



# Annual Stock Assessment and Fishery Evaluation Report: 2021

## Hawaii Fishery Ecosystem Plan

*Photo: Layne Nakagawa*

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*The ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT for the HAWAII ARCHIPELAGO FISHERY ECOSYSTEM PLAN 2021 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council (WPRFMC), National Marine Fisheries Service (NMFS)-Pacific Island Fisheries Science Center (PIFSC), Pacific Islands Regional Office (PIRO), Hawaii Division of Aquatic Resources (HDAR), American Samoa Department of Marine and Wildlife Resources (DMWR), Guam Division of Aquatic and Wildlife Resources (DAWR), and Commonwealth of the Mariana Islands (CNMI) Division of Fish and Wildlife (DFW).*

*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 and 2021, there were notable impacts to fishery operations due to the 2019 novel coronavirus (COVID-19) outbreak and subsequent recovery. Impacts associated with the pandemic, its restrictions, and recovery are described in Sections 1.1 through 1.4, 2.1, 2.2, and 2.5.*

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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 in early 2019 classified 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 regularly monitored 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 State of 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 reporting harvest.

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 ACLs, 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 2021, none of the MUS had a recent three-year average catch that exceeded their specified ACL, allowable biological catch (ABC) values, annual catch targets (ACT), or overfishing limits (OFL). Data for deepwater shrimp and precious coral were not disclosed due to data confidentiality rules that prohibit the reporting of data from less than three licensed fishers.

In 2021, the Main Hawaiian Islands (MHI) Deep 7 bottomfish fishery was generally characterized by decreasing trends in catch and effort relative to its 10- and 20-year averages (i.e., short- and long-term trends, respectively). This decline can likely be attributed to recent challenges associated with difficulty in locating normal aggregations, high shark depredation, difficult environmental conditions, and atypical fish behavior. Catches of ‘ōpakapaka (*Pristipomoides filamentosus*; 57,102 lb) declined around 47% relative to its 10-year and 20-year averages. Catches for two Deep 7 bottomfish species, ehu (*Etelis carbunculus*; 29,125 lb) and gindai (*Pristipomoides zonatus*; 5,573 lb), increased relative to its short- and long-term trends,

while catches for kalekale (*Pristipomoides sieboldii*; 11,163 lb) increased of nearly 6% compared to their 20-year trend. The deep-sea handline gear type experienced declines in the number of licenses, trips, catch, and catch per unit effort (CPUE) relative to their short- and long-term trends. Non-deep sea handline methods catching Deep 7 bottomfish species are responsible for a much lower portion of catch but did have increases in the total number of licenses, catch, and CPUE relative to historical averages, especially for lehi (*Aphareus rutilans*) catches that show an increase of over 100% compared with historical trends.

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 (60,358 lb) was over 37% lower than its 10-year average and 31% lower than its 20-year average, likely due to challenging fishing conditions and high shark depredation, especially when targeting uku in high number. In addition to the decrease in uku catch, there was a decrease in the number of license, trips, and individuals caught. Breaking down the fishery by gear type, all gears had decreases in catch relative to historical trends; however, CPUE for deep-sea handline increased relative to its 20-year average and CPUE for all gears other than handline and trolling increased relative to both of its historical averages. The number of licenses and trips (i.e., effort) for uku harvested by trolling with bait increased relative to the 20-year trend.

The Hawaii coral reef ecosystem component fishery had mixed trends in 2021, though most experienced declines in participation, catch, and effort relative to their historical averages. The most harvested ECS in 2021 were akule (*Selar crumenophthalmus*; 231,161 lb) and ‘opelu (*Decapterus macarellus*; 83,055 lb) followed by menpachi (*Myripristis* spp.; 30,937 lb), palani (*Acanthurus dussumieri*; 24,506 lb), parrotfish (multi-species; 24,090 lb), and opihi (*Cellana* spp.; 16,423 lb). In general, all 10 prioritized ECS (as selected by DAR) had decreases in the number of licenses fishing and the number of fishing trips taken except for day tako relative to its 10-year average. The number of ta‘ape caught in 2021 represented an increase relative to its 10- and 20-year trends, but pounds caught is typically a more useful metric in identifying fishery performance. The number and weight of harvested ‘opihī (limpets) increased relative to both its short- and long-term averages. Nine of the 10 prioritized Hawaii ECS had decreases in catch in 2021 relative to 2020, with the lone exception being kala (*Naso* spp.).

In 2021, the MHI crustacean fisheries, comprised of deepwater shrimp and Kona crab, had an overall decline in catch and effort relative to their short- and long-term trends. However, these two fisheries differ greatly in both their operation and catch trends, and combining the crustacean MUS to analyze fishery performance may not be conducive to evaluating the state of each individual fisheries. The 2021 catch and effort data for the deepwater shrimp trapping fishery are not disclosed in this report due to rules associated with data confidentiality for statistics derived from less than three sources (i.e., fishers). In the Kona crab loop net fishery, there was declines in the number of licenses, trips, and catch relative to historical averages. However, CPUE for Kona crab increased relative to its 10- and 20-year averages, likely because effort decreased to a greater extent than catch in 2021. Data for gear types harvesting crustacean MUS other than shrimp trap and loop net indicated an increase in the number of trips relative to historical trends and an increase in catch relative to the short-term average but had notable decreases for CPUE; however, this gear type is typically comprised of Kona crab caught incidentally with other crab gears and associated values are variable year-to-year.

In addition to reported creel survey data estimates, federal logbook catch data were recently added to the report. In Hawaii, there was one federal special coral reef ecosystem permit and

three shrimp permits issued in 2021, but there were no permits issued for non-commercial bottomfish, precious coral, or lobsters. None of the federal permit holders reported any catch for the fishing 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, fisher observations, socioeconomics, protected species, climate and oceanographic, essential fish habitat, and marine planning information are included in Ecosystem Considerations. In addition, a special section is included in the report this year, similar to the 2020 report, describing the impacts of COVID-19 on Hawaii 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 Area (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 or 2021 due to restrictions associated with the COVID-19 pandemic, so the data summaries in this 2021 report are identical 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 2021, no new life history parameters were determined for any of the reported species.

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. Fish prices were generally high for Hawaii archipelagic MUS fisheries in 2021. For Hawaii MUS, the Deep-7 bottomfish complex comprised 77% of the revenue, uku comprised 21%, and crustaceans comprised just 2%. While the total number of sales from commercial marine licenses (CMLs) has continuously declined since 2015, there were 347 CMLs that reported sales data to DAR in 2021, down from 362 in 2020. In the Hawaii Deep 7 bottomfish fishery, there were 136,062 lb sold in 2021 at an average adjusted price of \$8.36/lb for a revenue of \$1,137,655. In the uku fishery, 52,087 lb were sold at an average adjusted price of \$5.98/lb for a revenue of \$311,521. There were 3,169 lb of crustacean MUS sold at an average adjusted price of \$8.17/lb for a revenue of \$25,881. For the top-ten harvested ECS in Hawaii, there were 458,972 lb sold for a revenue of \$1,684,115 in 2021, which was less than the revenue and pounds sold for the top 10 species in 2020. Priority ECS in Hawaii had 106,730 lb sold for a revenue of \$410,290 in 2021, which was also less than the revenue and pounds sold for the top 10 species (i.e., a different list composition) in 2020.

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<sub>2</sub>) is increasing exponentially with a time series maximum at 416 ppm in 2021. Since 1989, the oceanic pH at Station ALOHA in Hawaii has shown a significant linear decrease of -0.042 pH units, or roughly a 10.2% increase in acidity ([H<sup>+</sup>]) and was 8.07 in 2020. The Oceanic Niño Index, which is a measure of the El Niño – Southern Oscillation (ENSO) phase, indicated La Niña conditions for most of 2021, with two consecutive neutral seasons punctuating the year mid-year. The Pacific Decadal Oscillation (PDO) was negative in 2021. The Accumulated Cyclone Energy (ACE) Index (x 10<sup>4</sup> kt<sup>2</sup>) was below average in Eastern and Central North Pacific and average in the Western North and South Pacific. Annual mean sea surface temperature (SST) was 25.67 °C in 2021, and the annual anomaly was 0.13 °C hotter than average with some intensification in the northern part of the region and a colder than usual area southeast of the Big Island. The MHI experienced no coral heat stress in 2021. Annual mean chlorophyll-a was 0.084 mg/m<sup>3</sup> in 2021, with an annual anomaly that was 0.0049 mg/m<sup>3</sup> higher than average. Precipitation in the MHI had monthly anomalies higher than average at the very beginning and ending of the year, with negative anomalies being experienced in mid-2021. The relative trend in sea level rise in the Hawaiian Archipelago continues to be 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. There were no EFH reviews completed in 2021, and the typical benthic monitoring conducted by PIFSC has not occurred for the past two years.

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 expired at the end of 2021. The next Rim of the Pacific (RIMPAC) multinational exercise will be held in summer 2022 with fewer restrictions than the 2020 RIMPAC due to the alleviation of COVID-19 restrictions.

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. Also presented is a list of recent relevant abstracts from 2021 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 may be expanded to other top species and potentially viable ecological parameters in pursuit of standardization in future report cycles.

Plan Team members agreed to carry out the following recommendations, some of which are relevant to the Hawaii Archipelago annual SAFE report:

*Regarding American Samoa and Guam BMUS catch, the Archipelagic Plan Team:*

1. Recommended the Council request PIFSC, DAWR, DMWR, and the Guam and American Samoa Advisory Panels review the reported increase and decrease, respectively, of total estimated BMUS landings in 2021 to determine whether the values are statistical and/or operational anomalies associated with data collection or if the values are indicative of the actual 2021 BMUS fishery performance.

*Regarding the bycatch reporting improvements in the annual SAFE reports, the Archipelagic Plan Team:*

2. Endorsed the current bycatch tables, noting that fisher-reported data may be biased downward, and recommends adding a separate table to describe the type of bycatch (e.g., a top-10 ranked species list and/or top 90 percentile) that comprises the number released for non-target species in the archipelagic bycatch tables.
3. Formed a working group comprised of Keith Bigelow, Brad Gough, Matt Seeley, Brian Ishida, and Thomas Remington to address the development of the top-10 ranked species and/or top 90 percentile list approach and the issue of reporting non-target species bycatch for MUS fisheries that are targeted by multiple gear types (e.g., uku in the main Hawaiian Islands).

*Regarding the territorial non-commercial fisheries module to be included in the annual SAFE reports, the Archipelagic Plan Team:*

4. Recommended the following members: Marc Nadon, Danika Kleiber, Ashley Tomita, and Keith Bigelow, finalize the configuration and content for the territorial non-commercial modules, based on the commercial catch summarization procedure presented to the APT, at the upcoming intersessional meeting for incorporation in the 2022 annual SAFE reports.
5. Recommended the following members: Bryan Ishida and Paul Murakawa, and Thomas Remington work with Hongguang Ma and Thomas Ogawa in the development of the Hawaii non-commercial module utilizing a similar approach as the NOAA Saltwater Recreational Fisheries Snapshot for Western Pacific Non-Commercial Fisheries.

*Regarding the estimation of total catch, the Archipelagic Plan Team:*

6. Recommended the Council request PIFSC to continue the development of scripts that would enable consistency between the catch time series used in stock assessment and the annual SAFE reports to improve the monitoring of catch relative to implemented Annual Catch Limits.

*Regarding the management of ecosystem component species, the Archipelagic Plan Team:*

7. Recommended the PIFSC-ESD coordinate with the Council in the planning of the EBFM Workshop, incorporating the management of ECS as a thematic area. The APT notes that providing separate data streams together to inform the status of ECS in the context of EBFM would be useful to support the territorial management process. Further, the APT recommends PIFSC-ESD invite staff from Office of Sustainable Fisheries to provide guidance on the NS1 provision for designating and managing ECS as part of the workshop in combination with provisions of NS1 criteria 10.

*Regarding the aquaculture management framework alternatives, the Archipelagic Plan Team:*

8. Endorsed Alternative 3, which includes an expanded scope for the management framework, but notes concerns regarding the proposed 20-year duration for issued permits, non-native species, and ensuring there are appropriate monitoring plans implemented. However, the APT notes that at least a portion of these appropriate monitoring plans will be implicit through the permitting process.

*Regarding the alternatives for the NWHI fishing regulations, the Archipelagic Plan Team:*

9. Deferred the development of recommendations until the Office of National Marine Sanctuaries provides explicit boundaries for the proposed sanctuary relative to the

Papahānaumokuākea Marine National Monument. When the sanctuary boundaries are further defined, the Archipelagic Plan Team will revisit this topic at a future meeting.

*Regarding the CNMI BMUS hierarchical cluster analysis, the Archipelagic Plan Team:*

10. Recommended the Council endorse the proposed BMUS list for CNMI and include this BMUS list for consideration by the previously established Archipelagic Plan Team MSA subgroup in the development of their MSA requirement sections for the FEP amendment associated with the BMUS revisions.

*Regarding the main Hawaiian Island Uku Essential Fish Habitat modeling approaches, the Archipelagic Plan Team:*

11. Recommended the Council endorse both modeling approaches to formulate the habitat module of the annual SAFE report noting concerns regarding the limitations of the data inputs. The modules should include qualitative information to supplement the model results. PIFSC and Council should work towards improving the data inputs (i.e., seasonal pattern to distribution and spawning aggregation) and include commercial fishery data and size frequency data in future EFH modeling work.

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## ACRONYMS AND ABBREVIATIONS

| Acronym           | Meaning                                                      |
|-------------------|--------------------------------------------------------------|
| A <sub>50</sub>   | Age at 50% Maturity                                          |
| AΔ <sub>50</sub>  | 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 <sub>FLAG</sub> | 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                                                       |

| <b>Acronym</b>   | <b>Meaning</b>                                    |
|------------------|---------------------------------------------------|
| 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                        |
| $L_{\infty}$     | Asymptotic Length                                 |
| $L_{\text{bar}}$ | Mean Fish Length                                  |
| $L_{\text{max}}$ | 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                           |

| <b>Acronym</b>   | <b>Meaning</b>                                            |
|------------------|-----------------------------------------------------------|
| 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 <sub>L-W</sub> | 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                    |

| <b>Acronym</b> | <b>Meaning</b>                                         |
|----------------|--------------------------------------------------------|
| PIBPMC         | 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                              |
| to             | 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                                  |

| <b>Acronym</b> | <b>Meaning</b>                                      |
|----------------|-----------------------------------------------------|
| 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 Deep-7 bottomfish management unit species (BMUS) group is comprised of seven deepwater bottomfish including ‘ōpakapaka (*Pristipomoides filamentosus*; pink snapper), onaga (*Etelis coruscans*; longtail snapper), ehu (*Etelis carbunculus*; ruby snapper), hapu‘upu‘u (*Epinephelus quernus*; Hawaiian grouper), kalekale (*Pristipomoides seiboldii*; Von Siebold’s snapper), gindai (*Pristipomoides zonatus*; oblique-banded snapper), and lehi (*Aphareus rutilans*; silverjaw snapper). The three most directly targeted species are ‘ōpakapaka, onaga, and ehu, which together average about 85% of the total Deep-7 catch each year. ‘Ōpakapaka in many years alone make up approximately half of the total catch. Hapu‘upu‘u, kalekale, gindai, and lehi are typically caught incidentally while targeting the three primary species.

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. Many local families will consume red fish (primarily onaga and ehu) during New Year and/or Christmas celebrations. As a result, retail price and demand both increase markedly around this time. Deep-7, especially onaga, ‘ōpakapaka, and ehu, are also preferred by Hawaii’s restaurant and hotel sectors. Size preference varies between consumers, with local consumers preferring smaller fish that can be cooked whole and the hotel and restaurant industries preferring larger fish more conducive to filleting.

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 three collaborating 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.

### 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 fishers 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.

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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

Following a minor peak in catch occurring in 2014, the MHI Deep-7 fishery has been in an overall state of decline both in terms of landings and effort. Potential causes of these declines, including the impacts of the COVID-19 pandemic, will be discussed further in Section 1.1.3. In 2021, 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 2021 fishing year in the MHI Deep-7 bottomfish fishery compared with short-term (10-year) and long-term (20-year) averages**

| Fishery     | Parameter    | 2021 Value | 2021 Comparative Trends      |                             |
|-------------|--------------|------------|------------------------------|-----------------------------|
|             |              |            | Short-Term Avg.<br>(10-year) | Long-Term Avg.<br>(20-year) |
| Deep-7 BMUS | No. Licenses | 320        | ↓15.8%                       | ↓17.1%                      |
|             | Trips        | 2,092      | ↓16.3%                       | ↓21.1%                      |
|             | No. Caught   | 66,373     | ↓16.6%                       | ↓16.5%                      |
|             | Catch (lb)   | 164,171    | ↓29.5%                       | ↓28.3%                      |

#### 1.1.2.2 Species Summary

‘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, like onaga prized during the holiday season for its bright red color, 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 in any year.

Deep-7 species composition in Fishing Year 2021 had a relatively low (36%) contribution from ‘ōpakapaka. This falls in line with challenges reported by fishers in recent years, which included difficulty in locating normal ‘ōpakapaka aggregations, high shark depredation, challenging environmental conditions, and poor bite. Fishers additionally noted that when ‘ōpakapaka and onaga aggregations were located, they were often composed of smaller size classes than typically seen (see Section 2.2 in WPRFMC 2021). Some Deep-7 fishers also expressed the belief that normal aggregations of some bottomfish had shifted their behavior and/or habitat use, perhaps due to coinciding unusual current and weather patterns. Despite lowered participation and effort in the fishery, ehu and gindai had catch in excess of both their short- and long-term averages. Above average ehu catch is largely attributed to high landings in December 2020. At 6,857 lb, ehu catch in December 2020 was the highest single-month landings for the species since December 2009. Gindai, comprising less than 10% of the total Deep-7 catch, continue to show catch increases in recent years with Fishing Year 2021 landings being the highest on record.

**Table 2. Annual fishing parameters by gear and species for the 2021 fishing year in the MHI Deep-7 bottomfish fishery compared with short-term (10-year) and long-term (20-year) averages**

| Method                              | Species/<br>Fishery<br>Indicator | 2021 Value    | 2021 Comparative Trends      |                             |
|-------------------------------------|----------------------------------|---------------|------------------------------|-----------------------------|
|                                     |                                  |               | Short-Term Avg.<br>(10-year) | Long-Term Avg.<br>(20-year) |
| Deep-Sea<br>Handline                | ‘Ōpakapaka                       | 57,102 lb     | ↓47.7%                       | ↓46.9%                      |
|                                     | Onaga                            | 45,309 lb     | ↓24.4%                       | ↓29.8%                      |
|                                     | Ehu                              | 29,125 lb     | ↑4.88%                       | ↑21.5%                      |
|                                     | Hapu‘upu‘u                       | 4,065 lb      | ↓51.8%                       | ↓50.6%                      |
|                                     | Kalekale                         | 11,163 lb     | ↓13.2%                       | ↑5.86%                      |
|                                     | Gindai                           | 5,573 lb      | ↑61.0%                       | ↑91.2%                      |
|                                     | Lehi                             | 6,874 lb      | ↓14.7%                       | ↓16.2%                      |
|                                     | No. Lic.                         | 299           | ↓17.6%                       | ↓18.1%                      |
|                                     | Trips                            | 1,885         | ↓20.7%                       | ↓25.7%                      |
|                                     | Catch                            | 159,212 lb    | ↓30.7%                       | ↓29.6%                      |
|                                     | CPUE                             | 84.46 lb/trip | ↓13.0%                       | ↓6.10%                      |
| Non-Deep-Sea<br>Handline<br>Methods | ‘Ōpakapaka                       | 2,025 lb      | ↑36.1%                       | ↑41.3%                      |
|                                     | Onaga                            | 49            | ↓46.2%                       | ↓62.9%                      |
|                                     | Ehu                              | 161           | ↑78.9%                       | ↓5.85%                      |
|                                     | Hapu‘upu‘u                       | n.d.          | -                            | -                           |
|                                     | Kalekale                         | 60 lb         | ↑5.26%                       | ↓41.2%                      |
|                                     | Gindai                           | 74 lb         | ↑270%                        | ↑15.6%                      |
|                                     | Lehi                             | 2,560 lb      | ↑108%                        | ↑154%                       |
|                                     | No. Lic.                         | 39            | ↑21.9%                       | 0.00%                       |
|                                     | Trips                            | 209           | ↑68.6%                       | ↑78.6%                      |
|                                     | Catch                            | 4,959 lb      | ↑64.8%                       | ↑64.0%                      |
|                                     | CPUE                             | 23.73 lb/trip | ↓2.18%                       | ↓10.9%                      |

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 was 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 they were issued. During that period, each fisher received a different CML number, reducing duplicate licensee counts through June 1993. Today, all CML numbers are permanently assigned to fishers. 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. In 1965, only 84 licensed fishers participated in this fishery. As the availability of modernized fishing boats and equipment 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 (Makahū‘ena, Kaua‘i), BRFA F (Penguin Banks), BRFA J (Mokumana-Umalei Pt, Maui), and BRFA L (Leleiwi Pt, Hawai‘i Island) were re-opened to bottomfish fishing. On February 25, 2022, the Board of Land and Natural Resources (BLNR) voted to immediately open all remaining BRFAs to both commercial and non-commercial fishing. The BLNR found that given the management regime in place and healthy stock status of the Deep-7 complex, the benefits of the BRFAs did not outweigh their burden on fishers.

Following the peak and subsequent decline in catch in the late 1980s, the Deep-7 fishery had another (albeit much smaller) 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 the spring of 2020, travel and gathering restrictions were implemented to combat the then-new COVID-19 pandemic. Early COVID -19 mandates and restrictions resulted in near-complete shutdowns of Hawaii’s hotel and restaurant industries as in-person dining and non-essential travel were prohibited. Deep-7 wholesale prices during the initial (most restrictive) lockdown in the spring and summer of 2020 were low, likely due in-part to the lack of demand from the restaurant and tourism-based sectors. The seasonal peak in local demand around the holiday period (November 2020 – January 2021) occurred as usual, though catch was lower than previous years. The release of COVID -19 vaccines and easing of travel restrictions resulted in

the quick return of domestic travelers seeking cheap airfares. By March 2021 domestic traveler arrivals to the state were approaching pre-pandemic levels, and in June 2021 began to exceed 2019 arrivals during the same period. Deep-7 wholesale prices spiked to unprecedented levels in the summer of 2021. The return of tourists, along with disruptions to global seafood supply chains, and rising costs of other locally caught species commonly consumed by restaurants and tourism-based sectors such as ahi and opah all likely played a role in the jump in price.

**Table 3. Time series of commercial fishing reports for Deep-7 BMUS reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2021**

| Year   | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|--------|-------------|-------|-------------|------------|------------|
| 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    |
| 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    |

| Year                | No. License | Trips        | No. Reports  | No. Caught    | Catch (lb)     |
|---------------------|-------------|--------------|--------------|---------------|----------------|
| 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        |
| 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         | 2,023        | 1,045        | 47,879        | 181,125        |
| 2020                | 334         | 1,843        | 1,000        | 45,903        | 161,713        |
| 2021                | 320         | 2,092        | 1,042        | 52,050        | 164,171        |
| <b>10-year avg.</b> | <b>380</b>  | <b>2,500</b> | <b>1,249</b> | <b>66,373</b> | <b>232,694</b> |
| <b>20-year avg.</b> | <b>386</b>  | <b>2,651</b> | <b>1,240</b> | <b>62,346</b> | <b>229,044</b> |

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

Nearly all (~99%) combined Deep-7 BMUS are caught using deep-sea handline gear. With few exceptions, deep-sea handline gear is today largely a Deep-7-specific gear type. Though traditionally literally a “handline” gear, today most deep-sea handline fishers use hydraulic or electric reels due the great depths fished and heavy lead weights. Rigging varies between fishers but commonly employs the use of a heavy lead weight and multiple baited hooks fished either near the bottom or higher in the water column depending on fish behavior and species targeted. The use of palu (chum) is common in deep-sea handline fishing and is typically delivered to depth using a palu bag attached above the hooks, or methods like “make dog” (maki-dogu) in

which the lead weight, baited hooks, and chum are contained in a wrapped package and deployed at a desired depth releasing the contents.

Though fishing methods continue to evolve, with some fishers today catching Deep-7 from jet skis and even kayaks, the deep-sea handline gear type remains dominant. In Fishing Year 2021 the approximately 97% of Deep-7 were caught with deep-sea handline. The persistent dominance of this gear may suggest that it is simply the most effective way to target multiple relatively large species at great depth. Lighter methods such as inshore handline or jigging may be used by some but are likely too light to make consistent large catches.

**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 1994-2021**

| Year | ‘Ōpakapaka  |            | Onaga       |            | Ehu         |            | Hapu‘upu‘u  |            |
|------|-------------|------------|-------------|------------|-------------|------------|-------------|------------|
|      | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb) |
| 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     |
| 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     |

| Year              | ‘Ōpakapaka  |                | Onaga       |               | Ehu         |               | Hapu‘upu‘u  |              |
|-------------------|-------------|----------------|-------------|---------------|-------------|---------------|-------------|--------------|
|                   | No. License | Catch (lb)     | No. License | Catch (lb)    | No. License | Catch (lb)    | No. License | Catch (lb)   |
| 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        |
| 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         | 67,256         | 158         | 60,396        | 218         | 24,948        | 107         | 6,359        |
| 2020              | 235         | 63,649         | 158         | 41,333        | 220         | 24,984        | 104         | 5,602        |
| 2021              | 197         | 57,102         | 157         | 45,309        | 220         | 29,125        | 91          | 4,065        |
| <b>10-yr avg.</b> | <b>276</b>  | <b>109,162</b> | <b>200</b>  | <b>59,942</b> | <b>251</b>  | <b>27,769</b> | <b>129</b>  | <b>8,438</b> |
| <b>20-yr avg.</b> | <b>281</b>  | <b>107,614</b> | <b>207</b>  | <b>64,554</b> | <b>244</b>  | <b>23,970</b> | <b>137</b>  | <b>8,222</b> |

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 1994-2021**

| Year   | Kalekale    |            | Gindai      |            | Lehi        |            |
|--------|-------------|------------|-------------|------------|-------------|------------|
|        | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb) |
| 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     |
| 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      |

| Year              | Kalekale    |               | Gindai      |              | Lehi        |              |
|-------------------|-------------|---------------|-------------|--------------|-------------|--------------|
|                   | No. License | Catch (lb)    | No. License | Catch (lb)   | No. License | Catch (lb)   |
| 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          | 5,844        |
| 2020              | 194         | 11,041        | 155         | 5,123        | 81          | 7,401        |
| 2021              | 163         | 11,163        | 146         | 5,573        | 80          | 6,874        |
| <b>10-yr avg.</b> | <b>194</b>  | <b>12,858</b> | <b>145</b>  | <b>3,461</b> | <b>100</b>  | <b>8,056</b> |
| <b>20-yr avg.</b> | <b>178</b>  | <b>10,545</b> | <b>136</b>  | <b>2,914</b> | <b>100</b>  | <b>8,203</b> |

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 includes Deep-7 species that are harvested using gear types other than 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 to target yellowfin and bigeye tuna. Deep-7 BMUS are common bycatch for Hawai'i 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 ‘ōpakapaka and lehi, both of which can be found in relatively shallower waters in comparison to the other deep-7 species. ‘Ōpakapaka are also the most targeted of the Deep-7 species. It is likely that some of the ‘ōpakapaka 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 was a small increase in the catch of Deep-7 using these gears in Fishing Year 2021, it does not appear outwardly that another 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 1994-2021**

| Year | ‘Ōpakapaka  |            | Onaga       |            | Ehu         |            | Hapu‘upu‘u  |            |
|------|-------------|------------|-------------|------------|-------------|------------|-------------|------------|
|      | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb) |
| 1965 | 18          | 662        | n.d.        | n.d.       | 11          | 222        | 3           | 37         |
| 1966 | 7           | 756        | n.d.        | n.d.       | 7           | 537        | -           | -          |
| 1967 | 3           | 263        | -           | -          | -           | -          | n.d.        | n.d.       |
| 1968 | n.d.        | n.d.       | -           | -          | n.d.        | n.d.       | n.d.        | n.d.       |
| 1969 | 4           | 281        | n.d.        | n.d.       | 4           | 80         | n.d.        | n.d.       |
| 1970 | 3           | 152        | -           | -          | -           | -          | 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        | -           | -          | 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        |

| Year              | ‘Ōpakapaka  |              | Onaga       |            | Ehu         |            | Hapu‘upu‘u  |            |
|-------------------|-------------|--------------|-------------|------------|-------------|------------|-------------|------------|
|                   | No. License | Catch (lb)   | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb) |
| 1991              | -           | -            | -           | -          | -           | -          | 11          | 127        |
| 1992              | n.d.        | n.d.         | -           | -          | -           | -          | 6           | 118        |
| 1993.1            | n.d.        | n.d.         | -           | -          | -           | -          | 6           | 88         |
| 1993.2            | n.d.        | n.d.         | -           | -          | -           | -          | n.d.        | n.d.       |
| 1994              | n.d.        | n.d.         | -           | -          | -           | -          | 8           | 126        |
| 1995              | 3           | 45           | -           | -          | -           | -          | 8           | 144        |
| 1996              | 7           | 262          | -           | -          | 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          | -           | -          | n.d.        | n.d.       | n.d.        | n.d.       |
| 2000              | 10          | 148          | -           | -          | 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         |
| 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          | -           | -          | 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        | -           | -          | 4           | 126        | 7           | 182        |
| 2018              | 14          | 1,471        | n.d.        | n.d.       | 7           | 111        | n.d.        | n.d.       |
| 2019              | 24          | 1,259        | -           | -          | n.d.        | n.d.       | 4           | 139        |
| 2020              | 17          | 1,015        | 4           | 103        | 3           | 21         | n.d.        | n.d.       |
| 2021              | 24          | 2,025        | 4           | 49         | 7           | 161        | n.d.        | n.d.       |
| <b>10-yr avg.</b> | <b>21</b>   | <b>1,488</b> | <b>2</b>    | <b>91</b>  | <b>4</b>    | <b>90</b>  | <b>3</b>    | <b>64</b>  |
| <b>20-yr avg.</b> | <b>23</b>   | <b>1,433</b> | <b>4</b>    | <b>132</b> | <b>7</b>    | <b>171</b> | <b>4</b>    | <b>136</b> |

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 for non-deep-sea handline methods, reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2021**

| Year   | Kalekale    |            | Gindai      |            | Lehi        |            |
|--------|-------------|------------|-------------|------------|-------------|------------|
|        | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb) |
| 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.       | -           | -          | 3           | 19         |
| 1968   | n.d.        | n.d.       | -           | -          | -           | -          |
| 1969   | 3           | 26         | 4           | 8          | -           | -          |
| 1970   | n.d.        | n.d.       | -           | -          | 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.       | -           | -          | n.d.        | n.d.       |
| 1975   | 7           | 76         | 4           | 38         | 10          | 349        |
| 1976   | 14          | 345        | 21          | 133        | 13          | 489        |
| 1977   | 21          | 1,008      | 16          | 382        | 18          | 601        |
| 1978   | 36          | 1,003      | 34          | 245        | 43          | 1,168      |
| 1979   | 71          | 1,152      | 33          | 378        | 58          | 2,043      |
| 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.       | -           | -          | -           | -          |
| 1991   | -           | -          | -           | -          | -           | -          |
| 1992   | n.d.        | n.d.       | -           | -          | -           | -          |
| 1993.1 | n.d.        | n.d.       | -           | -          | -           | -          |
| 1993.2 | -           | -          | -           | -          | -           | -          |
| 1994   | 3           | 22         | -           | -          | n.d.        | n.d.       |
| 1995   | n.d.        | n.d.       | -           | -          | 6           | 92         |
| 1996   | 5           | 32         | 3           | 62         | 13          | 253        |
| 1997   | 7           | 650        | 5           | 91         | 22          | 345        |
| 1998   | 5           | 205        | -           | -          | 15          | 351        |
| 1999   | 5           | 224        | n.d.        | n.d.       | 27          | 843        |

| Year                 | Kalekale    |            | Gindai      |            | Lehi        |              |
|----------------------|-------------|------------|-------------|------------|-------------|--------------|
|                      | No. License | Catch (lb) | No. License | Catch (lb) | No. License | Catch (lb)   |
| 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        |
| 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         | -           | -          | 15          | 1,365        |
| 2021                 | 10          | 60         | 7           | 74         | 27          | 2,560        |
| <b>10-year avg.</b>  | <b>6</b>    | <b>57</b>  | <b>2</b>    | <b>20</b>  | <b>20</b>   | <b>1,230</b> |
| <b>20- year avg.</b> | <b>7</b>    | <b>102</b> | <b>4</b>    | <b>64</b>  | <b>20</b>   | <b>1,009</b> |

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 decreased markedly during 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. Following the expansion of the small boat fleet, deep-sea handline CPUE has remained relatively stable with a slight decline between 1998 and 2021.

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 in part 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 BMUS CPUE (lb/trip) by dominant fishing methods reported by Fiscal Year from 1965-1993 and by Fishing Year from 1994-2021**

| Year   | Deep-Sea Handline |       |            |        | Non-Deep-Sea Handline Gears |       |            |       |
|--------|-------------------|-------|------------|--------|-----------------------------|-------|------------|-------|
|        | No. Lic.          | Trips | Catch (lb) | CPUE   | No. Lic.                    | Trips | Catch (lb) | 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  |
| 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     | 29.8  |
| 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     | 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      | 59.6  |
| 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 |

| Year                 | Deep-Sea Handline |              |                |              | Non-Deep-Sea Handline Gears |            |              |              |
|----------------------|-------------------|--------------|----------------|--------------|-----------------------------|------------|--------------|--------------|
|                      | No. Lic.          | Trips        | Catch (lb)     | CPUE         | No. Lic.                    | Trips      | Catch (lb)   | CPUE         |
| 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        | 21.2         |
| 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        | 85.1         | 34                          | 104        | 4,872        | 46.84        |
| 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        | 109.3        | 33                          | 109        | 2,929        | 26.87        |
| 2016                 | 360               | 2,266        | 259,009        | 114.3        | 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               | 1,900        | 178,439        | 93.92        | 38                          | 125        | 2,686        | 21.49        |
| 2020                 | 320               | 1,698        | 159,132        | 93.72        | 26                          | 146        | 2,581        | 17.68        |
| 2021                 | 299               | 1,885        | 159,212        | 84.46        | 39                          | 209        | 4,959        | 23.73        |
| <b>10-year avg.</b>  | <b>363</b>        | <b>2,377</b> | <b>229,685</b> | <b>97.12</b> | <b>32</b>                   | <b>124</b> | <b>3,009</b> | <b>24.26</b> |
| <b>20- year avg.</b> | <b>365</b>        | <b>2,536</b> | <b>226,022</b> | <b>89.95</b> | <b>39</b>                   | <b>117</b> | <b>3,023</b> | <b>26.62</b> |

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

### 1.1.6 Bycatch Summary

BMUS bycatch when using deep-sea handline gear is generally low due to a lack of commercial bag limits and largely nonrestrictive one-pound commercial size limits for ‘ōpākāpāka and onaga only. The increase in percent bycatch beginning in 2007 and peaking in 2013 is due primarily to tagging efforts by PIFSC and Pacific Islands Fisheries Group (PIFG). Tagging was performed by local fishers with CMLs, so all Deep-7 caught and released for research purposes was included in their reports. In 2021, percent bycatch for the Deep-7 fishery is below 10- and 20-year averages primarily due to a decrease in the amount of tagging activity reported by CML holders. Bycatch of non-Deep-7 when using deep-sea handline gear is consistently higher. A primary cause is that kahala (*Seriola* spp.) are frequently caught alongside Deep-7 species. Avoided by many local consumers due to their reputation for carrying ciguatera and often having parasite-laden flesh, kahala are some of the most frequently released species by commercial fishers. Though making up less than three percent of the total non-target catch using deep-sea handline, kahala make up approximately 60% of the releases.

