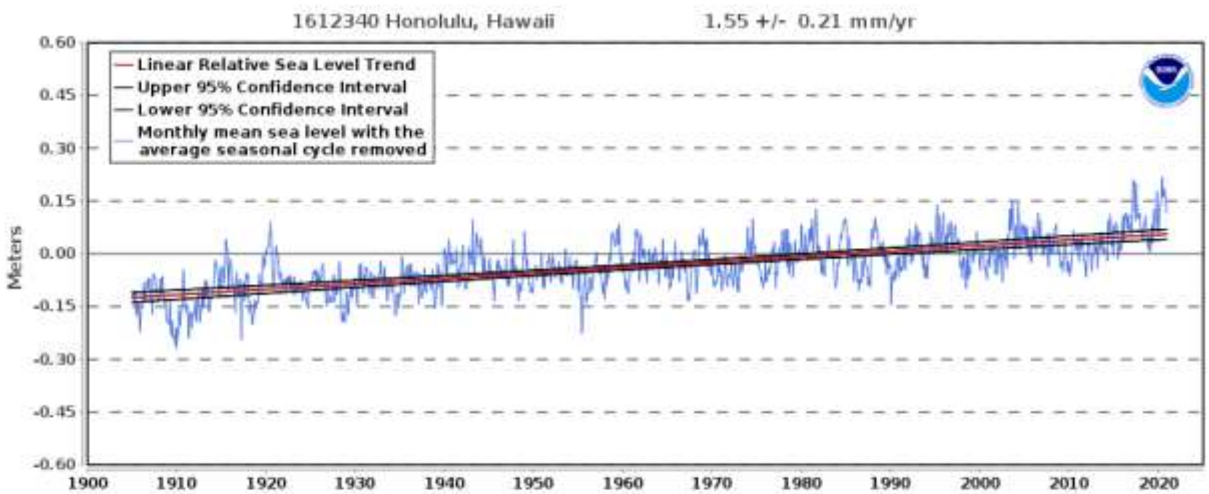

Figure 34. Monthly mean sea level without regular seasonal variability due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents

2.8 ESSENTIAL FISH HABITAT

2.8.1 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. Fishery management actions must be evaluated for impacts to all EFH and HAPC in the area of effect and not just the EFH and HAPC for the fishery to which the management action applies.

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.

2.8.1.1 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 2.8.4;
- Updated research and information needs, which can be found in Section 2.8.5. 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.

2.8.1.2 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.

2.8.1.3 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 was 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 revising existing beds and designating new beds as EFH, updating geographic extent and habitat characteristics, and updating 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.

At its 182nd meeting in June 2020, the Council requested that NMFS work with the Council to determine "non-essential" fish habitat to look at ways to remove areas that are degraded from being considered EFH.

2.8.2 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.

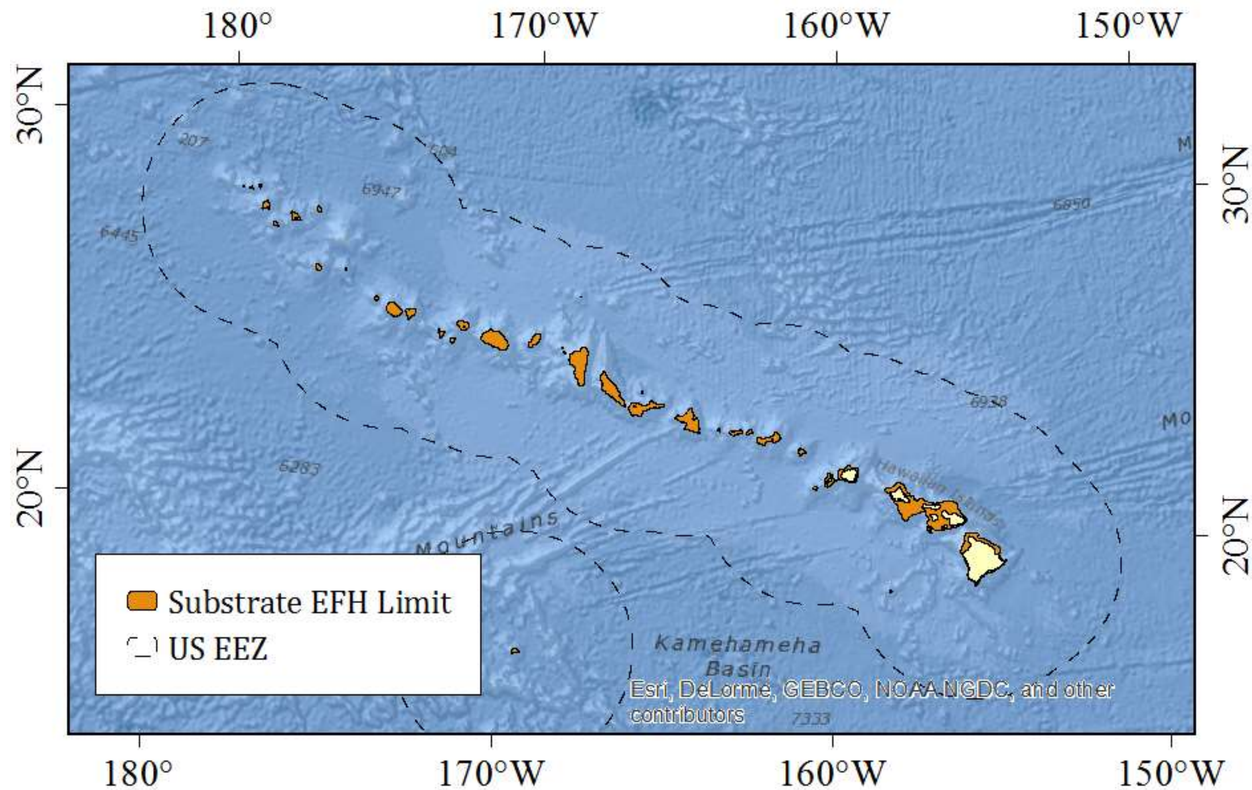

Figure 35. Substrate EFH limit of 700 m isobath around the Hawaiian Archipelago (from GMRT; Ryan et al. 2009)

2.8.2.1 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 61. 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 62. 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
LAND AREA (km²)	<1	6	<1	0	2	0	0	4	0	0
SEA FLOOR AREA 0-30 m (km²)	83	102	467	0	1004	306	0	488	1075	128
SEA FLOOR AREA 30-150 m (km²)	218	236	276	90	226	125	360	69	696	310
BATHYMETRY 0-30 m (km²)	25	24	23	0	0	<1	0	0	73	0
BATHYMETRY 30-150 m (km²)	218	180	251	34	125	54	20	58	588	0
OPTICAL COVERAGE 0-30 m (km)	32	43	63	0	57	0	0	14	40	1
OPTICAL COVERAGE 30-150 m (km)	21	13	20	0	8	0	0	<1	2	<1

ISLAND CODE	GAR	SRW	BBW	BBM	BBB	FFS	NEC	TWI	WNB	NIH
LAND AREA (km²)	0	0	0	0	0	<1	<1	0	0	<1
SEA FLOOR AREA 0-30 m (km²)	1269	250	3	<1	0	678	1028	0	0	<1
SEA FLOOR AREA 30-150 m (km²)	1136	124	142	135	23	244	473	63	320	573
BATHYMETRY 0-30 m (km²)	<1	<1	2	<1	0	222	8	0	<1	<1
BATHYMETRY 30-150 m (km²)	126	40	142	135	23	214	312	13	165	163
OPTICAL COVERAGE 0-30 m (km)	4	0	<1	<1	0	106	8	0	0	0
OPTICAL COVERAGE 30-150 m (km)	<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

2.8.2.2 Benthic Habitat

EFH for juvenile and adult life stages of 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). 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).

2.8.2.2.1 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 collected by towed-diver survey and summarized by island. These data were shown in previous reports but have since been replaced by more recent data using different collection methods.

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 63 through Table 65. A stratified random sampling design is used to determine status, trends, and variability of benthic communities at Rapid Ecological Assessment (REA) sites. Starting 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 63. 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

Island	Island Area	2010-12	2013-15	2016	2019
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 64. 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
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			

Island	Island Area	2010-12	2013-15	2016	2019
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 65. 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			
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	

Island	Island Area	2010-12	2013-15	2016	2019
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

2.8.2.3 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 Climate and Oceanic Indicator section (Section 2.7) for information related to oceanography and water quality.

2.8.3 Report on Review of EFH Information

There were no EFH reviews for Hawaii completed in 2020. A review of the biological components of crustacean EFH in Guam and Hawaii was finalized in 2019 and can be found in Appendix C of the 2019 reports for the Hawaiian and Mariana Archipelagos. Non-fishing and cumulative impacts to EFH were reviewed in 2016 through 2017, which can be found in Minton (2017).

2.8.4 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.

2.8.4.1 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 66.

Table 66. Level of EFH available for Hawaii 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
Hemicorallium laauense (prev. *C. laauense)*	0	1	HURL Database
Gold Coral			
Kulamanamana haumeaae (prev. Gerardia spp.)	0	1	Sinniger et al. (2013); HURL Database
Bamboo Coral			
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

2.8.4.2 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 67. Level of EFH information available for Hawaii bottomfish and seamount groundfish 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
Epinephelus quernus (sea bass)	0	0	1	1
Etelis carbunculus (red snapper)	0	0	1	1
E. coruscans (red snapper)	0	0	1	1
Pristipomoides filamentosus (pink snapper)	0	0	1	1
P. sieboldii (pink snapper)	0	0	1	1
P. zonatus (snapper)	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

2.8.4.3 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 68. Level of EFH information available for Hawaii Kona crab

Life History Stage	Eggs	Larvae	Juvenile	Adult
Kona crab (*Ranina ranina*)	1	0	1	1-2

Table 69. EFH and HAPC for Hawaii MUS

MUS	Species Complex	EFH	HAPC
Bottomfish and Seamount Groundfish	**Shallow-water species (0–50 fm):** uku (*Aprion virescens*)	**Eggs and larvae:** the water column extending from the shoreline to the outer limit of the EEZ down to a depth of 400 m (200 fm). **Juvenile/adults:** the water column and all bottom habitat extending from the shoreline to a depth of 400 m (200 fm).	All slopes and escarpments between 40–280 m (20 and 140 fm).
Bottomfish and Seamount Groundfish	**Deep-water species (50–200 fm):** ehu (*Etelis carbunculus*), onaga (*E. coruscans*), ʻōpakapaka (*Pristipomoides filamentosus*), kalekale (*P. sieboldii*), gindai (*P. zonatus*), hapuʻupuʻu (*Epinephelus quernus*), lehi (*Aphareus rutilans*)	**Eggs and larvae:** the water column extending from the shoreline to the outer limit of the EEZ down to a depth of 400 m (200 fathoms). **Juvenile/adults:** the water column and all bottom habitat extending from the shoreline to a depth of 400 meters (200 fm).	All slopes and escarpments between 40–280 m (20 and 140 fm). Three known areas of juvenile ʻōpakapaka habitat: two off Oahu and one off Molokai.