**Table 7. Time series of commercial fishing bycatch of Deep-7 BMUS and non-target species harvested with deep-sea handline, reported by Fishing Year from 2002-2021**

| Target Species (Deep-7 Bottomfish) |            |              |              |               |              |                 | Non-Target Species (Harvested with Deep-Sea Handline) |              |              |               |              |                 |
|------------------------------------|------------|--------------|--------------|---------------|--------------|-----------------|-------------------------------------------------------|--------------|--------------|---------------|--------------|-----------------|
| Year                               | No. Lic.   | Trips        | No. Reports  | No. Retained  | No. Released | Percent Bycatch | No. Lic.                                              | Trips        | No. Reports  | No. Retained  | No. Released | Percent Bycatch |
| 2002                               | 393        | 2,920        | 1,355        | 56,438        | 3            | 0.01            | 345                                                   | 1,648        | 960          | 11,889        | 14           | 0.12            |
| 2003                               | 364        | 2,959        | 1,255        | 63,311        | 217          | 0.34            | 342                                                   | 1,795        | 958          | 13,125        | 3,135        | 19.28           |
| 2004                               | 333        | 2,669        | 1,145        | 57,588        | 117          | 0.20            | 326                                                   | 1,776        | 923          | 16,871        | 1,130        | 6.28            |
| 2005                               | 352        | 2,705        | 1,200        | 61,406        | 156          | 0.25            | 329                                                   | 1,908        | 977          | 17,452        | 1,643        | 8.6             |
| 2006                               | 352        | 2,287        | 1,053        | 46,154        | 55           | 0.12            | 331                                                   | 1,665        | 856          | 17,284        | 1,214        | 6.56            |
| 2007                               | 357        | 2,553        | 1,148        | 50,008        | 535          | 1.06            | 328                                                   | 1,969        | 976          | 24,506        | 1,162        | 4.53            |
| 2008                               | 351        | 2,354        | 1,027        | 49,397        | 542          | 1.09            | 330                                                   | 2,009        | 944          | 29,287        | 2,827        | 8.80            |
| 2009                               | 478        | 3,283        | 1,479        | 67,065        | 507          | 0.75            | 424                                                   | 2,311        | 1,135        | 26,918        | 1,231        | 4.37            |
| 2010                               | 461        | 2,802        | 1,229        | 56,942        | 1,102        | 1.90            | 431                                                   | 2,504        | 1,181        | 40,116        | 1,589        | 3.81            |
| 2011                               | 474        | 3,456        | 1,432        | 74,886        | 2,098        | 2.73            | 458                                                   | 2,583        | 1,280        | 37,560        | 1,787        | 4.54            |
| 2012                               | 480        | 3,108        | 1,529        | 68,024        | 1,420        | 2.05            | 447                                                   | 2,201        | 1,204        | 30,269        | 1,537        | 4.83            |
| 2013                               | 459        | 2,990        | 1,501        | 68,441        | 2,010        | 2.85            | 414                                                   | 2,102        | 1,152        | 29,691        | 1,823        | 5.78            |
| 2014                               | 423        | 3,182        | 1,496        | 90,296        | 1,474        | 1.61            | 373                                                   | 2,201        | 1,139        | 31,149        | 1,355        | 4.17            |
| 2015                               | 411        | 2,890        | 1,415        | 90,790        | 1,378        | 1.50            | 355                                                   | 2,065        | 1,106        | 31,395        | 1,709        | 5.16            |
| 2016                               | 372        | 2,348        | 1,194        | 74,536        | 733          | 0.97            | 331                                                   | 1,84         | 995          | 28,177        | 1,432        | 4.84            |
| 2017                               | 340        | 2,351        | 1,162        | 66,483        | 411          | 0.61            | 314                                                   | 1,923        | 975          | 29,248        | 1,623        | 5.26            |
| 2018                               | 341        | 2,169        | 1,102        | 59,332        | 440          | 0.74            | 331                                                   | 1,669        | 933          | 27,152        | 2,515        | 8.48            |
| 2019                               | 318        | 2,023        | 1,045        | 47,879        | 630          | 1.30            | 300                                                   | 1,505        | 881          | 29,100        | 1,671        | 5.43            |
| 2020                               | 334        | 1,843        | 1,000        | 45,903        | 211          | 0.46            | 298                                                   | 1,196        | 755          | 17,677        | 1,353        | 7.11            |
| 2021                               | 320        | 2,092        | 1,042        | 52,050        | 196          | 0.38            | 276                                                   | 1,453        | 818          | 30,544        | 1,994        | 6.13            |
| <b>10-year avg.</b>                | <b>380</b> | <b>2,500</b> | <b>1,249</b> | <b>66,373</b> | <b>890</b>   | <b>1.25</b>     | <b>344</b>                                            | <b>1,818</b> | <b>996</b>   | <b>28,440</b> | <b>1,701</b> | <b>5.72</b>     |
| <b>20-year avg.</b>                | <b>386</b> | <b>2,649</b> | <b>1,240</b> | <b>62,346</b> | <b>712</b>   | <b>1.04</b>     | <b>354</b>                                            | <b>1,917</b> | <b>1,007</b> | <b>25,971</b> | <b>1,637</b> | <b>6.20</b>     |

## **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 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 like ‘ōpakapaka, onaga, and other Deep-7 regarded highly for their firm and flavorful white flesh good for both cooking and raw consumption. Unlike Deep-7, uku are not typically used to fill the seasonal demand for whole fish during the holiday season due to the 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.

Like 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**

Like Deep-7, MHI uku fishery landings and effort are in a state of decline following a peak 2017. Potential causes of these declines, including the impact of the COVID-19 pandemic on landings and effort will be discussed further in section 1.2.3 Time Series Statistics. In 2021, participation, catch, and effort for the MHI uku fishery were all below their corresponding short- and long-term averages.

**Table 8. Annual fishing parameters for 2021 in the MHI uku fishery compared with short-term (10-year) and long-term (20-year) averages**

| Fishery | Parameter   | 2021 Value | 2021 Comparative Trends      |                             |
|---------|-------------|------------|------------------------------|-----------------------------|
|         |             |            | Short-Term Avg.<br>(10-year) | Long-Term Avg.<br>(20-year) |
| Uku     | No. License | 233        | ↓31.5%                       | ↓29.4%                      |
|         | Trips       | 1,005      | ↓34.5%                       | ↓30.5%                      |
|         | No. Caught  | 7,439      | ↓37.8%                       | ↓29.7%                      |
|         | Catch (lb)  | 60,358     | ↓37.2%                       | ↓31.0%                      |

**1.2.2.2 Gear Summary**

The MHI uku fishery as a whole is not easy to define in terms of gear use, especially in recent years. Because of the wide range of depths and habitat types frequented by uku, they are caught both intentionally and incidentally using a wide range of gears including spearfishing and shore-based casting. Deep-sea handline has historically been the dominant gear. However, other gears such as inshore handline, trolling, and casting can make up a sizable proportion of the total catch.

**Table 9. Annual fishing parameters for 2021 in the MHI uku fishery compared with short-term (10-year) and long-term (20-year) averages**

| Method               | Species/<br>Fishery<br>Indicator | 2021 Value    | 2021 Comparative Trends      |                             |
|----------------------|----------------------------------|---------------|------------------------------|-----------------------------|
|                      |                                  |               | Short-Term Avg.<br>(10-year) | Long-Term Avg.<br>(20-year) |
| Deep-Sea<br>Handline | No. Lic.                         | 122           | ↓25.6%                       | ↓27.8%                      |
|                      | No. Trips                        | 444           | ↓33.3%                       | ↓37.3%                      |
|                      | Catch                            | 37,942 lb     | ↓34.5%                       | ↓33.1%                      |
|                      | CPUE                             | 85.45 lb/trip | ↓0.15%                       | ↑7.99%                      |
| Inshore<br>Handline  | No. Lic.                         | 27            | ↓50.0%                       | ↓59.7%                      |
|                      | No. Trips                        | 142           | ↓50.9%                       | ↓50.9%                      |
|                      | Catch                            | 5,108 lb      | ↓63.3%                       | ↓58.9%                      |
|                      | CPUE                             | 35.97 lb/trip | ↓24.4%                       | ↓14.8%                      |
| Troll with Bait      | No. Lic.                         | 29            | ↓19.4%                       | ↑7.41%                      |
|                      | No. Trips                        | 156           | ↓4.88%                       | ↑23.8%                      |
|                      | Catch                            | 6,697 lb      | ↓14.6%                       | ↓0.80%                      |
|                      | CPUE                             | 42.93 lb/trip | ↓10.3%                       | ↓21.6%                      |
| All Other Gears      | No. Lic.                         | 100           | ↓32.4%                       | ↓18.7%                      |
|                      | No. Trips                        | 264           | ↓37.3%                       | ↓18.8%                      |
|                      | Catch                            | 10,611 lb     | ↓35.8%                       | ↓8.56%                      |
|                      | CPUE                             | 40.19 lb/trip | ↑1.49%                       | ↑18.5%                      |

### 1.2.3 Time Series Statistics

#### 1.2.3.1 Commercial Fishing Parameters

Uku catch spiked dramatically 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 in 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 around 2008 may have influenced new entrants into the fishery and/or more effort by existing fishers in attempts to offset economic losses.

The initial impact of the COVID-19 pandemic on the MHI uku fishery was significant as hotel and restaurant demand was almost eliminated following the lockdown in March 2020. As a result, some wholesalers limited their purchases drastically to adjust for the low demand. Unlike Deep-7, uku do not have a seasonal local demand in addition to the hotel and restaurant markets. As tourists returned to Hawaii following the easing of travel restrictions, uku wholesale prices increased. However, the fishery did not show an immediate commensurate response, with 2021 landings remaining below pre-pandemic levels. Additionally, as with the Deep-7 fishery, uku fishers have noted that shark depredation and challenging fishing conditions (e.g., unusual current patterns) have been problematic in recent years. Depredation can be especially bad when uku are targeted directly in high number, such as the fishery on Penguin Bank where a sizable proportion of MHI uku are caught annually. As a result, fishers have noted that some have moved away from targeting uku.

**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 | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 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     |

| <b>Year</b> | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|-------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 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            |
| 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           |

| <b>Year</b>         | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|---------------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 2014                | 379                | 1,679        | 1,004              | 11,687            | 97,003            |
| 2015                | 417                | 1,846        | 1,085              | 12,882            | 101,897           |
| 2016                | 378                | 1,914        | 1,051              | 15,129            | 118,597           |
| 2017                | 363                | 1,776        | 1,019              | 17,507            | 132,735           |
| 2018                | 286                | 1,235        | 746                | 10,145            | 75,250            |
| 2019                | 286                | 1,295        | 793                | 11,106            | 90,016            |
| 2020                | 253                | 1,031        | 626                | 5,952             | 48,038            |
| 2021                | 233                | 1,005        | 611                | 7,439             | 60,358            |
| <b>10-year avg.</b> | <b>340</b>         | <b>1,535</b> | <b>906</b>         | <b>11,950</b>     | <b>96,177</b>     |
| <b>20-year avg.</b> | <b>330</b>         | <b>1,446</b> | <b>854</b>         | <b>10,586</b>     | <b>87,532</b>     |

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 to direct targeting with unique gears and/or techniques specifically aimed at uku. Fishers moving to target uku specifically have in some cases chosen to report as different methods. While some fishers have redefined 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”). CPUE for all major gear types has been increasing. This again may be an indication that direct targeting of uku with uku specialized gears and techniques is increasing over time.

**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.          | Trips | Catch (lb) | CPUE   | No. Lic.         | Trips | Catch (lb) | CPUE  | No. Lic.        | Trips | Catch (lb) | CPUE | No. Lic.             | Trips | Catch (lb) | CPUE   |
| 1965 | 74                | 560   | 66,926     | 119.51 | 10               | 17    | 822        | 48.35 | -               | -     | -          | -    | 7                    | 51    | 483        | 9.47   |
| 1966 | 78                | 514   | 46,358     | 90.19  | 4                | 4     | 50         | 12.5  | -               | -     | -          | -    | 6                    | 53    | 408        | 7.70   |
| 1967 | 101               | 683   | 63,303     | 92.68  | 4                | 5     | 554        | 110.8 | -               | -     | -          | -    | 9                    | 46    | 358        | 7.78   |
| 1968 | 104               | 510   | 51,715     | 101.4  | 8                | 13    | 345        | 26.54 | -               | -     | -          | -    | 8                    | 48    | 302        | 6.29   |
| 1969 | 107               | 615   | 52,824     | 85.89  | 3                | 3     | 24         | 8     | -               | -     | -          | -    | 11                   | 98    | 1,291      | 13.17  |
| 1970 | 115               | 633   | 48,645     | 76.85  | 3                | 4     | 20         | 5     | -               | -     | -          | -    | 10                   | 94    | 1,129      | 12.01  |
| 1971 | 133               | 548   | 48,038     | 87.66  | 3                | 4     | 25         | 6.25  | -               | -     | -          | -    | 5                    | 56    | 355        | 6.34   |
| 1972 | 154               | 663   | 53,336     | 80.45  | 3                | 3     | 12         | 4     | -               | -     | -          | -    | 12                   | 95    | 791        | 8.33   |
| 1973 | 161               | 675   | 45,817     | 67.88  | 8                | 9     | 47         | 5.22  | -               | -     | -          | -    | 12                   | 83    | 714        | 8.60   |
| 1974 | 216               | 969   | 72,132     | 74.44  | 7                | 10    | 158        | 15.8  | -               | -     | -          | -    | 21                   | 61    | 665        | 10.90  |
| 1975 | 191               | 947   | 74,325     | 78.48  | 16               | 23    | 331        | 14.39 | -               | -     | -          | -    | 24                   | 71    | 834        | 11.75  |
| 1976 | 166               | 732   | 63,048     | 86.13  | 42               | 97    | 2,453      | 25.29 | -               | -     | -          | -    | 33                   | 106   | 3,508      | 33.09  |
| 1977 | 187               | 716   | 36,177     | 50.53  | 60               | 211   | 7,792      | 36.93 | -               | -     | -          | -    | 49                   | 166   | 3,125      | 18.83  |
| 1978 | 303               | 1097  | 75,501     | 68.82  | 134              | 298   | 14,348     | 48.15 | -               | -     | -          | -    | 49                   | 181   | 4,949      | 27.34  |
| 1979 | 248               | 857   | 67,218     | 78.43  | 211              | 431   | 12,673     | 29.4  | -               | -     | -          | -    | 26                   | 70    | 2,856      | 40.80  |
| 1980 | 290               | 1196  | 57,753     | 48.29  | 71               | 113   | 1,836      | 16.25 | -               | -     | -          | -    | 78                   | 181   | 4,125      | 22.79  |
| 1981 | 338               | 1763  | 90,177     | 51.15  | 67               | 110   | 1,198      | 10.89 | -               | -     | -          | -    | 59                   | 247   | 3,652      | 14.79  |
| 1982 | 354               | 1752  | 88,334     | 50.42  | 43               | 64    | 582        | 9.09  | -               | -     | -          | -    | 40                   | 180   | 3,955      | 21.97  |
| 1983 | 368               | 2451  | 115,347    | 47.06  | 46               | 67    | 581        | 8.67  | -               | -     | -          | -    | 56                   | 141   | 5,570      | 39.50  |
| 1984 | 381               | 2152  | 134,986    | 62.73  | 53               | 76    | 1,169      | 15.38 | -               | -     | -          | -    | 69                   | 166   | 5,446      | 32.81  |
| 1985 | 361               | 1785  | 94,464     | 52.92  | 4                | 4     | 207        | 51.75 | -               | -     | -          | -    | 33                   | 89    | 1,343      | 15.09  |
| 1986 | 270               | 1220  | 63,788     | 52.29  | 22               | 52    | 2,323      | 44.67 | -               | -     | -          | -    | 47                   | 75    | 1,584      | 21.12  |
| 1987 | 247               | 988   | 61,460     | 62.21  | 91               | 245   | 11,695     | 47.73 | -               | -     | -          | -    | 53                   | 120   | 14,650     | 122.08 |
| 1988 | 350               | 2091  | 167,959    | 80.32  | 91               | 186   | 10,401     | 55.92 | -               | -     | -          | -    | 59                   | 177   | 7,329      | 41.41  |

| Year   | Deep-Sea Handline |       |            |       | Inshore Handline |       |            |       | Troll with Bait |       |            |       | All Other Gear Types |       |            |       |
|--------|-------------------|-------|------------|-------|------------------|-------|------------|-------|-----------------|-------|------------|-------|----------------------|-------|------------|-------|
|        | No. Lic.          | Trips | Catch (lb) | CPUE  | No. Lic.         | Trips | Catch (lb) | CPUE  | No. Lic.        | Trips | Catch (lb) | CPUE  | No. Lic.             | Trips | Catch (lb) | CPUE  |
| 1989   | 424               | 2667  | 298,435    | 111.9 | 75               | 162   | 4,532      | 27.98 | -               | -     | -          | -     | 77                   | 209   | 11,318     | 54.15 |
| 1990   | 375               | 1799  | 122,703    | 68.21 | 78               | 218   | 2,653      | 12.17 | -               | -     | -          | -     | 91                   | 189   | 14,031     | 74.24 |
| 1991   | 322               | 1427  | 103,311    | 72.40 | 106              | 236   | 4,719      | 20.00 | -               | -     | -          | -     | 75                   | 165   | 9,054      | 54.87 |
| 1992   | 281               | 1119  | 68,813     | 61.50 | 127              | 441   | 18,850     | 42.74 | -               | -     | -          | -     | 73                   | 144   | 5,898      | 40.96 |
| 1993.1 | 222               | 808   | 54,507     | 67.46 | 114              | 354   | 8,286      | 23.41 | -               | -     | -          | -     | 60                   | 166   | 3,132      | 18.87 |
| 1993.2 | 172               | 508   | 30,667     | 60.37 | 45               | 90    | 1,740      | 19.33 | -               | -     | -          | -     | 40                   | 99    | 2,056      | 20.77 |
| 1994   | 259               | 1026  | 59,416     | 57.91 | 93               | 275   | 11,415     | 41.51 | -               | -     | -          | -     | 74                   | 158   | 2,455      | 15.54 |
| 1995   | 249               | 931   | 52,322     | 56.20 | 76               | 222   | 4,836      | 21.78 | -               | -     | -          | -     | 78                   | 152   | 2,970      | 19.54 |
| 1996   | 223               | 743   | 41,024     | 55.21 | 140              | 400   | 8,612      | 21.53 | -               | -     | -          | -     | 87                   | 179   | 3,710      | 20.73 |
| 1997   | 231               | 912   | 47,676     | 52.28 | 189              | 634   | 17,575     | 27.72 | -               | -     | -          | -     | 87                   | 161   | 2,752      | 17.09 |
| 1998   | 224               | 771   | 44,129     | 57.24 | 146              | 550   | 14,049     | 25.54 | -               | -     | -          | -     | 69                   | 134   | 2,970      | 22.16 |
| 1999   | 236               | 836   | 76,039     | 90.96 | 153              | 508   | 11,700     | 23.03 | -               | -     | -          | -     | 61                   | 150   | 3,253      | 21.69 |
| 2000   | 246               | 914   | 67,280     | 73.61 | 143              | 485   | 12,948     | 26.7  | -               | -     | -          | -     | 71                   | 148   | 3,113      | 21.03 |
| 2001   | 185               | 700   | 38,547     | 55.07 | 115              | 356   | 15,369     | 43.17 | -               | -     | -          | -     | 62                   | 143   | 5,179      | 36.22 |
| 2002   | 176               | 618   | 44,885     | 72.63 | 81               | 279   | 9,765      | 35.00 | 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      | 75.20 | 89                   | 209   | 6,726      | 32.18 |
| 2006   | 147               | 665   | 39,997     | 60.15 | 51               | 230   | 9,554      | 41.54 | 12              | 76    | 6,171      | 81.20 | 80                   | 216   | 5,430      | 25.14 |
| 2007   | 153               | 684   | 45,566     | 66.62 | 66               | 276   | 11,488     | 41.62 | 12              | 112   | 7,500      | 66.96 | 78                   | 193   | 4,552      | 23.58 |
| 2008   | 177               | 826   | 63,152     | 76.46 | 84               | 319   | 12,983     | 40.7  | 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               | 1068  | 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.          | Trips      | Catch (lb)    | CPUE         | No. Lic.         | Trips      | Catch (lb)    | CPUE         | No. Lic.        | Trips      | Catch (lb)   | CPUE         | No. Lic.             | Trips      | Catch (lb)    | 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               | 822        | 73,362        | 89.25        | 59               | 308        | 11,518        | 37.39        | 33              | 222        | 12,721       | 57.3         | 173                  | 565        | 20,997        | 37.16        |
| 2017              | 201               | 901        | 85,567        | 94.97        | 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        | 63.60        | 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              | 121               | 402        | 26,381        | 65.62        | 33               | 227        | 8,112         | 35.73        | 29              | 108        | 4,132        | 38.26        | 107                  | 294        | 9,413         | 32.02        |
| 2021              | 122               | 444        | 37,942        | 85.45        | 27               | 142        | 5,108         | 35.97        | 29              | 156        | 6,697        | 42.93        | 100                  | 264        | 10,611        | 40.19        |
| <b>10-yr avg.</b> | <b>164</b>        | <b>663</b> | <b>57,906</b> | <b>85.58</b> | <b>54</b>        | <b>289</b> | <b>13,902</b> | <b>47.55</b> | <b>36</b>       | <b>164</b> | <b>7,839</b> | <b>47.84</b> | <b>148</b>           | <b>421</b> | <b>16,531</b> | <b>39.60</b> |
| <b>20-yr avg.</b> | <b>169</b>        | <b>708</b> | <b>56,749</b> | <b>79.13</b> | <b>67</b>        | <b>289</b> | <b>12,428</b> | <b>42.23</b> | <b>27</b>       | <b>126</b> | <b>6,751</b> | <b>54.76</b> | <b>123</b>           | <b>325</b> | <b>11,604</b> | <b>33.92</b> |

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 percent bycatch is typically low (<2%) 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 has seen steady increase since 2002. One contributing factor is the increasing use of inshore handline gear over time. In the past ten years, inshore handline gear landed approximately 15% of the total uku catch yet contributed about 50% of all releases. Peak uku percent bycatch in 2020 is likely also the result of COVID-19 restrictions limiting market demand. Individual fishers noted that during the most restrictive lockdown periods, local dealers were drastically limiting the amount of uku they were willing to purchase per day. Percent bycatch for uku in 2021 was relatively high, though it should be noted still low in comparison to other fisheries.

In comparison to other species targeted with similar gears, uku are retained at a slightly higher rate. This is due in part to the fact that commonly released species such as kahala and sharks are caught with similar gears and drive the non-uku bycatch rates up slightly. However, it should be noted that the majority of the non-target species included in the below table were caught while not targeting uku (e.g., inshore handline for akule and deep-sea handline for Deep-7).

**Table 12. Time series of commercial fishing bycatch of uku and non-target species harvested with deep-sea handline, inshore handline, or casting, reported by Fishing Year from 2002-2021**

| Target Species (Uku) |            |              |             |               |              |                 | Non-Target Species (Harvested with Deep-Sea Handline, Inshore Handline, or Casting) |              |              |                |              |                 |
|----------------------|------------|--------------|-------------|---------------|--------------|-----------------|-------------------------------------------------------------------------------------|--------------|--------------|----------------|--------------|-----------------|
| Year                 | No. Lic.   | Trips        | No. Reports | No. Retained  | No. Released | Percent Bycatch | No. Lic.                                                                            | Trips        | No. Reports  | No. Retained   | No. Released | Percent Bycatch |
| 2002                 | 276        | 1,040        | 671         | 6,788         | 12           | 0.18            | 794                                                                                 | 9,325        | 3,144        | 353,966        | 2,105        | 0.59            |
| 2003                 | 282        | 1,028        | 670         | 5,446         | 2            | 0.04            | 696                                                                                 | 8,819        | 2,833        | 686,361        | 4,883        | 0.71            |
| 2004                 | 319        | 1,291        | 772         | 8,751         | 44           | 0.50            | 692                                                                                 | 8,473        | 2,755        | 586,526        | 4,161        | 0.70            |
| 2005                 | 302        | 1,170        | 741         | 7,891         | 12           | 0.15            | 642                                                                                 | 6,964        | 2,433        | 430,528        | 3,654        | 0.84            |
| 2006                 | 259        | 1,186        | 673         | 6,852         | 27           | 0.39            | 633                                                                                 | 7,035        | 2,410        | 554,901        | 3,124        | 0.56            |
| 2007                 | 280        | 1,265        | 717         | 8,390         | 13           | 0.15            | 675                                                                                 | 7,637        | 2,640        | 590,755        | 3,748        | 0.63            |
| 2008                 | 318        | 1,486        | 812         | 11,298        | 27           | 0.24            | 823                                                                                 | 8,288        | 2,910        | 564,609        | 5,908        | 1.04            |
| 2009                 | 371        | 1,479        | 906         | 10,091        | 52           | 0.51            | 921                                                                                 | 10,603       | 3,680        | 725,166        | 7,613        | 1.04            |
| 2010                 | 407        | 1,924        | 1,075       | 13,660        | 81           | 0.59            | 893                                                                                 | 10,157       | 3,618        | 689,383        | 10,223       | 1.46            |
| 2011                 | 383        | 1,695        | 986         | 13,048        | 148          | 1.12            | 865                                                                                 | 8,884        | 3,243        | 625,634        | 8,115        | 1.28            |
| 2012                 | 407        | 1,753        | 1,075       | 13,600        | 132          | 0.96            | 903                                                                                 | 8,855        | 3,475        | 589,752        | 8,135        | 1.36            |
| 2013                 | 395        | 1,811        | 1,054       | 14,052        | 134          | 0.94            | 897                                                                                 | 8,890        | 3,444        | 610,168        | 9,062        | 1.46            |
| 2014                 | 379        | 1,678        | 1,004       | 11,687        | 169          | 1.43            | 857                                                                                 | 8,473        | 3,428        | 604,623        | 10,844       | 1.76            |
| 2015                 | 417        | 1,844        | 1,085       | 12,882        | 208          | 1.59            | 809                                                                                 | 7,844        | 3,123        | 599,997        | 9,639        | 1.58            |
| 2016                 | 378        | 1,908        | 1,051       | 15,129        | 154          | 1.01            | 736                                                                                 | 7,084        | 2,849        | 497,611        | 8,243        | 1.63            |
| 2017                 | 363        | 1,771        | 1,019       | 17,507        | 100          | 0.57            | 718                                                                                 | 7,145        | 2,916        | 502,824        | 10,922       | 2.13            |
| 2018                 | 286        | 1,222        | 746         | 10,145        | 119          | 1.16            | 651                                                                                 | 5,752        | 2,428        | 458,744        | 9,759        | 2.08            |
| 2019                 | 286        | 1,283        | 793         | 11,106        | 171          | 1.52            | 637                                                                                 | 5,732        | 2,485        | 444,122        | 7,663        | 1.70            |
| 2020                 | 253        | 1,026        | 626         | 5,952         | 147          | 2.41            | 609                                                                                 | 4,651        | 2,153        | 409,912        | 6,595        | 1.58            |
| 2021                 | 233        | 998          | 611         | 7,439         | 148          | 1.95            | 563                                                                                 | 4,403        | 1,988        | 347,127        | 7,210        | 2.03            |
| <b>10-year avg.</b>  | <b>340</b> | <b>1,529</b> | <b>906</b>  | <b>11,950</b> | <b>148</b>   | <b>1.35</b>     | <b>738</b>                                                                          | <b>6,883</b> | <b>2,829</b> | <b>506,488</b> | <b>8,807</b> | <b>1.73</b>     |
| <b>20-year avg.</b>  | <b>330</b> | <b>1,443</b> | <b>854</b>  | <b>10,586</b> | <b>95</b>    | <b>0.87</b>     | <b>751</b>                                                                          | <b>7,751</b> | <b>2,898</b> | <b>543,635</b> | <b>7,080</b> | <b>1.31</b>     |

## 1.3 CORAL REEF ECOSYSTEM COMPONENTS

### 1.3.1 Fishery Descriptions

Hawaii's inshore commercial fisheries cover a broad range of species and gear types. Top-5 gears (by landings) used to target these inshore non-MUS include gill nets, inshore handline, seine nets, spearfishing, and lift ('opelu) nets. Overwhelmingly these inshore resources are consumed locally, with exports occurring very rarely. Some species such as opihi (limpets) and ula (spiny lobsters) are prized delicacies and fetch high retail prices. Others like palani, nenu, pualu are often found in markets priced below imports. These species fill an important niche in Hawaii's small independent fish markets, offering fresh local fish at an affordable price.

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.

As a 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 'opihī (*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), nenu (*Kyphosus* spp.; chubs), manini (*Acanthurus triostegus*; convict tang), and ta'ape (*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.

### 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 2021 Most Harvested ECS

As usual, akule dominated 2021 ECS fisheries. Akule are consistently the top species harvested in the MHI due to their ability to be caught in large quantities with both net and hook and line gears and persistent high demand from local consumers. Between years, the top-10 ECS ranking can vary in composition as fishing activity, including that of specific highliners, changes. However, the species most harvested in 2021 are all commonly found in the top ranks in most years.

**Table 13. Top ten landed species (lb) in Hawaii ECS fisheries in 2021**

| Species                                       | No. Licenses | Trips | Catch (lb) |
|-----------------------------------------------|--------------|-------|------------|
| <i>Selar crumenophthalmus</i> (akule)         | 174          | 1,295 | 231,161    |
| <i>Decapterus macarellus</i> (‘opelu)         | 93           | 957   | 83,055     |
| <i>Myripristis</i> spp. (menpachi)            | 138          | 753   | 47,706     |
| <i>Lutjanus kasmira</i> (ta‘ape)              | 142          | 702   | 30,937     |
| <i>Acanthurus dussumieri</i> (palani)         | 42           | 350   | 24,506     |
| Parrotfish spp. (uhu)                         | 44           | 418   | 24,090     |
| Cellana spp. (opihi)                          | 14           | 222   | 16,423     |
| <i>Mulloidichthys vanicolensis</i> (red weke) | 41           | 159   | 12,609     |
| <i>Naso annulatus</i> (kala)                  | 23           | 123   | 12,486     |
| <i>Portunus sanguinolentus</i> (kuahonu crab) | 3            | 99    | 11,876     |

### 1.3.2.2 Prioritized Species Summary

With the exception of ‘opihi, all prioritized ECS had catch in pounds below their short-and long-term averages. As previously noted, for fisheries where target species are small and/or numerous catch in pounds is seen as a more reliable measure than catch in pieces as fishers will commonly omit such information or provide only rough estimates. Increases in effort and participation in 2021 in comparison to short and long term trends were only seen in he‘e or day octopus.

**Table 14. Annual fishing parameters for 2021 for prioritized MHI ECS designated by DAR compared with short-term (10-year) and long-term (20-year) averages**

| Species         | Fishery Indicator | 2021 Value | 2021 Comparative Trends   |                          |
|-----------------|-------------------|------------|---------------------------|--------------------------|
|                 |                   |            | Short-Term Avg. (10-year) | Long-Term Avg. (20-year) |
| ‘Opihi          | No. Lic.          | 14         | ↓26.3%                    | ↓33.3%                   |
|                 | Trips             | 222        | ↓8.64%                    | ↓11.2%                   |
|                 | No. Caught        | 108,060    | ↑118%                     | ↑253%                    |
|                 | Catch             | 16,423 lb  | ↑3.65%                    | ↑12.4%                   |
| Lobster         | No. Lic.          | 6          | ↓53.9%                    | ↓68.4%                   |
|                 | Trips             | 76         | ↓55.6%                    | ↓64.0%                   |
|                 | No. Caught        | 1,187      | ↓61.3%                    | ↓68.9%                   |
|                 | Catch             | 1,945 lb   | ↓68.7%                    | ↓75.1%                   |
| Kūmū            | No. Lic.          | 28         | ↓56.3%                    | ↓62.2%                   |
|                 | Trips             | 94         | ↓67.8%                    | ↓74.7%                   |
|                 | No. Caught        | 424        | ↓78.1%                    | ↓79.2%                   |
|                 | Catch             | 589 lb     | ↓79.7%                    | ↓83.3%                   |
| Omilu           | No. Lic.          | 66         | ↓41.1%                    | ↓44.1%                   |
|                 | Trips             | 211        | ↓40.1%                    | ↓42.0%                   |
|                 | No. Caught        | 469        | ↓56.2%                    | ↓57.6%                   |
|                 | Catch             | 3,401 lb   | ↓44.7%                    | ↓48.0%                   |
| Uhu             | No. Lic.          | 44         | ↓39.7%                    | ↓47.6%                   |
|                 | Trips             | 418        | ↓46.0%                    | ↓51.7%                   |
|                 | No. Caught        | 5,083      | ↓53.3%                    | ↓52.6%                   |
|                 | Catch             | 24,090 lb  | ↓50.7%                    | ↓48.3%                   |
| He’e (Day tako) | No. Lic.          | 41         | ↑7.89%                    | ↓35.9%                   |
|                 | Trips             | 206        | ↑0.49%                    | ↓67.1%                   |
|                 | No. Caught        | 1,521      | ↓33.8%                    | ↓79.5%                   |
|                 | Catch             | 4,360 lb   | ↓37.0%                    | ↓80.0%                   |
| Kala            | No. Lic.          | 23         | ↓48.9%                    | ↓57.4%                   |
|                 | Trips             | 123        | ↓63.2%                    | ↓67.6%                   |
|                 | No. Caught        | 3,345      | ↓30.1%                    | ↓33.2%                   |
|                 | Catch             | 12,486 lb  | ↓38.2%                    | ↓42.2%                   |
| Nenue           | No. Lic.          | 26         | ↓53.6%                    | ↓60.0%                   |
|                 | Trips             | 136        | ↓55.3%                    | ↓58.3%                   |
|                 | No. Caught        | 2,928      | ↓32.6%                    | ↓53.9%                   |
|                 | Catch             | 8,468 lb   | ↓42.7%                    | ↓56.2%                   |
| Manini          | No. Lic.          | 32         | ↓37.3%                    | ↓47.5%                   |
|                 | Trips             | 306        | ↓36.6%                    | ↓46.5%                   |
|                 | No. Caught        | 20,889     | ↓8.81%                    | ↓15.0%                   |
|                 | Catch             | 8,663 lb   | ↓24.0%                    | ↓31.4%                   |
| Ta‘ape          | No. Lic.          | 142        | ↓35.7%                    | ↓36.3%                   |
|                 | Trips             | 702        | ↓33.8%                    | ↓38.1%                   |
|                 | No. Caught        | 62,198     | ↑33.5%                    | ↑40.1%                   |

| Species | Fishery Indicator | 2021 Value | 2021 Comparative Trends   |                          |
|---------|-------------------|------------|---------------------------|--------------------------|
|         |                   |            | Short-Term Avg. (10-year) | Long-Term Avg. (20-year) |
|         | Catch             | 30,937     | ↓3.57%                    | ↓13.1%                   |

### 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 is thought to be in part due to the 2008 recession. 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 unemployment rates post-2011 influenced the declining participation, effort, and catch in many of these fisheries.

Many ECS fisheries may have been largely spared from the effects of COVID-19 restrictions since they are purchased almost entirely by locals for home consumption. Some ECS fisheries like ‘opihi, kūmū, kala, manini, and ta‘ape even 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.

**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 1994-2021**

| Year | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 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     |
| 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      |

| <b>Year</b> | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|-------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 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            |
| 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        | 18                 | 231          | 94                 | 76,541            | 13,368            |
| 2019        | 20                 | 182          | 91                 | 50,631            | 11,018            |
| 2020        | 11                 | 205          | 67                 | 108,529           | 16,558            |

| Year                | No. License | Trips      | No. Reports | No. Caught    | Catch (lb)    |
|---------------------|-------------|------------|-------------|---------------|---------------|
| 2021                | 14          | 222        | 67          | 108,060       | 16,423        |
| <b>10-year avg.</b> | <b>19</b>   | <b>243</b> | <b>83</b>   | <b>49,594</b> | <b>15,844</b> |
| <b>20-year avg.</b> | <b>21</b>   | <b>250</b> | <b>79</b>   | <b>30,580</b> | <b>14,614</b> |

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 2003-2021**

| Year                | No. License | Trips      | No. Reports | No. Caught   | Catch (lb)   |
|---------------------|-------------|------------|-------------|--------------|--------------|
| 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                | 18          | 227        | 53          | 4,883        | 10,524       |
| 2015                | 14          | 141        | 41          | 2,941        | 5,922        |
| 2016                | 14          | 159        | 42          | 2,247        | 4,519        |
| 2017                | 14          | 182        | 46          | 2,806        | 5,569        |
| 2018                | 8           | 157        | 36          | 2,585        | 5,015        |
| 2019                | 9           | 126        | 30          | 2,111        | 4,207        |
| 2020                | 9           | 134        | 28          | 1,991        | 3,711        |
| 2021                | 6           | 76         | 18          | 1,187        | 1,945        |
| <b>10-year avg.</b> | <b>13</b>   | <b>171</b> | <b>42</b>   | <b>3,068</b> | <b>6,217</b> |
| <b>20-year avg.</b> | <b>19</b>   | <b>211</b> | <b>55</b>   | <b>3,816</b> | <b>7,816</b> |

**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 1994-2021**

| Year | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 1965 | 62          | 700   | 234         | 1,874      | 12,060     |
| 1966 | 51          | 546   | 201         | 2,900      | 8,515      |
| 1967 | 62          | 575   | 216         | 3,826      | 9,599      |
| 1968 | 51          | 482   | 179         | 3,570      | 8,599      |
| 1969 | 72          | 649   | 240         | 3,215      | 8,616      |
| 1970 | 78          | 635   | 248         | 2,883      | 8,408      |
| 1971 | 96          | 598   | 270         | 1,649      | 7,205      |

| <b>Year</b> | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|-------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 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             |
| 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             |

| Year                | No. License | Trips      | No. Reports | No. Caught   | Catch (lb)   |
|---------------------|-------------|------------|-------------|--------------|--------------|
| 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          | 127        | 95          | 629          | 870          |
| 2021                | 28          | 94         | 70          | 424          | 589          |
| <b>10-year avg.</b> | <b>64</b>   | <b>292</b> | <b>167</b>  | <b>1,934</b> | <b>2,896</b> |
| <b>20-year avg.</b> | <b>74</b>   | <b>371</b> | <b>204</b>  | <b>2,043</b> | <b>3,536</b> |

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 1994-2021**

| Year | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 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     |
| 1985 | 117         | 333   | 212         | 850        | 7,341      |
| 1986 | 115         | 368   | 205         | 1,317      | 8,145      |
| 1987 | 150         | 560   | 337         | 1,808      | 12,190     |

| <b>Year</b>         | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|---------------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 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                | 116                | 326          | 223                | 815               | 5,172             |
| 2021                | 66                 | 211          | 142                | 469               | 3,401             |
| <b>10-year avg.</b> | <b>112</b>         | <b>352</b>   | <b>242</b>         | <b>1,071</b>      | <b>6,148</b>      |
| <b>20-year avg.</b> | <b>118</b>         | <b>364</b>   | <b>252</b>         | <b>1,107</b>      | <b>6,535</b>      |

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 1994-2021**

| Year   | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|--------|-------------|-------|-------------|------------|------------|
| 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    | Catch (lb)    |
|---------------------|-------------|------------|-------------|---------------|---------------|
| 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         | 17,484        | 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          | 746        | 247         | 10,487        | 51,615        |
| 2019                | 62          | 605        | 209         | 9,834         | 45,606        |
| 2020                | 50          | 549        | 188         | 9,487         | 43,893        |
| 2021                | 44          | 418        | 149         | 5,083         | 24,090        |
| <b>10-year avg.</b> | <b>73</b>   | <b>774</b> | <b>281</b>  | <b>10,888</b> | <b>48,883</b> |
| <b>20-year avg.</b> | <b>84</b>   | <b>865</b> | <b>323</b>  | <b>10,713</b> | <b>46,639</b> |

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 2003-2021**

| Year | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 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     |

| <b>Year</b>         | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|---------------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 2017                | 60                 | 523          | 205                | 7,265             | 19,895            |
| 2018                | 57                 | 431          | 198                | 4,512             | 12,642            |
| 2019                | 49                 | 367          | 167                | 4,070             | 11,082            |
| 2020                | 41                 | 206          | 122                | 1,521             | 4,360             |
| <b>10-year avg.</b> | <b>38</b>          | <b>205</b>   | <b>101</b>         | <b>2,299</b>      | <b>6,922</b>      |
| <b>20-year avg.</b> | <b>64</b>          | <b>627</b>   | <b>235</b>         | <b>7,426</b>      | <b>21,800</b>     |

**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 1994-2021**

| <b>Year</b> | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|-------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 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             |

| Year                | No. License | Trips      | No. Reports | No. Caught   | Catch (lb)    |
|---------------------|-------------|------------|-------------|--------------|---------------|
| 1993.2              | 50          | 174        | 90          | 325          | 4,445         |
| 1994                | 84          | 419        | 229         | 1,332        | 12,945        |
| 1995                | 87          | 478        | 250         | 780          | 17,679        |
| 1996                | 102         | 496        | 270         | 859          | 15,105        |
| 1997                | 91          | 500        | 268         | 940          | 12,929        |
| 1998                | 97          | 497        | 276         | 1,413        | 15,244        |
| 1999                | 90          | 477        | 266         | 1,384        | 16,439        |
| 2000                | 74          | 455        | 223         | 1,912        | 18,115        |
| 2001                | 84          | 426        | 238         | 1,832        | 24,427        |
| 2002                | 77          | 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          | 182        | 110         | 3,149        | 11,302        |
| 2021                | 23          | 123        | 74          | 3,345        | 12,486        |
| <b>10-year avg.</b> | <b>45</b>   | <b>334</b> | <b>155</b>  | <b>4,788</b> | <b>20,217</b> |
| <b>20-year avg.</b> | <b>54</b>   | <b>380</b> | <b>175</b>  | <b>5,006</b> | <b>21,607</b> |

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

**Table 22. Time series of commercial fishing reports for nenuke (*Kyphosus* spp.; chubs) from reported by Fiscal Year from 1965-1993 and by Calendar Year from 1994-2021**

| Year | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 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      |

| <b>Year</b> | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|-------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 1970        | 48                 | 120          | 89                 | 558               | 3,088             |
| 1971        | 57                 | 163          | 118                | 84                | 4,187             |
| 1972        | 53                 | 146          | 105                | 322               | 4,621             |
| 1973        | 61                 | 131          | 106                | 332               | 4,746             |
| 1974        | 58                 | 175          | 122                | 658               | 10,553            |
| 1975        | 83                 | 208          | 146                | 1,110             | 16,750            |
| 1976        | 78                 | 227          | 151                | 971               | 10,433            |
| 1977        | 104                | 288          | 215                | 1,692             | 9,426             |
| 1978        | 119                | 292          | 239                | 1,499             | 10,535            |
| 1979        | 107                | 247          | 223                | 1,294             | 8,780             |
| 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            |

| Year                | No. License | Trips      | No. Reports | No. Caught   | Catch (lb)    |
|---------------------|-------------|------------|-------------|--------------|---------------|
| 2009                | 104         | 469        | 279         | 5,735        | 14,583        |
| 2010                | 79          | 450        | 240         | 14,410       | 31,690        |
| 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          | 210        | 107         | 3,666        | 9,346         |
| 2021                | 26          | 136        | 85          | 2,928        | 8,468         |
| <b>10-year avg.</b> | <b>56</b>   | <b>304</b> | <b>157</b>  | <b>4,346</b> | <b>14,785</b> |
| <b>20-year avg.</b> | <b>65</b>   | <b>326</b> | <b>178</b>  | <b>6,356</b> | <b>19,346</b> |

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 1994-2021**

| Year | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 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      |

| <b>Year</b>         | <b>No. License</b> | <b>Trips</b> | <b>No. Reports</b> | <b>No. Caught</b> | <b>Catch (lb)</b> |
|---------------------|--------------------|--------------|--------------------|-------------------|-------------------|
| 1985                | 97                 | 533          | 275                | 1,737             | 9,472             |
| 1986                | 98                 | 549          | 274                | 4,226             | 6,971             |
| 1987                | 94                 | 654          | 299                | 5,374             | 11,042            |
| 1988                | 94                 | 670          | 319                | 7,739             | 9,037             |
| 1989                | 101                | 705          | 330                | 8,126             | 12,637            |
| 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                | 31,005            | 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                 | 333          | 139                | 26,565            | 12,779            |
| 2021                | 32                 | 306          | 112                | 20,889            | 8,663             |
| <b>10-year avg.</b> | <b>51</b>          | <b>483</b>   | <b>197</b>         | <b>22,908</b>     | <b>11,404</b>     |
| <b>20-year avg.</b> | <b>61</b>          | <b>572</b>   | <b>228</b>         | <b>24,562</b>     | <b>12,624</b>     |

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 1994-2021**

| Year   | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|--------|-------------|-------|-------------|------------|------------|
| 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     |

| Year                | No. License | Trips        | No. Reports | No. Caught    | Catch (lb)    |
|---------------------|-------------|--------------|-------------|---------------|---------------|
| 2005                | 176         | 1,033        | 487         | 45,580        | 39,479        |
| 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         | 57,553        | 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         | 761          | 435         | 72,749        | 37,828        |
| 2021                | 142         | 702          | 370         | 62,198        | 30,937        |
| <b>10-year avg.</b> | <b>221</b>  | <b>1,061</b> | <b>580</b>  | <b>46,607</b> | <b>32,083</b> |
| <b>20-year avg.</b> | <b>223</b>  | <b>1,135</b> | <b>590</b>  | <b>44,408</b> | <b>35,611</b> |

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

### 1.3.4 Bycatch Summary

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. Fishers will occasionally do so to avoid flooding the market and/or release fish they cannot handle. 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%. Non-MUS bycatch was below average in 2021 largely due to proportionally low releases of akule and ‘opelu.

**Table 25. Time series of commercial fishing bycatch of non-MUS reported by Calendar Year from 2002-2021**

| Year | No. Lic. | Trips  | No. Reports | No. Retained | No. Released | Percent Bycatch |
|------|----------|--------|-------------|--------------|--------------|-----------------|
| 2002 | 997      | 12,060 | 3,897       | 794,750      | 44,156       | 5.26            |
| 2003 | 888      | 11,718 | 3,608       | 1,352,457    | 100,021      | 6.89            |
| 2004 | 875      | 11,865 | 3,539       | 1,249,356    | 57,736       | 4.42            |

| <b>Year</b>         | <b>No. Lic.</b> | <b>Trips</b>  | <b>No. Reports</b> | <b>No. Retained</b> | <b>No. Released</b> | <b>Percent Bycatch</b> |
|---------------------|-----------------|---------------|--------------------|---------------------|---------------------|------------------------|
| 2005                | 862             | 10,081        | 3,155              | 1,068,289           | 167,912             | 13.58                  |
| 2006                | 761             | 9,446         | 2,891              | 1,193,618           | 133,748             | 10.08                  |
| 2007                | 824             | 10,792        | 3,262              | 2,217,897           | 369,774             | 14.29                  |
| 2008                | 963             | 11,463        | 3,662              | 1,877,246           | 237,940             | 11.25                  |
| 2009                | 1,116           | 13,789        | 4,377              | 1,788,814           | 230,382             | 11.41                  |
| 2010                | 1,102           | 14,387        | 4,538              | 1,703,320           | 135,766             | 7.38                   |
| 2011                | 1,028           | 12,630        | 4,084              | 1,736,035           | 99,615              | 5.43                   |
| 2012                | 1,032           | 12,592        | 4,220              | 1,511,879           | 17,225              | 1.13                   |
| 2013                | 980             | 12,225        | 4,077              | 1,503,004           | 43,129              | 2.79                   |
| 2014                | 951             | 10,901        | 3,848              | 1,559,658           | 32,191              | 2.02                   |
| 2015                | 915             | 10,127        | 3,641              | 1,433,792           | 21,683              | 1.49                   |
| 2016                | 792             | 8,879         | 3,209              | 1,502,188           | 97,984              | 6.12                   |
| 2017                | 801             | 8,717         | 3,259              | 1,417,473           | 21,228              | 1.48                   |
| 2018                | 721             | 7,522         | 2,832              | 1,303,903           | 28,208              | 2.12                   |
| 2019                | 678             | 7,057         | 2,737              | 1,197,640           | 22,769              | 1.87                   |
| 2020                | 650             | 6,238         | 2,492              | 1,235,894           | 24,969              | 1.98                   |
| 2021                | 600             | 5,554         | 2,174              | 1,112,220           | 21,814              | 1.92                   |
| <b>10-year avg.</b> | <b>812</b>      | <b>8,981</b>  | <b>3,249</b>       | <b>1,377,765</b>    | <b>33,120</b>       | <b>2.29</b>            |
| <b>20-year avg.</b> | <b>877</b>      | <b>10,402</b> | <b>3,475</b>       | <b>1,437,972</b>    | <b>95,413</b>       | <b>5.64</b>            |

## **1.4 CRUSTACEAN**

### **1.4.1 Fishery Descriptions**

The crustacean management unit species (CMUS) include two species of deepwater shrimp (*Heterocarpus laevigatus* and *H. ensifer*) and the Kona crab (*Ranina ranina*). Despite being combined into one MUS, these two fisheries are extremely different. Kona crab are found across the MHI in habitat comprised soft sandy bottoms in which they spend nearly their entire lives burrowed. Though found at depths as great as 200 m, they are commonly fished at shallower depths allowing gear to be set and retrieved by hand. Kona crab have long been considered a delicacy in Hawaii eaten both cooked and raw. DAR records of commercial Kona crab catch date back to the mid-1940's. In 1972, commercial landings peaked at approximately 72,000 lbs.

Conversely, the deepwater shrimp fishery is relatively new to Hawaii, with landings first appearing in commercial records in the early 1980s. As their name implies, these species are often fished at depths in excess of 300 m requiring automatic haulers to retrieve gear. Deepwater shrimp are most commonly known for their use in Japanese restaurants where they are often sold as amaebi. Today, with a lack of an export market and limited local demand, the deepwater shrimp fishery in the MHI remains small in comparison to its previous size.

### **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 2021 were all below 10- and 20-year averages. Both the deepwater shrimp and Kona crab fisheries have seen substantial changes in both the short- and long-term effort and landings due to a variety of factors including the demise of the deepwater shrimp export fishery, highliner loss, and new Kona crab restrictions.

**Table 26. Annual fishing parameters for 2021 in the MHI crustacean fishery compared with short-term (10-year) and long-term (20-year) averages**

| Fishery    | Parameters  | 2021 Value | 2021 Comparative Trends      |                             |
|------------|-------------|------------|------------------------------|-----------------------------|
|            |             |            | Short-Term Avg.<br>(10-year) | Long-Term Avg.<br>(20-year) |
| Crustacean | No. License | 20         | ↓28.6%                       | ↓45.9%                      |
|            | Trips       | 117        | ↓49.6%                       | ↓51.9%                      |
|            | No. Caught  | 4,418      | ↓94.8%                       | ↓91.7%                      |
|            | Catch (lb)  | 8,720 lb   | ↓58.7%                       | ↓65.9%                      |

**1.4.2.2 Species Summary**

Shrimp trap parameters could not be reported due to fewer than three distinct CML holders reporting catch. The number of licenses and trips using the Kona crab net gear type in 2021 were below both short- and long-term averages. Pounds caught using Kona crab nets was also below short- and long-term averages, but to a lesser degree than the 2021 decrease in trips. As a result, CPUE for the Kona crab net gear type in 2021 increased in comparison to short- and long-term averages. CMUS catch using All Other Gears is typically comprised entirely of Kona Crab caught incidentally in other crab gears. Catch and effort trends from All Other Gears fluctuate between years due to the low catch and effort and incidental nature.

**Table 27. Annual fishing parameters for 2021 in the MHI crustacean fishery compared with short-term (10-year) and long-term (20-year) averages**

| Methods         | Fishery Indicator    | 2021 Value    | 2021 Comparative Trends      |                             |
|-----------------|----------------------|---------------|------------------------------|-----------------------------|
|                 |                      |               | Short-Term Avg.<br>(10-year) | Long-Term Avg.<br>(20-year) |
| Shrimp Trap     | <i>H. laevigatus</i> | n.d.          | -                            | -                           |
|                 | <i>H. ensifer</i>    | n.d.          | -                            | -                           |
|                 | No. Lic.             | n.d.          | -                            | -                           |
|                 | No. Trips            | n.d.          | -                            | -                           |
|                 | Catch                | n.d.          | -                            | -                           |
|                 | CPUE                 | n.d.          | -                            | -                           |
| Kona Crab Net   | Kona crab            | 3,822 lb      | ↓4.97%                       | ↓47.0%                      |
|                 | No. Lic.             | 17            | ↓26.1%                       | ↓48.5%                      |
|                 | No. Trips            | 45            | ↓26.2%                       | ↓61.9%                      |
|                 | Catch                | 3,822 lb      | ↓4.97%                       | ↓47.0%                      |
|                 | CPUE                 | 84.93 lb/trip | ↑32.8%                       | ↑37.1%                      |
| All Other Gears | No. Lic.             | 3             | ↑50.0%                       | 0.00%                       |
|                 | No. Trips            | 24            | ↑71.4%                       | ↑14.3%                      |
|                 | Catch                | 124           | ↑42.5%                       | ↓23.5%                      |
|                 | CPUE                 | 5.17 lb/trip  | ↓26.4%                       | ↓71.4%                      |

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 (pieces often unreported). CMUS fishery licenses and reports both peaked in 1998 and have been declining steadily since. Like catch, effort has been variable over the time series with multiple distinct peaks in annual number of trips occurring since 1965. It is again important to note that the two fisheries included in CMUS are very different in both their operation and catch trends. Because of those differences, 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 1994-2021**

| Year | No. License | Trips | No. Reports | No. Caught | Catch (lb) |
|------|-------------|-------|-------------|------------|------------|
| 1965 | 26          | 171   | 71          | 4,238      | 11,421     |
| 1966 | 22          | 179   | 67          | 3,604      | 10,033     |
| 1967 | 30          | 185   | 82          | 3,071      | 17,444     |
| 1968 | 25          | 167   | 71          | 1,764      | 26,419     |
| 1969 | 29          | 233   | 84          | 3,109      | 35,955     |
| 1970 | 30          | 197   | 78          | 2,544      | 35,042     |
| 1971 | 40          | 254   | 111         | 4,162      | 43,576     |
| 1972 | 41          | 260   | 102         | 3,042      | 69,331     |
| 1973 | 32          | 231   | 97          | 2,111      | 62,515     |
| 1974 | 49          | 211   | 112         | 7,562      | 40,552     |
| 1975 | 59          | 241   | 127         | 5,076      | 24,616     |
| 1976 | 59          | 234   | 136         | 8,568      | 26,577     |
| 1977 | 54          | 233   | 114         | 4,144      | 23,153     |
| 1978 | 61          | 243   | 159         | 5,224      | 31,675     |
| 1979 | 52          | 202   | 128         | 5,817      | 28,711     |
| 1980 | 42          | 108   | 67          | 1,920      | 10,390     |
| 1981 | 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     |

| Year                | No. License | Trips      | No. Reports | No. Caught    | Catch (lb)    |
|---------------------|-------------|------------|-------------|---------------|---------------|
| 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        |
| 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        |
| 2021                | 20          | 117        | 46          | 4,418         | 8,720         |
| <b>10-year avg.</b> | <b>28</b>   | <b>232</b> | <b>69</b>   | <b>85,092</b> | <b>21,109</b> |
| <b>20-year avg.</b> | <b>37</b>   | <b>243</b> | <b>83</b>   | <b>52,933</b> | <b>25,602</b> |

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.” Of the two species caught, *H. laevis* is preferred over *H. 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. Today, the remaining Hawaii-based deepwater shrimp fishery supplies a limited amount of in-state demand and in recent years is limited to fewer than three reporting license holders.

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 shrimp trap fishery occurred in 2013 with ten fishers reporting. Since the peak, participation has declined to three or fewer fishers per year. Catch (weight) has also declined primarily because of the loss the mainland-based vessels and to a lesser extent a few Hawaii-based highliners. Catch and participation for the shrimp trap gear type in 2021 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 1994-2021**

| Year   | <i>Heterocarpus laevis</i> |            | <i>Heterocarpus ensifer</i> |            |
|--------|----------------------------|------------|-----------------------------|------------|
|        | No. License                | Catch (lb) | No. License                 | Catch (lb) |
| 1987   | 3                          | 1,796      | n.d.                        | n.d.       |
| 1988   | n.d.                       | n.d.       | 3                           | 1,568      |
| 1989   | n.d.                       | n.d.       | n.d.                        | n.d.       |
| 1990   | 5                          | 341,780    | n.d.                        | n.d.       |
| 1991   | n.d.                       | n.d.       | -                           | -          |
| 1992   | n.d.                       | n.d.       | -                           | -          |
| 1993.1 | 3                          | 35,631     | -                           | -          |
| 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.       | -                           | -          |
| 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.       |

| Year                | <i>Heterocarpus laevis</i> |               | <i>Heterocarpus ensifer</i> |            |
|---------------------|----------------------------|---------------|-----------------------------|------------|
|                     | No. License                | Catch (lb)    | No. License                 | Catch (lb) |
| 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.       |
| 2021                | n.d.                       | n.d.          | n.d.                        | n.d.       |
| <b>10-year avg.</b> | <b>5</b>                   | <b>16,864</b> | <b>2</b>                    | <b>136</b> |
| <b>20-year avg.</b> | <b>4</b>                   | <b>17,430</b> | <b>2</b>                    | <b>835</b> |

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. 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. The nets are baited with fish bait and clipped at set intervals along a weighted main line stretched along the sandy bottom and marked by a buoy at one or both of its terminal ends.

The MHI Kona crab fishery can historically be split into two distinct parts: the inshore fishery occurring in State waters, and the Penguin Bank fishery. The Penguin Bank fishery emerged in the early 1960s and peaked in 1972 when it contributed approximately 90% of catch. Following a second minor peak in 1991, the Penguin Bank fishery steadily declined in catch and discontinued in 2016. The inshore fishery peaked in 1995 and has been in steady decline since.

Effort and landings for the entire MHI Kona Crab fishery have been in a state of overall decline since the late 1990s. The downward trend in catch is due in part to overall declining fishery participation and progressively decreasing activity and the eventual loss of the prominent highliners. Additionally, 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. 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. However, without the emergence of new dedicated highliners and return of the Penguin Bank fishery, the fishery may not return to 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 1994-2021**

| Year   | No. License | Catch (lb) |
|--------|-------------|------------|
| 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     |
| 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     |

| <b>Year</b>         | <b>No. License</b> | <b>Catch (lb)</b> |
|---------------------|--------------------|-------------------|
| 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             |
| 2021                | 17                 | 3,822             |
| <b>10-year avg.</b> | <b>23</b>          | <b>4,022</b>      |
| <b>20-year avg.</b> | <b>33</b>          | <b>7,217</b>      |

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. In 2021 catch parameters for the deepwater shrimp trap fishery could not be reported due to fewer than three participants.

Kona crab net CPUE spiked in the early 1970s. Rising CPUE during that time was the result of the developing Penguin Bank fishery, where Kona crab are more abundant and larger in size than many inshore fishing areas. Over time, highliner activity decreased and the fishery progressively moved to occurring predominantly in State waters. As a result, CPUE 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.    | Trips | Catch (lb) | CPUE | No. Lic.             | Trips | Catch (lb) | CPUE | No. Lic.             | Trips | Catch (lb) | CPUE |
| 1965 | -           | -     | -          | -    | 25                   | 169   | 11,378     | 67   | n.d.                 | n.d.  | n.d.       | n.d. |
| 1966 | -           | -     | -          | -    | 21                   | 178   | 10,029     | 56   | n.d.                 | n.d.  | n.d.       | n.d. |
| 1967 | -           | -     | -          | -    | 30                   | 185   | 17,444     | 94   | -                    | -     | -          | -    |
| 1968 | -           | -     | -          | -    | 25                   | 167   | 26,419     | 158  | -                    | -     | -          | -    |
| 1969 | -           | -     | -          | -    | 28                   | 232   | 35,939     | 155  | n.d.                 | n.d.  | n.d.       | n.d. |
| 1970 | -           | -     | -          | -    | 29                   | 195   | 35,033     | 180  | n.d.                 | n.d.  | n.d.       | n.d. |
| 1971 | -           | -     | -          | -    | 38                   | 241   | 42,977     | 178  | n.d.                 | n.d.  | n.d.       | n.d. |
| 1972 | -           | -     | -          | -    | 40                   | 259   | 69,328     | 268  | n.d.                 | n.d.  | n.d.       | n.d. |
| 1973 | -           | -     | -          | -    | 32                   | 230   | 62,455     | 272  | n.d.                 | n.d.  | n.d.       | n.d. |
| 1974 | -           | -     | -          | -    | 49                   | 199   | 39,121     | 197  | 3                    | 12    | 1,431      | 119  |
| 1975 | -           | -     | -          | -    | 58                   | 233   | 23,996     | 103  | n.d.                 | n.d.  | n.d.       | n.d. |
| 1976 | -           | -     | -          | -    | 50                   | 203   | 23,195     | 114  | 20                   | 31    | 3,382      | 109  |
| 1977 | -           | -     | -          | -    | 33                   | 133   | 15,966     | 120  | 34                   | 100   | 7,187      | 72   |
| 1978 | -           | -     | -          | -    | 60                   | 227   | 28,582     | 126  | n.d.                 | n.d.  | n.d.       | n.d. |
| 1979 | -           | -     | -          | -    | 51                   | 188   | 24,674     | 131  | 3                    | 14    | 4,037      | 288  |
| 1980 | -           | -     | -          | -    | 39                   | 100   | 8,162      | 82   | 6                    | 8     | 2,228      | 279  |
| 1981 | -           | -     | -          | -    | 47                   | 143   | 12,102     | 85   | 8                    | 14    | 5,756      | 411  |
| 1982 | -           | -     | -          | -    | 48                   | 163   | 8,291      | 51   | 8                    | 15    | 410        | 27   |
| 1983 | -           | -     | -          | -    | 48                   | 146   | 9,009      | 62   | 9                    | 34    | 4,121      | 121  |
| 1984 | -           | -     | -          | -    | 58                   | 179   | 12,944     | 72   | 29                   | 207   | 201,848    | 975  |
| 1985 | -           | -     | -          | -    | 71                   | 309   | 20,846     | 67   | 18                   | 151   | 61,895     | 410  |
| 1986 | -           | -     | -          | -    | 80                   | 302   | 27,200     | 90   | 9                    | 10    | 375        | 38   |
| 1987 | 4           | 22    | 1,831      | 83   | 62                   | 158   | 16,310     | 103  | 17                   | 59    | 5,735      | 97   |
| 1988 | 3           | 44    | 12,934     | 294  | 47                   | 179   | 12,475     | 70   | 6                    | 19    | 5,275      | 278  |

| Year   | Shrimp Trap |       |            |       | Kona Crab Net (Loop) |       |            |      | All Other Gear Types |       |            |      |
|--------|-------------|-------|------------|-------|----------------------|-------|------------|------|----------------------|-------|------------|------|
|        | No. Lic.    | Trips | Catch (lb) | CPUE  | No. Lic.             | Trips | Catch (lb) | CPUE | No. Lic.             | Trips | Catch (lb) | CPUE |
| 1989   | n.d.        | n.d.  | n.d.       | n.d.  | 32                   | 134   | 11,790     | 88   | 4                    | 8     | 1,326      | 166  |
| 1990   | 5           | 87    | 343,102    | 3,944 | 32                   | 130   | 16,118     | 124  | 14                   | 30    | 2,694      | 90   |
| 1991   | n.d.        | n.d.  | n.d.       | n.d.  | 44                   | 161   | 22,789     | 142  | 6                    | 11    | 852        | 77   |
| 1992   | n.d.        | n.d.  | n.d.       | n.d.  | 71                   | 316   | 34,291     | 109  | 4                    | 21    | 2,363      | 113  |
| 1993.1 | 3           | 86    | 35,631     | 414   | 66                   | 309   | 25,305     | 82   | n.d.                 | n.d.  | n.d.       | n.d. |
| 1993.2 | 3           | 36    | 16,531     | 459   | 50                   | 151   | 15,464     | 102  | -                    | -     | -          | -    |
| 1994   | 5           | 86    | 85,657     | 996   | 69                   | 253   | 19,472     | 77   | n.d.                 | n.d.  | n.d.       | n.d. |
| 1995   | 4           | 140   | 70,737     | 505   | 84                   | 327   | 27,741     | 85   | -                    | -     | -          | -    |
| 1996   | 8           | 114   | 34,973     | 307   | 83                   | 283   | 27,603     | 98   | 3                    | 4     | 86         | 22   |
| 1997   | 6           | 51    | 22,792     | 447   | 82                   | 288   | 27,931     | 97   | 3                    | 7     | 190        | 27   |
| 1998   | 7           | 129   | 181,912    | 1,410 | 91                   | 299   | 30,639     | 102  | 4                    | 10    | 516        | 52   |
| 1999   | 5           | 75    | 33,644     | 449   | 81                   | 221   | 18,698     | 85   | n.d.                 | n.d.  | n.d.       | n.d. |
| 2000   | n.d.        | n.d.  | n.d.       | n.d.  | 62                   | 152   | 14,143     | 93   | n.d.                 | n.d.  | n.d.       | n.d. |
| 2001   | 4           | 81    | 9,313      | 115   | 59                   | 158   | 10,763     | 68   | 3                    | 4     | 133        | 33   |
| 2002   | 3           | 50    | 3,989      | 80    | 63                   | 196   | 12,830     | 65   | n.d.                 | n.d.  | n.d.       | n.d. |
| 2003   | 3           | 56    | 5,420      | 97    | 49                   | 158   | 11,841     | 75   | 3                    | 3     | 370        | 123  |
| 2004   | n.d.        | n.d.  | n.d.       | n.d.  | 48                   | 167   | 12,164     | 73   | 3                    | 30    | 133        | 4    |
| 2005   | 5           | 178   | 114,789    | 645   | 46                   | 161   | 9,937      | 62   | n.d.                 | n.d.  | n.d.       | n.d. |
| 2006   | n.d.        | n.d.  | n.d.       | n.d.  | 35                   | 128   | 6,749      | 53   | 3                    | 26    | 172        | 7    |
| 2007   | n.d.        | n.d.  | n.d.       | n.d.  | 31                   | 188   | 9,773      | 52   | 4                    | 13    | 142        | 11   |
| 2008   | n.d.        | n.d.  | n.d.       | n.d.  | 36                   | 201   | 10,940     | 54   | 4                    | 42    | 456        | 11   |
| 2009   | n.d.        | n.d.  | n.d.       | n.d.  | 41                   | 191   | 9,097      | 48   | 3                    | 38    | 325        | 9    |
| 2010   | n.d.        | n.d.  | n.d.       | n.d.  | 46                   | 178   | 9,913      | 56   | 4                    | 45    | 282        | 6    |
| 2011   | 4           | 69    | 8,098      | 117   | 46                   | 172   | 10,876     | 63   | 5                    | 39    | 103        | 3    |
| 2012   | 5           | 143   | 11,894     | 83    | 35                   | 121   | 7,980      | 66   | 3                    | 8     | 232        | 29   |
| 2013   | 10          | 205   | 19,383     | 95    | 33                   | 83    | 7,330      | 88   | n.d.                 | n.d.  | n.d.       | n.d. |
| 2014   | 9           | 323   | 48,707     | 151   | 24                   | 59    | 2,029      | 34   | 3                    | 16    | 72         | 5    |

| Year              | Shrimp Trap |            |               |            | Kona Crab Net (Loop) |            |              |           | All Other Gear Types |           |            |           |
|-------------------|-------------|------------|---------------|------------|----------------------|------------|--------------|-----------|----------------------|-----------|------------|-----------|
|                   | No. Lic.    | Trips      | Catch (lb)    | CPUE       | No. Lic.             | Trips      | Catch (lb)   | CPUE      | No. Lic.             | Trips     | Catch (lb) | CPUE      |
| 2015              | 6           | 200        | 28,775        | 144        | 26                   | 62         | 2,902        | 47        | n.d.                 | n.d.      | n.d.       | n.d.      |
| 2016              | 5           | 133        | 17,203        | 129        | 16                   | 25         | 745          | 30        | n.d.                 | n.d.      | n.d.       | n.d.      |
| 2017              | 3           | 80         | 5,984         | 75         | 19                   | 53         | 2,753        | 52        | n.d.                 | n.d.      | n.d.       | n.d.      |
| 2018              | 3           | 131        | 11,598        | 89         | 20                   | 52         | 2,769        | 53        | 3                    | 12        | 184        | 15        |
| 2019              | 3           | 196        | 12,692        | 65         | 24                   | 71         | 5,688        | 80        | n.d.                 | n.d.      | n.d.       | n.d.      |
| 2020              | n.d.        | n.d.       | n.d.          | n.d.       | 12                   | 42         | 4,201        | 100       | n.d.                 | n.d.      | n.d.       | n.d.      |
| 2021              | n.d.        | n.d.       | n.d.          | n.d.       | 17                   | 45         | 3,822        | 85        | 3                    | 24        | 124        | 5         |
| <b>10-yr avg.</b> | <b>5</b>    | <b>157</b> | <b>17,000</b> | <b>101</b> | <b>23</b>            | <b>61</b>  | <b>4,022</b> | <b>64</b> | <b>2</b>             | <b>14</b> | <b>87</b>  | <b>7</b>  |
| <b>20-yr avg.</b> | <b>4</b>    | <b>106</b> | <b>18,223</b> | <b>172</b> | <b>33</b>            | <b>118</b> | <b>7,217</b> | <b>62</b> | <b>3</b>             | <b>21</b> | <b>162</b> | <b>18</b> |

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

Percent bycatch for the Kona crab fishery is extremely high due to the current suite of regulations in place. MHI Kona crab populations typically (seasonal and place-based differences in sex ratio have also been noted) have a near 1:1 male to female sex ratio meaning that at minimum about half the catch would need to be released during an average trip. Considering that undersized males also need to be released, it is easy to see how fishers today struggle to retain catch legally. Reported percent Kona crab bycatch appears to be increasing, with 2021 percent bycatch (87%) being the second highest on record. It is likely though that this is influenced by significant under reporting of releases, especially early in the time series. Percentage of total Kona crab reports with zero releases (highly improbable) have been declining steadily suggesting that fishers are progressively reporting releases more frequently. However, under reporting is still an issue today and may suggest that percent bycatch may be even higher than reflected below.

Non-target species catch using Kona crab nets is extremely limited, and typically comprised almost entirely of the kuahonu crab (*P. sanguinolentus*) which also favors sandy bottoms. Unlike Kona crab, kuahonu crab are not as prone to entanglement in the mesh of Kona crab nets and can often escape capture during retrieval. A relatively high percent bycatch for kuahonu crab is due in part to current regulations including a minimum size and the prohibition of the take of females carrying eggs. In 2021 non-target species catch for the Kona crab loop net fishery could not be reported due to fewer than three reporting licensees.

Percent bycatch for the deepwater shrimp trap fishery is hard to determine from report data since releases can only be reported in pieces, and catch is often only reported in pounds. Seemingly high percent bycatch as seen in 2016 is the result of fishers reporting releases in pieces but neglecting to report at all catch in pieces. It is likely though that target species releases are infrequent since there are no size or sex-based restrictions. Releases of deepwater shrimp in 2021 could not be detailed below due to fewer than three participants in the fishery.

Non-target species catch in shrimp traps is not commonly reported. In many years no non-target catch is reported at all. Once again, non-target catch and releases using deepwater shrimp traps could not be detailed below due to fewer than three participants in the fishery

**Table 32. Time series of commercial fishing bycatch of Kona crab and non-target species harvested with loop net, reported by Fishing Year from 2002-2021**

| Target Species (Kona Crab) |           |            |             |              |               |                 | Non-Target Species (Harvested with Loop Net) |             |             |              |              |                 |
|----------------------------|-----------|------------|-------------|--------------|---------------|-----------------|----------------------------------------------|-------------|-------------|--------------|--------------|-----------------|
| Year                       | No. Lic.  | Trips      | No. Reports | No. Retained | No. Released  | Percent Bycatch | No. Lic.                                     | Trips       | No. Reports | No. Retained | No. Released | Percent Bycatch |
| 2002                       | 63        | 196        | 119         | 6,593        | 195           | 2.87            | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2003                       | 51        | 161        | 85          | 6,044        | 1,080         | 15.16           | 4                                            | 6           | 6           | 42           | -            | -               |
| 2004                       | 50        | 197        | 85          | 7,441        | 1,620         | 17.88           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2005                       | 47        | 203        | 84          | 8,110        | 1,173         | 12.64           | 3                                            | 9           | 6           | 24           | -            | -               |
| 2006                       | 36        | 154        | 70          | 5,941        | 3,688         | 38.30           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2007                       | 32        | 200        | 69          | 9,657        | 3,422         | 26.16           | 3                                            | 6           | 4           | 43           | -            | -               |
| 2008                       | 38        | 243        | 84          | 12,076       | 1,376         | 10.23           | 3                                            | 10          | 10          | 64           | 6            | 8.57            |
| 2009                       | 41        | 229        | 97          | 7,783        | 2,295         | 22.77           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2010                       | 48        | 198        | 92          | 8,863        | 6,511         | 42.35           | 3                                            | 12          | 8           | 27           | 4            | 12.90           |
| 2011                       | 49        | 189        | 105         | 8,783        | 7,360         | 45.59           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2012                       | 36        | 115        | 77          | 8,138        | 3,716         | 31.35           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2013                       | 34        | 97         | 66          | 5,122        | 7,816         | 60.41           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2014                       | 26        | 75         | 53          | 1,666        | 5,576         | 77.00           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2015                       | 26        | 71         | 50          | 2,185        | 7,450         | 77.32           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2016                       | 17        | 28         | 26          | 617          | 1,917         | 75.65           | -                                            | -           | -           | -            | -            | -               |
| 2017                       | 19        | 62         | 39          | 2,697        | 6,947         | 72.03           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2018                       | 22        | 63         | 40          | 2,760        | 12,141        | 81.48           | 3                                            | 4           | 4           | 164          | 748          | 82.02           |
| 2019                       | 24        | 86         | 45          | 4,654        | 27,186        | 85.38           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2020                       | 12        | 60         | 25          | 3,190        | 24,297        | 88.39           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| 2021                       | 18        | 69         | 38          | 2,688        | 17,764        | 86.86           | n.d.                                         | n.d.        | n.d.        | n.d.         | n.d.         | n.d.            |
| <b>10-year avg.</b>        | <b>23</b> | <b>73</b>  | <b>46</b>   | <b>3,372</b> | <b>11,481</b> | <b>73.59</b>    | <b>n.d.</b>                                  | <b>n.d.</b> | <b>n.d.</b> | <b>n.d.</b>  | <b>n.d.</b>  | <b>n.d.</b>     |
| <b>20-year avg.</b>        | <b>34</b> | <b>135</b> | <b>67</b>   | <b>5,750</b> | <b>7,177</b>  | <b>48.49</b>    | <b>n.d.</b>                                  | <b>n.d.</b> | <b>n.d.</b> | <b>n.d.</b>  | <b>n.d.</b>  | <b>n.d.</b>     |

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

**Table 33. Time series of commercial fishing bycatch of deepwater shrimp and non-target species harvested with shrimp traps, reported by Fishing Year from 2002-2021**

| Target Species (Deepwater Shrimp) |          |            |             |               |              |                 | Non-Target Species (Harvested with Shrimp Traps) |          |             |              |              |                 |
|-----------------------------------|----------|------------|-------------|---------------|--------------|-----------------|--------------------------------------------------|----------|-------------|--------------|--------------|-----------------|
| Year                              | No. Lic. | Trips      | No. Reports | No. Retained  | No. Released | Percent Bycatch | No. Lic.                                         | Trips    | No. Reports | No. Retained | No. Released | Percent Bycatch |
| 2002                              | 3        | 52         | 15          | -             | -            | -               | -                                                | -        | -           | -            | -            | -               |
| 2003                              | 3        | 56         | 18          | 4,038         | -            | -               | -                                                | -        | -           | -            | -            | -               |
| 2004                              | n.d.     | n.d.       | n.d.        | n.d.          | n.d.         | n.d.            | -                                                | -        | -           | -            | -            | -               |
| 2005                              | 5        | 178        | 24          | 130           | 4            | 2.99            | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2006                              | n.d.     | n.d.       | n.d.        | n.d.          | n.d.         | n.d.            | -                                                | -        | -           | -            | -            | -               |
| 2007                              | 3        | 39         | 10          | 16,830        | -            | -               | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2008                              | n.d.     | n.d.       | n.d.        | n.d.          | n.d.         | n.d.            | -                                                | -        | -           | -            | -            | -               |
| 2009                              | n.d.     | n.d.       | n.d.        | n.d.          | n.d.         | n.d.            | -                                                | -        | -           | -            | -            | -               |
| 2010                              | n.d.     | n.d.       | n.d.        | n.d.          | n.d.         | n.d.            | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2011                              | 4        | 69         | 16          | 46,569        | -            | -               | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2012                              | 5        | 143        | 21          | 107,119       | 100          | 0.09            | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2013                              | 10       | 205        | 36          | 100,832       | -            | -               | -                                                | -        | -           | -            | -            | -               |
| 2014                              | 9        | 323        | 41          | 371,010       | 34           | 0.01            | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2015                              | 6        | 200        | 36          | 148,345       | 310          | 0.21            | -                                                | -        | -           | -            | -            | -               |
| 2016                              | 5        | 133        | 27          | 29,417        | 3,205        | 9.82            | -                                                | -        | -           | -            | -            | -               |
| 2017                              | 3        | 80         | 10          | 7,510         | 20           | 0.27            | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2018                              | 3        | 131        | 16          | 31,196        | -            | -               | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2019                              | 3        | 196        | 23          | 18,425        | -            | -               | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| 2020                              | n.d.     | n.d.       | n.d.        | n.d.          | n.d.         | n.d.            | -                                                | -        | -           | -            | -            | -               |
| 2021                              | n.d.     | n.d.       | n.d.        | n.d.          | n.d.         | n.d.            | n.d.                                             | n.d.     | n.d.        | n.d.         | n.d.         | n.d.            |
| <b>10-year avg.</b>               | <b>5</b> | <b>157</b> | <b>23</b>   | <b>81,720</b> | <b>367</b>   | <b>1.04</b>     | <b>1</b>                                         | <b>9</b> | <b>3</b>    | <b>38</b>    | <b>0</b>     | <b>0</b>        |
| <b>20-year avg.</b>               | <b>4</b> | <b>106</b> | <b>18</b>   | <b>47,182</b> | <b>184</b>   | <b>0.79</b>     | <b>1</b>                                         | <b>9</b> | <b>3</b>    | <b>263</b>   | <b>7</b>     | <b>14.02</b>    |

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

## **1.5 PRECIOUS CORALS FISHERY**

### **1.5.1 Fishery Descriptions**

This species group is comprised of pink/red coral (*Corallium secundum*, *C. regale*, *C. laauense*), gold coral (*Gerardia* spp., *Callogorgia gilberti*, *Narella* spp., *Calyptrophora* spp.), bamboo coral (*Lepidisis olapa*, *Acanella* spp.), and black coral (*Antipathes griggi*, *A. grandis*, *A. ulex*).