MUS	Species Complex	EFH	HAPC
Bottomfish and Seamount Groundfish	**Seamount groundfish species (50–200 fm):** armorhead (*Pentaceros wheeleri*), ratfish/butterfish (*Hyperoglyphe japonica*), alfonsin (*Beryx splendens*)	**Eggs and larvae:** the (epipelagic zone) water column down to a depth of 200 m (100 fm) of all EEZ waters bounded by latitude 29°–35°. **Juvenile/adults:** all EEZ waters and bottom habitat bounded by latitude 29°–35° N and longitude 171° E–179° W between 200 and 600 m (100 and 300 fm).	No HAPC designated for seamount groundfish.
Crustaceans	Kona crab (*Ranina ranina*)	**Eggs and larvae:** the water column from the shoreline to the outer limit of the EEZ down to a depth of 150 m (75 fm). **Juvenile/adults:** all of the bottom habitat from the shoreline to a depth of 100 m (50 fm).	All banks in the NWHI with summits less than or equal to 30 m (15 fathoms) from the surface.
Crustaceans	Deepwater shrimp (*Heterocarpus* spp.)	**Eggs and larvae:** the water column and associated outer reef slopes between 550 and 700 m. **Juvenile/adults:** the outer reef slopes at depths between 300-700 m.	No HAPC designated for deepwater shrimp.

MUS	Species Complex	EFH	HAPC
Precious Corals	**Deep-water precious corals (150–750 fm):** Pink coral (*Pleurocorallium secundum*), red coral (*Hemicorallium laauense*), gold coral (*Kulamanamana haumeaae*), bamboo coral (*Acanella* spp.) **Shallow-water precious corals (10-50 fm):** Black coral (*Antipathes griggi*), black coral (*Antipathes grandis*), black coral (*Myriopathes ulex*)	EFH for precious corals is confined to six known precious coral beds located off Keāhole Point, Makapuʻu, Kaʻena Point, Wespac bed, Brooks Bank, and 180 Fathom Bank. EFH has also been designated for three beds known for black corals in the MHI between Milolii and South Point on the Big Island, the ʻAuʻau Channel, and the southern border of Kauai.	Includes the Makapuʻu bed, Wespac bed, Brooks Banks bed. For black corals, the ʻAuʻau Channel has been identified as HAPC.

Source: WPRFMC (2009).

2.8.5 Ongoing Projects

2.8.5.1 Enhancing reef resilience through process investigations

This project is a set of process investigations focused on revealing differential resilience to habitat stressors by describing interacting trends in coral populations, reef structure, and their ecological and physical forcing. In 2020, this project included improving quality control and access to environmental data collected by the coral program over the last 20 years, and in future years will examine reef-scale coral cover change, drivers of juvenile coral density, drivers of change in reef structure, drivers of complexity, carbonate budgets, and *in-situ* temperatures relative to benthic changes. Efforts are beginning to link habitat structural complexity/rugosity (quantified from Structure-from-Motion models across the MHI) to fish composition and abundance.

2.8.5.2 Assessing impacts of Hawaii's 2019 coral bleaching event on coral recovery

Research is being conducted to identify which reefs and coral taxa in Hawaii are especially resilient to bleaching and what the potential long term impacts of bleaching are at the colony and reef-level by identifying resilient coral communities following multiple bleaching events, automating bleaching quantification, and tracking colonies over time to investigate growth and mortality in years prior, during, and following bleaching.

2.8.5.3 Understanding importance of nearshore habitats for MUS

The primary goal of this research is to refine the understanding of how inshore habitats, including coral reefs, contribute to the productivity of MUS fisheries and/or ESA listed species, focusing particularly on those MUS that are primarily caught in federal waters and certain key coral reef fishes that are classified as ECS. The quantitative information linking offshore and nearshore habitats can be applied to the Council's efforts to refine existing BMUS designations. Most of these nearshore and laboratory research efforts are designed to bridge a key life history stage data gap, and feed into an essential fish habitat modeling effort described later.

Another project is assessing larval uku (*Aprion virescens*) habitat use in nearshore and offshore of Hawaii. Uku is the only shallow bottomfish stock in Hawaii within the BMUS complex. EFH for uku is currently broadly designated from the shoreline to offshore down to 240 meters deep, and more information is needed on connectivity from offshore to nearshore to refine EFH designations. This study will assess uku habitat and prey base utilization in nearshore and offshore ecosystems. This effort will include lab work for processing (i.e., sorting, identifying, and measuring) larval uku from a backlog of existing wet-archived ichthyoplankton samples from nearshore and offshore ecosystems along Oahu and Hawaii Island. Through this work, PIFSC plans to quantify the connectivity of uku from offshore to nearshore, including the presence/absence of larval uku in the nearshore coral reef ecosystem, to assist with potential future habitat models and refining Hawaii EFH and HAPC.

Derived habitat requirements for larval uku will be used to inform statistical species distribution models (SDMs). The fitted SDMs will be coupled with spatially and temporally resolved hydrographic and oceanographic reanalysis derived from three-dimensional Regional Ocean Modeling System (ROMS). The ROMs-SDMs outputs can be used to evaluate spatiotemporal trends in boundaries delineating larval uku habitat in key nearshore management areas. Further development of a generalized statistical species distribution modeling framework that will be useful for predicting distributional responses of reef fish species and other archipelagic fishes to environmental variabilities is continuing. The modeling framework uses Tweedie Generalized Additive Models (GAM) to quantify association among size-specific reef fish biomass and relevant environmental variables (e.g., SST, chl-*a*, salinity, depth). GAMs are fitted to the PIFSC CREP survey data that encompasses 44 islands across the Western Pacific region and include ~500 species. Fitted GAMs are coupled with either the remotely-sensed environmental data (e.g., OceanWatch and CoastWatch) or the output from regional circulation models (e.g., ROMS) to determine reef fish distributions at various spatial scales. The model outputs can be used to evaluate spatiotemporal trends in boundaries delineating EFH for each species. The model results should contribute to Council determinations on how best to manage ECS. A collaboration with University of Hawaii researchers on contract to the Council has recently started.

2.8.5.4 Predicting the impacts of climate change on ‘opelu koas

Koas are temporally and spatially ephemeral habitats for ‘opelu (*Decapterus macarellus*), also known as the mackerel scad. The ‘opelu koa work will explore the environmental factors that characterize these aggregation sites, as well as what drives CPUE, abundance, and catchability. ‘Opelu are important forage species in the coastal pelagic ecosystem and are an important fishery in Hawai‘i. To further investigate what factors may drive changes in catch, compilation of remotely sensed and modeled data products, small-boat field surveys, and interviews will be conducted with ‘opelu fishermen since there is a long history of ‘opelu fishing in Hawaii. Information from the fishermen interviews will assist in parameterizing the field work planned for 2021. Koas serve as an important subset of the overall pelagic habitat for ‘opelu, and this work will further the understanding of the definition, function, and criticalities of these small areas for this species.

2.8.5.5 Bottomfish fishery independent surveys (BFISH)

Annual bottomfish surveys were successfully conducted in 2020 despite COVID-19. The BFISH survey collects species-specific abundance information on key Deep 7 species throughout the MHI. Habitat data, including depth, temperature, and seafloor type, are also collected. This information can be used to inform and refine existing Deep 7 EFH through methods outlined by Oyafuso et al. (2017) and Moore et al. (2013). As part of the 2020 refined BFISH stratification, researchers modeled species-specific depth stratification as well as response to different substrate complexity metrics (Vector Ruggedness Measure Arc Chord Ration). A quarterly report on this monitoring can be found at Ault and Smith (2020).

2.8.6 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:

2.8.6.1 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.

2.8.6.2 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.

2.8.6.3 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.

2.8.6.4 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.

2.9 MARINE PLANNING

2.9.1 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 Restricted Fishing 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.

2.9.2 Response to Previous Council Recommendations

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

2.9.3 Marine Managed Areas Established Under FEPs

Council-established MMAs were compiled in Table 70 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 70. 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	351,514.0	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	248,682.4	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	60,826.8	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								
Keāhole 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	-
Ka‘ena 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	-
Makapu‘u	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	-

Name	FEP	Island	50 CFR/FR/ Amendment Reference	Marine Area (km^2)	Fishing Restriction	Goals	Most Recent Evaluation	Review Deadline
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	-
‘Au‘au 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	-

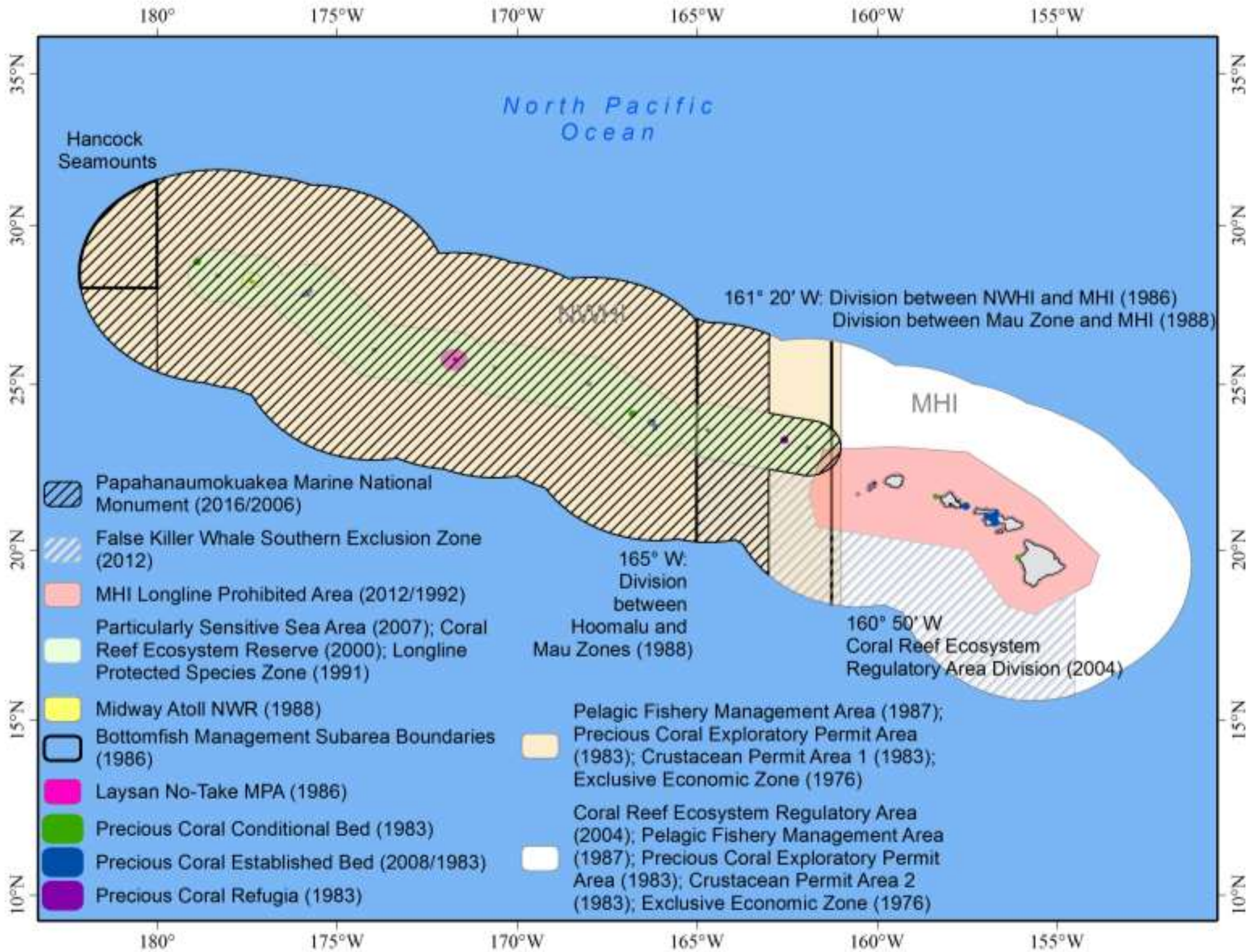

Figure 38. Regulated fishing areas of the Hawaii Archipelago

2.9.4 Fishing Activities and Facilities

2.9.4.1 Aquaculture Facilities

Hawaii has operational 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 71). A new nearshore aquaculture operation by Ocean Era is current in the pre-consultation stage, with a preliminary environmental review being circulated to resource management agencies for review. The aquaculture farm will be situated off of Ewa Beach, Oahu, and will aim to cultivate nenue (*Kyphosus vaigiensis*), moi (*Polydactylus sexifilis*), ogo (*Gracilari* sp.), *Sargassum,* and sea grapes (*Caulerpa* sp.).

Table 71. 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 allowed the harvest of two cohorts of fish. The permit renewal process is currently ongoing.

2.9.5 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.

2.9.5.1 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 were disengaged around 2018

(BOEM Hawaii Activities). In December 2020, BOEM put out a new call for recommendations on environmental studies regarding offshore wind facilities, and the Hawaii State Energy Office is facilitating and providing input on studies that could be conducted to mitigate impacts on various resources, including aquatic. There are several alternative energy projects also being tracked in this report).

Table **72**).

Table 72. 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 2018, HSWAC and the State of Hawaii finalized an agreement to provide seawater air conditioning for eight State buildings. Construction was planned to start in late 2019 or, but the operation was shut down in late 2020 due to increasing costs.	Final Environmental Assessment, June 2014 West Hawaii Today
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. A buoy that was planned to be connected in early 2020 was delayed due to COVID-19. An autonomous offshore power system began tests in late 2020.	Final Environmental Assessment, NAVFAC PAC, January 2014 E&E News Hawaii Natural Energy Institute Tethys The Maritime Executive

2.9.5.2 Military Training and Testing Activities and Impacts

The Department of Defense major planning activities in the region are summarized in Table 73.

Table 73. 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 most recent being in August 2020 around the Hawaiian Islands.	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
Naval Special Operations Training in the State of Hawaii	Small-unit maritime training activities for naval special operations personnel.	Public comment period through Dec. 10, 2018 was extended to Jan. 7, 2019.	Access. Draft Environmental Assessment 2018

2.9.6 Additional Considerations

2.9.6.1 State of Hawaii Initiatives

The State of Hawaii has several initiatives ongoing, including its 30x30 Initiative and its Ocean Resource Management Plan, which was most recently updated in 2020 (Hawaii Office of Planning 2020). Interested parties are encouraged to provide input to and track the progress of these plans.

2.9.6.2 Bottomfish Restricted Fishing Areas (BRFAs)

In 1997, in response to a federal stock assessment indicating that certain species of the MHI bottomfish stock complex were in danger of being overfished, DAR developed a bottomfish management plan, which included the creation of 19 bottomfish restricted fishing areas (BRFAs) where bottomfish fishing was prohibited. These BRFAs were enacted in 1998. The MHI BRFAs are situated in both State and federal waters. Upon review in 2005, it was determined that the BRFA system did not protect an adequate amount of preferred habitat for bottomfish, so a new system was created with 12 BRFAs (Figure 39) with the objective of reducing fishing mortality of MHI bottomfish stocks, rebuilding bottomfish populations on habitats within the BRFAs, and improve bottomfish populations in adjacent fishing areas (Drazen et al. 2014). In 2019, four of the 12 BRFAs were opened: RFA C (Poipu, Kauai), BRFA F (Penguin Banks), BRFA J (Hana, Maui), and BRFA L (Leleiwi, Hawaii Island) (Figure 39).

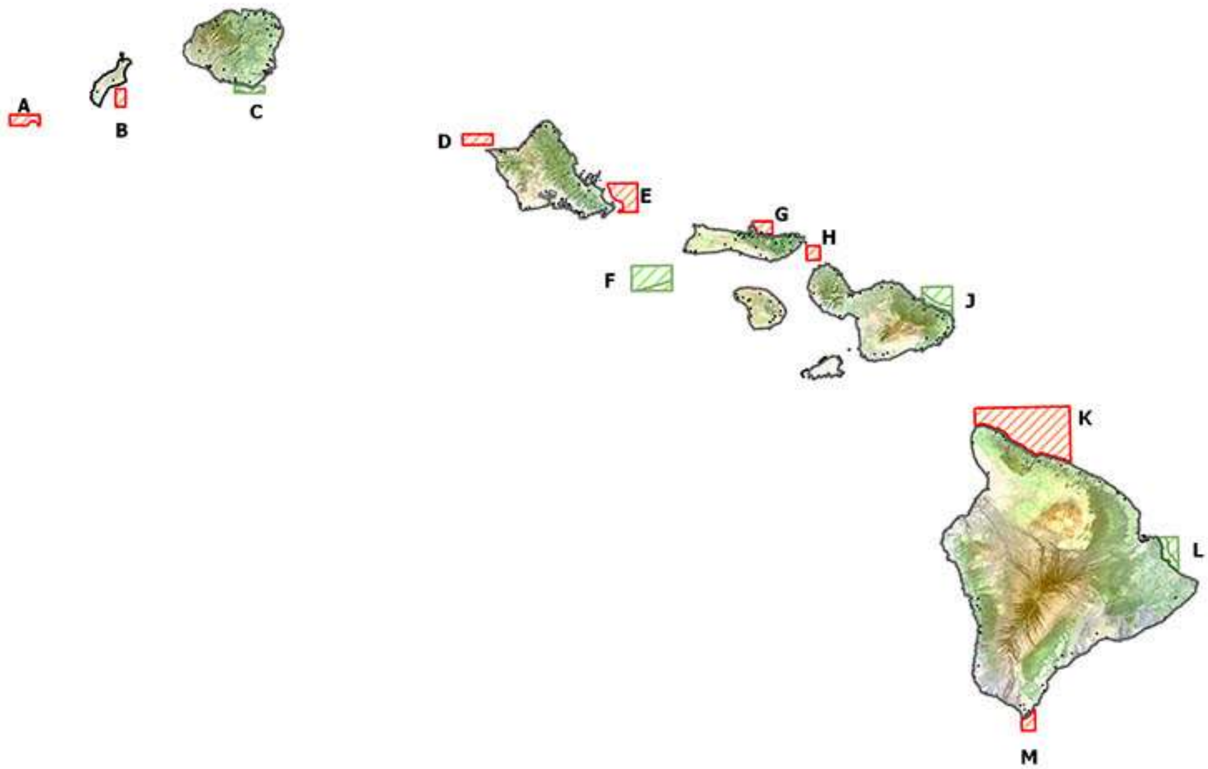

Figure 39. Map of the 12 BRFAs around the MHI; red boxes indicate that the area is closed to bottomfish fishing, and green boxes indicate those areas recently opened to bottomfish fishing (Source: DAR website)

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 2.7.4, and as the strength of certain fishery ecosystem relationships relevant to advancing ecosystem-based fishery management are determined.

3.1.2 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 deepwater 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 2.7.4). 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 40). 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.