Precious corals have long been prized by a wide range of cultures for their use in jewelry making. In 1987 black coral was adopted as the official state “gem” of Hawaii. Throughout the entire time series of commercial reporting, black corals compose almost the entirety of the precious coral harvest. Approximately 93% of all precious coral harvest reported to DAR has occurred in or around the Auau channel. MHI precious coral fisheries are characterized by extremely low participation which peaked at five individuals in 1987 and 1990. In the past eleven years combined, fewer than three individuals have reported harvest of these species.

### **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 FEDERAL LOGBOOK DATA

### 1.6.1 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.

#### 1.6.1.1 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.

#### 1.6.1.2 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.

#### 1.6.1.3 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 E](#), and [Title 50, Part 404](#) (Papahānaumokuākea Marine National Monument).

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

Table 34 provides the number of permits issued to Hawaii FEP fisheries between 2012 and 2021. Data are from the PIRO Sustainable Fisheries Division (SFD) permits program.

**Table 34. Number of federal permits in Hawaii FEP fisheries**

| Year | Special Coral Reef Ecosystem | MHI Non-Commercial Bottomfish | Precious Coral | Crustacean - Shrimp | Crustacean - Lobster |
|------|------------------------------|-------------------------------|----------------|---------------------|----------------------|
| 2012 | 1                            | 18                            | 2              | 0                   | 0                    |
| 2013 | 0                            | 10                            | 1              | 3                   | 2                    |
| 2014 | 0                            | 3                             | 1              | 7                   | 1                    |
| 2015 | 0                            | 2                             | 1              | 4                   | 2                    |

| Year | Special Coral Reef Ecosystem | MHI Non-Commercial Bottomfish | Precious Coral | Crustacean - Shrimp | Crustacean - Lobster |
|------|------------------------------|-------------------------------|----------------|---------------------|----------------------|
| 2016 | 1                            | 0                             | 1              | 4                   | 1                    |
| 2017 | 1                            | 1                             | 1              | 6                   | 2                    |
| 2018 | 1                            | 0                             | 1              | 4                   | 1                    |
| 2019 | 0                            | 2                             | 1              | 3                   | 1                    |
| 2020 | 1                            | 2                             | 0              | 2                   | 0                    |
| 2021 | 1                            | 0                             | 0              | 3                   | 0                    |

Source: PIRO SFD unpublished data.

## 1.6.2 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 the federal permit and logbook reporting requirements became effective as well as available catch and effort data are presented in Table 35 through Table 37.

### 1.6.2.1 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.

### 1.6.2.2 Non-Commercial Bottomfish

**Table 35. Summary of available federal logbook data for the non-commercial bottomfish fishery in Hawaii**

| Year    | No. of Federal Bottomfish Permits Issued <sup>1</sup> | No. of Federal Bottomfish Permits Reporting Catch | No. of Trips in MHI EEZ | Total Reported Logbook Catch (lb)                              |                                                                       | Total Reported Logbook Release/Discard (#)                     |                                                                       |
|---------|-------------------------------------------------------|---------------------------------------------------|-------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------|
|         |                                                       |                                                   |                         | Deep-7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year | Non-Deep-7 Bottomfish (MUS & ECS) <sup>2</sup> from Jan. 1 to Dec. 31 | Deep-7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year | Non-Deep-7 Bottomfish (MUS & ECS) <sup>2</sup> 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 <sup>1</sup> | No. of Federal Bottomfish Permits Reporting Catch | No. of Trips in MHI EEZ | Total Reported Logbook Catch (lb)                              |                                                                       | Total Reported Logbook Release/Discard (#)                     |                                                                       |
|---------|-------------------------------------------------------|---------------------------------------------------|-------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------|
|         |                                                       |                                                   |                         | Dee- 7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year | Non-Deep-7 Bottomfish (MUS & ECS) <sup>2</sup> from Jan. 1 to Dec. 31 | Deep-7 Bottomfish (MUS) from Sept 1-Aug. 31 the following year | Non-Deep-7 Bottomfish (MUS & ECS) <sup>2</sup> 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                                                 |                         |                                                                |                                                                       |                                                                |                                                                       |
| 2020-21 | 0                                                     | 0                                                 |                         |                                                                |                                                                       |                                                                |                                                                       |

<sup>1</sup> Source: PIRO SFD unpublished data.

<sup>2</sup> 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.

### 1.6.2.3 Spiny and Slipper Lobster

**Table 36. Summary of available federal logbook data for the lobster fisheries in Hawaii**

| Year | No. of Federal Lobster Permits Issued <sup>1</sup> | 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 | 0                                                  | 0                                                     |                         |                                   |                     |                                             |                     |

| Year | No. of Federal Lobster Permits Issued <sup>1</sup> | 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) |                            |
|------|----------------------------------------------------|-------------------------------------------------------|-------------------------|-----------------------------------|----------------------------|---------------------------------------------|----------------------------|
|      |                                                    |                                                       |                         | <i>Spiny lobster MUS</i>          | <i>Slipper lobster MUS</i> | <i>Spiny lobster MUS</i>                    | <i>Slipper lobster MUS</i> |
| 2013 | 2                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2014 | 1                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2015 | 2                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2016 | 1                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2017 | 2                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2018 | 1                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2019 | 1                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2020 | 0                                                  | 0                                                     |                         |                                   |                            |                                             |                            |
| 2021 | 0                                                  | 0                                                     |                         |                                   |                            |                                             |                            |

<sup>1</sup> Source: PIRO SFD unpublished data.

Note: n.d. = Not available due to confidentiality.

#### 1.6.2.4 Deepwater Shrimp

**Table 37. Summary of available federal logbook data for the deepwater shrimp fishery in Hawaii**

| Year | No. of Federal Shrimp Permits Issued <sup>1</sup> | No. of Federal Shrimp Permits Reporting Catch <sup>2</sup> | 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 | 0                                                 | n.d.                                                       | n.d.                    | n.d.                                         | n.d.                                                   |
| 2013 | 3                                                 | 6                                                          | 80                      | 10,520                                       | 113                                                    |
| 2014 | 7                                                 | 6                                                          | 61                      | 11,676                                       | 212                                                    |
| 2015 | 4                                                 | 3                                                          | 24                      | 13,020                                       | 261                                                    |
| 2016 | 4                                                 | 3                                                          | 123                     | 39,781                                       | 7,257                                                  |
| 2017 | 6                                                 | 4                                                          | 27                      | 5,529                                        | 74                                                     |
| 2018 | 4                                                 | n.d.                                                       | n.d.                    | n.d.                                         | n.d.                                                   |
| 2019 | 3                                                 | 3                                                          | 192                     | 23,939                                       | 0                                                      |
| 2020 | 2                                                 | n.d.                                                       | n.d.                    | n.d.                                         | n.d.                                                   |
| 2021 | 3                                                 | n.d.                                                       | n.d.                    | n.d.                                         | n.d.                                                   |

<sup>1</sup> Source: PIRO SFD unpublished data.

<sup>2</sup> 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.

## 1.7 STATUS DETERMINATION CRITERIA

### 1.7.1 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 38. Note that the MFMT listed here only applies to Hawaiian bottomfish.

**Table 38. Overfishing threshold specifications for Hawaiian bottomfish and NWHI lobsters**

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

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

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

Since the MSY control rule specified here applies to multi-species stock complexes, it is important to ensure that no species within the complex has a mortality rate that leads to excessive depletion. In order to accomplish this, a secondary set of reference points is specified to evaluate stock status with respect to recruitment overfishing. A secondary “recruitment overfishing” control rule is specified to control fishing mortality with respect to that status. The rule applies only to those component stocks (species) for which adequate data are available. The ratio of a current spawning stock biomass proxy ( $SSBP_t$ ) 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 39. Again,  $E_{MSY}$  is used as a proxy for  $F_{MSY}$ .

**Table 39. Recruitment overfishing control rule specifications for the BMUS in Hawaii**

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

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

## 1.7.2 Current Stock Status

### 1.7.2.1 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 2021 update stock assessment by PIFSC utilized a state-space surplus production model with explicit process and observation error terms (Syslo et al. 2021). Determinations of overfishing and overfished status were made by comparing current biomass and harvest rates to MSY-based reference points. As of 2018, the MHI Deep-7 bottomfish complex is not subject to overfishing and is not overfished (Table 40).

**Table 40. Stock assessment parameters for the MHI Deep-7 bottomfish complex (Langseth et al. 2018)**

| Parameter              | Value                 | Notes                                      | Status                   |
|------------------------|-----------------------|--------------------------------------------|--------------------------|
| MSY for total catch    | $1.025 \pm 0.487$     | Mean $\pm$ std. error, units in million lb |                          |
| MSY for reported catch | $473,000 \pm 225,000$ | Mean $\pm$ std. error, units in lb         |                          |
| H <sub>2018</sub>      | 3.0%                  |                                            |                          |
| H <sub>MSY</sub>       | $6.8\% \pm 2.6\%$     | Mean $\pm$ std. error                      |                          |
| H/H <sub>MSY</sub>     | 0.37                  |                                            | No overfishing occurring |
| B <sub>2018</sub>      | 21.88                 | Mean, units in million lb                  |                          |
| B <sub>MSY</sub>       | $15.5 \pm 5.0$        | Mean $\pm$ std. error, units in million lb |                          |
| B/B <sub>MSY</sub>     | 1.43                  |                                            | Not overfished           |

**1.7.2.2 Uku**

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<sub>30</sub>) 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 due to the ecosystem component amendment to the FEPs (84 FR 2767, February 8, 2019). The assessment indicated that the uku stock around Hawaii was not experiencing overfishing.

In 2020, PIFSC performed a stock assessment only on uku in the MHI using the Stock Synthesis 3.30 modeling framework, an integrated statistical catch-at-age model that fits a population model to relative abundance and size composition data in a likelihood-based statistical framework to generate maximum likelihood estimates of population parameters (Nadon et al. 2020). The assessment concluded that the MHI uku stock is not overfished and is not experiencing overfishing. Results from the uku assessment are presented in Table 41, where “SSB” refers to spawning stock biomass.

**Table 41. Results from 2020 stock assessment for MHI uku (Nadon et al. 2020)**

| Parameter                                | Value | Notes                  | Status                   |
|------------------------------------------|-------|------------------------|--------------------------|
| MSY                                      | 93    | Units mt               |                          |
| F <sub>2018</sub> (age 5-30)             | 0.08  | Units yr <sup>-1</sup> |                          |
| F <sub>MSY</sub> (age 5-30)              | 0.14  | Units yr <sup>-1</sup> |                          |
| F <sub>2018</sub> /F <sub>MSY</sub>      | 0.57  |                        | No overfishing occurring |
| SSB <sub>2018</sub>                      | 819   | Units mt               |                          |
| SSB <sub>MSST</sub>                      | 301   | Units mt               |                          |
| SSB <sub>2018</sub> /SSB <sub>MSST</sub> | 2.7   |                        | Not overfished           |

**1.7.2.3 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<sup>2</sup> (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 42).

**Table 42. 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 <sub>2016</sub>                   | 0.0081  | Expressed as proportion |                          |
| H <sub>MSY</sub>                    | 0.114   | Expressed as proportion |                          |
| H/H <sub>MSY</sub>                  | 0.0714  |                         | No overfishing occurring |
| B <sub>2016</sub>                   | 885,057 | In lb                   |                          |
| B <sub>MSY</sub>                    | 640,489 | In lb                   |                          |
| B <sub>2016</sub> /B <sub>MSY</sub> | 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 43.

**Table 43. 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).

## **1.8 OVERFISHING LIMIT, ACCEPTABLE BIOLOGICAL CATCH, AND ANNUAL CATCH LIMITS**

### **1.8.1 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 utilizes the best scientific information available (BSIA) in the form of, but not limited to, stock assessments, published papers, reports, and/or available data. Available 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 low activity 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. ACLs may be derived 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 typically implements ACLs on an annual basis, but the Council normally recommends a multi-year specification.

The AM typically implemented for Hawaii insular fisheries is a post-season AM in the form of an overage adjustment. If the recent three-year average catch for a fishery exceeded the implemented ACL, the subsequent ACL is downward adjusted by the amount of overage. A three-year average of recent catch is utilized as recommended by the Council at its 160<sup>th</sup> meeting to avoid large fluctuations in catch due to data quality and outliers. The uku and Kona crab fisheries, however, also have 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.

### **1.8.2 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 (84 FR 29394, June 24, 2019), 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 inactive except for limited harvest of black corals. ACLs are no longer specified for coral reef species nor several crustacean species due to the recent ECS amendment (84 FR 2767, February 9, 2019). It is also of note that the MHI Deep-7 stock complex operates based on fishing year and is still open for the 2021–2022 fishing year. The ACT for Kona crab was newly implemented as of the most recent specification, and any projected exceedance of the ACT will result in a federal fishery closure for the species. The ACLs shown in Table 44 are the most recently implemented ACLs by NMFS. Recent average catch for the MHI Deep-7

Bottomfish stock complex (169,003 lb) accounted for 34.3% of its implemented ACL (492,000 lb; Table 44).

**Table 44. ACLs for Hawaii MUS in 2021 and three-year recent average catch (lb) from 2019–2021**

| <b>Fishery</b> | <b>Management Unit Species</b>          | <b>OFL</b> | <b>ABC</b> | <b>ACL</b> | <b>ACT</b> | <b>Catch</b> |
|----------------|-----------------------------------------|------------|------------|------------|------------|--------------|
| Bottomfish     | MHI Deep-7 stock complex                | 558,000    | 508,000    | 492,000    | NA         | 164,171      |
|                | <i>Aprion virescens</i> (uku)           | 132,277    | 127,205    | 127,205    | NA         | 66,137       |
| Crustacean     | Deepwater shrimp                        | NA         | 250,773    | 250,773    | NA         | n.d.         |
|                | Kona crab                               | 33,989     | 30,802     | 30,802     | 25,491     | 4,570        |
| 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 2020–2021 fishing year only and not a three-year average.

## **1.9 BEST SCIENTIFIC INFORMATION AVAILABLE**

### **1.9.1 Main Hawaiian Island Deep-7 Bottomfish Fishery**

#### **1.9.1.1 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 estimated 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 at 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.

The next benchmark stock assessment for the MHI Deep-7 bottomfish complex will be completed in 2023.

#### **1.9.1.2 Stock Assessment Updates**

In 2021, PIFSC completed an stock assessment update for the MHI Deep-7 bottomfish fishery (2021 stock assessment) using data through 2018 (Syslo et al. 2021). The 2021 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 2021 assessment estimates MSY for reported catch of 473,000 lb for the MHI Deep-7 bottomfish stock complex. The 2021 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 at 1 percent intervals. If 618,000 lb of reported catch occurs from fishing years 2021–2025, there is a 50% risk of overfishing in 2021; this is the overfishing limit.

#### **1.9.1.3 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 2021 benchmark stock assessment by Syslo et al. (2021) was the BSIA. This is based on the assessment passing a Western Pacific Stock Assessment Review by a three-person independent peer review panel.

## 1.9.2 Uku Fishery

### 1.9.2.1 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.

The 2017 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.

In May 2020, PIFSC released the final species level assessment for the main Hawaiian Islands uku stock. This assessment built off previous assessment efforts and used catch, CPUE, diver surveys, and size composition time series in the Stock Synthesis modeling framework, which is an integrated catch-at-age model.

Stock Synthesis uses observed catch, size/age composition, and relative abundance indices, such as CPUE, as inputs and incorporates the main population processes (e.g., mortality, selectivity, growth) to recreate population biomass trajectory and derived indicators of stock status to be measured against reference points in the Hawaii FEP. The 2020 assessment results differed slightly from the 2017 assessment that used a data-limited approach on mean length data only, as the 2020 assessment estimated a lower recent fishing mortality rate of approximately 0.08 versus 0.15 for the 2017 assessment. The 2020 stock assessment determined a higher OFL than the 2017 assessment based on catch-derived biomass, though the SPR-based  $F_{MSY}$  proxy used in the 2017 assessment ( $F_{30} = 0.16$ ) is close to the  $F_{MSY}$  value estimated in the 2020 assessment (0.14).

### 1.9.2.2 Stock Assessment Updates

There are no stock assessment updates available for uku.

### 1.9.2.3 Best Scientific Information Available

The Nadon et al. (2020) assessment underwent peer review by a Western Pacific Stock Assessment Review (WRSPAR) panel from February 24 to 28, 2020 (85 FR 5633, January 31, 2020). The review panel, comprised of E. Franklin, Y. Chen, and Y. Jiao was asked to review a

set of 11 Terms of Reference according to guidelines established in the WPSAR framework. The assessment author revised the draft assessment addressing the WPSAR panel comments and recommendations and presented the final stock assessment document at the 136<sup>th</sup> and 182<sup>nd</sup> meetings of the SSC and Council, respectively. PIFSC and the Council consider these assessments the BSIA for these species.

### **1.9.3 Crustacean Fishery**

#### **1.9.3.1 Stock Assessment Benchmark**

Deepwater Shrimp: The deepwater shrimp (*Heterocarpus laevis* 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.

#### **1.9.3.2 Stock Assessment Updates**

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

#### **1.9.3.3 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)

## 1.10 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 45 summarizes the harvest extent and harvest capacity information for Hawaii in 2021 using three-year average catch.

**Table 45. Hawaii proportion of harvest capacity and extent relative to the ACL in 2021**

| Fishery        | Management Unit Species       | ACL     | Catch (lb) | Harvest Extent (%) | Harvest Capacity (%) |
|----------------|-------------------------------|---------|------------|--------------------|----------------------|
| Bottomfish     | MHI Deep-7 stock complex      | 492,000 | 164,171    | 33.4               | 66.6                 |
|                | <i>Aprion virescens</i> (uku) | 127,205 | 66,137     | 52.0               | 48.0                 |
| Crustacean     | Deepwater shrimp              | 250,773 | n.d.       | NA                 | NA                   |
|                | Kona crab                     | 30,802  | 4,570      | 14.8               | 85.2                 |
| 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                   |

| <b>Fishery</b> | <b>Management Unit Species</b>          | <b>ACL</b> | <b>Catch (lb)</b> | <b>Harvest Extent (%)</b> | <b>Harvest Capacity (%)</b> |
|----------------|-----------------------------------------|------------|-------------------|---------------------------|-----------------------------|
|                | 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 2020–2021 fishing year.

### **1.11 ADMINISTRATIVE AND REGULATORY ACTIONS**

This summary describes management actions NMFS implemented for insular fisheries in the Hawaiian Archipelago during calendar year 2021.

On June 17, 2021, NMFS established the annual harvest guideline for the commercial lobster fishery in the Northwestern Hawaiian Islands (NWHI) for calendar year 2021 at zero lobsters (86 FR 32239). 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 2021 at zero lobsters. Harvesting NWHI lobster resources was not allowed.

On September 28, 2021, NMFS published a final rule (86 FR 53818) to enhance the protection of Hawaiian spinner dolphins and prevent their disturbance. This rule prohibits swimming with, approaching, or remaining within 50 yards of a Hawaiian spinner dolphin, including approach by interception, or placing a vessel, person, or other object in the path of a Hawaiian spinner dolphin so that the dolphin approaches within 50 yards. The final rule applies within two nautical miles from shore of the MHI and in designated waters bounded by the islands of Lanai, Maui, and Kahoolawe.

On December 16, 2021, NMFS established the annual harvest guideline for the commercial lobster fishery in the Northwestern Hawaiian Islands (NWHI) for calendar year 2022 at zero lobsters (86 FR 71395). For the reasons described above, harvesting NWHI lobster resources is not allowed in 2022.

## **2 ECOSYSTEM CONSIDERATIONS**

### **2.1 COVID IMPACTS (TO BE UPDATED)**

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 FISHER OBSERVATIONS (TO BE UPDATED)

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 'ōpakapaka (pink snapper) around both islands but were mostly made up of smaller fish. Maui, which normally would catch an average of 8 lb 'ōpakapaka, saw an average of 2 to 3 lb in 2020. Oahu fishermen saw large 'ōpakapaka 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 'ōpakapaka 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 hapu'upu'u (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 surveys occurred in 2020 or 2021 due to COVID-19 and the numbers presented here are identical to the 2019 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.

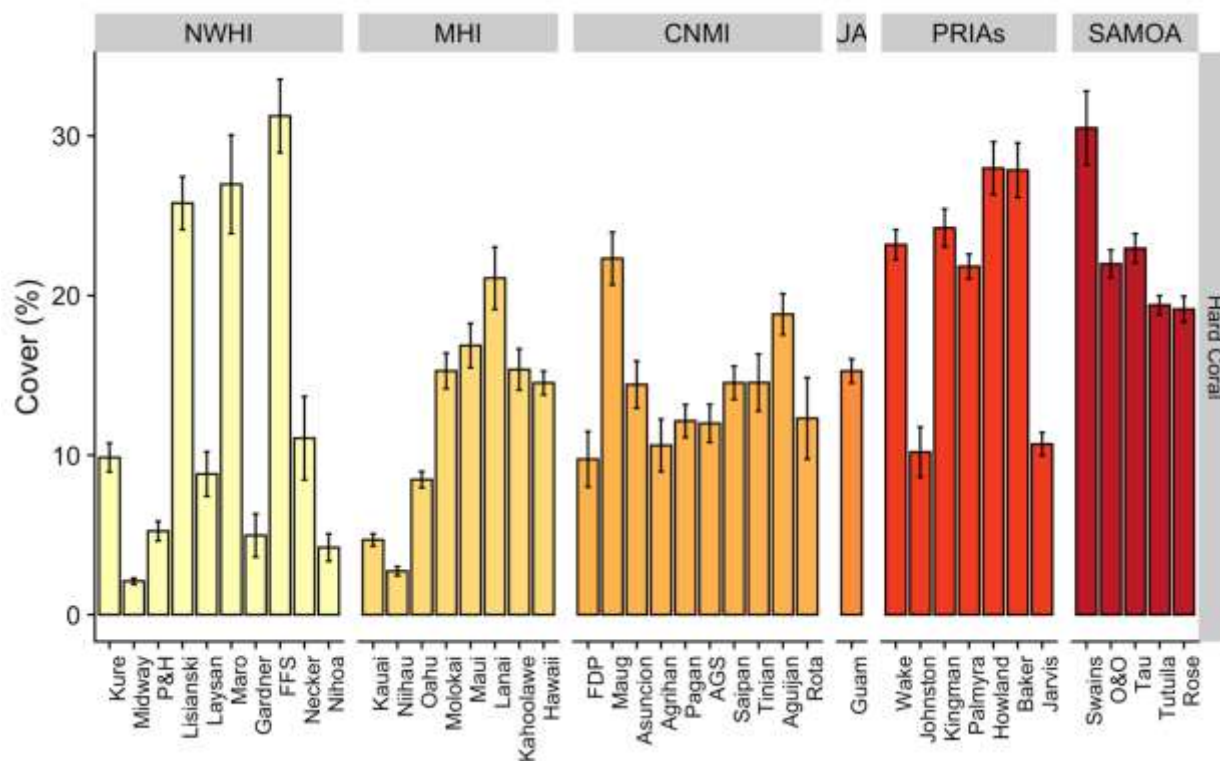
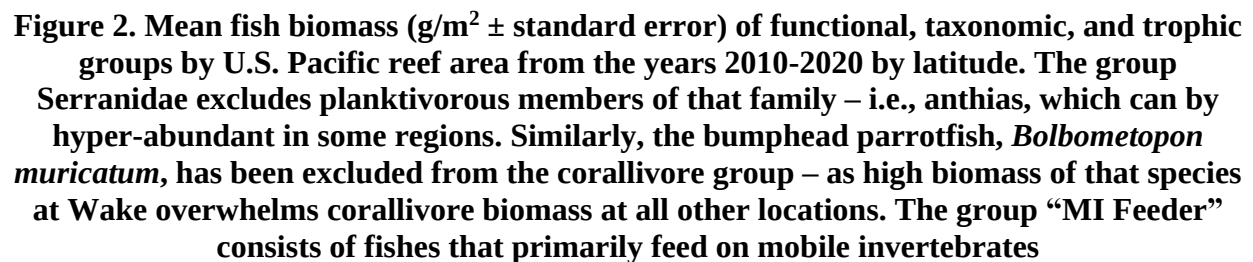


**Figure 1. Mean coral cover (%) per U.S. Pacific Island averaged over the years 2010-2020 by latitude**



### 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. No new surveys occurred in 2020 or 2021 due to COVID-19 and the numbers presented here are identical to the 2019 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:** 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.

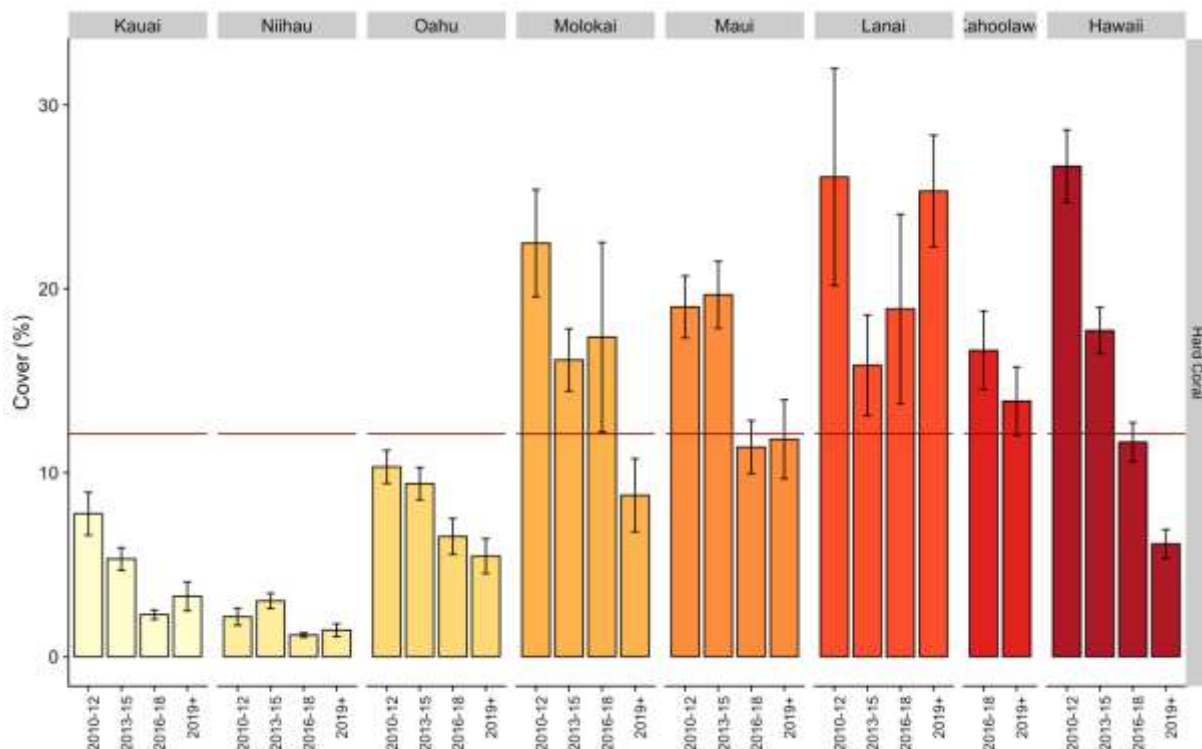


**Figure 3. Mean coral cover (%) per island averaged over the years 2010-2020 by latitude with MHI mean estimates plotted for reference (red line)**

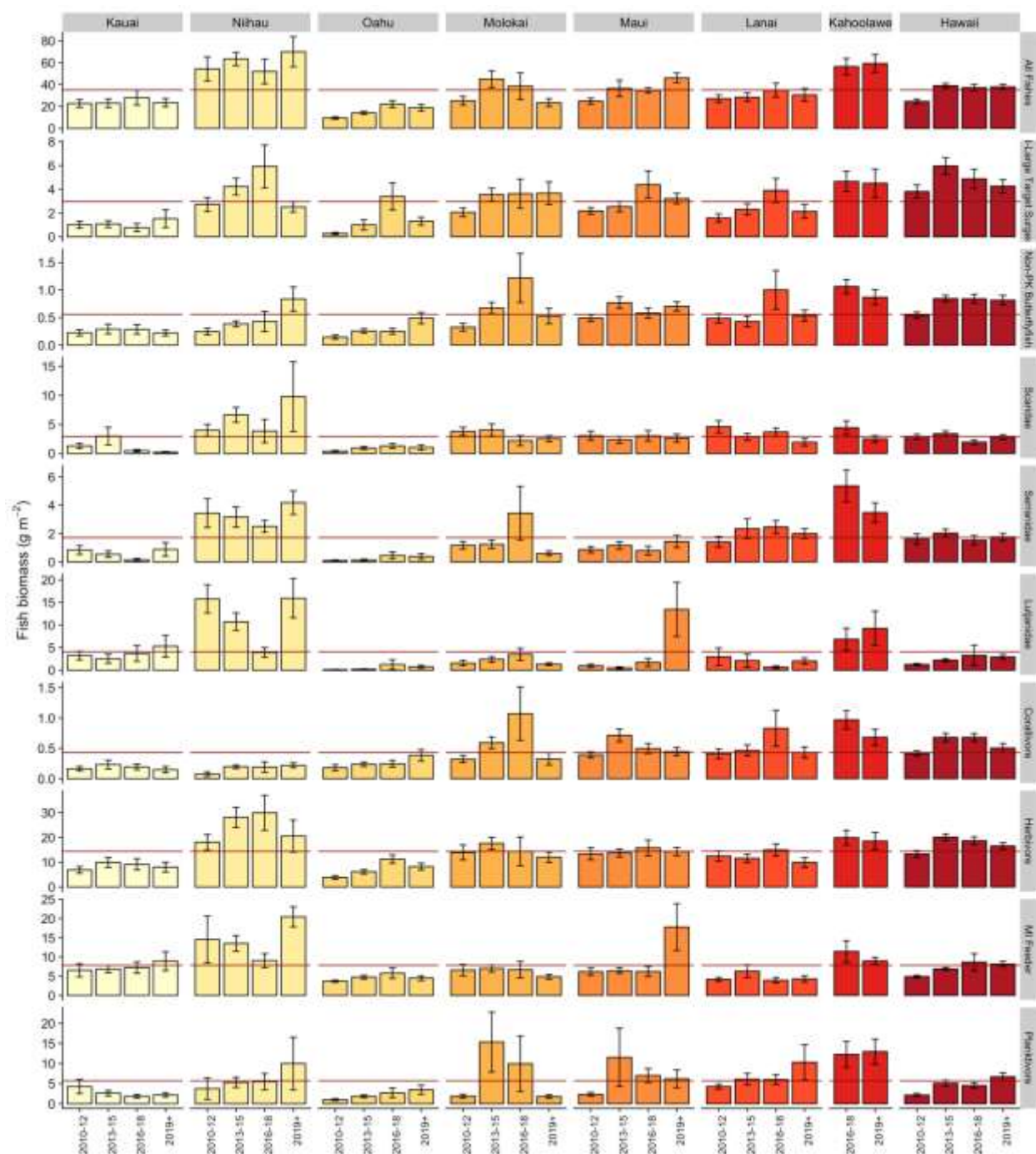


**Figure 4. Mean fish biomass (g/m<sup>2</sup> ± standard error) of MHI functional, taxonomic, and trophic groups from the years 2010-2020 by island. The group Serranidae excludes planktivorous members of that family (i.e., anthias, which can be hyper-abundant in some regions). The group “MI Feeder” 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 surveys occurred in 2020 or 2021 due to COVID-19 and the numbers presented here are identical to the 2019 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.

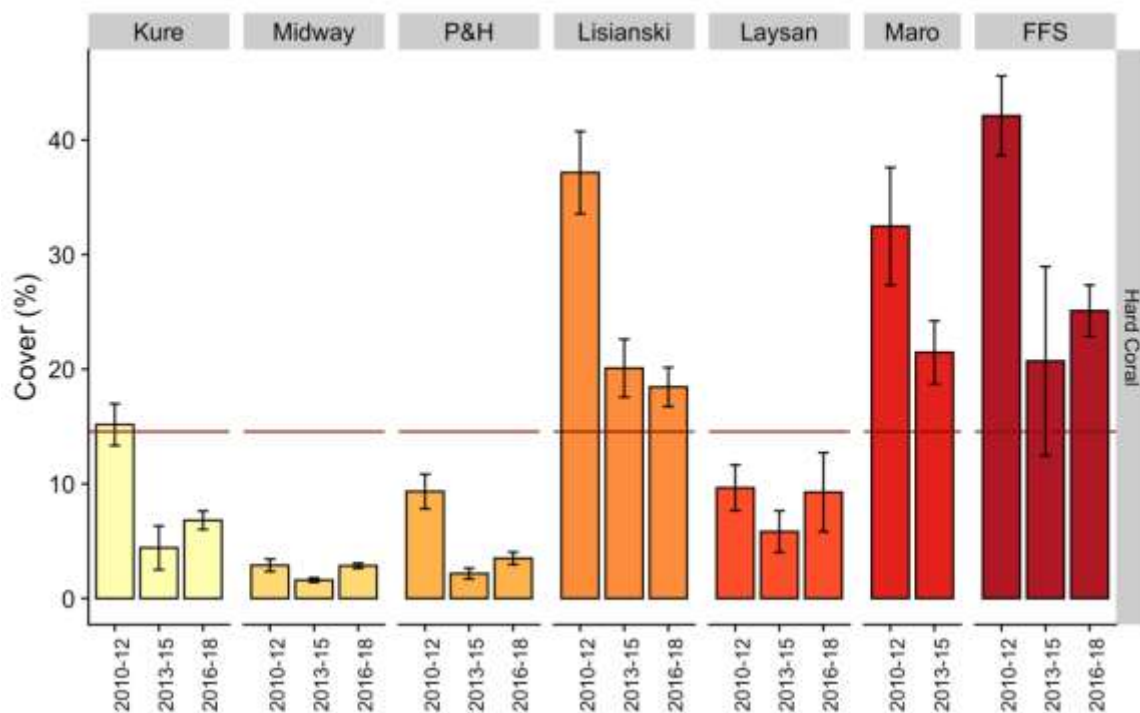


**Figure 5. Mean coral cover (%) per island averaged over the years 2010-2020 by latitude with NWHI mean estimates plotted for reference (red line)**

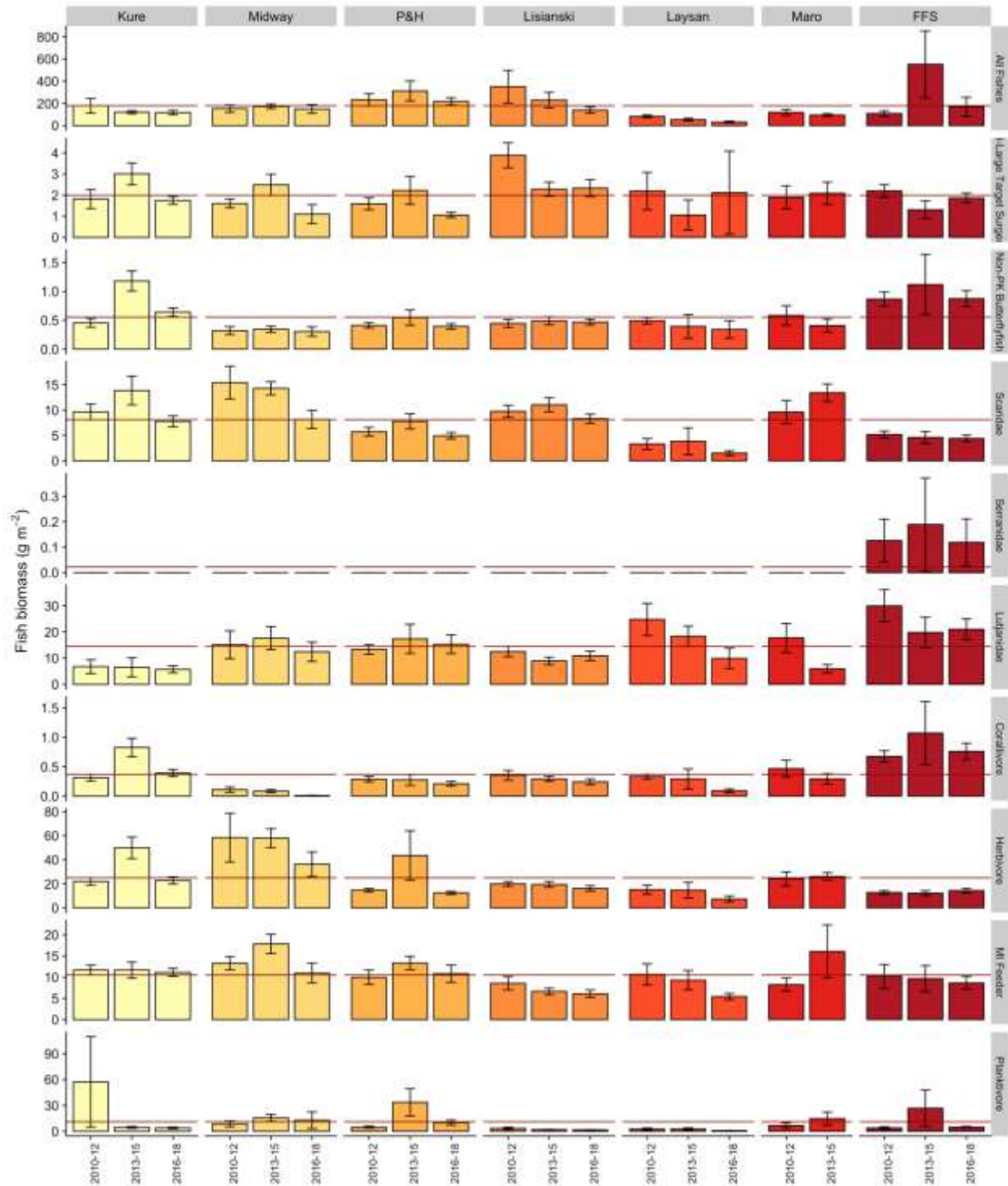


**Figure 6. Mean fish biomass ( $\text{g/m}^2 \pm \text{standard error}$ ) of NWHI functional, taxonomic, and trophic groups from the years 2010-2019 by island. The group Serranidae excludes planktivorous members of that family (i.e., anthias, which can be hyper-abundant in some regions). The group “MI 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  $^{14}\text{C}$ ) 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  $^{14}\text{C}$  values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the  $^{14}\text{C}$  otolith core values back in time from its capture date to where it intersects with the known age  $^{14}\text{C}$  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 ( $L_\infty$ ,  $k$ , 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 46 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 ( $^{14}\text{C}$ ) analysis of otolith core material. Units are years.