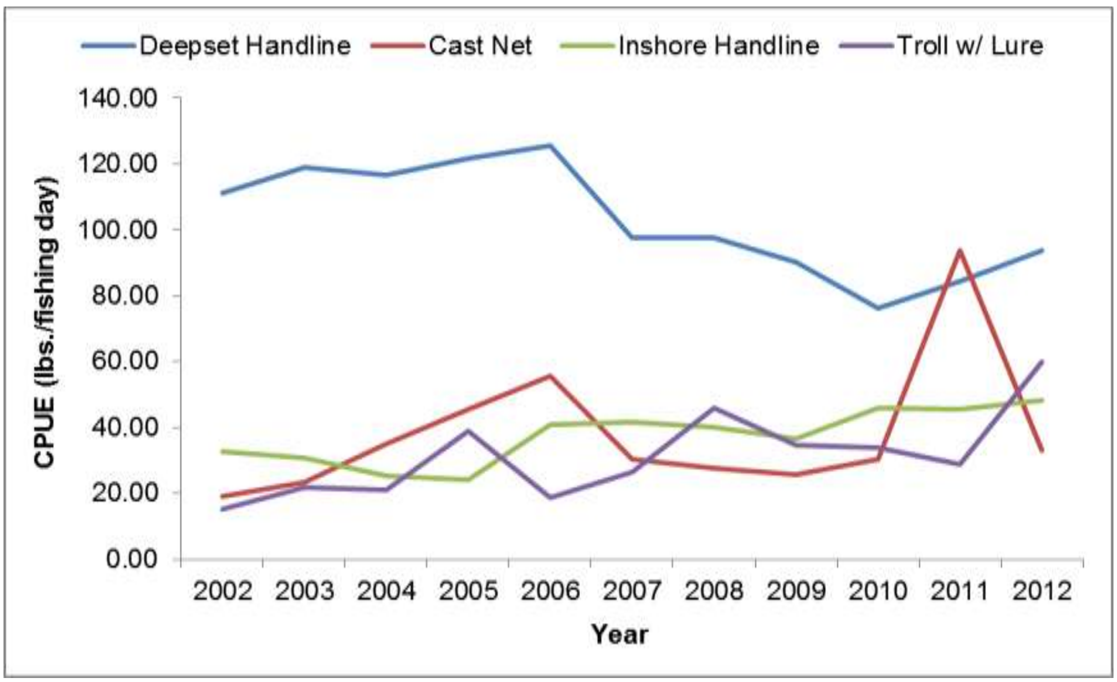

Figure 40. CPUE for uku harvested in the MHI for four top gear types from 2002-2012

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 41). 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 and Underkoffler 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 and Underkoffler (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).

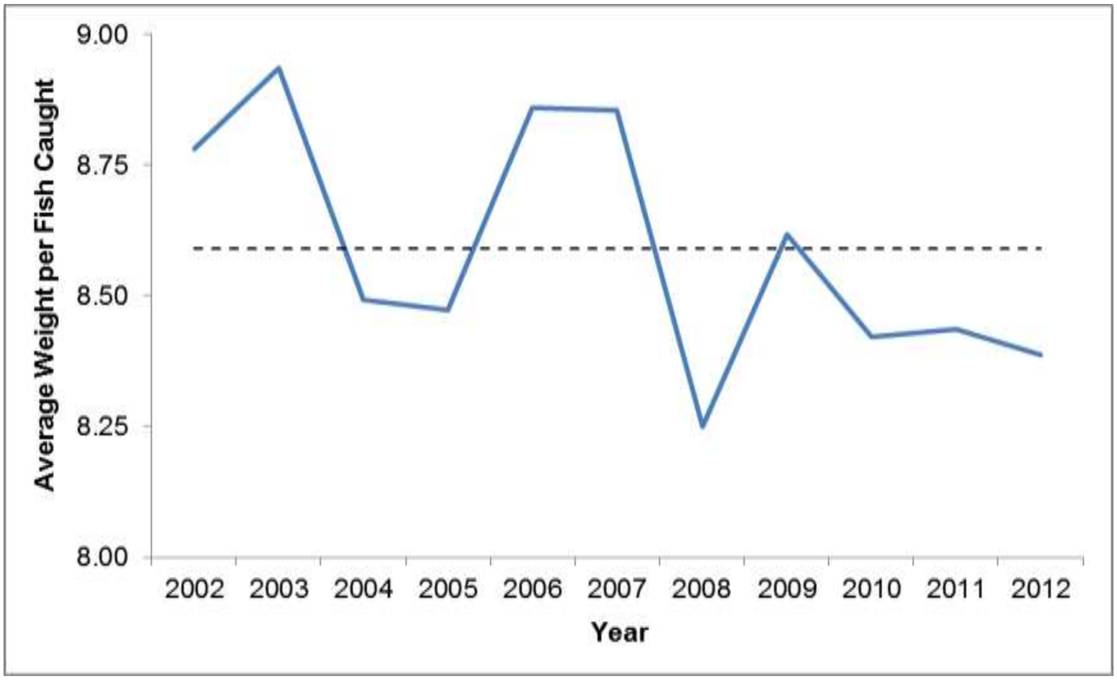

Figure 41. Average annual weight per fish (lb) for uku (*Aprion virescens*) harvested around the Main Hawaiian Islands from 2002-2012

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 42; 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 43; 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 44) and the coefficient of determination (R^2) was 0.53 (Figure 45), 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.

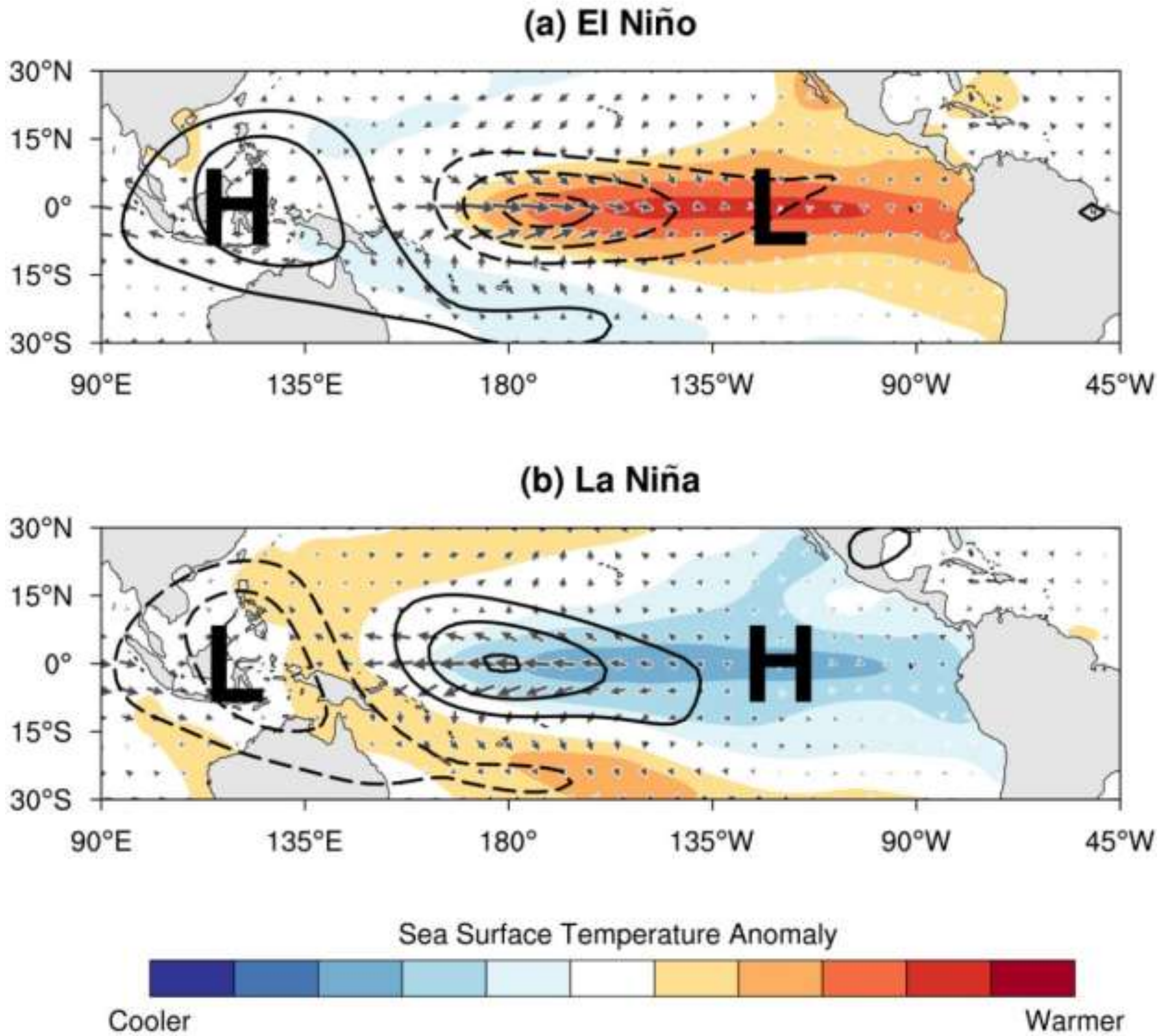

Figure 42. Diagram showing the physical mechanisms by which the SST (shaded), OLR (contours), surface zonal and meridional winds (vectors), and sea level pressure (represented by "H" and "L") determine the wintertime Multivariate ENSO Index (MEI) during (a) El Niño and (b) La Niña events" (from NOAA 2019)