**$L_{\infty}$  (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 ( $L_{\infty}$ ).

**$t_0$  (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  $L_{\infty}$ ) 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  $L_{\infty}$ ) 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 46. 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                                            |
|---------------------------------|---------------------------------------------------|-------------------|-------------------|--------------------|-----|------------------|------------------|-----------------|-----------------|------------------------------------------------------|
|                                 | $T_{max}$                                         | $L_{\infty}$      | $k$               | $t_0$              | $M$ | $A_{50}$         | $A\Delta_{50}$   | $L_{50}$        | $L\Delta_{50}$  |                                                      |
| <i>Acanthurus triostegus</i>    |                                                   |                   |                   |                    |     |                  |                  |                 |                 |                                                      |
| <i>Calotomus carolinus</i>      | 4 <sup>d</sup>                                    |                   |                   |                    |     | 1.3 <sup>d</sup> | 3.2 <sup>d</sup> | 24 <sup>d</sup> | 37 <sup>d</sup> | DeMartini et al. (2017); DeMartini and Howard (2016) |
| <i>Caranx melampygus</i>        |                                                   |                   |                   |                    |     |                  |                  |                 |                 |                                                      |
| <i>Cellana</i> spp.             |                                                   |                   |                   |                    |     |                  |                  |                 |                 |                                                      |
| <i>Chlorurus perspicillatus</i> | 19 <sup>d</sup>                                   | 53.2 <sup>d</sup> | 0.23 <sup>d</sup> | -1.48 <sup>d</sup> |     | 3.1 <sup>d</sup> | 7 <sup>d</sup>   | 34 <sup>d</sup> | 46 <sup>d</sup> | DeMartini et al. (2017); DeMartini and Howard (2016) |
| <i>Chlorurus spilurus</i>       | 11 <sup>d</sup>                                   | 34.4 <sup>d</sup> | 0.40 <sup>d</sup> | -0.13 <sup>d</sup> |     | 1.5 <sup>d</sup> | 4 <sup>d</sup>   | 17 <sup>d</sup> | 27 <sup>d</sup> | DeMartini et al. (2017); DeMartini and Howard (2016) |
| <i>Kyphosus bigibbus</i>        |                                                   |                   |                   |                    |     |                  |                  |                 |                 |                                                      |
| Lobster                         |                                                   |                   |                   |                    |     |                  |                  |                 |                 |                                                      |
| <i>Lutjanus</i>                 |                                                   |                   |                   |                    |     |                  |                  |                 |                 |                                                      |

| Species                                    | Age, growth, and reproductive maturity parameters |                            |                        |                    |     |                  |                  |                                            |                 | Reference                                            |
|--------------------------------------------|---------------------------------------------------|----------------------------|------------------------|--------------------|-----|------------------|------------------|--------------------------------------------|-----------------|------------------------------------------------------|
|                                            | $T_{max}$                                         | $L_{\infty}$               | $k$                    | $t_0$              | $M$ | $A_{50}$         | $A\Delta_{50}$   | $L_{50}$                                   | $L\Delta_{50}$  |                                                      |
| <i>kasmira</i>                             |                                                   |                            |                        |                    |     |                  |                  |                                            |                 |                                                      |
| <i>Naso annulatus</i>                      |                                                   |                            |                        |                    |     |                  |                  |                                            |                 |                                                      |
| <i>Octopus cyanea</i>                      |                                                   |                            |                        |                    |     |                  |                  |                                            |                 |                                                      |
| <i>Panulirus marginatus</i> <sup>1</sup>   |                                                   | 104.33-147.75 <sup>d</sup> | 0.05-0.58 <sup>d</sup> |                    |     |                  |                  | 40.5 <sup>d</sup>                          |                 | O'Malley (2009); DeMartini et al. (2005)             |
| <i>Parupeneus porphyus</i>                 |                                                   |                            |                        |                    |     |                  |                  |                                            |                 |                                                      |
| Scaridae                                   |                                                   |                            |                        |                    |     |                  |                  |                                            |                 |                                                      |
| <i>Scarus psittacus</i>                    | 6 <sup>d</sup>                                    | 32.7 <sup>d</sup>          | 0.49 <sup>d</sup>      | -0.01 <sup>d</sup> |     | 1 <sup>d</sup>   | 2.4 <sup>d</sup> | 14 <sup>d</sup>                            | 23 <sup>d</sup> | DeMartini et al. (2017); DeMartini and Howard (2016) |
| <i>Scarus rubroviolaceus</i>               | 19 <sup>d</sup>                                   | 53.5 <sup>d</sup>          | 0.41 <sup>d</sup>      | 0.12 <sup>d</sup>  |     | 2.5 <sup>d</sup> | 5 <sup>d</sup>   | 35 <sup>d</sup>                            | 47 <sup>d</sup> | DeMartini et al. (2017); DeMartini and Howard (2016) |
| <i>Scyllarides squammosus</i> <sup>2</sup> |                                                   | X <sup>a</sup>             | X <sup>a</sup>         |                    |     |                  |                  | 51.1                                       |                 | O'Malley (2009); DeMartini et al. (2005)             |
| <i>Naso unicornis</i>                      | 54 <sup>d</sup>                                   | 47.8 <sup>d</sup>          | 0.44 <sup>d</sup>      | -0.12 <sup>d</sup> |     |                  |                  | f=35.5 <sup>d</sup><br>m=30.1 <sup>d</sup> |                 | Andrews et al. (2016); DeMartini et al. (2014)       |

<sup>a</sup> signifies estimate pending further evaluation in an initiated and ongoing study.

<sup>b</sup> signifies a preliminary estimate taken from ongoing analyses.

<sup>c</sup> signifies an estimate documented in an unpublished report or draft manuscript.

<sup>d</sup> signifies an estimate documented in a finalized report or published journal article (including in press).

<sup>1</sup> *Panulirus marginatus* growth rates ( $k$  and  $L_{\infty}$ ) are from a range of locations in the NWHI for both sexes.

<sup>2</sup> *Scyllarides squammosus* growth rates available for Schnute growth model but not from von Bertalanffy growth model (i.e., no  $k$  or  $L_{\infty}$ ).

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;  $L_{\infty}$ ,  $L_{50}$ , and  $L\Delta_{50}$  are in units of mm fork length (FL);  $k$  is in units of year<sup>-1</sup>; 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 <sup>14</sup>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 <sup>14</sup>C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the <sup>14</sup>C otolith core values back in time from its capture date to where it intersects with the known age <sup>14</sup>C coral

reference series. Fish growth is estimated by fitting the length-at-age data to a VBGF. This function typically uses three coefficients ( $L_{\infty}$ ,  $k$ , 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 47 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;  $L_{\infty}$ ,  $L_{50}$ , and  $L\Delta_{50}$  are in units of mm FL;  $k$  is in units of year<sup>-1</sup>; 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 47. Available age, growth, reproductive maturity, and natural mortality information for bottomfish MUS in the Hawaiian Archipelago**

| Species                            | Age, growth, and reproductive maturity parameters |                                            |                                            |                                              |                   |                |                |                                            |                   | Reference                                         |
|------------------------------------|---------------------------------------------------|--------------------------------------------|--------------------------------------------|----------------------------------------------|-------------------|----------------|----------------|--------------------------------------------|-------------------|---------------------------------------------------|
|                                    | $T_{max}$                                         | $L_{\infty}$                               | $k$                                        | $t_0$                                        | $M$               | $A_{50}$       | $A\Delta_{50}$ | $L_{50}$                                   | $L\Delta_{50}$    |                                                   |
| <i>Aphareus rutilans</i>           |                                                   |                                            |                                            |                                              |                   |                | NA             |                                            | NA                |                                                   |
| <i>Aprion virescens</i>            | 27 <sup>d</sup>                                   | 72.78 <sup>d</sup>                         | 0.31 <sup>d</sup>                          |                                              | 0.24 <sup>d</sup> |                | NA             | 42.5-47.5 <sup>d</sup>                     | NA                | Everson et al. (1989); O'Malley et al. (in press) |
| <i>Etelis carbunculus</i>          | 22 <sup>c</sup>                                   | 50.3 <sup>c</sup>                          | 0.07 <sup>c</sup>                          |                                              |                   |                | NA             | 23.4 <sup>d</sup>                          | NA                | Nichols et al. (in review); DeMartini (2016)      |
| <i>Etelis coruscans</i>            | f=55 <sup>d</sup><br>m=51 <sup>d</sup>            | f=87.6 <sup>d</sup><br>m=82.7 <sup>d</sup> | f=0.12 <sup>d</sup><br>m=0.13 <sup>d</sup> | f=-1.02 <sup>d</sup><br>m=-1.37 <sup>d</sup> |                   | X <sup>a</sup> | NA             | 62.2 <sup>d</sup>                          | NA                | Reed et al. (in press); Andrews et al. (2020)     |
| <i>Hyporthodus quernus</i>         | 76 <sup>d</sup>                                   | 0.078 <sup>d</sup>                         | 95.8 <sup>d</sup>                          |                                              |                   |                |                | 58.0 <sup>d</sup>                          | 89.5 <sup>d</sup> | Andrews et al. (2019); DeMartini et al. (2010)    |
| <i>Pristipomoides filamentosus</i> | 42 <sup>d</sup>                                   | 67.5 <sup>d</sup>                          | 0.24 <sup>d</sup>                          | -0.29 <sup>d</sup>                           |                   |                | NA             | f=40.7 <sup>d</sup><br>m=43.3 <sup>d</sup> | NA                | Andrews et al. (2012); Luers et al. (2017)        |
| <i>Pristipomoides sieboldii</i>    |                                                   |                                            |                                            |                                              |                   |                | NA             | 23.8 <sup>d</sup>                          | NA                | DeMartini (2016)                                  |
| <i>Pristipomoides zonatus</i>      |                                                   |                                            |                                            |                                              |                   |                | NA             |                                            | NA                |                                                   |

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

## 2.5 SOCIOECONOMICS (TO BE UPDATED)

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 165<sup>th</sup> 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 7), which is reflected in local culture, customs, and traditions.



Figure 7. Settlement of the Pacific Islands, courtesy Wikimedia Commons  
[https://commons.wikimedia.org/wiki/File:Polynesian\\_Migration.svg](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 184<sup>th</sup> 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 182<sup>nd</sup> 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 ahupua'a-based management, divided the islands into large parcels called moku, which are reflected in modern political boundaries (Census County Districts).

Immigrants from many other countries with high seafood consumption and cultural ties to fishing and the ocean came to work on the plantations around the turn of the 20<sup>th</sup> Century, establishing in Hawaii large populations of Chinese, Japanese, Koreans, Filipinos, and Portuguese, among others. In 1985, the Compact of Free Association also encouraged a large

Micronesian population to migrate to Hawaii. According to the 2010 Census, the State of Hawaii's population was almost 1.4 million during the last census. Ethnically, it has the highest percentage of Asian Americans (38.6%) and multiracial Americans (23.6%) while having the lowest percentage of White Americans (24.7%) of all states. Approximately 21% of the population identifies as Native Hawaiian or part Native Hawaiian. Tourism from many Asian countries also increases the demand for fresh, high-quality seafood, especially sushi, sashimi, and related raw fish products such as poke.

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

Seafood consumption in Hawai'i is estimated at approximately two to three times higher than the rest of the entire U.S., and Hawai'i consumes more fresh and frozen finfish while shellfish and processed seafood is consumed more across the rest of the country (Geslani et al. 2012; Davidson et al. 2012). In addition, studies have shown that seafood is eaten frequently, at least once a week by most, and at least once a month by almost all respondents (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 'ahi poke (bite-sized cubes of seasoned raw tuna) and ahi sashimi (sliced raw tuna). 'Ahi is also a significant part of cultural celebrations, especially during the holiday period from late November (Thanksgiving) through late January to mid-February (Chinese New Year). Changes in bigeye regulations can have far-reaching effects not only on Hawai'i's fishing community but also on the general population

(Richmond et al. 2015). While most of the fresh tuna consumed in Hawaii is supplied by the local industry, market observations suggest that imported tuna is becoming more commonplace to meet local demands (Pan 2014).

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 48.

**Table 48. Catch disposition by fisherman self-classification (from Chan and Pan 2017)**

|                                     | Number of<br>respondents<br>(n) | Caught and<br>released<br>(%) | Given away<br>(%) | Consumed at<br>home<br>(%) | Sold<br>(%) |
|-------------------------------------|---------------------------------|-------------------------------|-------------------|----------------------------|-------------|
| All Respondents                     | 738                             | 5.6                           | 13.9              | 15.4                       | 65.0        |
| <i>By Fisherman Classification:</i> |                                 |                               |                   |                            |             |
| 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 48). 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 Hawai'i DAR have been collecting information on recreational fishing in Hawai'i, administered through the Hawai'i 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<sup>1</sup>.

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%).

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<sup>1</sup> Presentation is available at:

[https://data.nodc.noaa.gov/coris/library/NOAA/CRCP/monitoring/SocioEconomic/NCRMPSOCHawaiiReportOut2016\\_FINAL\\_061616\\_update.pdf](https://data.nodc.noaa.gov/coris/library/NOAA/CRCP/monitoring/SocioEconomic/NCRMPSOCHawaiiReportOut2016_FINAL_061616_update.pdf)

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

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

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

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

### **2.5.3.3 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 socioeconomic 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 49 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 49. 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. laevis* 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 8 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 9 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 10 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 8, Figure 9, and Figure 10 are presented in Table 50. 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 51.

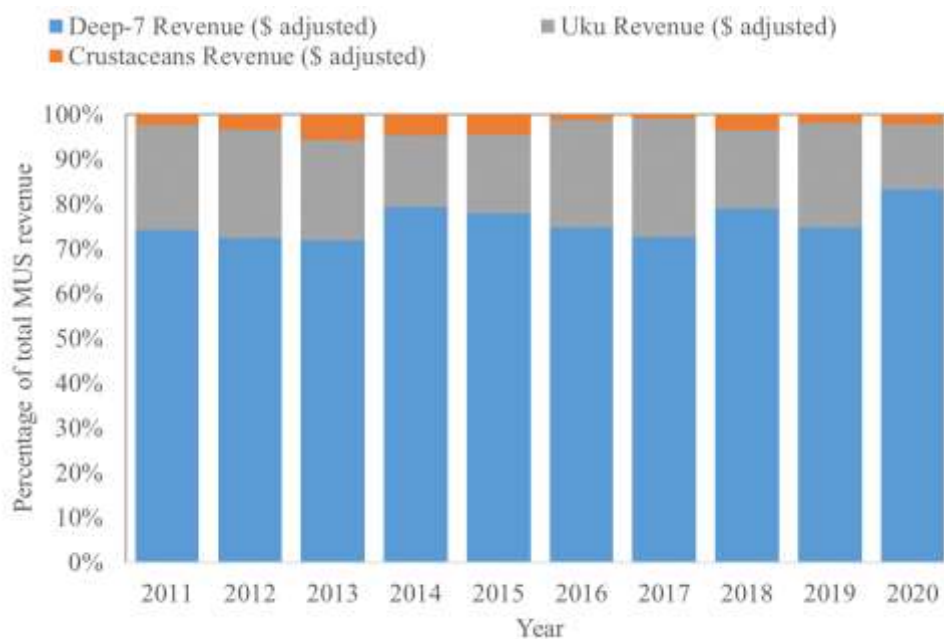


**Figure 8. The revenue structure of the three species groups in the MUS, 2011-2020**

**Table 50. 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.

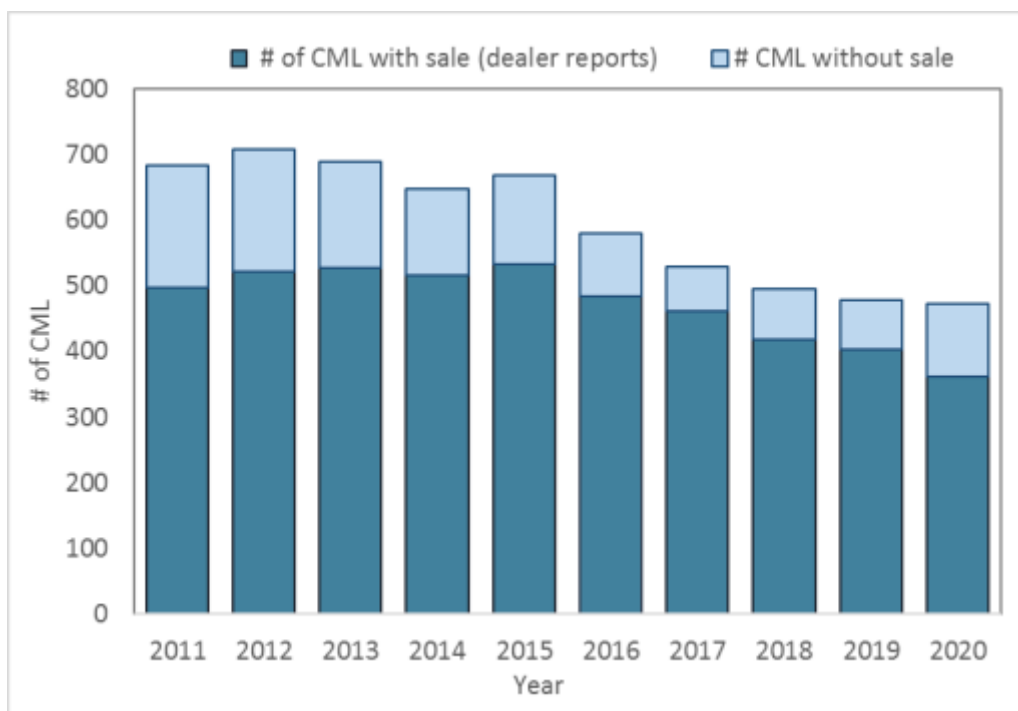


**Figure 9. Total fishers in Hawaii MUS, 2011-2020**

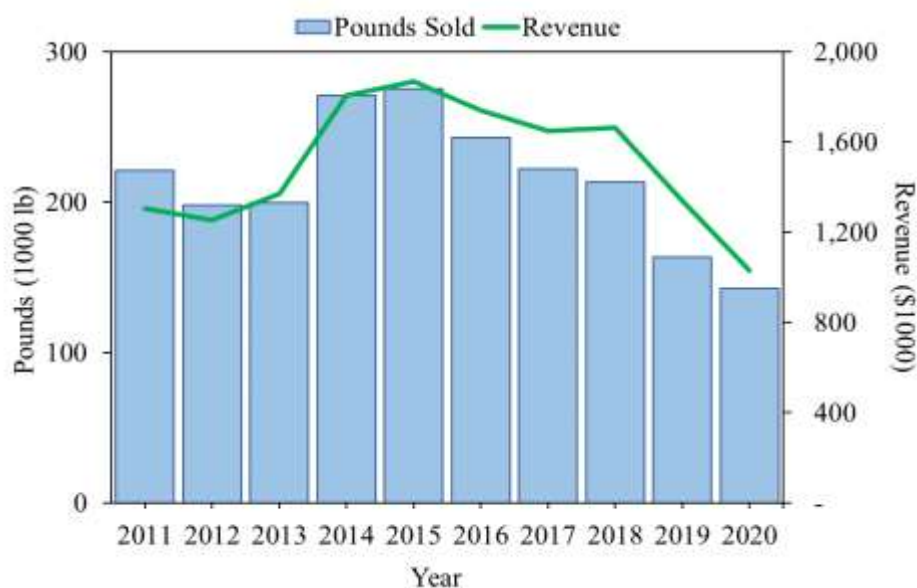


**Figure 10. Pounds sold and revenue of Deep-7 of Hawaii bottomfish fishery, 2011-2020, adjusted to 2020 dollars**

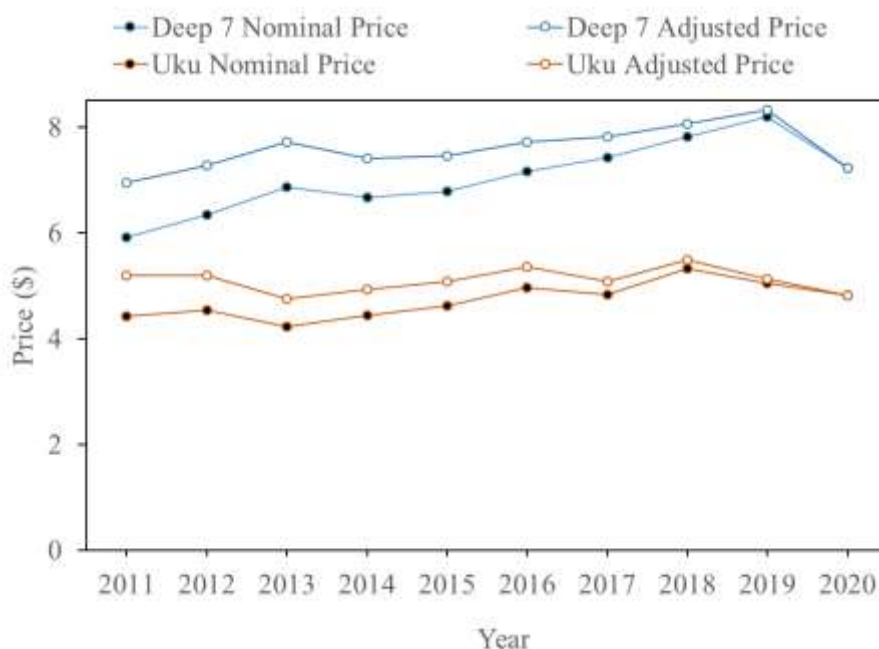


**Figure 11. Fish prices of Deep-7 and Uku of Hawaii bottomfish fishery, 2011-2020**

**Table 51. 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](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, ‘ōpakapaka, kalekale, gindai, lehi, and hapu‘upu‘u. 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 12, while trends in revenue per trip and the share of Deep-7 as a percentage of total fishery revenues are shown in Figure 13. In Figure 12, “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 12, 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 13, 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 12 and Figure 18 are provided in Table 52, 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 12 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).

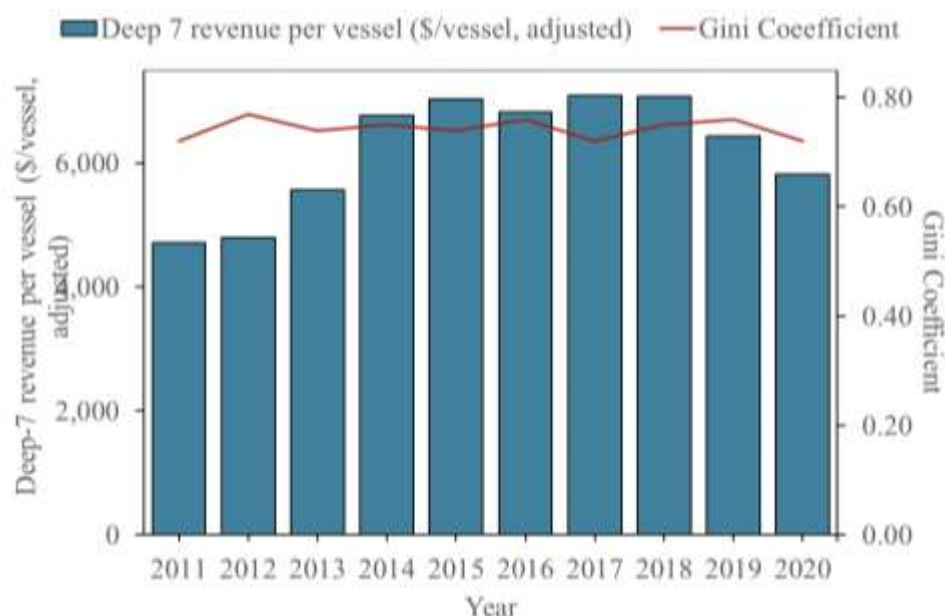


**Figure 12. Trends in fishery revenue per vessel and Gini coefficient for the MHI Deep-7 Bottomfish fishery, 2011-2020**

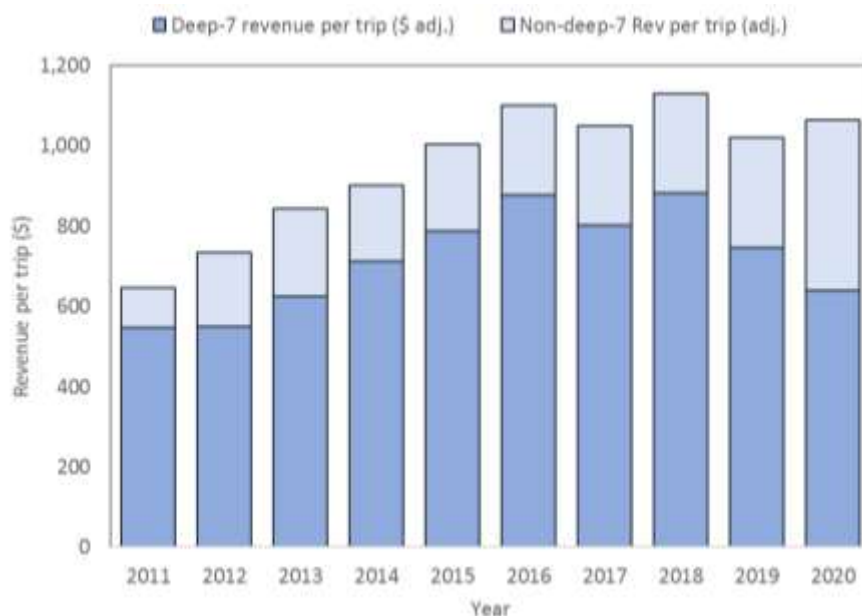


**Figure 13. Trends in fishery revenue per trip and Deep-7 as a percentage of total revenues of all Bottomfish sold (2011-2020)**

**Table 52. MHI Deep-7 bottomfish fishery economic performance measures, 2011-2020**

| Year | Total revenue per vessel (\$) | Total revenue per vessel adj. (\$) | Gini Coefficient | 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](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 53 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 54. The total revenue of the 10 priority species also was also over half a million dollars in 2020, slightly higher than 2019.

**Table 53. 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               |
| <b>Sum</b>      |              | 560,221     | 505,044     | 1,736,904 |     | 3.44        |              | 574,145     | 492,254     | 1,710,396      |     | 3.47               |

**Table 54. 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            |
| Nenu            | 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            |
| <b>Total</b>    |              | 138,631     | 137,329     | <b>525,349</b> |                | 3.83        |              | 134,606     | 134,480     | <b>549,910</b> |                | 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 55. 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<br>Most Recent Year       | Operating Cost<br>Most Recent<br>Year | Fixed Cost<br>Most Recent<br>Year | Returns Above<br>Operating Costs<br>(Quasi Rent)<br>Assessment Most<br>Recent Year | Profit<br>Assessment<br>Most Recent<br>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                                        |
| <b>HI Small Boat (bottomfish)</b> | <b>2020</b>                               | <b>2014</b>                           | <b>2014</b>                       | <b>2017</b>                                                                        | <b>2019</b>                                 |
| <b>HI Small Boat (reef)</b>       | <b>2020</b>                               | <b>2014</b>                           | <b>2014</b>                       | <b>2017</b>                                                                        | <b>2019</b>                                 |
| 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 56. 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<br>Most Recent Year       | Operating Cost<br>Most Recent<br>Year | Fixed Cost<br>Most Recent<br>Year | Returns Above<br>Operating Costs<br>(Quasi Rent)<br>Assessment Most<br>Recent Year | Profit<br>Assessment<br>Most Recent<br>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                                        |
| <b>HI Small Boat (bottomfish)</b> | <b>2021</b>                               | <b>2021</b>                           | <b>2021</b>                       | <b>2017</b>                                                                        | <b>2019</b>                                 |
| <b>HI Small Boat (reef)</b>       | <b>2021</b>                               | <b>2021</b>                           | <b>2021</b>                       | <b>2017</b>                                                                        | <b>2019</b>                                 |
| 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

| <b>Publication</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>MSRA<br/>Priority</b>    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Ayers AL, Leong K. 2020. Examining the Seascape of Compliance in U.S. Pacific Island fisheries. <i>Marine Policy</i> . 115:103820. <a href="https://doi.org/10.1016/j.marpol.2020.103820">https://doi.org/10.1016/j.marpol.2020.103820</a>                                                                                                                                                                                                                                                                      | PS1.4.2<br>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. <a href="https://doi.org/10.25923/q8ya-8t22">https://doi.org/10.25923/q8ya-8t22</a>                                                                                                                                                                                                      | IF8.1.1<br>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. <a href="https://doi.org/10.25923/54tf-kh65">https://doi.org/10.25923/54tf-kh65</a>                                                                                                                                                                                                            | PS1.4.2<br>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. <a href="https://doi.org/10.3133/tm15C8">https://doi.org/10.3133/tm15C8</a>                                                                                                                                                                                                                                                                  | HC3.2.3<br>HC3.2.4          |
| Leong KM, Gramza AR, Lepczyk CA. 2020. Understanding conflicting cultural models of outdoor cats to overcome conservation impasse. <i>Conservation Biology</i> . 34(5):1190-1199. <a href="https://doi.org/10.1111/cobi.13530">https://doi.org/10.1111/cobi.13530</a>                                                                                                                                                                                                                                           | HC3.2.3<br>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. <a href="https://doi.org/10.25923/k5hk-x319">https://doi.org/10.25923/k5hk-x319</a>                                                                                                                                                                                                            | HC1.2<br>HC3.1.1<br>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. <a href="https://spo.nmfs.noaa.gov/content/tech-memo/economiccontribution-marine-angler-expenditures-fishing-trips-united-states-2017">https://spo.nmfs.noaa.gov/content/tech-memo/economiccontribution-marine-angler-expenditures-fishing-trips-united-states-2017</a> | HC1.2<br>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. <a href="https://doi.org/10.25923/d74y-j565">https://doi.org/10.25923/d74y-j565</a>                                                                                                                                                                                                | 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. <a href="https://media.fisheries.noaa.gov/2021-02/Initial-COVID-19-ImpactAssessment-webready.pdf">https://media.fisheries.noaa.gov/2021-02/Initial-COVID-19-ImpactAssessment-webready.pdf</a> | 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. <a href="https://doi.org/10.25923/xd2-t259">https://doi.org/10.25923/xd2-t259</a>                                                                      | HC2.1.2<br>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. <a href="https://doi.org/10.25923/5xhp-5k12">https://doi.org/10.25923/5xhp-5k12</a>                                                                  | HC2.1.2<br>HC2.2.1            |
| Pacific Islands Fisheries Science Center. 2020. Fishery Ecosystem Analysis Tool (FEAT). <a href="https://origin-apps-pifsc.fisheries.noaa.gov/FEAT/#/">https://origin-apps-pifsc.fisheries.noaa.gov/FEAT/#/</a>                                                                                                                                                                                  | HC1.1.1<br>HC3.1.3            |
| Pacific Islands Fisheries Science Center. 2020. Pacific Islands Fisheries Impacts from COVID-19: Pacific Islands Snapshot, March-July 2020. 10p. <a href="https://media.fisheries.noaa.gov/2021-02/Pacific-Islands-COVID-19-ImpactSnapshot-webready.pdf">https://media.fisheries.noaa.gov/2021-02/Pacific-Islands-COVID-19-ImpactSnapshot-webready.pdf</a>                                       | 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. <a href="https://doi.org/10.1007/s11625-020-00822-w">https://doi.org/10.1007/s11625-020-00822-w</a>           | HC2.1.1<br>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. <a href="https://doi.org/10.1093/icesjms/fsaa194">https://doi.org/10.1093/icesjms/fsaa194</a>                                                                       | IF8.1.6<br>HC2.1.2<br>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. <a href="https://doi.org/10.25923/27jh-pm07">https://doi.org/10.25923/27jh-pm07</a>                                                            | HC1.1.7<br>HC1.1.9<br>HC2.1.2 |

## **2.6 PROTECTED SPECIES**

This section of the report summarizes information on protected species interactions in fisheries managed under the Hawaii 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 Hawaii 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 Hawaii 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**

Hawaii 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 Hawaii Archipelago (Table 57).

Table 57. Summary of ESA consultations for Hawaii FEP Fisheries

| Fishery                                                                               | Consultation Date  | Consultation Type <sup>a</sup> | Outcome <sup>b</sup> | 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 <sup>a</sup> | Outcome <sup>b</sup> | 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                                                                                                                                                                                                                                                    |

<sup>a</sup> BiOp = Biological Opinion; LOC = Letter of Concurrence.

<sup>b</sup> 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 Hawaii 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) (updated July 9, 2021).

#### **2.6.1.2.2 Crustacean Fishery**

In an informal consultation completed on December 5, 2013, NMFS concluded that the Hawaii 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 Hawaii crustacean fishery is not likely to adversely affect monk seal critical habitat.

On September 18, 2018, NMFS concluded the Hawaii 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 Hawaii 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 Hawaii coral reef ecosystem fishery is not likely to adversely affect monk seal critical habitat.

On September 18, 2018, NMFS concluded the Hawaii 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 Hawaii 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 Hawaii precious coral fishery is not likely to adversely affect monk seal critical habitat.

On September 18, 2018, NMFS concluded the Hawaii 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 2022 LOF (87 FR 23122, April 19, 2022), 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 Hawaii 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 Hawaii Archipelago. NMFS has also concluded that the Hawaii 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 58 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 58. 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 | <i>Carcharhinus longimanus</i> | 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        | <i>Manta birostris</i>         | 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) | <i>Pseudorca crassidens</i>                                                                                                                                  | 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) | Final Recovery Plan published November 3, 2021 (85 FR 60615) |
| Green Sea Turtle                     | <i>Chelonia mydas</i>                                                                                                                                        | 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                                                          |
| Giant Clams                          | <i>Hippopus hippopus</i> , <i>H. porcellanus</i> , <i>Tridacna costata</i> , <i>T. derasa</i> , <i>T. gigas</i> , <i>T. Squamosa</i> , and <i>T. tevoroa</i> | Positive (82 FR 28946, 06/26/2017) | TBA (status review ongoing)                                                   | TBA                                                                 | N/A                                                                                                                                               | N/A                                                          |
| Shortfin Mako Shark                  | <i>Isurus oxyrinchus</i>                                                                                                                                     | Positive (86 FR 19863, 04/15/2021) | 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 2021.

### **2.7.3 Conceptual Model**

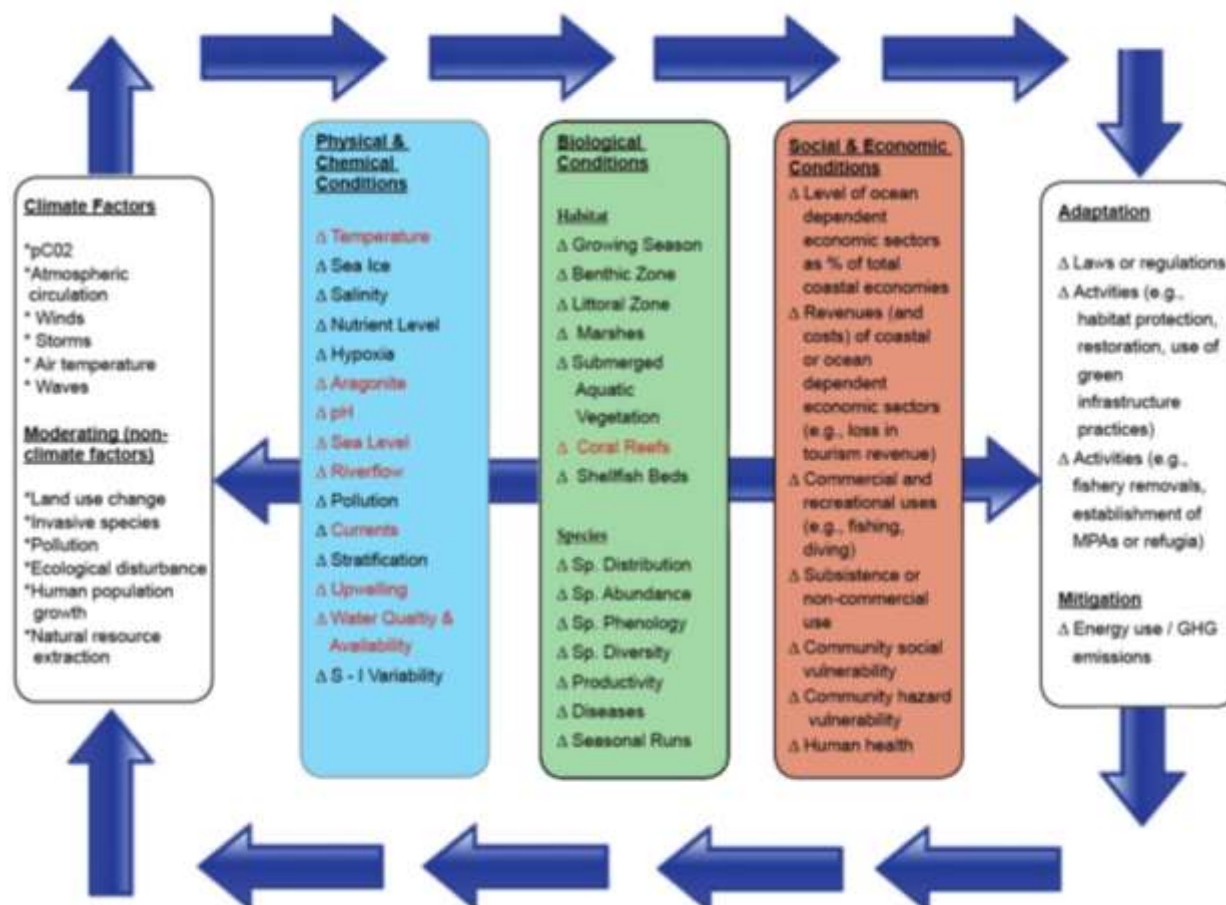
In developing this chapter, the Council relied on a number of recent reports conducted in the context of the U.S. National Climate Assessment including, most notably, the 2012 Pacific Islands Regional Climate Assessment (PIRCA) and the Ocean and Coasts chapter of the 2014 report on a Pilot Indicator 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 14).

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

**Indicators of Change to Archipelagic Coastal and Marine Systems\***  
*(Items in red to be monitored for 2015 Annual Reports of the Archipelagic Fishery Ecosystem Plans for the Western Pacific Region)*



*\*Adapted from National Climate Assessment and Development Advisory Committee. February 2014. National Climate Indicators System Report. B-59.*

**Figure 14. Indicators of change of archipelagic coastal and marine systems; conceptual model**

## 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<sub>2</sub>)
- 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 15 and Figure 16 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.