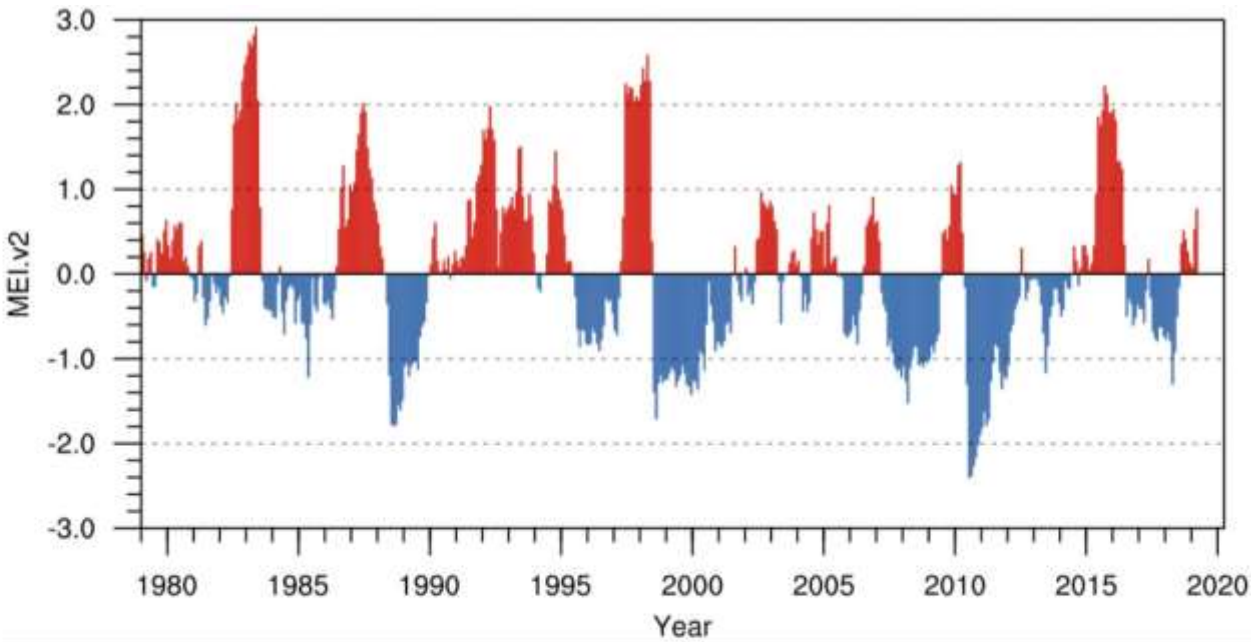

Figure 43. Time series of the Multivariate ENSO Index (MEI) v2 from 1980-2019

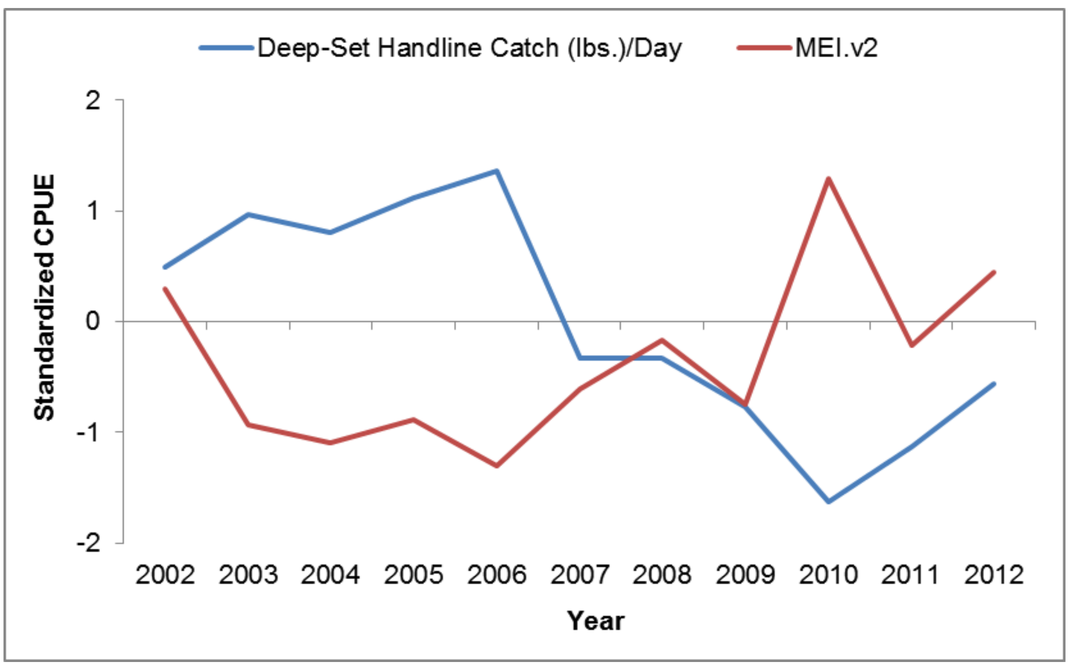

Figure 44. Comparison of standardized MHI Deep-Set Handline CPUE and MEI.v2 with a phase lag of two years from 2002-2012 (*r* = -0.729)

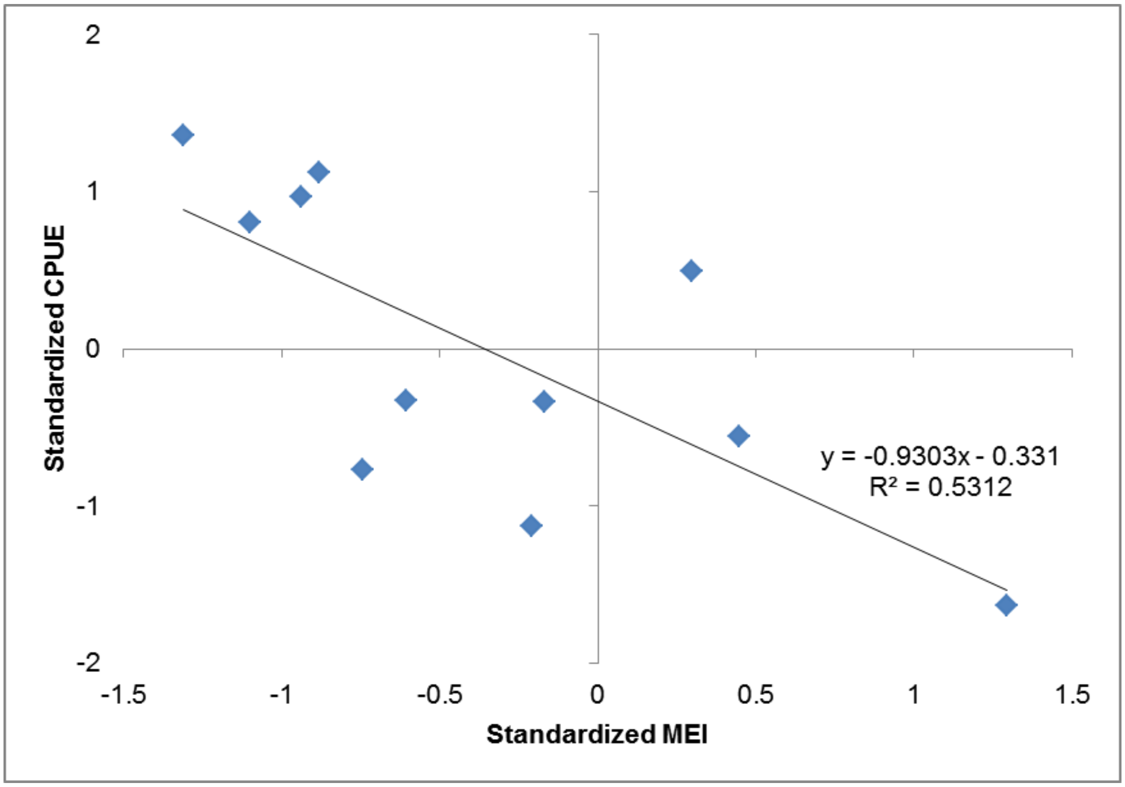

Figure 45. Standardized CPUE for uku from the MHI from 2002-2012 plotted against standardized MEI.v2 with a phase lag of two years

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 is 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 46. 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).

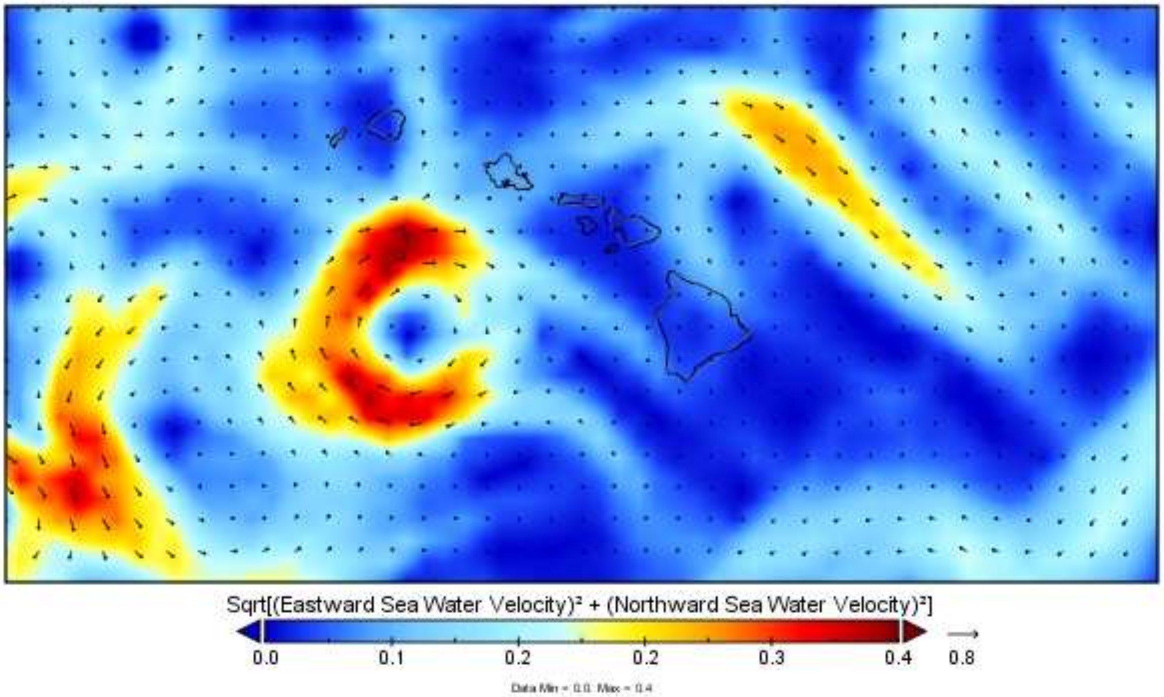

Figure 46. Example of eastward sea water current velocity around the MHI (from 2004)

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 47) and the coefficient of determination (R^2) was approximately 0.56 (Figure 48), 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.