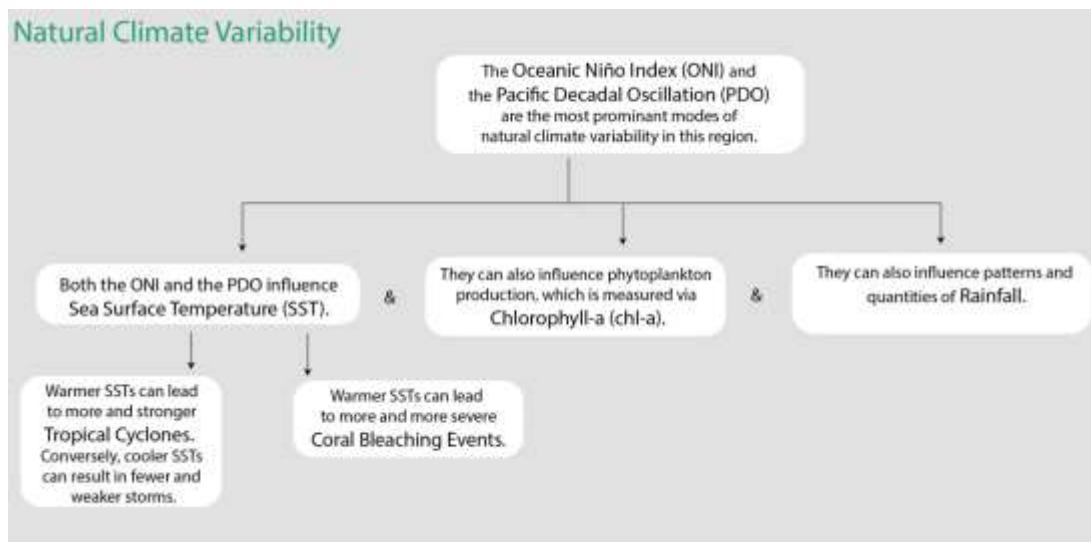


**Figure 15. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability**

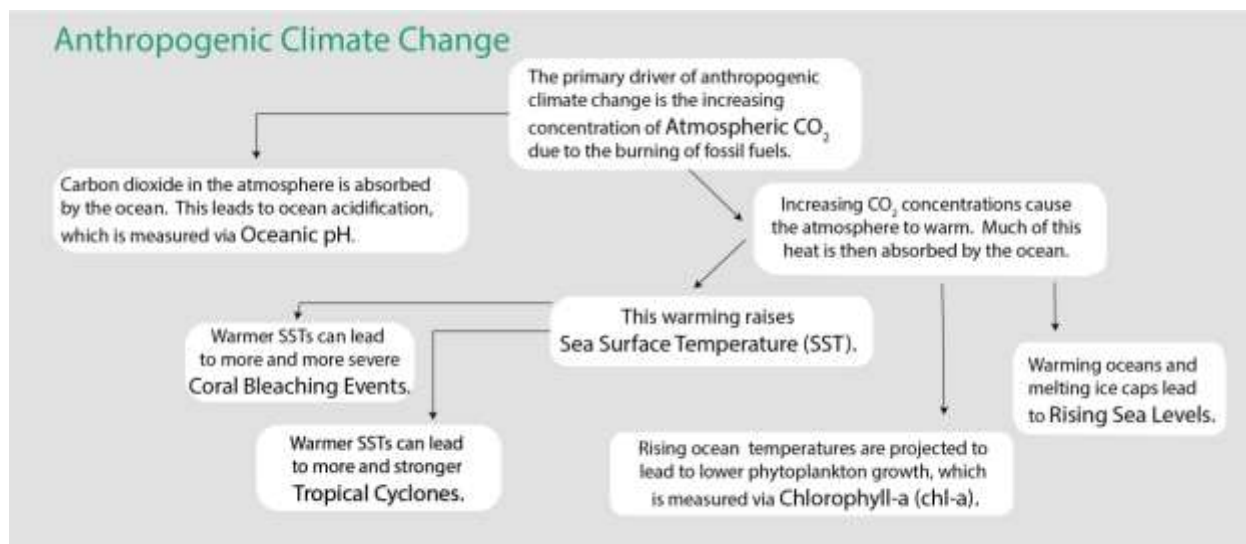


**Figure 16. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of anthropogenic climate change**

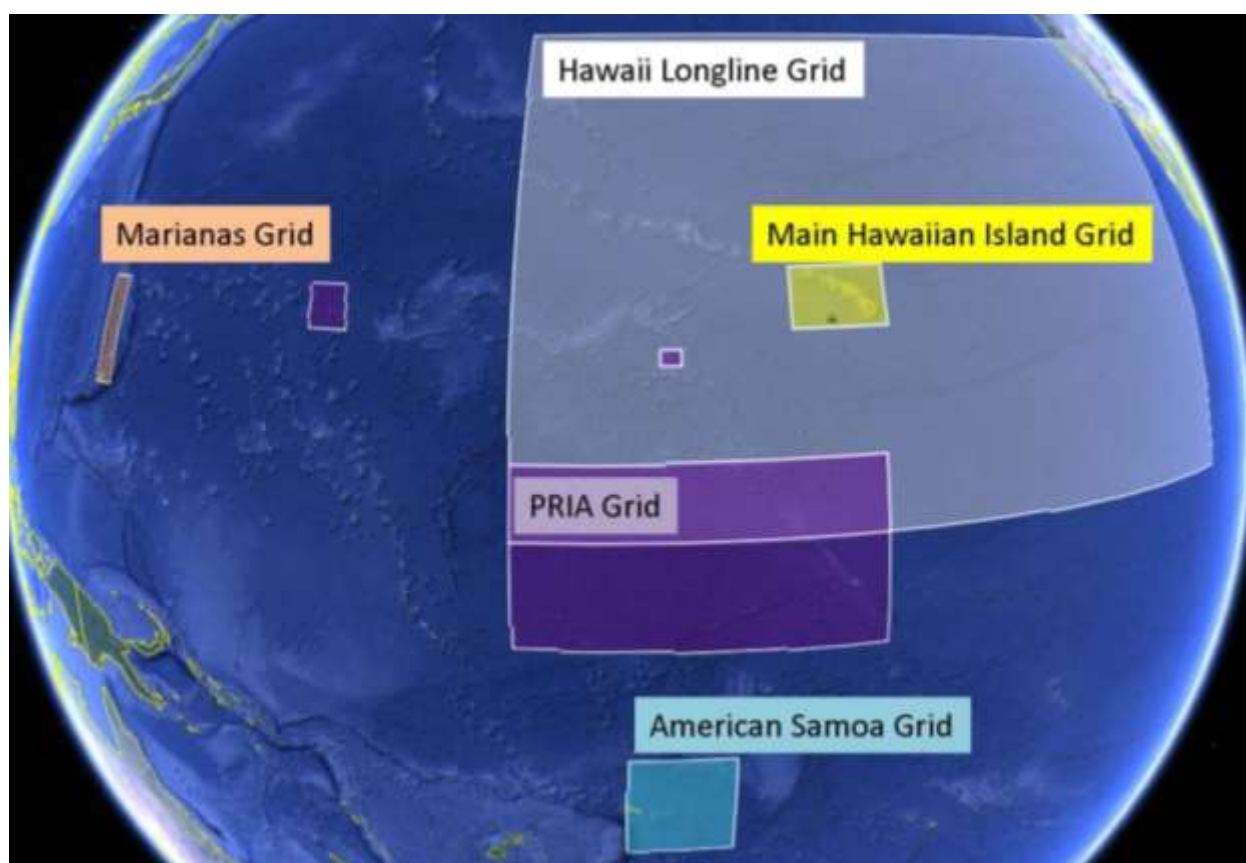


**Figure 17. Regional spatial grids representing the scale of the climate change indicators being monitored**

#### 2.7.4.1 Atmospheric Concentration of Carbon Dioxide at Mauna Loa

**Rationale:** Atmospheric carbon dioxide (CO<sub>2</sub>) 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<sub>2</sub> is increasing exponentially. This means that atmospheric CO<sub>2</sub> is increasing more quickly over time. In 2021, the annual mean concentration of CO<sub>2</sub> was 416 ppm. This is the highest annual value recorded. This year also saw the highest monthly value, which was 419 ppm. In 1959, the first year of the time series, the atmospheric concentration of CO<sub>2</sub> 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 parts per million (ppm) from March 1958 to present. The observed increase in monthly average carbon dioxide concentration is primarily due to CO<sub>2</sub> 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<sub>2</sub> is removed from the atmosphere. In the winter (outside the growing season), respiration exceeds photosynthesis, and CO<sub>2</sub> 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.

**Data available at:** <https://gml.noaa.gov/ccgg/trends/data.html>.

**Sourced from:** Keeling et al. (1976), Thoning et al. (1989), and NOAA (2022a).

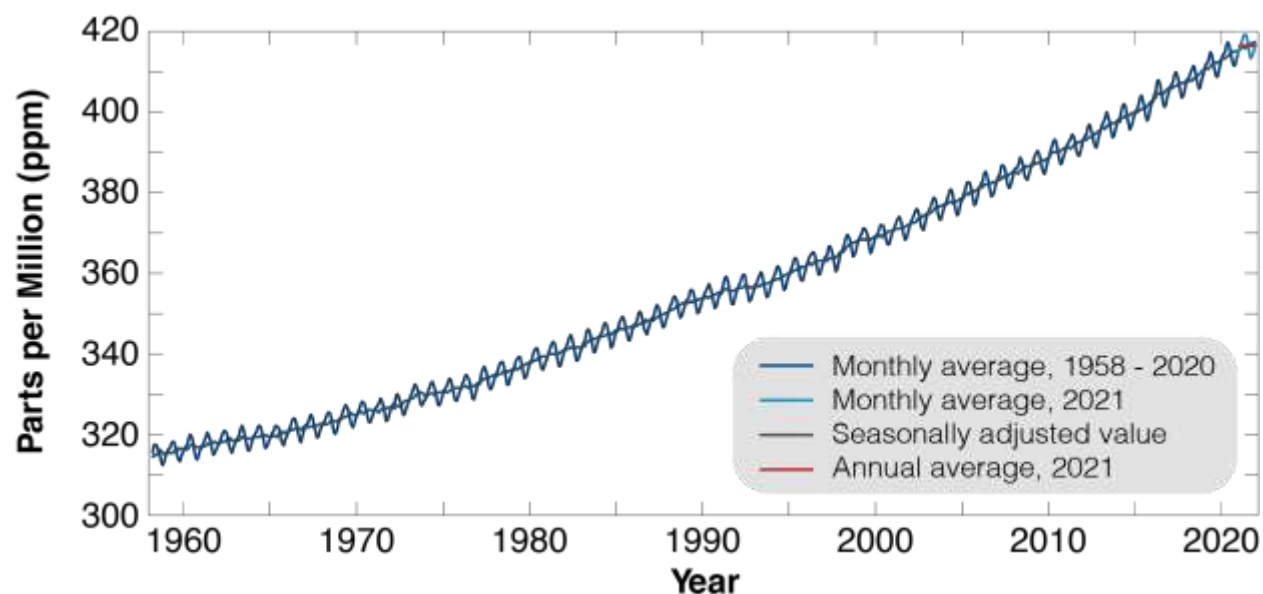


**Figure 18. Monthly mean (black) and seasonally corrected (blue) atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii**

#### 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 10.2% more acidic than it was 30 years ago at the start of this time series. Over this time, pH has declined by 0.042 at a constant rate. In 2020, the most recent year for which data are available, the average pH was 8.07. Additionally, small variations seen over the course of the year are outside the range seen in the first year of the time series for the fourth 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 (8.083).

**Description:** Trends in surface (5 m) pH at Station ALOHA, north of Oahu (22.75°N, 158°W), collected by the Hawai'i Ocean Time Series (HOT) from October 1988 to 2020 (2021 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<sub>2</sub> and the amount of CO<sub>2</sub> 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.

Data available at: <https://hahana.soest.hawaii.edu/hot/hot-dogs/bseries.html>.

Sourced from: Fabry et al. (2008), Feely et al. (2016), and the Hawai‘i Ocean Time Series as described in Karl and Lukas (1996) and on its website (HOT 2022) using the methodology provided by Zeebe and Wolf-Gladrow (2001).

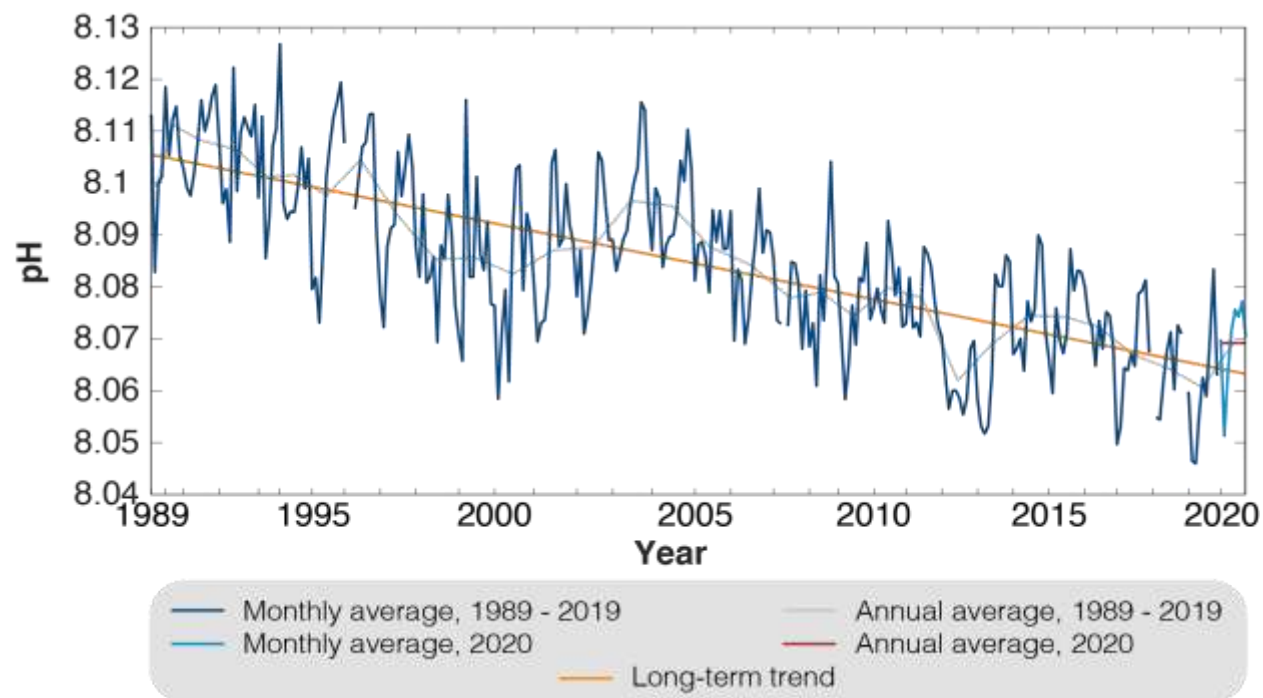


**Figure 19. Time series and long-term trend of oceanic pH measured at Station ALOHA from 1989-2020**

### 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 ONI focuses on ocean temperature, which has the most direct effect on these fisheries.

**Status:** The ONI indicated La Niña conditions for most of 2021, with two consecutive neutral seasons punctuating the year mid-year. In 2021, the ONI ranged from -1.1 to -0.4. This is within the range of values observed previously in the time series.

**Description:** The three-month running mean (referred to as a season) of satellite remotely-sensed sea surface temperature (SST) anomalies in the Niño 3.4 region (5°S – 5°N, 120° – 170°W). The Oceanic Niño Index (ONI) is a measure of the El Niño – Southern Oscillation (ENSO) phase. Warm and cool phases, termed El Niño and La Niña respectively, are based in part on an ONI threshold of  $\pm 0.5$  °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.

Data available at: <https://www.cpc.ncep.noaa.gov/data/indices/oni.ascii.txt>.

Sourced from NOAA CPC (2022).

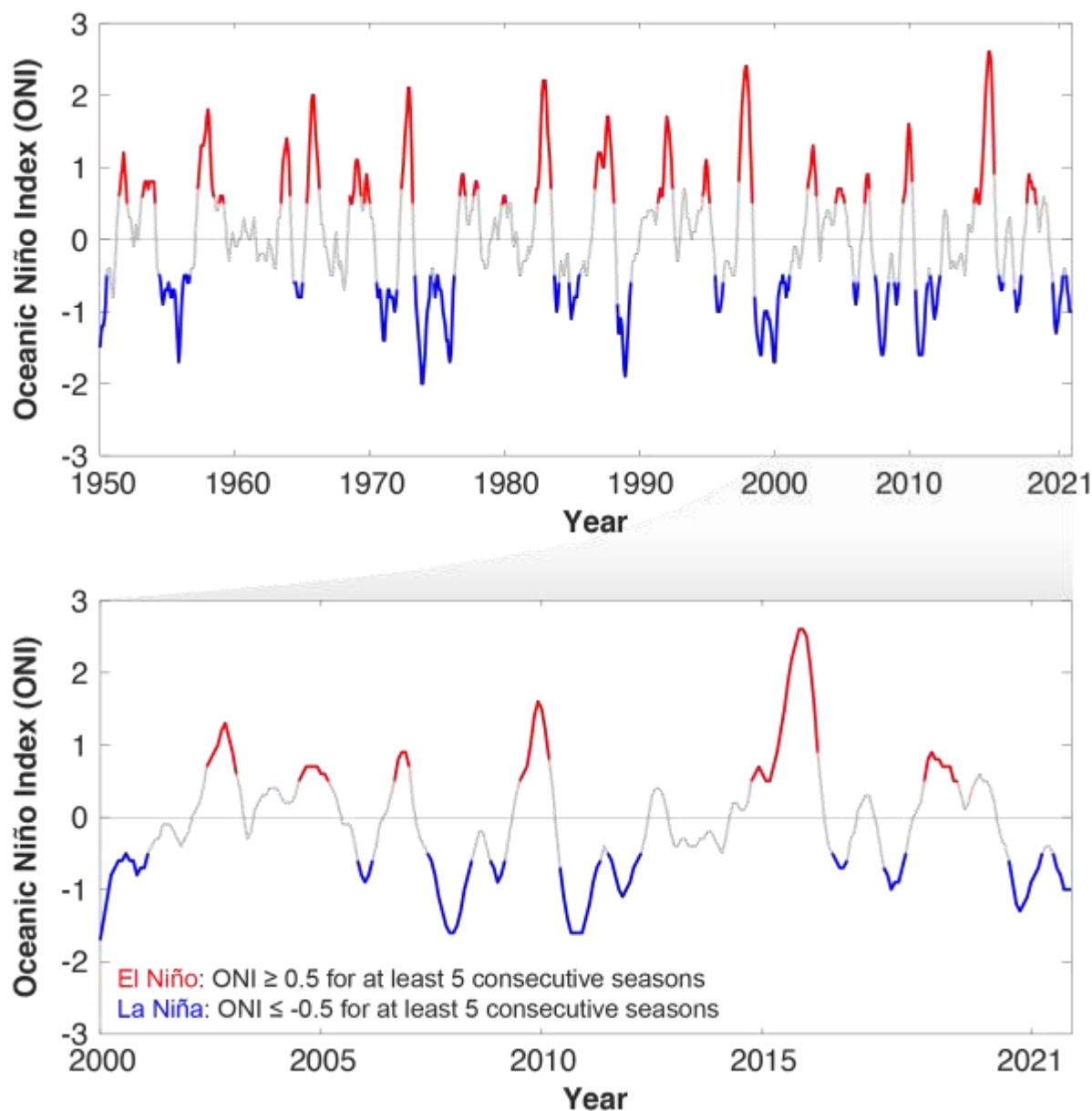


**Figure 20. Oceanic Niño Index from 1950-2021 (top) and 2000–2021 (bottom) with El Niño periods in red and La Niña periods in blue**

#### 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 was negative in 2021. The index ranged from -2.66 to -0.56 over the course of the year. This is within the range of values observed previously in the time series.

**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 [central] 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. Description inserted from NOAA (2021b).

**Timeframe:** Annual, monthly.

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

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

**Data available at:** <https://psl.noaa.gov/pdo/>.

**Sourced from:** NOAA (2022b), Mantua (1997), and Newman (2016).

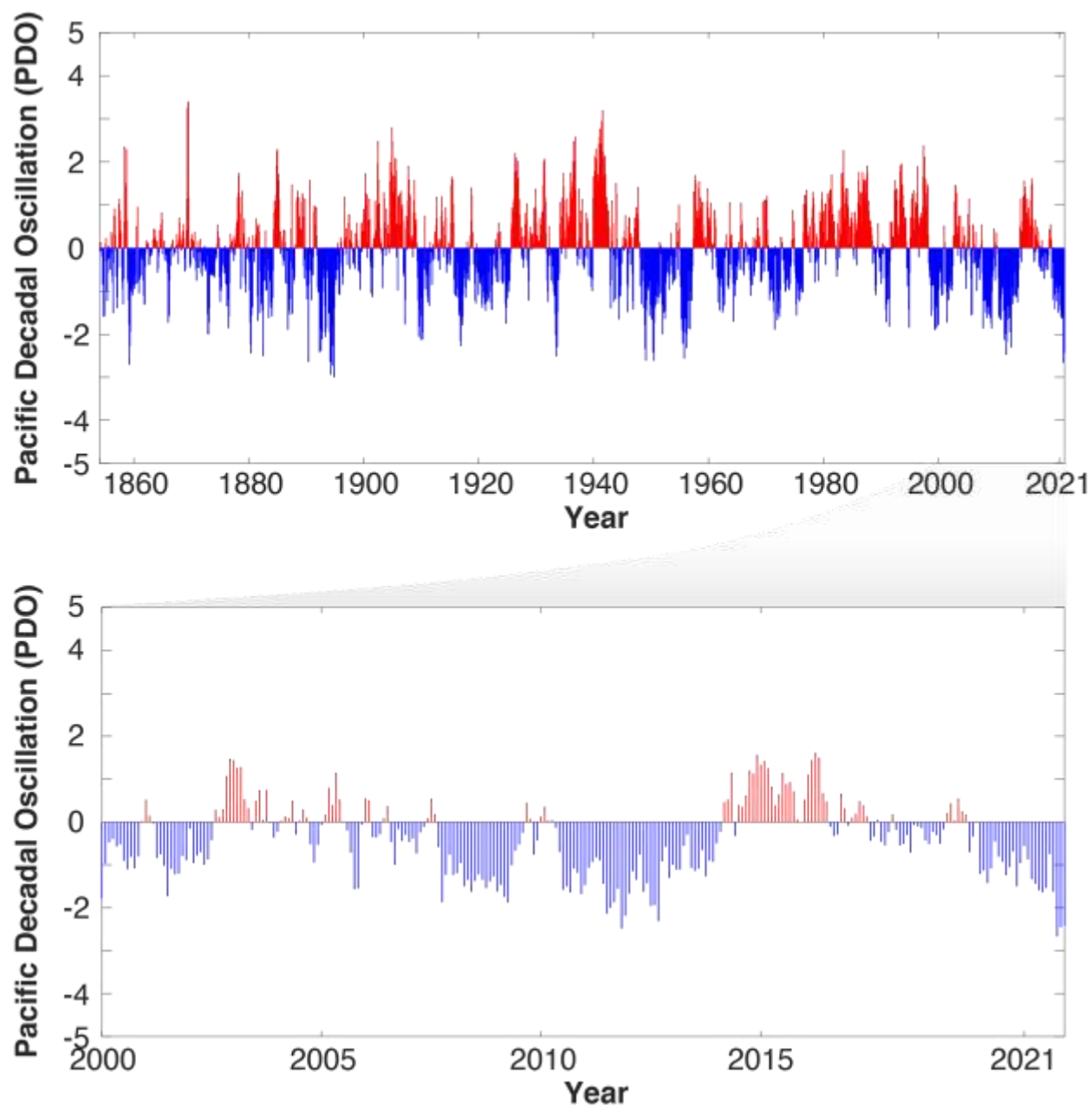


**Figure 21. Pacific Decadal Oscillation from 1950–2021 (top) and 2000–2021 (bottom) with positive warm periods in red and negative cool periods in blue**

#### 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 Hawai‘i longline fishery, for example, has had serious problems with vessels dodging storms at sea, delayed departures, and inability to make it safely back to Honolulu because of bad weather. When cyclones encounter land, their intense rains and high winds can cause severe property damage, loss of life, soil erosion, and flooding. Associated storm surge, the large volume of ocean water pushed toward shore by cyclones’ strong winds, can cause severe flooding and destruction.

**Status:**

*Eastern North Pacific.* In the East Pacific in 2021, the 19 named storms and eight hurricanes were both near normal. However, only two storms became major hurricanes, which is less than half of normal. The Accumulated Cyclone Energy (ACE) was also about 30% below the 1991–2020 average. The beginning and end of the hurricane season were noteworthy. The East Pacific had four named storms in June, which tied for the 4th most on record. The total of five for the year through June tied a record as well. Additionally, two tropical cyclones formed in November in the eastern Pacific basin. Based on a 30-year climatology (1991–2020), one named storm typically forms in November every second or third year. However, this is the fourth straight November with at least one named storm forming. In addition, both Sandra and Terry were tropical storms simultaneously, which is the first time this has occurred in the eastern Pacific in November.

Summary inserted from <https://www.ncdc.noaa.gov/sotc/tropical-cyclones/202113#summary>, <https://www.nhc.noaa.gov/text/MIATWSEP.shtml>, and <https://www.ncdc.noaa.gov/sotc/tropical-cyclones/202106>.

*Central North Pacific.* Tropical cyclone activity in the central Pacific in 2021 was below the 1991–2020 average. There was only one named storm, which did not reach hurricane status. However, the remnants of the Eastern Pacific’s Hurricane Linda caused heavy rainfall over the main Hawaiian Islands in August. On average (1991–2020), the central Pacific sees four named storms, two hurricanes, and one major hurricane. The 2021 ACE index was about two orders of magnitude, or roughly 100 times, below the 1991–2020 average. Information on Hurricane Linda inserted from <https://www.ncdc.noaa.gov/sotc/tropical-cyclones/202108>.

*Western North Pacific.* Tropical cyclone activity was below the 1991–2020 average in 2021. The 23 named storms in the West Pacific in 2021 was near normal (1991–2020), but the ten typhoons and five typhoons were both among the five lowest years since 1981. The ACE was also about 30% below the 1991–2020 average in the West Pacific. Portions of the summary inserted from <https://www.ncdc.noaa.gov/sotc/tropical-cyclones/202113#summary>

*South Pacific.* Tropical cyclone activity in the South Pacific was roughly average in 2021. The 10 named storms, 4 cyclones, and 2 major cyclones were very close to the 1991–2020 average of 9 named storms, 5 cyclones and 2 major cyclones. The 2021 ACE index was also close to the 1991–2020 average. Of note, the South Pacific produced two named storms in late January, including Tropical Cyclone Ana. Ana brought heavy rain and flooding to Fiji, which has been impacted by an unusual number of tropical cyclones in 2020–2021. Portions of the summary inserted from <https://www.ncdc.noaa.gov/sotc/tropical-cyclones/202101>

**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 Figure 22 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. Figure 166 shows the 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.

Data available at: <https://www.ncei.noaa.gov/data/international-best-track-archive-for-climate-stewardship-ibtracs/v04r00/access/csv>.

Sourced from: Knapp et al. (2010), Knapp et al. (2018), and NOAA (2022c).

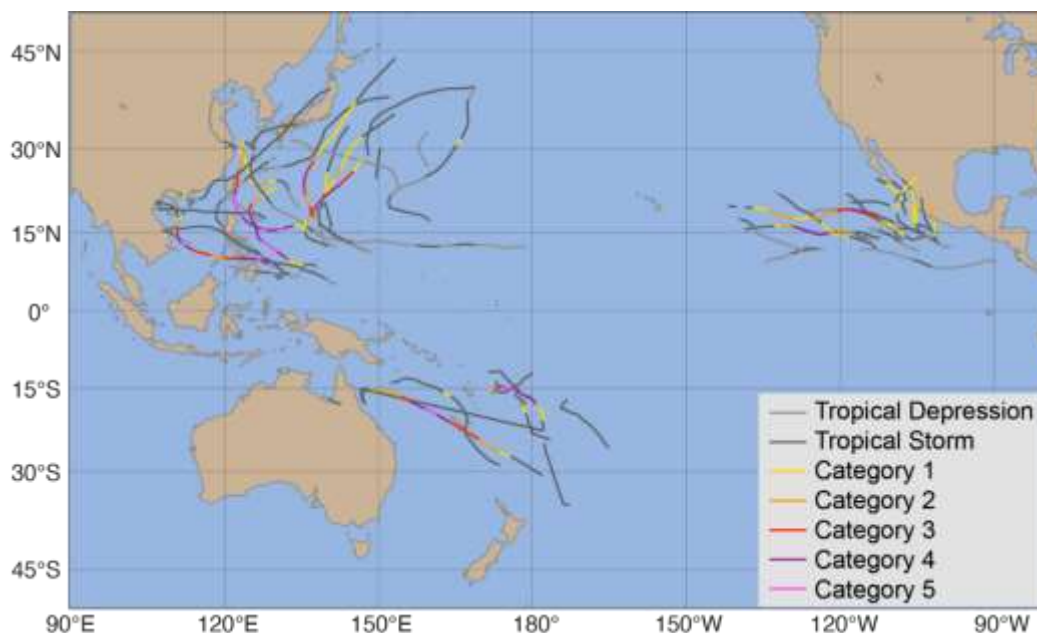


**Figure 22. 2021 Pacific basin tropical cyclone tracks**

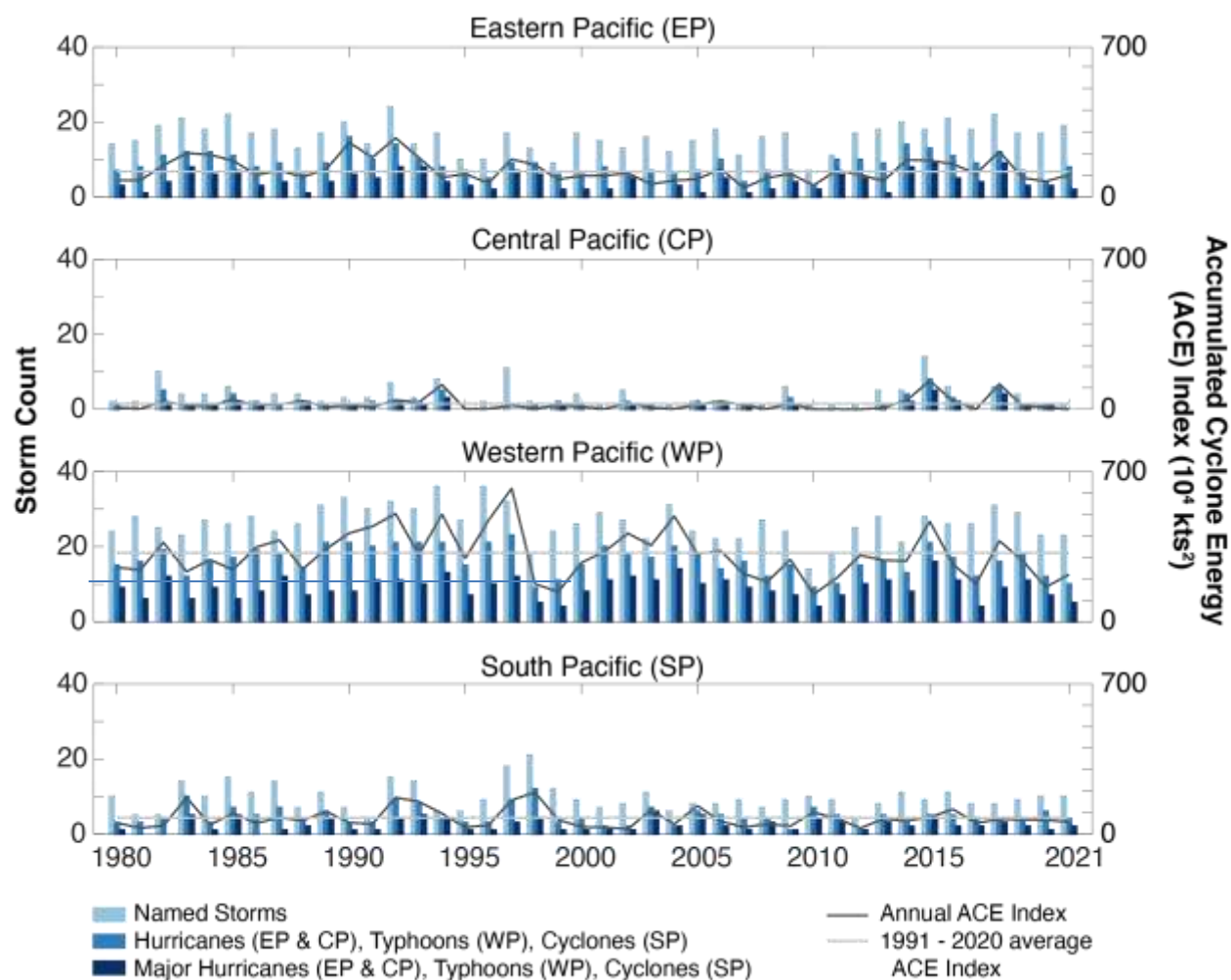


**Figure 23. 2021 tropical storm totals by region**

#### 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 El Niño – Southern Oscillation (ENSO) and is projected to rise as a result of anthropogenic climate change. Both short-term variability and long-term trends in SST impact the marine ecosystem. Understanding the mechanisms through which organisms are impacted and the time scales of these impacts is an area of active research.

**Status:** Annual mean SST was 25.67°C in 2021. Over the period of record, annual SST has increased at a rate of 0.0168 °C yr<sup>-1</sup>. Monthly SST values in 2021 ranged from 24.47 – 26.64 °C, outside the climatological range of 23.29 – 28.48 °C. The annual anomaly was 0.13 °C hotter than average, with some intensification in the northern part of the region, and a colder than usual area south-east of Hawaii Island.

Note that from the top to bottom in Figure 24, panels show climatological SST (1985-2020), 2021 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. Data from NOAA Coral Reef Watch CoralTemp v3.1 (NOAA 2022).

Timeframe: Monthly.

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

Measurement Platform: Satellite.

Sourced from: NOAA OceanWatch (2022a).

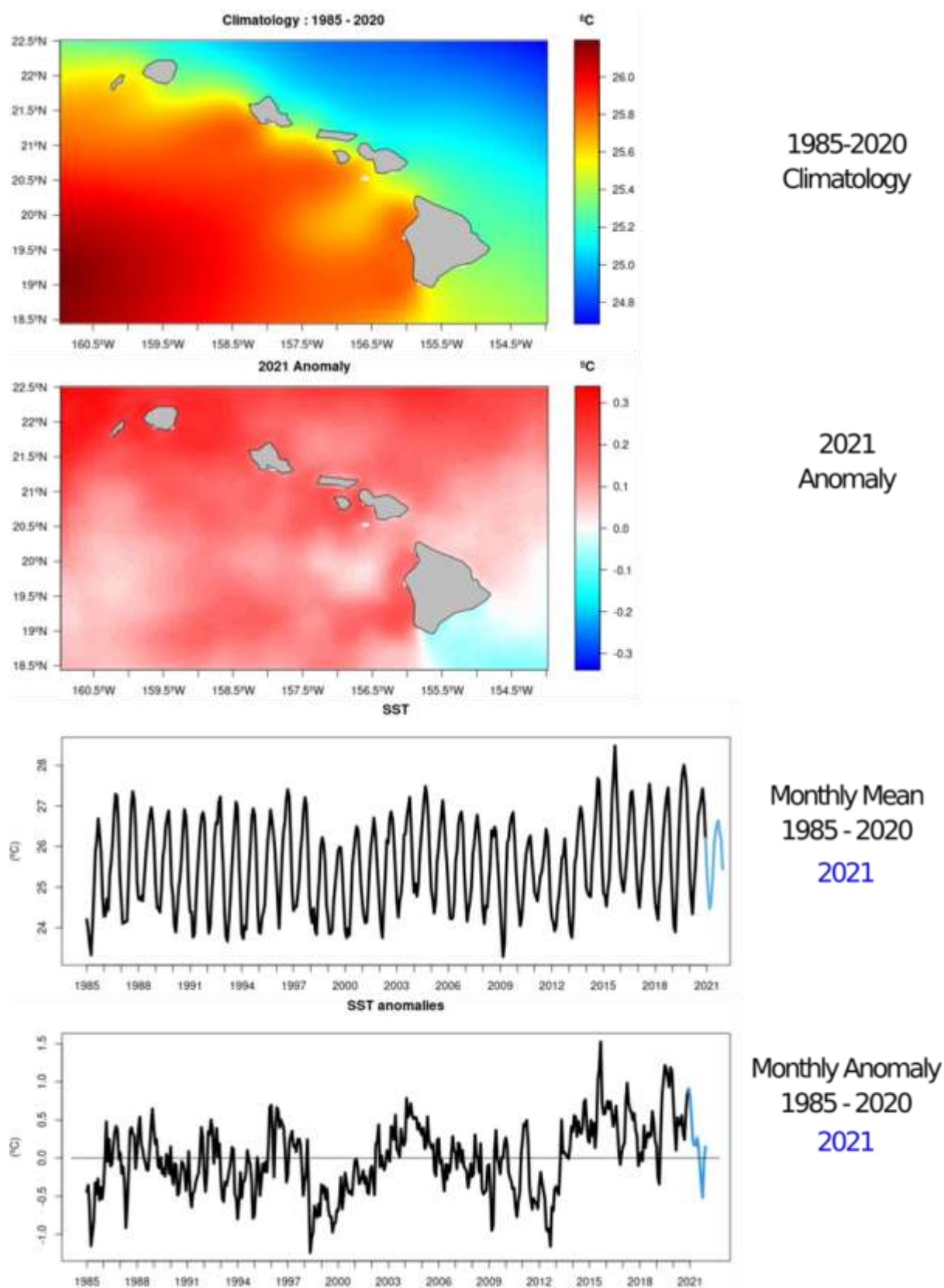


**Figure 24. Sea surface temperature climatology and anomalies from 1985-2021**

#### 2.7.4.7 Coral Thermal Stress Exposure: Degree Heating Weeks

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

Status: After a series of stress events in 2014, 2015, and 2019, the main Hawaiian Islands experienced no coral heat stress in 2021.

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

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

The NOAA Coral Reef Watch (CRW) daily 5-km satellite coral bleaching Degree Heating Week (DHW) product presented here shows accumulated heat stress, which can lead to coral bleaching and death. The scale goes from 0 to 20 °C-weeks. The DHW product accumulates the instantaneous bleaching heat stress (measured by Coral Bleaching HotSpots) during the most-recent 12-week period. It is directly related to the timing and intensity of coral bleaching. Significant coral bleaching usually occurs when DHW values reach 4 °C-weeks. By the time DHW values reach 8 °C-weeks, widespread bleaching is likely and significant mortality can be expected (NOAA Coral Reef Watch 2022).

Timeframe: 2014-2021, Daily data.

Region/Location: Global.

Sourced from: NOAA Coral Reef Watch (2022).

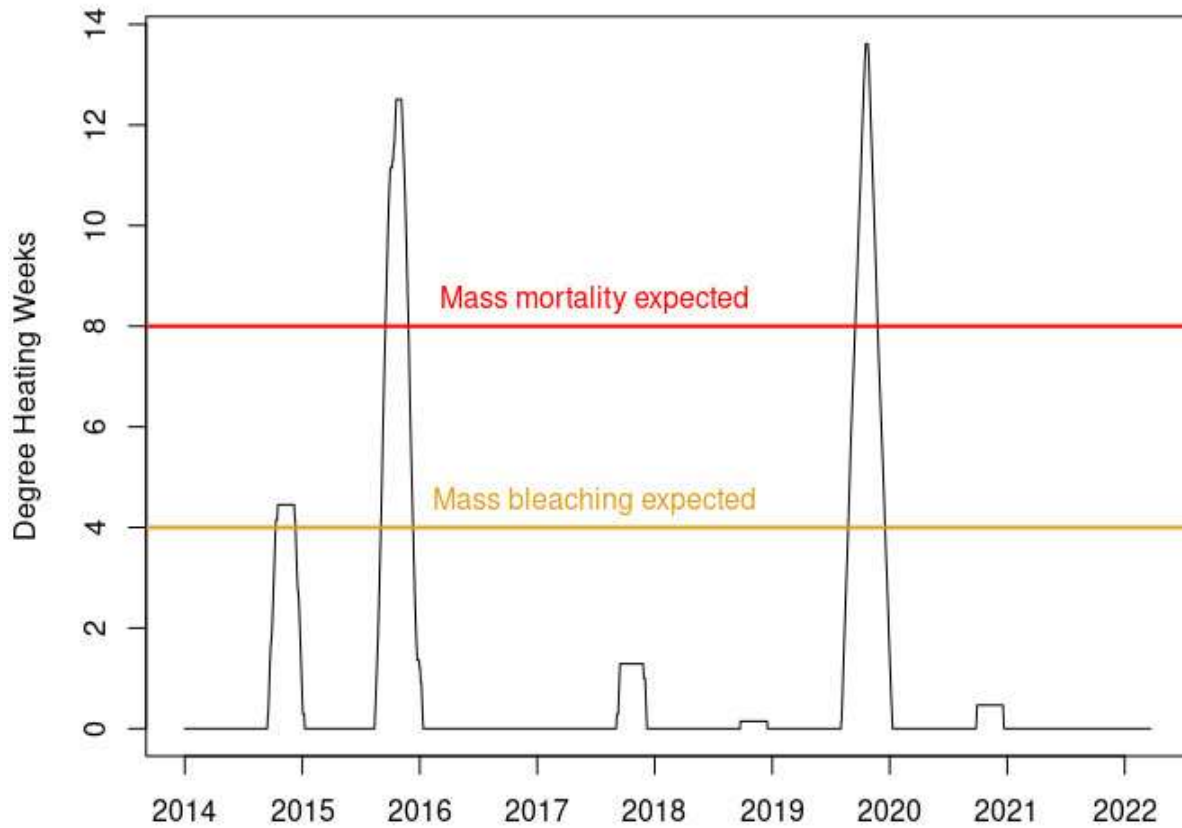


**Figure 25. Coral Thermal Stress Exposure, Main Hawaiian Island Virtual Station from 2014-2021, measured in Coral Reef Watch Degree Heating Weeks**

**2.7.4.8 Chlorophyll-A and Anomaly**

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

Status: Annual mean Chl-A was 0.084 mg/m<sup>3</sup> in 2020. Over the period of record, annual Chl-A has shown no significant temporal trend. Monthly Chl-A values in 2021 ranged from 0.069-0.10 mg/m<sup>3</sup>, within the climatological range of 0.057 – 0.121 mg/m<sup>3</sup>. The annual anomaly was 0.0049 mg/m<sup>3</sup> higher than average.

Description: Chlorophyll-A Concentration from 1998-2021, derived from the ESA Ocean Color Climate Change Initiative dataset, v5.0. A monthly climatology was generated across the entire period (1998-2020) to provide both a 2021 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: 1998-2021, Daily data available, Monthly means shown.

Region/Location: Global.

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

Sourced from: NOAA OceanWatch (2022b).

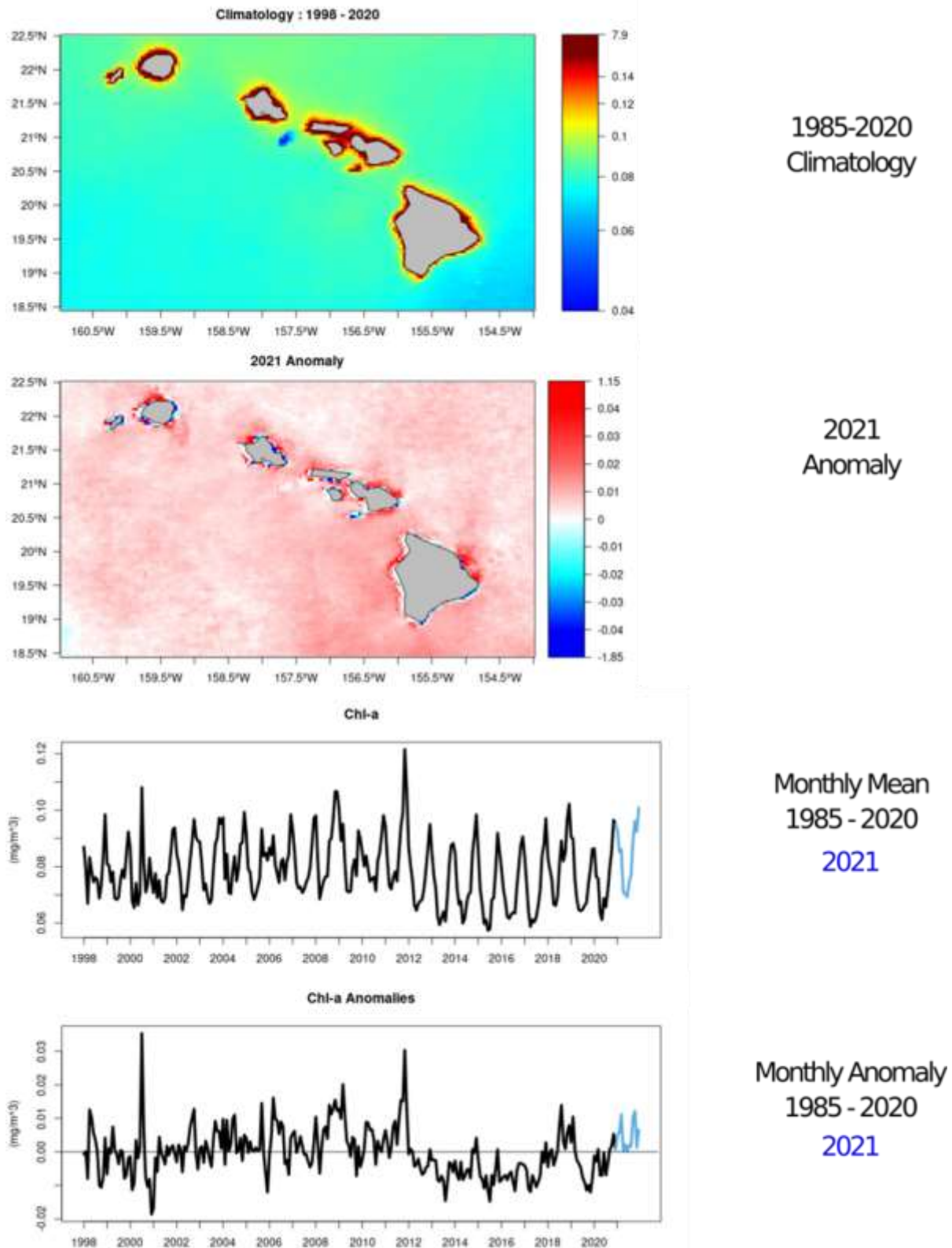


Figure 26. Chlorophyll-a (Chl-A) and Chl-A Anomaly from 1998-2021

#### 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 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 are provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their website at <https://www.esrl.noaa.gov/psd/>. The data are comparable (but should not be confused with) similarly combined analyses by the Global Precipitation Climatology Project described in Huffman et al. (1997).

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

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

Timeframe: Monthly.

Region/Location: Global.

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

Sourced from: APDRC (2022).

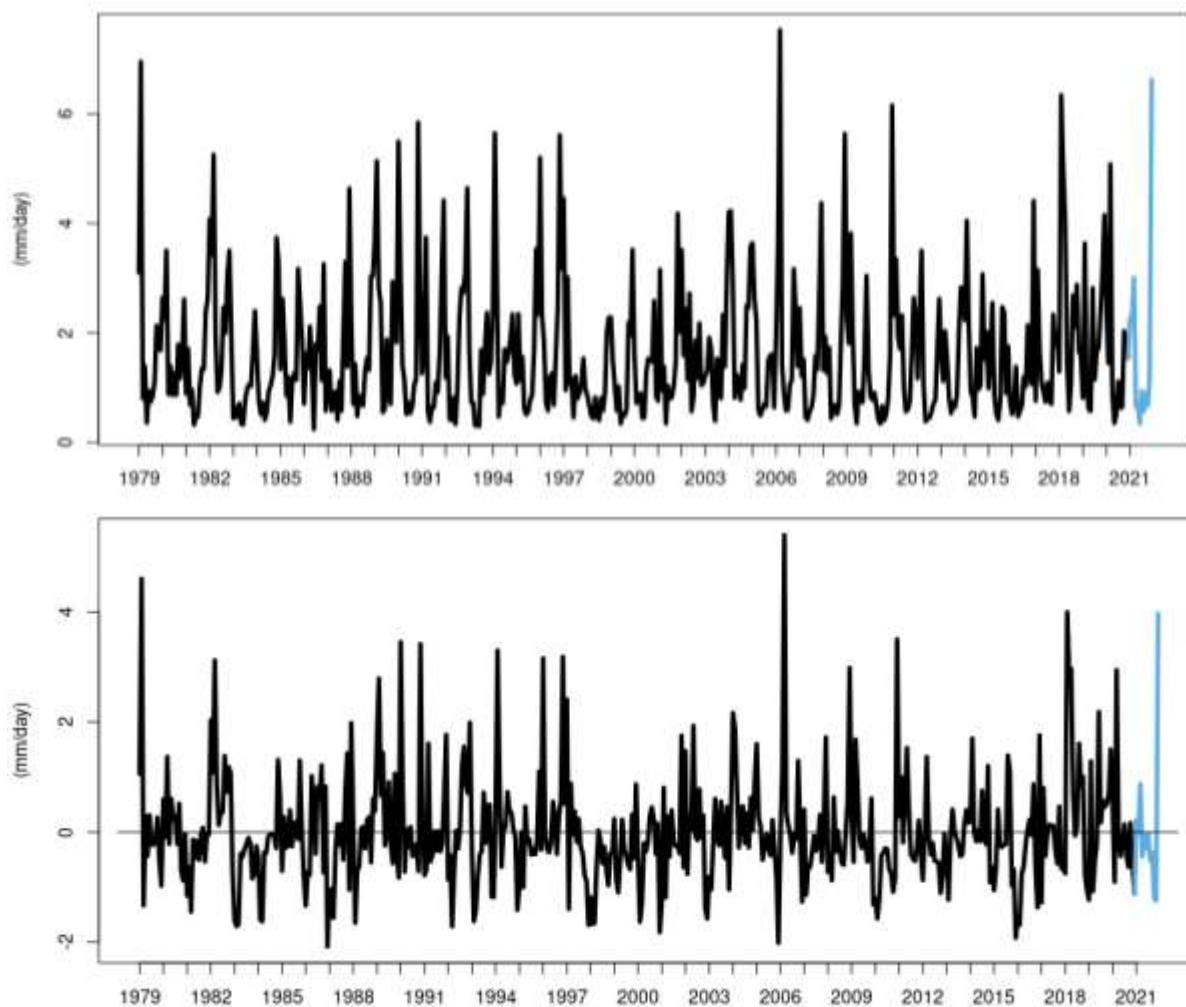


**Figure 27. CMAP precipitation (top) and anomaly (bottom) across the MHI Grid with 2021 values in blue**

#### 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 (2022), NOAA CoastWatch (2022), and NOAA (2022e).

##### 2.7.4.10.1 Basin-Wide Perspective

This image of the mean sea level anomaly for March 2021 compared to 1993–2016 climatology from satellite altimetry provides a glimpse into the 2021 weak La Niña conditions across the Pacific Basin. The image captures the fact that sea level is higher in the Western Pacific and lower 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).

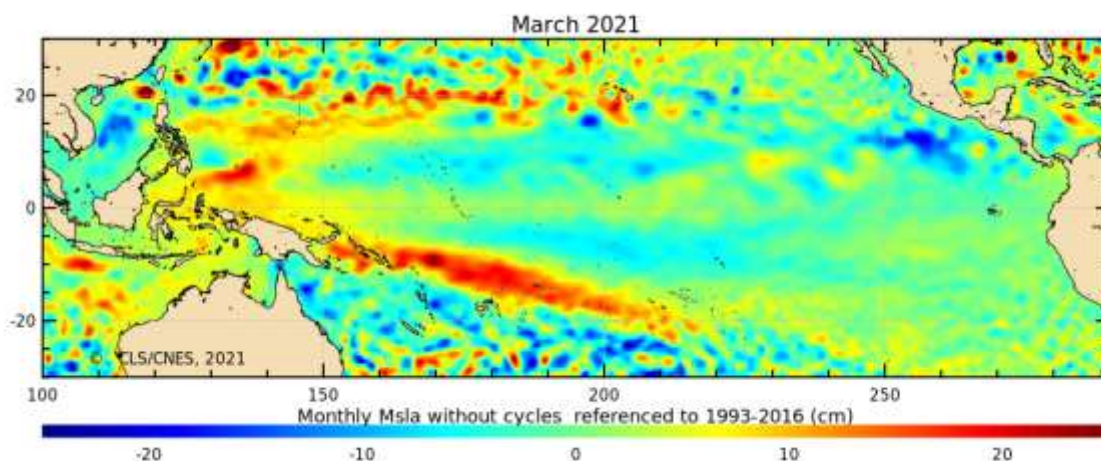


**Figure 28a. Sea surface height anomaly**

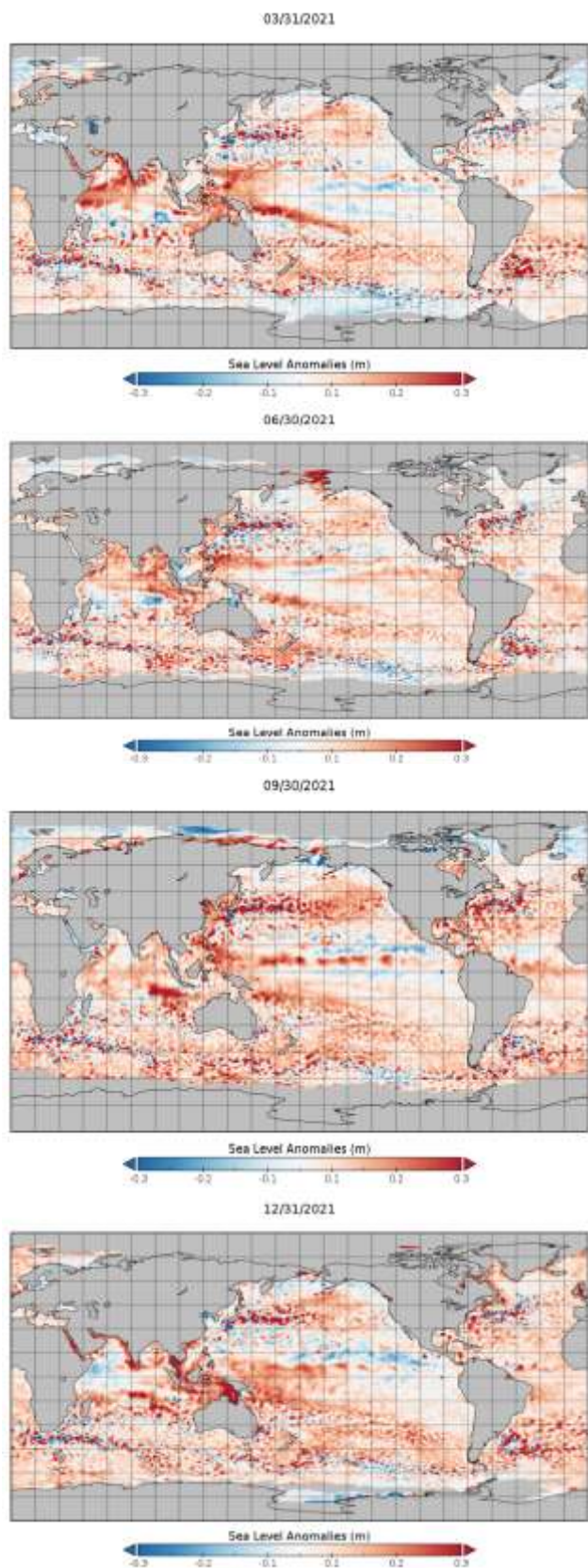


**Figure 28b. Quarterly time series of mean sea level anomalies during 2021.**

Altimetry data are provided by the NOAA Laboratory for Satellite Altimetry, accessed from NOAA CoastWatch (2022).

#### 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 29 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  $\pm 0.21$  mm/yr based on monthly mean sea level data from 1905 to 2021 which is equivalent to a change of 0.51 feet in 100 years.

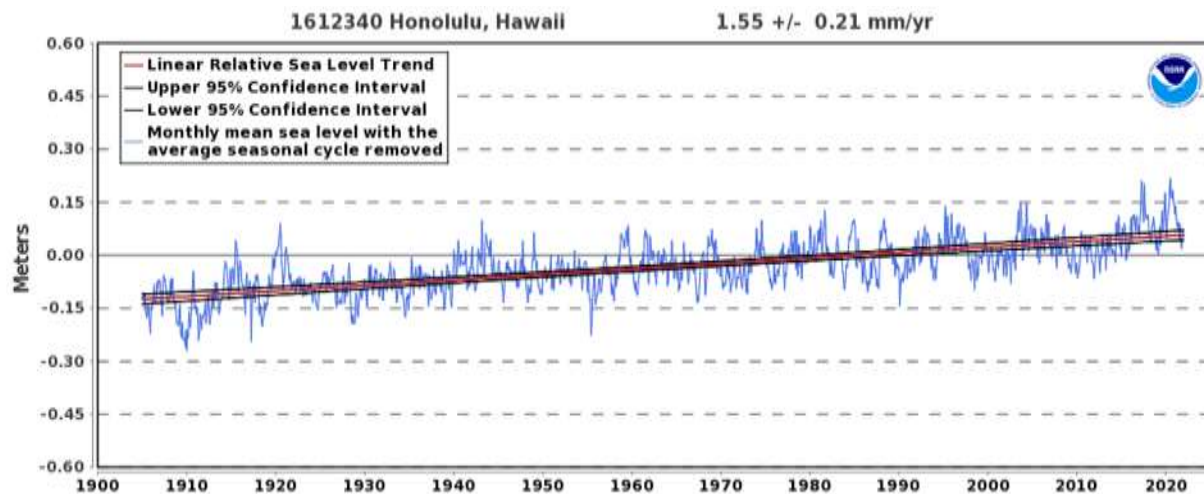


**Figure 29. Monthly mean sea level without regular seasonal variability due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents**

## **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 172<sup>nd</sup> 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 173<sup>rd</sup> 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 174<sup>th</sup> 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 178<sup>th</sup> 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 181<sup>st</sup> 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. The action will be reinitiated in 2022.

At its 182<sup>nd</sup> 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.

At its 187<sup>th</sup> meeting in September 2021, the Council recommended that the Chair recommend at the October 2021 CCC meeting that NMFS work with the Council to review EFH guidance in terms of how that guidance requiring the Council to identify and describe how EFH has been applied in the Western Pacific Region.

## **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 (see Figure 30). The coral reef ecosystems surrounding the islands in the MHI and NWHI have 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 was replaced by the Coral Reef Ecosystem Program (CREP) within the PIFSC Ecosystem Sciences Division (ESD) before being shifted to the Archipelagic Research Program (ARP).

No new data were collected in 2021 to inform updates of habitat use by MUS or trends in habitat condition. However, derived habitat requirements for larval uku (*Aprion virescens*) were developed to inform statistical species distribution models (SDMs). PIFSC staff analyzed spatiotemporal patterns of uku, a shallow water MUS, from 2010–2019 to explore spatially explicit changes in abundance and distributions and to identify the underlying drivers. The localized density (individuals per 100 square meters) and the center of gravity of the species' distribution in the shallow MHI waters (0–30 m) were estimated with a spatiotemporal generalized linear mixed model that accounts for spatial autocorrelation between spatially-referenced observations and effects of potential environmental drivers (i.e., oceanographic conditions). Changes in *A. virescens* densities were best explained by the combination of static and dynamic surface oceanographic conditions (i.e., density, and surface wind variability, respectively). The conventional model selection indicates that common oceanographic variables such as chlorophyll-a concentration and SST were less useful or unrelated. High variability in the geographic center of gravity of uku within the study region was observed between Oahu and Molokai. The observed shift over time in the center of gravity is not reflective of a uniform shift in densities but localized changes in density around some islands (i.e., Maui and Hawaii). Overall, these findings indicate that considering static variables (i.e., depth) alone is insufficient in projecting spatiotemporal patterns of highly mobile species in this region, and a model that can estimate local trends with spatiotemporal models improved the interpretation of changes to species distribution.

In addition to the EFH modeling work on uku conducted by PIFSC in 2021, the Council supported a similar EFH modeling project for the species (Franklin 2021). Fishery-independent data was applied to boosted regression tree models (i.e., a type of SDM) to define the geographic extent of EFH for sub-adult and adult life stages of uku in the MHI. Separate SDMs were constructed for shallow waters (0–30 m) and deep waters (30–300 m) using NOAA diver survey data and NOAA and University of Hawaii baited stereo-video camera arrays, respectively. For the shallow-water models, the direction that the habitat slope faces, depth, and wave height were strong predictors of uku occurrence. For the deep-water model, depth was the predominant habitat variable. Franklin (2021) also developed maps delineating and categorizing uku EFH based on predicted occurrence. Ultimately, over half of derived uku EFH was classified as “basic EFH”, with “hot spots” and “core EFH” representing anywhere from 0 to 2.4%.

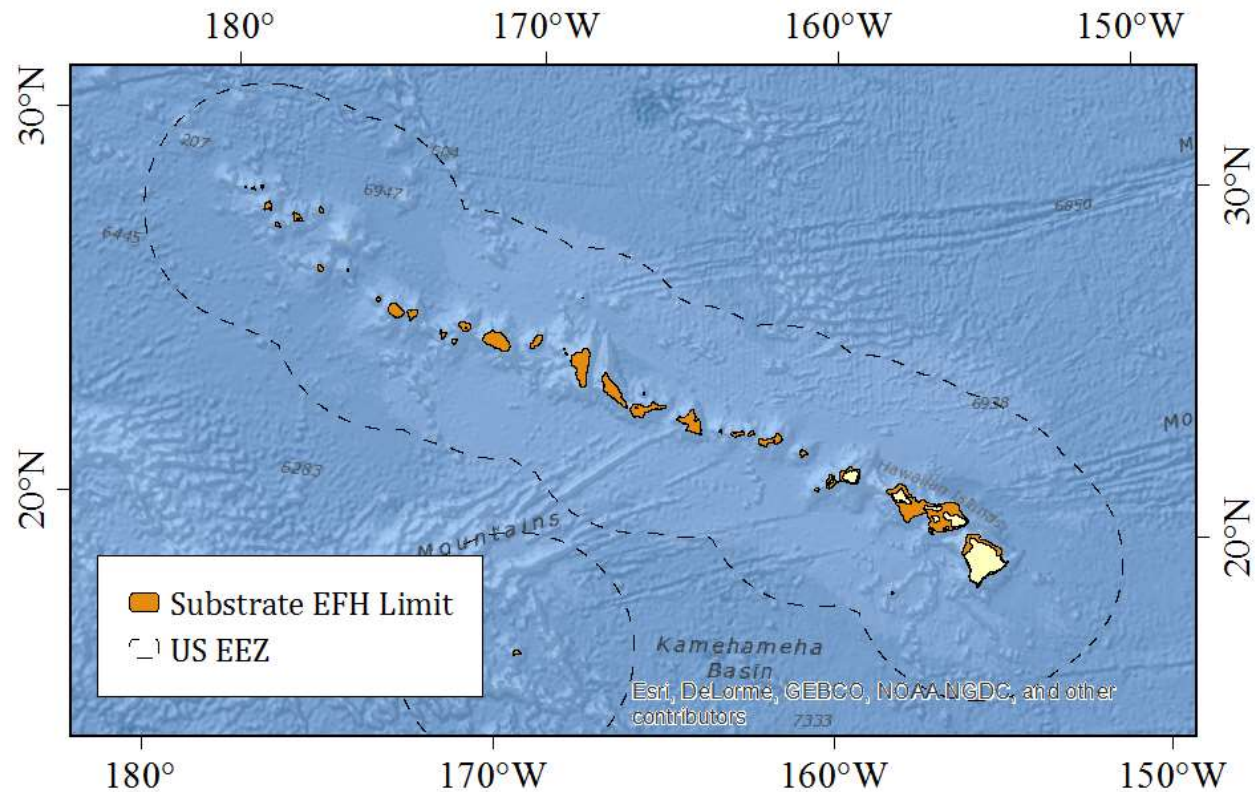


**Figure 30. Substrate EFH limit of 700 m isobath around the Hawaiian Archipelago (from GMRT; Ryan et al. 2009)**

### 2.8.2.1 Habitat Mapping

No new habitat mapping was conducted in 2021.

### 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). No RAMP field work was conducted in Hawaii in 2021.

### 2.8.2.3 Oceanography, Water Quality, and Other Environmental Data

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. While no substantial field research data

efforts occurred in 2021, satellite and buoy data are continuously collected and archived. PIFSC staff recently developed an advanced data compilation tool, the Environmental Data Summary (EDS), that gives users a simple, consistent way to enhance existing *in situ* observations with external gridded environmental data. The EDS is written in R and provides users an interface to NOAA CoastWatch and OceanWatch datasets through the ERDDAP server protocol. The EDS allows users to download, filter, and/or extract large amounts of gridded and tabular data given user-defined time stamps and geographical coordinates. The various external environmental data summarized at individual survey sites can aid scientists in assessing and understanding how environmental variabilities impact living marine resources. The EDS outputs were summarized at the National Coral Reef Monitoring Program (NCRMP) Rapid Ecological Assessment (REA) site level from 2000 to 2020 across 57 islands covered by the survey. PIFSC is planning to expand the utility of EDS with a broader range of gridded NOAA CoastWatch and OceanWatch data products (e.g., wave, wind) at finer spatiotemporal scales (e.g., water columns). Target data content includes spatial data (e.g., remote sensing), modeled data (e.g., Regional Ocean Modeling Systems), and socioeconomic data, including human density.

### 2.8.3 Report on Review of EFH Information

There were no EFH reviews for Hawaii completed in 2021. 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 (WPRFMC 2020a, WPRFMC 2020b). 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

No new data relevant to precious coral EFH were collected in 2021, but the Council is currently in the process of defining new EFH for precious coral MUS (see Section 2.8.1.3). 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 59.

**Table 59. Level of EFH available for Hawaii precious corals MUS**

| Species                                                               | Pelagic Phase<br>(Larval Stage) | Benthic<br>Phase | Source(s)                                   |
|-----------------------------------------------------------------------|---------------------------------|------------------|---------------------------------------------|
| <b>Pink Coral (<i>Corallium</i>)</b>                                  |                                 |                  |                                             |
| <i>Pleurocorallium secundum</i><br>(prev. <i>Corallium secundum</i> ) | 0                               | 1                | Figuerroa and Baco (2014);<br>HURL Database |
| <i>Hemicorallium laauense</i><br>(prev. <i>C. laauense</i> )          | 0                               | 1                | HURL Database                               |
| <b>Gold Coral</b>                                                     |                                 |                  |                                             |
| <i>Kulamanamana haumea</i><br>(prev. <i>Gerardia</i> spp.)            | 0                               | 1                | Sinniger et al. (2013);<br>HURL Database    |
| <b>Bamboo Coral</b>                                                   |                                 |                  |                                             |
| <i>Acanella</i> spp.                                                  | 0                               | 1                | HURL Database                               |
| <b>Black Coral</b>                                                    |                                 |                  |                                             |
| <i>Antipathes griggi</i> (prev.<br><i>Antipathes dichotoma</i> )      | 0                               | 1                | Opresko (2009); HURL<br>Database            |
| <i>A. grandis</i>                                                     | 0                               | 1                | HURL Database                               |
| <i>Myriopathes ulex</i> (prev. <i>A.</i><br><i>ulex</i> )             | 0                               | 1                | Opresko (2009); HURL<br>Database            |

#### 2.8.4.2 Bottomfish and Seamount Groundfish

No new data relevant to bottomfish or seamount groundfish EFH were collected in 2021. 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). The levels of information presented in Table 60 have not changed. To analyze the potential effects of a proposed fishery management action on EFH, one must consider all designated EFH, but research examining depth and habitat requirements for most species is generally lacking (PIFSC 2021). However, observations from baited cameras in the MHI (limited to 300 m depth) found that *Etelis* spp. are more abundant at 210–300 m and *Pristipomoides* spp. are more abundant at 90–270 m depth (Merritt et al. 2011; Misa et al. 2013). PIFSC (2021) concluded that evidence suggests that *Lethrinidae* spp. peak distribution is shallower than *Pristipomoides* spp., which is shallower than *Etelis* spp., but there is overlap between these groups.

**Table 60. Level of EFH information available for Hawaii bottomfish and seamount groundfish MUS**

| Life History Stage                                 | Eggs | Larvae | Juvenile | Adult |
|----------------------------------------------------|------|--------|----------|-------|
| <i>Aphareus rutilans</i> (red snapper/silvermouth) | 0    | 0      | 0        | 1     |

| Life History Stage                                | Eggs | Larvae | Juvenile | Adult |
|---------------------------------------------------|------|--------|----------|-------|
| <i>Aprion virescens</i> (gray snapper/jobfish)    | 0    | 0      | 1        | 1     |
| <i>Epinephelus quernus</i> (sea bass)             | 0    | 0      | 1        | 1     |
| <i>Etelis carbunculus</i> (red snapper)           | 0    | 0      | 1        | 1     |
| <i>E. coruscans</i> (red snapper)                 | 0    | 0      | 1        | 1     |
| <i>Pristipomoides filamentosus</i> (pink snapper) | 0    | 0      | 1        | 1     |
| <i>P. sieboldii</i> (pink snapper)                | 0    | 0      | 1        | 1     |
| <i>P. zonatus</i> (snapper)                       | 0    | 0      | 0        | 1     |
| <i>Beryx splendens</i> (alfonsin)                 | 0    | 1      | 2        | 2     |
| <i>Hyperoglyphe japonica</i> (ratfish/butterfish) | 0    | 0      | 0        | 1     |
| <i>Pseudopentaceros richardsoni</i> (armorhead)   | 0    | 1      | 1        | 3     |

#### 2.8.4.3 Crustaceans

No new data relevant to crustacean EFH were collected in 2021. 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 61. Level of EFH information available for Hawaii Kona crab**

| Life History Stage                 | Eggs | Larvae | Juvenile | Adult |
|------------------------------------|------|--------|----------|-------|
| Kona crab ( <i>Ranina ranina</i> ) | 1    | 0      | 1        | 1-2   |

**Table 62. EFH and HAPC for Hawaii MUS**

| MUS                                       | Species Complex                                                         | EFH                                                                                                                                                                                                                                                                             | HAPC                                                         |
|-------------------------------------------|-------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|
| <b>Bottomfish and Seamount Groundfish</b> | <b>Shallow-water species (0–50 fm):</b> uku ( <i>Aprion virescens</i> ) | <p><b>Eggs and larvae:</b> the water column extending from the shoreline to the outer limit of the EEZ down to a depth of 400 m (200 fm).</p> <p><b>Juvenile/adults:</b> the water column and all bottom habitat extending from the shoreline to a depth of 400 m (200 fm).</p> | All slopes and escarpments between 40–280 m (20 and 140 fm). |

| MUS                | Species Complex                                                                                                                                                                                                                                                                                          | EFH                                                                                                                                                                                                                                                                                                            | HAPC                                                                                                                                                    |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
|                    | <b>Deep-water species (50–200 fm):</b> ehu ( <i>Etelis carbunculus</i> ), onaga ( <i>E. coruscans</i> ), ‘ōpakapaka ( <i>Pristipomoides filamentosus</i> ), kalekale ( <i>P. sieboldii</i> ), gindai ( <i>P. zonatus</i> ), hapu‘upu‘u ( <i>Epinephelus quernus</i> ), lehi ( <i>Aphareus rutilans</i> ) | <b>Eggs and larvae:</b> the water column extending from the shoreline to the outer limit of the EEZ down to a depth of 400 m (200 fathoms).<br><br><b>Juvenile/adults:</b> 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).<br><br>Three known areas of juvenile ‘ōpakapaka habitat: two off Oahu and one off Molokai. |
|                    | <b>Seamount groundfish species (50–200 fm):</b> armorhead ( <i>Pentaceros wheeleri</i> ), ratfish/butterfish ( <i>Hyperoglyphe japonica</i> ), alfonsin ( <i>Beryx splendens</i> )                                                                                                                       | <b>Eggs and larvae:</b> the (epipelagic zone) water column down to a depth of 200 m (100 fm) of all EEZ waters bounded by latitude 29°–35°.<br><br><b>Juvenile/adults:</b> 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.                                                                                                             |
| <b>Crustaceans</b> | Kona crab ( <i>Ranina ranina</i> )                                                                                                                                                                                                                                                                       | <b>Eggs and larvae:</b> the water column from the shoreline to the outer limit of the EEZ down to a depth of 150 m (75 fm).<br><br><b>Juvenile/adults:</b> 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.                                                            |

| MUS             | Species Complex                                                                                                                                                                                                                                                                                                                                                                                             | EFH                                                                                                                                                                                                                                                                                                                                                                        | HAPC                                                                                                                                     |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
|                 | Deepwater shrimp<br>( <i>Heterocarpus</i> spp.)                                                                                                                                                                                                                                                                                                                                                             | <p><b>Eggs and larvae:</b> the water column and associated outer reef slopes between 550 and 700 m.</p> <p><b>Juvenile/adults:</b> the outer reef slopes at depths between 300-700 m.</p>                                                                                                                                                                                  | No HAPC designated for deepwater shrimp.                                                                                                 |
| Precious Corals | <p><b>Deep-water precious corals (150–750 fm):</b> Pink coral (<i>Pleurocorallium secundum</i>), red coral (<i>Hemicorallium laauense</i>), gold coral (<i>Kulamanamana haumea</i>), bamboo coral (<i>Acanella</i> spp.)</p> <p><b>Shallow-water precious corals (10-50 fm):</b> Black coral (<i>Antipathes griggi</i>), black coral (<i>Antipathes grandis</i>), black coral (<i>Myriopathes ulex</i>)</p> | <p>EFH for precious corals is confined to six known precious coral beds located off Keāhole Point, Makapu‘u, Ka‘ena Point, Wespac bed, Brooks Bank, and 180 Fathom Bank.</p> <p>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 ‘Au‘au Channel, and the southern border of Kauai.</p> | <p>Includes the Makapu‘u bed, Wespac bed, Brooks Banks bed.</p> <p>For black corals, the ‘Au‘au Channel has been identified as HAPC.</p> |

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. This work is ongoing.

### 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. This work is ongoing.

### 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. Though hampered by the COVID restrictions, this work has continued and results should be finalized in 2022.

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 PIFSC 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. Additionally, a report stemming from the collaboration between the Council and researchers at the University of Hawaii was recently released (Franklin 2021).

#### **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. This work was interrupted by the COVID-19 pandemic but is ongoing.

#### **2.8.5.5 Bottomfish fishery independent surveys (BFISH)**

Annual bottomfish surveys were successfully conducted in 2021 despite the COVID-19 pandemic. 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. The 2021 BFISH effort expanded from 500 to 750 survey grids to investigate optimal sampling intensity with respect to specific precision targets. The 2021 survey effort also expanded detailed temperature/depth sampling by incorporating temperature/depth recorders on hook-and-line sampling gear in addition to previously instrumented camera gear. 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). A quarterly report on this monitoring can be found at Ault and Smith (2020). In 2022, additional efforts will focus on refined species-distribution modeling for Hawaii Deep-7 bottomfish species.

### **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 Marianas 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 165<sup>th</sup> 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 63 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 31.