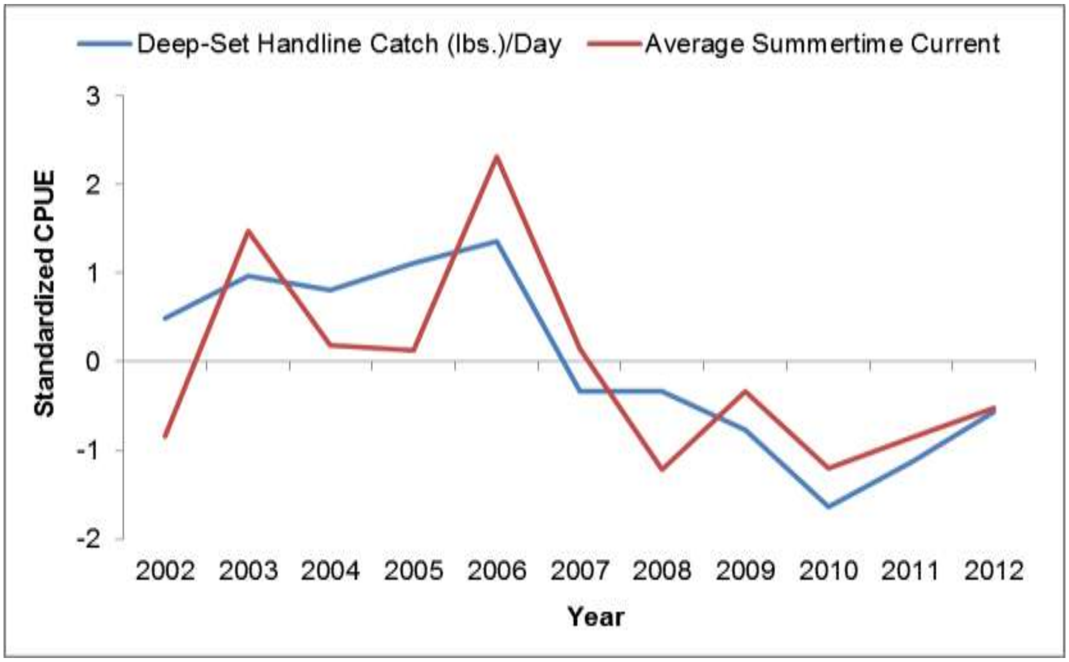

Figure 47. Comparison of standardized MHI Deep-Set Handline CPUE and the average summertime zonal current with a phase lag of two years from 2002-2012 (*r* = 0.748)

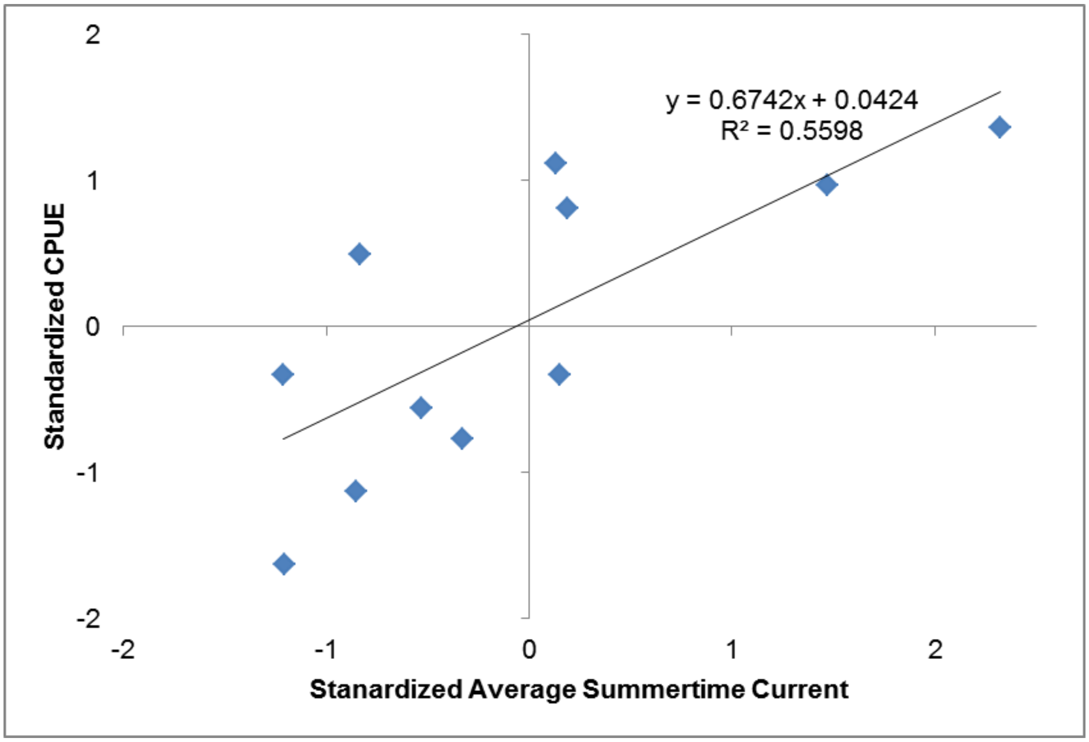

Figure 48. Standardized CPUE for uku from the MHI from 2002-2012 plotted against standardized average summertime zonal current with a phase lag of two years

3.4 RECENT RELEVANT ABSTRACTS

In this section, abstracts from primary journal articles published in 2020 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.

Arostegui MC, Braun CD, Woodworth-Jefcoats PA, Kobayashi DR, Gaube P. 2020. Spatiotemporal segregation of ocean sunfish species (Molidae) in the eastern North Pacific. *Mar Ecol Prog Ser 654*:109-125. https://doi.org/10.3354/meps13514

Ocean sunfishes or molas (Molidae) are difficult to study as a result of their extensive movements and low densities in remote waters. In particular, little is known of the environmental niche separation and differences in the reproductive or movement ecology of molids in sympatry. We investigated spatiotemporal dynamics in the distribution of the common mola *Mola mola*, sharptail mola *Masturus lanceolatus*, and slender mola *Ranzania laevis* in the eastern North Pacific. We used observer data from a commercial fishery consisting of 85000+ longline sets spanning 24 yr, >50° in longitude, and >45° in latitude. Satellite altimetry analysis, species distribution modeling, and multivariate ordination revealed thermal niche separation, spatiotemporal segregation, and distinct community associations of the 3 molid species. Our quantitative findings suggest that the common mola is a more temperate species, while slender and sharptail mola are more (sub)tropical species, and that slender (and possibly also sharptail) mola undergo spawning migrations to the region around the Hawaiian Islands. In addition, we identified potential effects of fishing gear type on molid catch probability, an increasing trend in catch probability of a vulnerable species perhaps related to a shift in the distribution of fishing effort, and the possible presence in the fishery of a fourth molid species being misidentified as a congener, all of which are important conservation considerations for these enigmatic fishes.

Guo C, Fu C, Olsen N, Xu Y, Grüss A, Liu H, Verley P, Shin Y-J. 2020 Incorporating environmental forcing in developing ecosystem-based fisheries management strategies, *ICES Journal of Marine Science*, Volume 77, Issue 2, Pages 500–514, https://doi.org/10.1093/icesjms/fsz246.

This study incorporated two pathways of environmental forcing (i.e. “larval mortality forcing” and “somatic growth forcing”) into an end-to-end ecosystem model (Object-oriented Simulator of Marine ecOSystEms, OSMOSE) developed for the Pacific North Coast Integrated Management Area (PNCIMA) off western Canada, in order to evaluate alternative fisheries management strategies under environmental changes. With a suite of ecosystem-level indicators, the present study first compared the ecosystem effects of different pathways of environmental forcing scenarios; and then evaluated the alternative fisheries management strategies which encompassed a series of fishing mortality rates relative to FMSY (the fishing mortality rate that produces maximum sustainable yield) and a set of precautionary harvest control rules (HCRs). The main objectives of this study were to (i) explore the ecosystem effects of different environmental forcing scenarios; (ii) identify the impacts of different fishing mortality rates on marine ecosystem structure and function; and (iii) evaluate the ecosystem-level performance of various levels of precautionary HCRs. Results indicated that different pathways of environmental forcing had different ecosystem effects and incorporating appropriate HCRs in the fisheries management process could help maintain ecosystem health and sustainable fisheries. This study provides important information on future fisheries management options within similar marine ecosystems that are facing global changes.

Heck N, Agostini V, Reguero B, Pfliegner K, Mucke P, Kirch L, Beck MW. 2020. Fisheries at Risk – Vulnerability of Fisheries to Climate Change. Technical Report. The Nature Conservancy, Berlin.

Fishing is vital to the lives and livelihoods of coastal communities and countries around the world. Yet marine fish and fishers face growing challenges from coastal hazards and climate change. Many coastal countries and communities need support to build resilience and adapt to these changes. This study examines the impacts of climate change on fish and fishers and informs strategies to support adaptation and risk reduction for fishing communities. It refines previous global fisheries risk assessments by: (i) focusing on overall risk (not just vulnerability) and (ii) separately examining multiple aspects of coastal hazards (e.g., waves, storms) and climate change (warming, acidification) that differentially affect fish and fishing communities. We show that these differences in exposure of fish and fishers to climate change affect the strategies to reduce these risks. We provide an assessment of nearterm and future risk based on expected changes in sea surface temperature, ocean acidification, and sea level rise.

Holsman KK, Haynie AC, Hollowed AB *et al.* 2020. Ecosystem-based fisheries management forestalls climate-driven collapse. *Nat Commun 11*, 4579. https://doi.org/10.1038/s41467-020-18300-3.

Climate change is impacting fisheries worldwide with uncertain outcomes for food and nutritional security. Using management strategy evaluations for key US fisheries in the eastern Bering Sea we find that Ecosystem Based Fisheries Management (EBFM) measures forestall future declines under climate change over non-EBFM approaches. Yet, benefits are species-specific and decrease markedly after 2050. Under high-baseline carbon emission scenarios (RCP 8.5), end-of-century (2075–2100) pollock and Pacific cod fisheries collapse in >70% and >35% of all simulations, respectively. Our analysis suggests that 2.1–2.3 °C (modeled summer bottom temperature) is a tipping point of rapid decline in gadid biomass and catch. Multiyear stanzas above 2.1 °C become commonplace in projections from ~2030 onward, with higher agreement under RCP 8.5 than simulations with moderate carbon mitigation (i.e., RCP 4.5). We find that EBFM ameliorates climate change impacts on fisheries in the near-term, but long-term EBFM benefits are limited by the magnitude of anticipated change.

Jones ST, Asher JM, Boland RC, Kanenaka BK, Weng KC. 2020. Fish biodiversity patterns of a mesophotic-to-subphotic artificial reef complex and comparisons with natural substrates. *PLOS ONE*, *15*(4): e0231668. https://doi.org/10.1371/journal.pone.0231668.

Artificial reefs act as high-rugosity habitats and are often deployed to enhance fishing; however, the effects of man-made features on fish communities can be unpredictable and are poorly understood in deeper waters. In this study, we used a submersible to describe a deep-water artificial reef complex (93–245 m) off of Ewa Beach, Oahu, Hawaii, USA, and evaluated possible conservation and/or fisheries-related contributions. Sixty-eight species were recorded, with larger features supporting greater diversity of species. Species composition changed strongly with depth and a faunal break was detected from 113–137 m. While the features supported diverse fish communities, they were not similar to those on natural substrates, and were numerically dominated by only two species, *Lutjanus kasmira* and *Chromis verater*. Depth-generalist and endemic species were present at levels comparable to natural substrates, but were less abundant and species-rich than at biogenic *Leptoseris* reefs at similar depths. While the non-native *L. kasmira* was highly abundant, its presence and abundance were not associated with discernable changes in the fish community, and was not present deeper than 120 m. Finally, five species of commercially- and recreationally-important 'Deep 7' fisheries species were also observed, but the artificial reef complex was mostly too shallow to provide meaningful benefits.

Kurota H, Szuwalski CS, Ichinokawa M. 2020. Drivers of recruitment dynamics in Japanese major fisheries resources: Effects of environmental conditions and spawner abundance. *Fisheries Research, 221*. https://doi.org/10.1016/j.fishres.2019.105353.

Identifying driving factors of recruitment dynamics is essential for understanding population dynamics of fisheries resources and managing them sustainably. Spawner abundance and environmental conditions have been assumed as driving factors of recruitment, and the relative influence of these two drivers in fish populations has been debated for a long time. We addressed this issue by applying cross-correlation analysis to the time series of recruitment and spawner abundance of 28 Japanese fisheries stocks. The analysis showed that spawner abundance was significantly related to recruitment in 18 of the 28 stocks, but in many stocks, particularly for small pelagic species, recruitment influenced the later spawner abundance more strongly, suggesting a strong influence of the environment. We also detected temporal shifts of recruitment levels corresponding to shifts of wide-area climatic and oceanographic conditions. These results indicate that both spawner abundance and environment might drive recruitment in many stocks, but the apparent effect of spawner abundance might be a by-product of long-term recruitment changes caused by environmental conditions in some cases. Considering our observations, efficient management strategies are needed that are robust to uncertainties of environmental impacts on fish dynamics and spawner-recruitment relationships and match life-history characteristics of managed stocks.

Lindo-Atichati D, Jia Y, Wren JLK, Antoniades A, Kobayashi DR. 2020. Eddies in the Hawaiian Archipelago Region: Formation, characterization, and potential implications on larval retention of reef fish. *Journal of Geophysical Research: Oceans, 125,* e2019JC015348. https://doi.org/10.1029/2019JC015348.

Here we present an assessment of eddy activity in a 3,500 × 2,000 km region of the North Pacific. Eddies were identified and tracked within a numerical simulation that used the Massachusetts Institute of Technology general circulation model and an eddy characterization algorithm. Spatially, eddy births were more frequent: (1) nearshore (cyclones) and offshore (anticyclones) on the windward side of the main Hawaiʻian Islands; (2) in patches of cyclones and anticyclones that resembled the dipole structure of wind stress curl along the islands' leeward side; and (3) in zonal patches of eddies of both polarities west and north of the islands. Temporally, high eddy activities occurred in spring. There was a meridional distribution of eddy lifespans, which increased northward. Cyclones were more abundant, longer-lived, smaller, and more nonlinear. Reef fish spawning locations in Hawaiʻi coincide with the regions of high eddy activity, with nonlinear eddies responsible for high larval retention.

McGowan DW, Goldstein ED, Arimitsu ML, Deary AL, Ormseth O, De Robertis A, Horne JK, Rogers LA, Wilson MT, Coyle KO, Holderied K. 2020. Spatial and temporal dynamics of Pacific capelin *Mallotus catervarius* in the Gulf of Alaska: implications for ecosystem-based fisheries management. *Marine Ecology Progress Series, 637*, pp.117-140.

Pacific capelin Mallotus catervarius are planktivorous small pelagic fish that serve an intermediate trophic role in marine food webs. Due to the lack of a directed fishery or monitoring of capelin in the Northeast Pacific, limited information is available on their distribution and abundance, and how spatio-temporal fluctuations in capelin density affect their availability as prey. To provide information on life history, spatial patterns, and population dynamics of capelin in the Gulf of Alaska (GOA), we modeled distributions of spawning habitat and larval dispersal, and synthesized spatially indexed data from multiple independent sources from 1996 to 2016. Potential capelin spawning areas were broadly distributed across the GOA. Models of larval drift show the GOA's advective circulation patterns disperse capelin larvae over the continental shelf and upper slope, indicating potential connections between spawning areas and observed offshore distributions that are influenced by the location and timing of spawning. Spatial overlap in composite distributions of larval and age-1+ fish was used to identify core areas where capelin consistently occur and concentrate. Capelin primarily occupy shelf waters near the Kodiak Archipelago, and are patchily distributed across the GOA shelf and inshore waters. Interannual variations in abundance along with spatio-temporal differences in density indicate that the availability of capelin to predators and monitoring surveys is highly variable in the GOA. We demonstrate that the limitations of individual data series can be compensated for by integrating multiple data sources to monitor fluctuations in distributions and abundance trends of an ecologically important species across a large marine ecosystem.

Parrish FA, Oliver TA. 2020. Comparative Observations of Current Flow, Tidal Spectra, and Scattering Strength in and Around Hawaiian Deep-Sea Coral Patches. *Frontiers in Marine Science, 7*, 310 pp. doi: 10.3389/fmars.2020.00310.

Environmental conditions of deep-sea corals were monitored with instruments placed in and adjacent to three Hawaiian deep-sea coral patches dominated by gorgonian octocorals and zoanthid gold coral. Temperature, backscatter, and flow differed among and within the patches and highlighted distinctions in distribution of focal taxa (*Hemicorallium laauense*, *Pleurocorallium secundum*, *Narella* spp., *Acanella dispar*, *Kulamanamana haumeaae*). Two of the patches (Barbers Pt., Makapuʻu Pt.) had more than double the sustained mean flow of the third patch (Keāhole Pt.), where backscatter levels of the passing water mass showed scattering strengths a third higher, suggesting greater food supply in the water at the Keāhole Pt. patch. Further, spectral analysis of flow speed and direction suggests that flow at the first two high-flow sites (Barbers Pt., Makapuʻu Pt.) are dominated by semi-diurnal tidal forcing (flow changing 4x daily, direction 2x daily), while Keāhole Pt. patch shows a distinct pattern more typical of diurnal forcing. Of the focus taxa, the two coralliids occupied a similar temperature range but differed in dominance between sites along a flow/scatter gradient, with the "red" coral, *H. laauense*, found at the site with low flow (0.5–4.9 cm/s) and higher scatter (−28 dB) and the "pink" coral, *P. secundum*, seen at the patch with higher sustained flow (12.6–18.4 cm/s) and lower backscatter (−43 dB). *Narella* spp. spanned a 10°C temperature range but were found more frequently at sites with the highest mean flow (18.4–21.7 cm/s). The final two corals, the parasitic zoanthid "gold" coral, *K. haumeaae*, and its most common host, bamboo coral, *A. dispar*, were found at all three sites over a wide temperature range with flow ranging from 2.8 to 18.9 cm/s. The number of gold colonies was negatively correlated with flow even though that relationship was not apparent for the bamboo coral. These patterns were considered in relation to what is known about the life history of deep-sea corals and how they might influence community settlement, growth, and diversity.

Sandoval-Lugo A, Espinosa-Carreón T, Seminoff J, Hart C, Ley-Quiñónez C, Aguirre A, Jones TT, and Zavala-Norzagaray A. 2020. Movements of loggerhead sea turtles (*Caretta caretta*) in the Gulf of California: Integrating satellite telemetry and remotely sensed environmental variables. *Journal of the Marine Biological Association of the United Kingdom, 100*(5), 817-824. doi:10.1017/S0025315420000636.

The loggerhead turtle (*Caretta caretta*) is a circumglobal species and is listed as vulnerable globally. The North Pacific population nests in Japan and migrates to the Central North Pacific and Pacific coast of North America to feed. In the Mexican Pacific, records of loggerhead presence are largely restricted to the Gulf of Ulloa along the Baja California Peninsula, where very high fisheries by-catch mortality has been reported. Records of loggerhead turtles within the Sea of Cortez also known as the Gulf of California (GC) exist; however, their ecology in this region is poorly understood. We used satellite tracking and an environmental variable analysis (chlorophyll-*a* (Chl-*a*) and sea surface temperature (SST)) to determine movements and habitat use of five juvenile loggerhead turtles ranging in straight carapace length from 62.7–68.3 cm (mean: 66.7 ± 2.3 cm). Satellite tracking durations ranged from 73–293 days (mean: 149 ± 62.5 days), transmissions per turtle from 14–1006 (mean: 462 ± 379.5 transmissions) and total travel distance from 1237–5222 km (mean: 3118 ± 1490.7 km). We used travel rate analyses to identify five foraging areas in the GC, which occurred mainly in waters from 10–80 m deep, with mean Chl-*a* concentrations ranging from 0.28–13.14 mg m−3 and SST ranging from 27.8–34.4°C. This is the first study to describe loggerhead movements in the Gulf of California and our data suggest that loggerhead foraging movements are performed in areas with eutrophic levels of Chl-*a*.

Weijerman M, Oyafuso ZS, Leong KM, Oleson KLL, Winston M. 2020. Supporting Ecosystem-based Fisheries Management in meeting multiple objectives for sustainable use of coral reef ecosystems, *ICES Journal of Marine Science*, https://doi.org/10.1093/icesjms/fsaa194.

Ecosystem-based Fisheries Management is a holistic management approach that integrates the dynamics of an entire ecosystem, including societal dimensions. However, this approach seldom lives up to its promise because economic and social objectives are rarely specified. To fill this gap, we explored how an ecosystem model could better integrate economic and social objectives, using the coral reef ecosystem around Hawai`i as a case study. After meeting with stakeholders and conducting a literature review of policy/strategy documents, we identified societal and ecological objectives and associated performance indicators for which data existed. We developed a social–ecological system conceptual framework to illustrate the relationships between ecological and social state components. This framework was the foundation for the development of the final social–ecological system model which we simulated using an Ecopath with Ecosim model. We simulated four gear/species restrictions for the reef-based fishery, two fishing scenarios associated with the opening of hypothetical no-take Marine Protected Areas for the deepwater-based fishery, and a Constant Effort (No Action) scenario. Despite limitations in the model, our approach shows that when social and economic objectives and social–ecological relationships are defined, we can quantify the trade-offs among the identified societal objectives to support managers in choosing among alternative interventions.

Winston M, Couch C, Huntingon B, Vargas-Ángel B,Suka R, Oliver T, Halperin A, Gray A, McCoy K, Asbury M, Barkley H, Gove J, Smith N, Kramer L, Rose J, Conklin E, Sukhraj N, Morioka J. 2020. Preliminary results of patterns of 2019 thermal stress and coral bleaching across the Hawaiian Archipelago. NOAA Admin Rep. H-20-04, 13p. doi:10.25923/8pqg-tq06.

As ocean temperatures continue to rise at an accelerated pace, coral bleaching events across the Hawaiian Archipelago have increased in frequency and severity. The 2015 bleaching event had significant, statewide impacts. In the main Hawaiian Islands (MHI), more than50% of the surveyed coral exhibited bleaching ranging from mild (paling evident) to severe (stark white), and the mortality that followed reduced coral cover by more than30% (Oliver et al. unpublished data). In June 2019, NOAA's Coral Reef Watch (coralreefwatch.noaa.gov) predicted that waters surrounding the MHI and Northwestern Hawaiian Islands (NWHI) were expected to reach a thermal stress Alert Level 1 (mass bleaching likely) by September and possibly Alert Level 2 (mass bleaching with likely mass mortality) by October. By September, CRW reported that ocean temperature anomalies in the NWHI and the MHI had already exceeded the 2°C mark, with heat stress up to Alert Level 2 projected to extend throughout October. Over the last six years, the 2019 event marked the third bleaching event in Hawai'i. The frequency of these events is unprecedented in the archipelago.

NOAA's Pacific Islands Fisheries Science Center (PIFSC) Ecosystems Sciences Division (ESD) planned and conducted a multi-institutional response in partnership with the Hawaii Coral Bleaching Collaborative to build a comprehensive dataset of the spatial extent and severity of coral bleaching in the Hawaiian Archipelago. Through a combination of bleaching assessment surveys and Structure-from-Motion (SfM) photogrammetry surveys, both real-time rapid data and permanent records of reef condition were collected during the peak of the forecasted 2019 bleaching event. This report presents preliminary results ofin-situ visual bleaching surveys. A forthcoming quantitative analysis will examine spatial patterns of bleaching prevalence and extent across taxa and the influence of depth and thermal stress on those patterns.

Woodworth-Jefcoats, PA, Wren, JLK. 2020. Toward an environmental predictor of tuna recruitment. *Fish Oceanogr., 29*: 436– 441. https://doi.org/10.1111/fog.12487

Bigeye tuna are of global economic importance and are the primary target species of Hawaii's most valuable commercial fishery. Due to their high commercial value, bigeye tuna are relatively well studied and routinely assessed. Larval and adult bigeye surveys have been conducted for many years and are supported by ongoing research on their physiology and life history. Yet, modeling stock dynamics and estimating future catch rates remain challenging. Here, we show that an appropriately lagged measure of phytoplankton size is a robust predictor of catch rates in Hawaii's bigeye tuna fishery with a forecast window of four years. We present a fishery-independent tool with the potential to improve stock assessments, aid dynamic fisheries management, and allow Hawaii's commercial longline fishing industry to better plan for the future.

Yano KM, Oleson EM, McCullough JLK, Hill MC, and Henry AE. 2020. Cetacean and seabird data collected during the Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January–March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78.

The primary goals of Winter HICEAS 2020 were to collect data required to estimate the abundance and distribution, examine the population structure, and understand the habitat of cetaceans around the main Hawaiian Islands during the winter months (January–March). There were 5 major research components to the project:

- visual observations for cetaceans following a line-transect survey design;
- passive acoustic monitoring for cetaceans using towed hydrophone arrays, sonobuoys, and autonomous drifting acoustic recorders;
- collection of photographs and tissue samples and deployment of satellite tags for select cetacean groups;
- visual observations for seabirds following a strip-transect survey design; and
- ecosystem measurements for assessment of cetacean and seabird habitat.

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Andrews, A.H., Brodziak, J., DeMartini, E.E., and E. Cruz, 2020. Long-lived life history for onaga *Etelis coruscans* in the Hawaiian Islands. *Marine and Freshwater Research*. https://doi.org/10.1071/MF20243.

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APPENDIX A: LIST OF SPECIES

HAWAII MANAGEMENT UNIT SPECIES

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

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

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

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

3. Seamount groundfish Complex (non-FSSI)

DAR 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)

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

709	deepwater shrimp (ensifer)	*Heterocarpus* spp.

5. Crustacean Kona crab Complex (non-FSSI)

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

6. ‘Au‘au Channel Black Coral Complex (non-FSSI)

DAR 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)

DAR 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

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

DAR Species Code	Species Name	Scientific Name
74	brown chub (nenue)	*Kyphosus bigibbus*
87/88/96	parrotfish (uhu)	Scaridae
114	bluestripe snapper (ta‘ape)	*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 Hawaii 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's 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
Sooty Shearwater	*Ardenna grisea*	Not Listed	N/A	Migrant	Pyle & Pyle 2009

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
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 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
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

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
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	Not common in Hawai`i. Occur worldwide in tropical, subtropical, and subpolar waters.	35 FR 8491, Eckert et al. 2012
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

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
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	Uncommon in Hawaiian waters. Possible separate nearshore and pelagic stocks.	McSweeney et al. 2007, Schorr et al. 2009, Baird et al. 2013
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	Common in both inshore shallow waters and offshore deep waters. Evidence for five different populations associated with different island groups and depths.	Baird et al. 2009, Martien et al 2012
Bryde's Whale	*Balaenoptera edeni*	Not Listed	Unknown	Common in Hawaiian Islands.	Bradford et al. 2013
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. Possible separate nearshore and pelagic stocks. Nearshore stock found up to 67 km from shore.	McSweeney et al. 2007, Baird et al. 2013
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	Possible resident population. Most common in waters between 500 m and 1,000 m in depth.	Baird et al. 2013
False Killer Whale	*Pseudorca crassidens*	Endangered (MHI Insular DPS)	Strategic	Found in waters within a modified 72 km radius around the MHI. Range overlaps with those of two other stocks around Kauai/Niihau. Population declining.	77 FR 70915, Bradford et al. 2015, Baird 2009, Reeves et al. 2009, Oleson et al. 2010

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
False Killer Whale	*Pseudorca crassidens*	Not Listed	Non-strategic	Two stocks with overlapping ranges around Kauai/Niihau: 1) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within the Papahānaumokuākea Marine National Monument and to the east around Kauai, and 2) the Hawai`i pelagic stock, which includes false killer whales inhabiting waters greater than 11 km from the main Hawaiian Islands, including adjacent high seas waters. Little known about these stocks.	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	Distributed worldwide in tropical waters. Rare in Hawaiian waters.	Perrin et al. 2009, Baird et al. 2013, Bradford et al. 2013, Barlow 2006
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

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
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
Pantropical Spotted dolphin	*Stenella attenuata*	Not Listed	Non-strategic	Common and abundant throughout the Hawaiian archipelago, including nearshore. Three stocks found in Hawaiian Islands.	Baird et al. 2013
Pygmy Killer Whale	*Feresa attenuata*	Not Listed	Non-strategic	Small resident population.	McSweeney et al. 2009
Pygmy Sperm Whale	*Kogia breviceps*	Not Listed	Non-strategic	Rare, found in nearshore waters.	Baird et al. 2013
Risso's Dolphin	*Grampus griseus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Uncommon in Hawai`i.	Perrin et al. 2009
Rough-Toothed Dolphin	*Steno bredanensis*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Present throughout Hawai`i and in offshore waters.	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
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	Not Listed	Non-strategic	Commonly observed around MHI and present around NWHI.	Shallenberger 1981, Bradford et al. 2013, Baird 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, Barlow 2006, Lee 1993, Rice 1960, Mobley et al. 2000, Shallenberger 1981
Spinner Dolphin	*Stenella longirostris*	Not Listed	Non-strategic	Occur in shallow protected bays during the day, feed offshore at night. Four stocks associated with island groups.	Karczmarski 2005, Norris & Dohl 1980, Hill et al. 2010, Norris et al. 1994, Andews et al. 2010

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	*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	*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 is 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

[a] These species have critical habitat designated under the ESA. See Table B-2.

Table B-2. 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 pupping and nursing areas, significant haul-out areas, and/or marine foraging areas, that will support conservation for the species.	53 FR 18988, 51 FR 16047, 80 FR 50925
North Pacific Right Whale	*Eubalaena japonica*	Endangered	Two specific areas are designated, one in the Gulf of Alaska and another in the Bering Sea,	73 FR 19000, 71 FR 38277

			comprising a total of approximately 95,200 square kilometers (36,750 square miles) of marine habitat.	

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

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