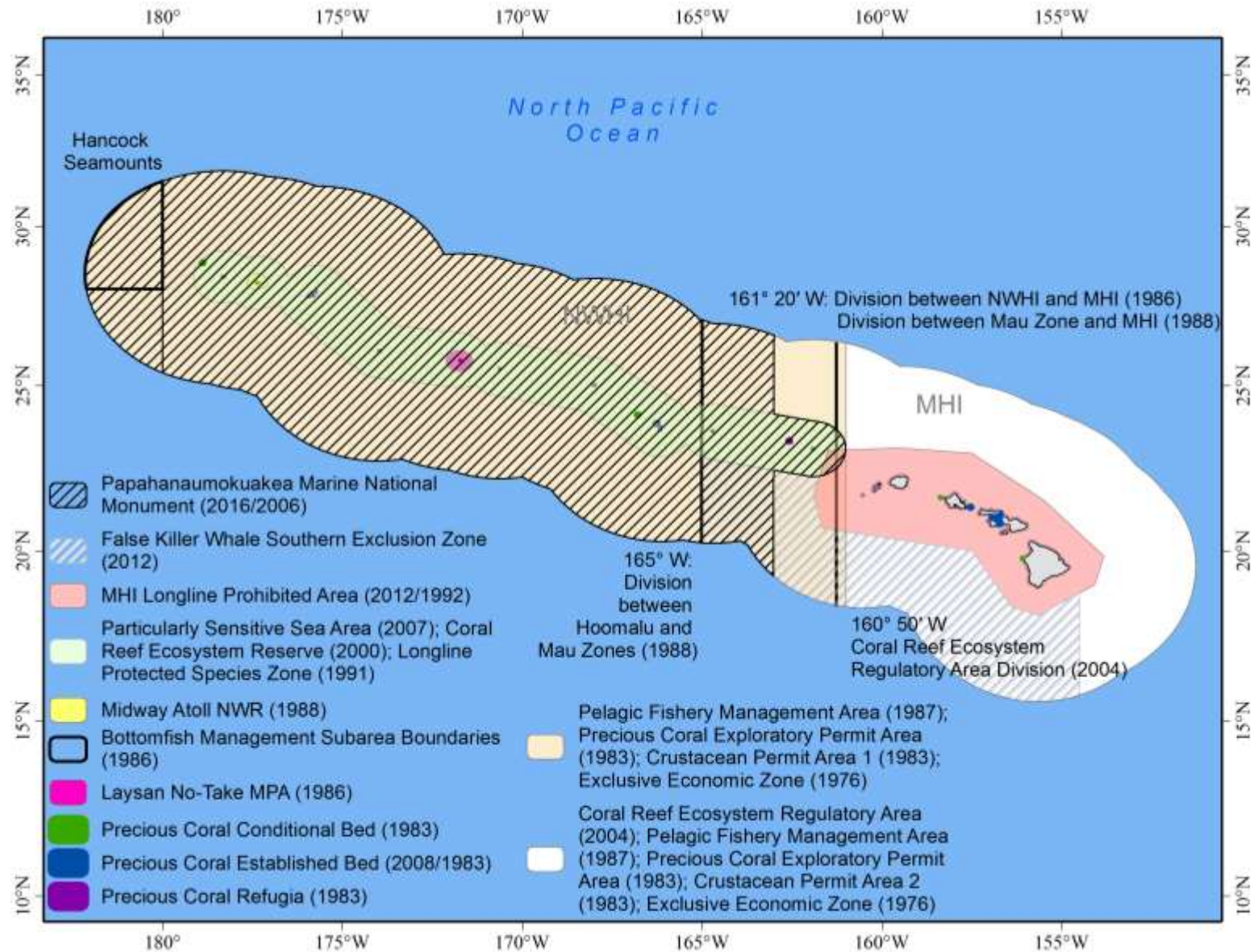


Figure 31. Regulated fishing areas of the Hawaii Archipelago

**Table 63. MMAs established under FEP from 50 CFR § 665**

| Name                                                               | FEP                   | Island                    | 50 CFR/FR/<br>Amendment<br>Reference                                                                                                               | Marine<br>Area<br>(km <sup>2</sup> ) | Fishing<br>Restriction            | Goals                                                                                                                                                                                                                                                  | Most<br>Recent<br>Evaluation | Review<br>Deadline |
|--------------------------------------------------------------------|-----------------------|---------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|--------------------|
| <b>Pelagic Restrictions</b>                                        |                       |                           |                                                                                                                                                    |                                      |                                   |                                                                                                                                                                                                                                                        |                              |                    |
| NWHI<br>Longline<br>Protected<br>Species Zone                      | Pelagic<br>(Hawaii)   | NWHI                      | 665.806(a)(1)<br><a href="#">56 FR 52214</a><br><a href="#">76 FR 37288</a><br><a href="#">Pelagic FMP<br/>Am. 3</a>                               | 351,514.0                            | Longline<br>fishing<br>prohibited | Prevent longline<br>interaction with<br>monk seals                                                                                                                                                                                                     | 1991                         | -                  |
| MHI<br>Longline<br>Prohibited<br>Area                              | Pelagic<br>(Hawaii)   | MHI                       | 665.806(a)(2)<br><a href="#">57 FR 7661</a><br><a href="#">77 FR 71286</a><br><a href="#">Pelagic FMP<br/>Am. 5</a>                                | 248,682.4                            | Longline<br>fishing<br>prohibited | Prevent gear<br>conflicts between<br>longline vessels<br>and troll/handline<br>vessels                                                                                                                                                                 | 1992                         | -                  |
| <b>Bottomfish Restrictions</b>                                     |                       |                           |                                                                                                                                                    |                                      |                                   |                                                                                                                                                                                                                                                        |                              |                    |
| Hancock<br>Seamounts<br>Ecosystem<br>Management<br>Area<br>(HSEMA) | Hawaii<br>Archipelago | NW of<br>Midway<br>Island | HSEMA:<br>665.209<br><a href="#">75 FR 52921</a><br><a href="#">84 FR 2772</a><br>Moratorium:<br>51 FR 27413<br><a href="#">Bottomfish<br/>FMP</a> | 60,826.8                             | Moratorium                        | The intent of the<br>continued<br>moratorium is to<br>facilitate rebuilding<br>of the armorhead<br>stock, and the<br>intent of the<br>ecosystem<br>management area is<br>to facilitate<br>research on<br>armorhead and<br>other seamount<br>groundfish | 2010                         | -                  |
| <b>Precious Coral Permit Areas</b>                                 |                       |                           |                                                                                                                                                    |                                      |                                   |                                                                                                                                                                                                                                                        |                              |                    |
| Keāhole<br>Point                                                   | Hawaii<br>Archipelago | Hawaii<br>Island          | 665.261(2)(i)<br><a href="#">73 FR 47098</a><br><a href="#">84 FR 2773</a><br><a href="#">Precious<br/>Corals FMP<br/>Am. 7</a>                    | 2.7                                  | Fishing by<br>permit only         | Manage harvest                                                                                                                                                                                                                                         | 2008                         | -                  |
| Ka'ena Point                                                       | Hawaii<br>Archipelago | Oahu                      | 665.261(2)(ii)<br><a href="#">73 FR 47098</a><br><a href="#">84 FR 2773</a><br><a href="#">Precious<br/>Corals FMP<br/>Am. 7</a>                   | 2.7                                  | Fishing by<br>permit only         | Manage harvest                                                                                                                                                                                                                                         | 2008                         | -                  |
| Makapu'u                                                           | Hawaii<br>Archipelago | Oahu                      | 665.261(1)(i)<br><a href="#">73 FR 47098</a><br><a href="#">84 FR 2773</a><br><a href="#">Precious<br/>Corals FMP<br/>Am. 7</a>                    | 43.15                                | Fishing by<br>permit only         | Manage harvest                                                                                                                                                                                                                                         | 2008                         | -                  |
| Brooks Bank                                                        | Hawaii<br>Archipelago | NWHI                      | 665.261(2)(iii)<br><a href="#">73 FR 47098</a><br><a href="#">84 FR 2773</a><br><a href="#">Precious<br/>Corals FMP<br/>Am. 7</a>                  | 43.15                                | Fishing by<br>permit only         | Manage harvest                                                                                                                                                                                                                                         | 2008                         | -                  |
| 180 Fathom<br>Bank                                                 | Hawaii<br>Archipelago | NWHI                      | 665.261(2)(iv)<br><a href="#">73 FR 47098</a><br><a href="#">84 FR 2773</a><br><a href="#">Precious<br/>Corals FMP<br/>Am. 7</a>                   | 43.15                                | Fishing by<br>permit only         | Manage harvest                                                                                                                                                                                                                                         | 2008                         | -                  |

| Name              | FEP                   | Island      | 50 CFR/FR/<br>Amendment<br>Reference                                                                                             | Marine<br>Area<br>(km <sup>2</sup> ) | Fishing<br>Restriction    | Goals                                                                                              | Most<br>Recent<br>Evaluation | Review<br>Deadline |
|-------------------|-----------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------------------------|----------------------------------------------------------------------------------------------------|------------------------------|--------------------|
| Westpac Bed       | Hawaii<br>Archipelago | NWHI        | 665.261(3)<br><a href="#">73 FR 47098</a><br><a href="#">84 FR 2773</a><br><a href="#">Precious<br/>Corals FMP<br/>Am. 7</a>     | 43.15                                | Fishing<br>prohibited     | Manage harvest                                                                                     | 2008                         | -                  |
| 'Au'au<br>Channel | Hawaii<br>Archipelago | Maui<br>Nui | 665.261(1)(ii)<br><a href="#">73 FR 47098</a><br><a href="#">84 FR 2773</a><br><a href="#">Precious<br/>Corals FMP<br/>Am. 7</a> | 728.42                               | Fishing by<br>permit only | Harvest quota for<br>black coral of<br>5,000 kg every two<br>years for federal<br>and State waters | 2008                         | -                  |

## 2.9.4 Fishing Activities and Facilities

### 2.9.4.1 Aquaculture Facilities

Hawaii has one offshore aquaculture facility recently operational in federal waters that was owned by Ocean Era (formerly Kampachi Farms), but the associated Special Coral Reef Ecosystem Fishing Permit (SCREFP) was transferred to Forever Oceans (see Table 64). A new nearshore aquaculture operation in the waters off of Ewa Beach, Oahu, by Ocean Era is currently in the pre-consultation stage, and a preliminary environmental review was made to resource management agencies for evaluation in March 2021. The aquaculture farm will be situated off of Ewa Beach, Oahu, and will aim to cultivate nenuke (*Kyphosus vaigiensis*), moi (*Polydactylus sexifilis*), ogo (*Gracilari* sp.), *Sargassum*, and sea grapes (*Caulerpa* sp.).

**Table 64. Offshore aquaculture facilities in Hawaii**

| Name                                                                 | Size                                                                                       | Location                                                                                                                                                                                  | Species                  | Status                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Forever Oceans, transferred from Ocean Era (formerly Kampachi Farms) | Shape: Cylindrical<br>Height: 33 ft.<br>Diameter: 39 ft.<br>Volume: 36,600 ft <sup>3</sup> | 5.5 nautical miles (nm) west of Keauhou Bay and 7 nm south-southwest of Kailua Bay, off the west coast of Hawaii Island<br>19° 33' N, 156° 04' W.<br>Mooring scope is 10,400-foot radius. | <i>Seriola rivoliana</i> | On July 6, 2016, NMFS authorized SCREFP for culture and harvest of 30,000 kampachi over two years on July 6, 2016.<br>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.<br>On March 30, 2017, NMFS authorized transfer of the two-year SCREFP from Ocean Era to Forever Oceans.<br>Forever Oceans' most recent SCREFP expired in December 2021, and there are currently no ongoing, in-water operations. |

Additionally, the [draft Programmatic Environmental Impact Statement \(DPEIS\) for an aquaculture management program in the Pacific Islands](#) was published in 2021. Once the DPEIS is finalized, the Council can amend their FEPs to create a permitting program for offshore

aquaculture. Relatedly, the State of Hawaii is interested in developing a pre-permitted demonstration/pilot area for offshore aquaculture technologies at their NELHA facility.

## 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. In October 2021, the National Renewable Energy Laboratory published a study providing estimates of the Levelized Cost of Energy of offshore wind in the region surrounding Oahu and investigates related topics relevant to planning for offshore wind (Shields et al. 2021). There are several other alternative energy projects also being tracked in this report (Table 65).

**Table 65. 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;<br>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.                                                             | <a href="#">NELHA Energy Projects</a><br><br><a href="#">Final Environmental Assessment, NELHA, July 2012</a> |
| 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 | <a href="#">Final Environmental Assessment, June 2014</a><br><br><a href="#">West Hawaii Today</a>            |

| Name                                                  | Type                                | Location                          | Impact to Fisheries  | Stage of Development                                                                                                                                                                           | Source                                                                                                                                               |
|-------------------------------------------------------|-------------------------------------|-----------------------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                       |                                     |                                   |                      | down in late 2020 due to increasing costs.                                                                                                                                                     |                                                                                                                                                      |
| 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 starting mid-2015. In 2021, deployments were planned for the C-Power 2 kW SeaRay, the Oscilla Triton-C, and the Ocean Energy 500 kW OE35. | <a href="#">Final Environmental Assessment, NAVFAC PAC, January 2014</a><br><br><a href="#">Tethys</a><br><br><a href="#">The Maritime Executive</a> |

### 2.9.5.2 Military Training and Testing Activities and Impacts

The Department of Defense (DOD) major planning activities in the region are summarized in Table 66.

**Table 66. 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 and is 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 ( <a href="#">71 FR 31170</a> ). Biennial exercises continue through the present, with the most recent occurring in August 2020 as an at-sea-only event. RIMPAC will occur again in Summer 2022 and will be more traditional.                                                                                    | <a href="#">Programmatic Environmental Assessment, June 2002</a><br><br><a href="#">U.S. Pacific Fleet</a>                                                    |
| <a href="#">Hawaii-Southern California Training and Testing (HSTT)</a> | 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 ( <a href="#">83 FR 66255</a> ). NMFS implemented regulations regarding to the incidental take of marine mammals in the HSTT area in July 2020 ( <a href="#">85 FR 41780</a> ). | The <a href="#">2018 HSTT EIS/OEIS</a> predicts impacts to access and habitat impact similar to previous analysis in the <a href="#">2013 HSTT EIS/OEIS</a> . |
| 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                                                                                               | 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                                                                                                                                                                                                                                                      | Access – closures during training.<br><br><a href="#">Final Environmental Assessment October 2016</a>                                                         |

| Action                                                   | Description                                                                     | Phase                                                                                                                                                                                                               | Impacts                                                                                                                       |
|----------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
|                                                          | at the Pacific Missile Range Facility at Kauai, Hawaii.                         | 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 ( <a href="#">82 FR 1702</a> ; <a href="#">82 FR 39684</a> ). | <a href="#">NMFS Biological Opinion August 2017</a>                                                                           |
| Naval Special Operations Training in the State of Hawaii | Small-unit maritime training activities for naval special operations personnel. | Draft EA released in October 2018. Public comment period through Dec. 10, 2018 was extended to Jan. 7, 2019.<br><br>Final EA released May 2021.                                                                     | Access.<br><br><a href="#">Draft Environmental Assessment 2018</a><br><br><a href="#">Final Environmental Assessment 2021</a> |

## 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 in 2007 with 12 BRFAs (Figure 32) with the objective of reducing fishing mortality of MHI bottomfish stocks, rebuilding bottomfish populations on habitats within the BRFAs, and improving bottomfish populations in adjacent fishing areas (Drazen et al. 2014). In 2019, four of the 12 BRFAs were opened: BRFA C (Poipu, Kauai), BRFA F (Penguin Banks), BRFA J (Hana, Maui), and BRFA L (Leleiwi, Hawaii Island) (Figure 32).

On February 25, 2022, the Hawaii Board of Land and Natural Resources (BLNR) approved the reopening of all BRFAs such that registered bottomfish vessels are now allowed to fish for Deep-7 bottomfish in all previously closed BRFAs. During deliberations, representatives from DAR suggested that, because the Deep-7 bottomfish complex is being fished at sustainable levels according to the 2021 stock assessment update (Syslo et al. 2021), DAR is comfortable in taking an adaptive management approach to co-management of the Hawaii bottomfish fishery by opening the BRFAs and relying on other existing conservation and management measures to sustain the fishery.

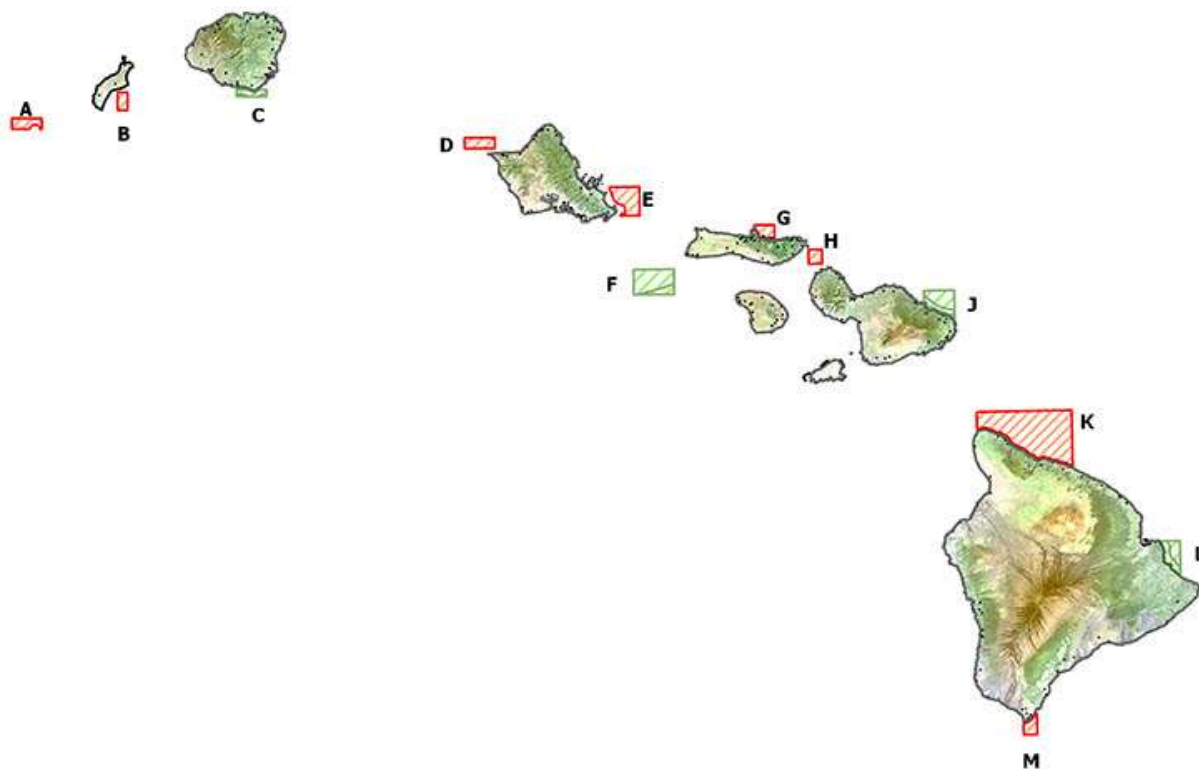


**Figure 32. Map of the 12 BRFAs around the MHI; green boxes indicate those areas were opened to bottomfish fishing in 2019 and red boxes indicate areas that remained closed to bottomfish fishing at this time. All BRFAs are now open (from DAR 2021)**

### **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 30<sup>th</sup> and May 1<sup>st</sup>, 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 33). 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.

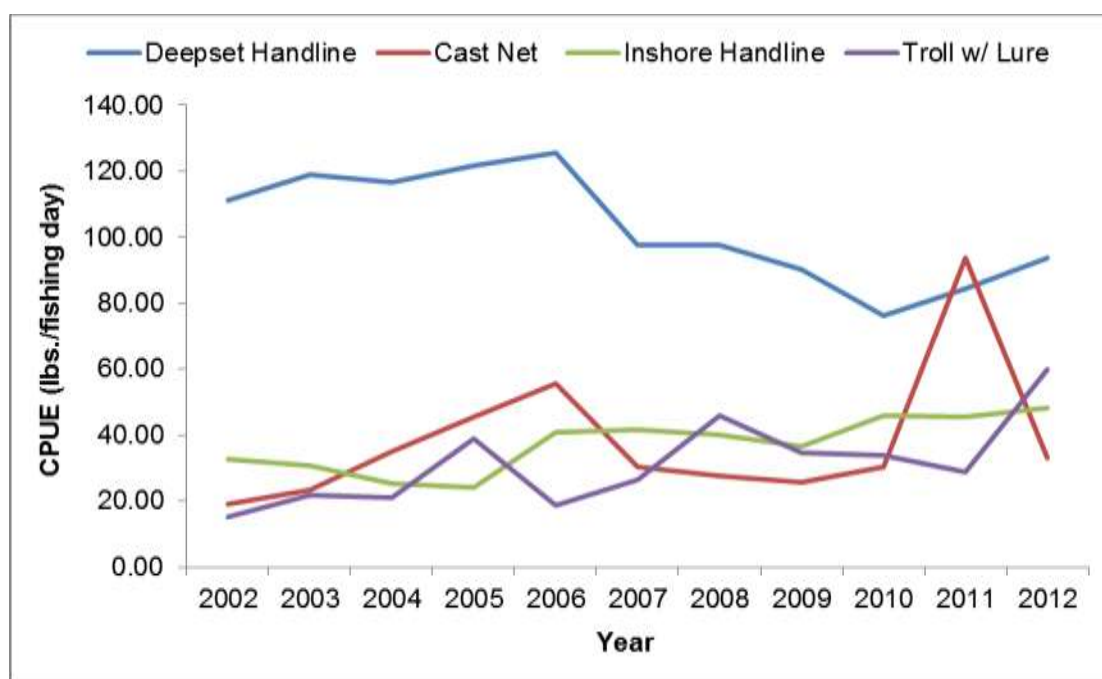


**Figure 33. CPUE for uku harvested in the MHI for four top gear types from 2002-2012**

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 34). 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).

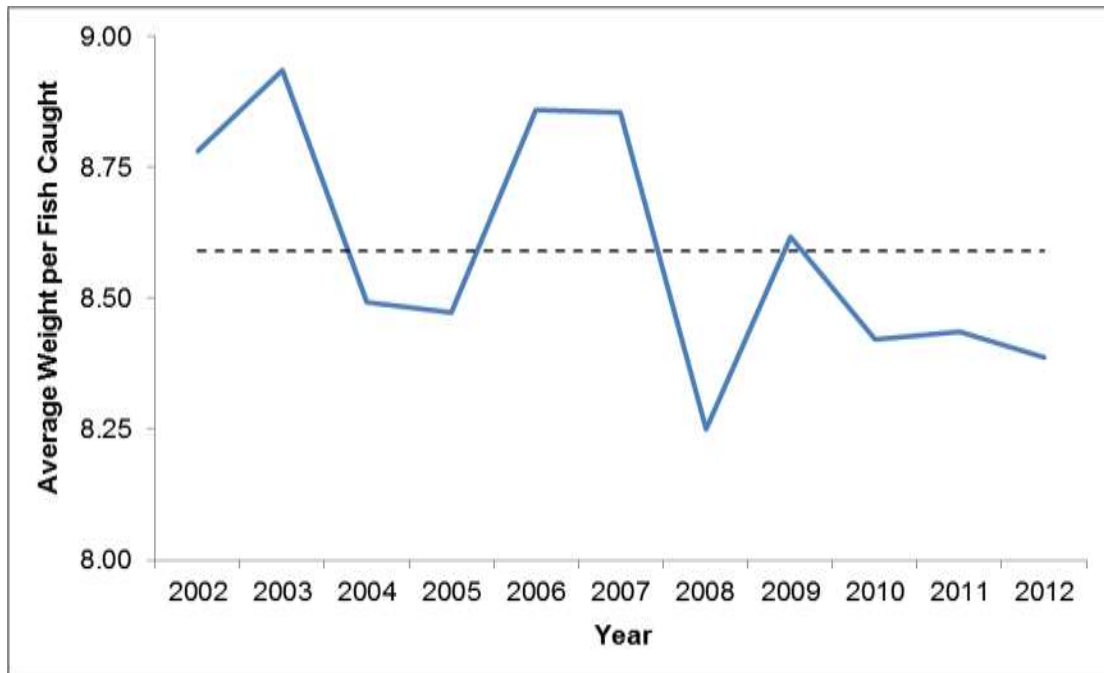


**Figure 34. Average annual weight per fish (lb) for uku (*Aprion virescens*) harvested around the Main Hawaiian Islands from 2002-2012**

### 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 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 35; 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 36; 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 37) and the coefficient of determination ( $R^2$ ) was 0.53 (Figure 38), 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.

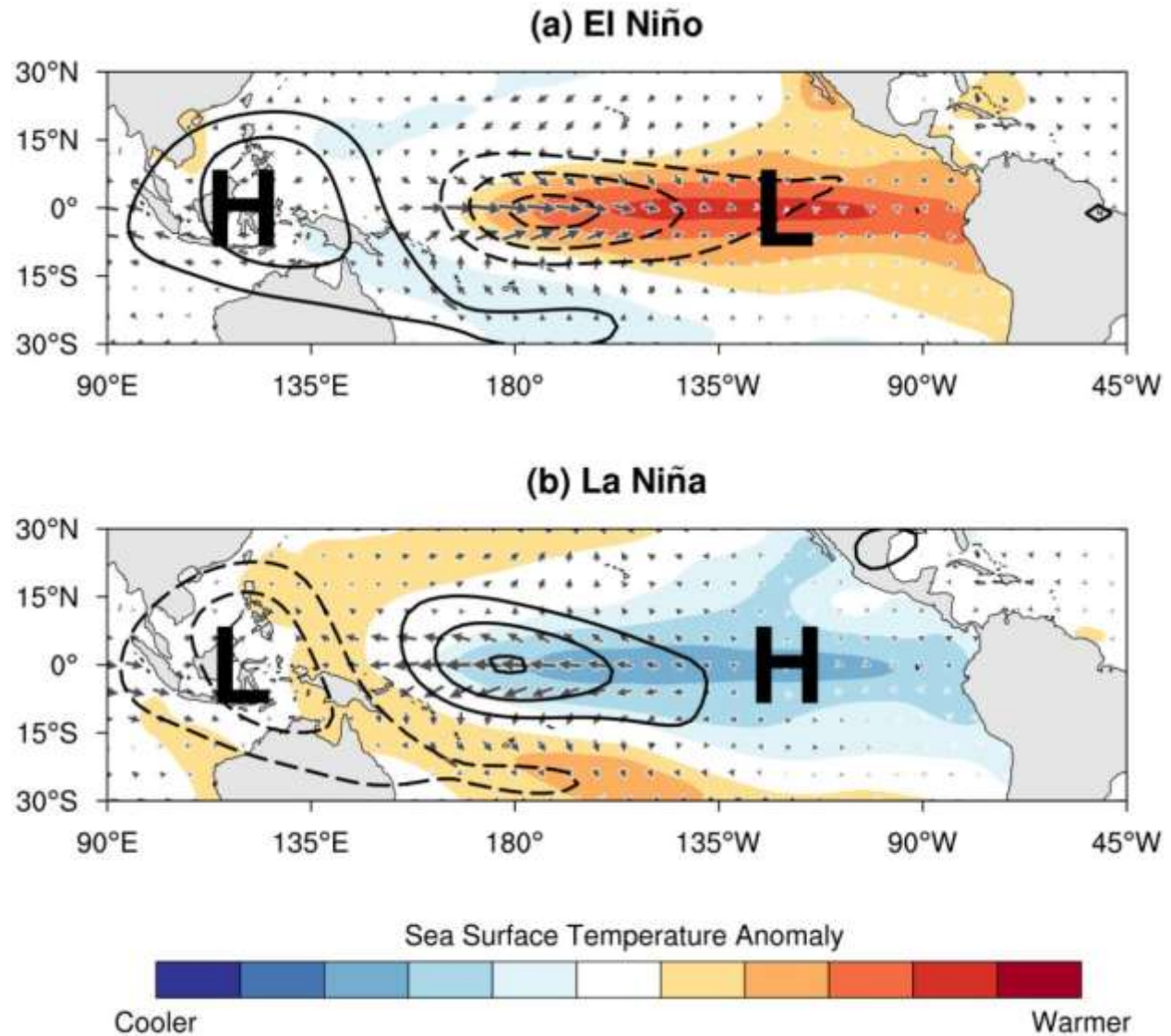


**Figure 35. Diagram showing the physical mechanisms by which the SST (shaded), OLR (contours), surface zonal and meridional winds (vectors), and sea level pressure (represented by “H” and “L”) determine the wintertime Multivariate ENSO Index (MEI) during (a) El Niño and (b) La Niña events” (from NOAA 2019)**

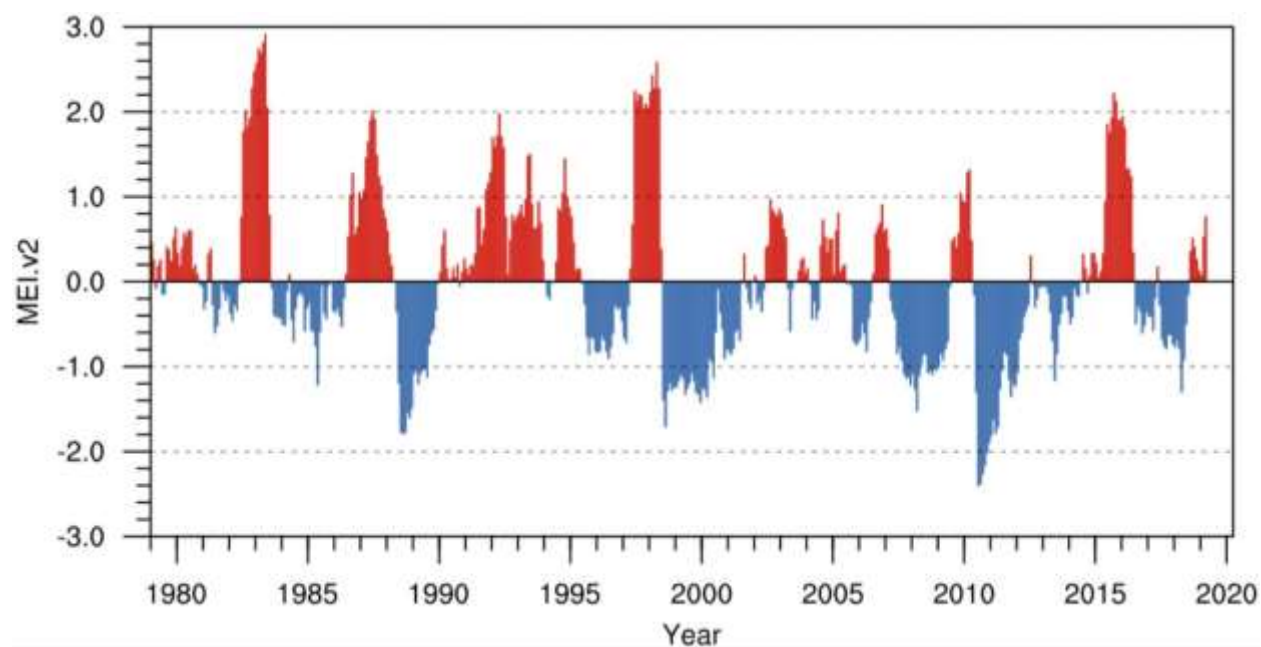


Figure 36. Time series of the Multivariate ENSO Index (MEI) v2 from 1980-2019

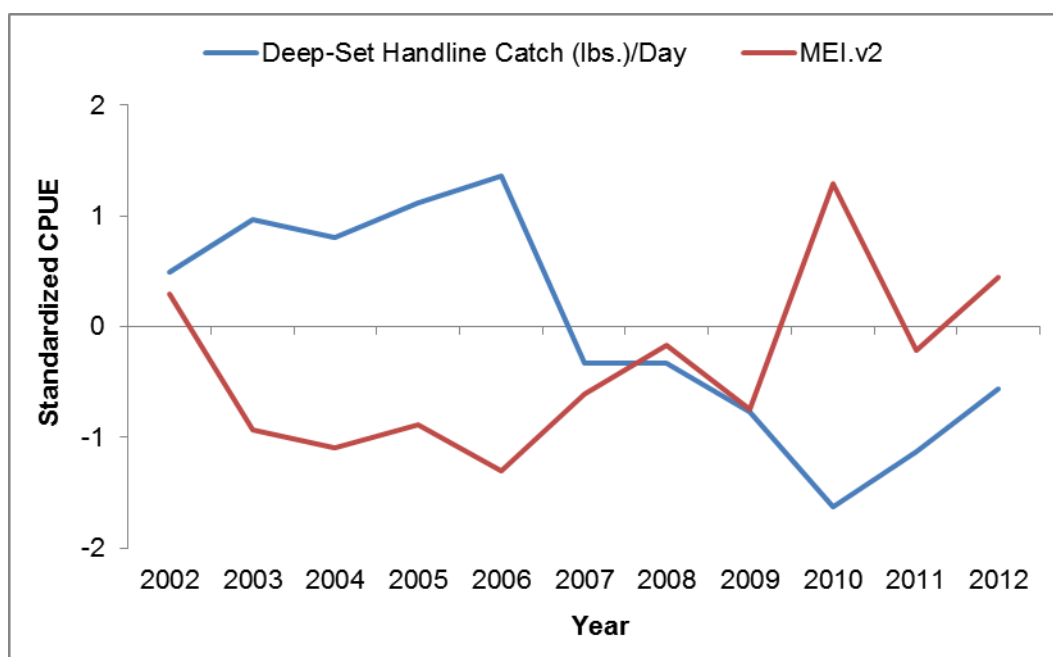


Figure 37. Comparison of standardized MHI Deep-Set Handline CPUE and MEI.v2 with a phase lag of two years from 2002-2012 ( $r = -0.729$ )

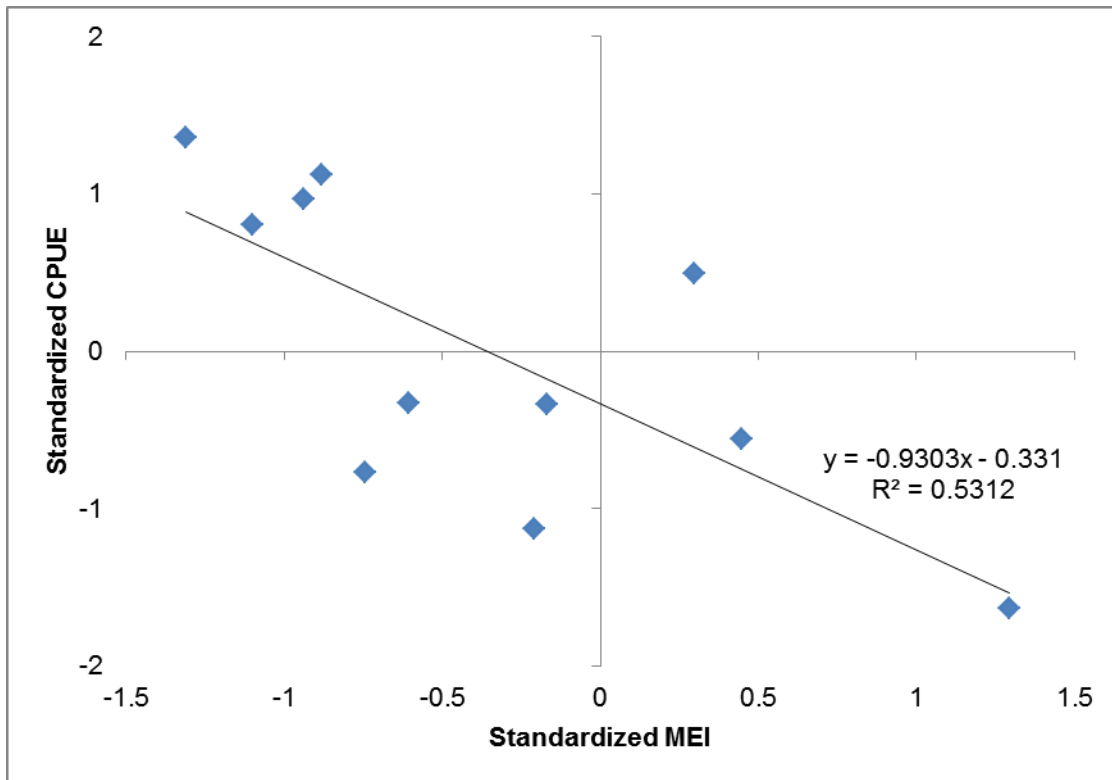


**Figure 38. Standardized CPUE for uku from the MHI from 2002-2012 plotted against standardized MEI.v2 with a phase lag of two years**

### 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 (Wyrtki 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 39. 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 ( $r = 0.304$ ).

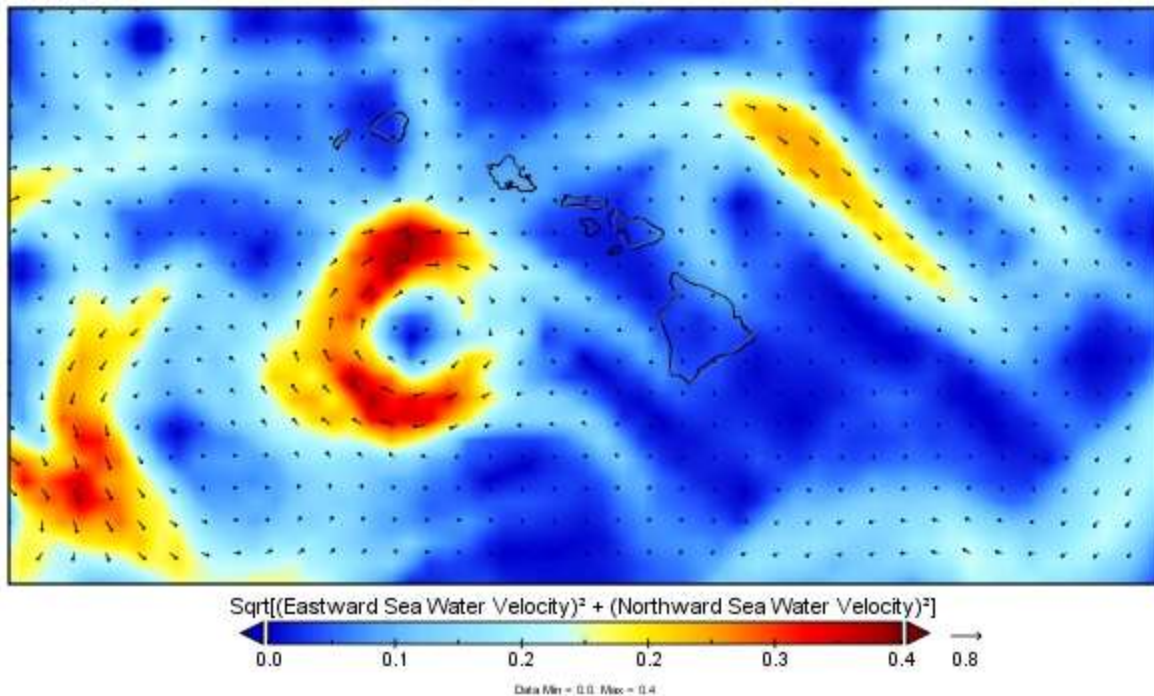


**Figure 39. Example of eastward sea water current velocity around the MHI (from 2004)**

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 40) and the coefficient of determination ( $R^2$ ) was approximately 0.56 (Figure 41), 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.

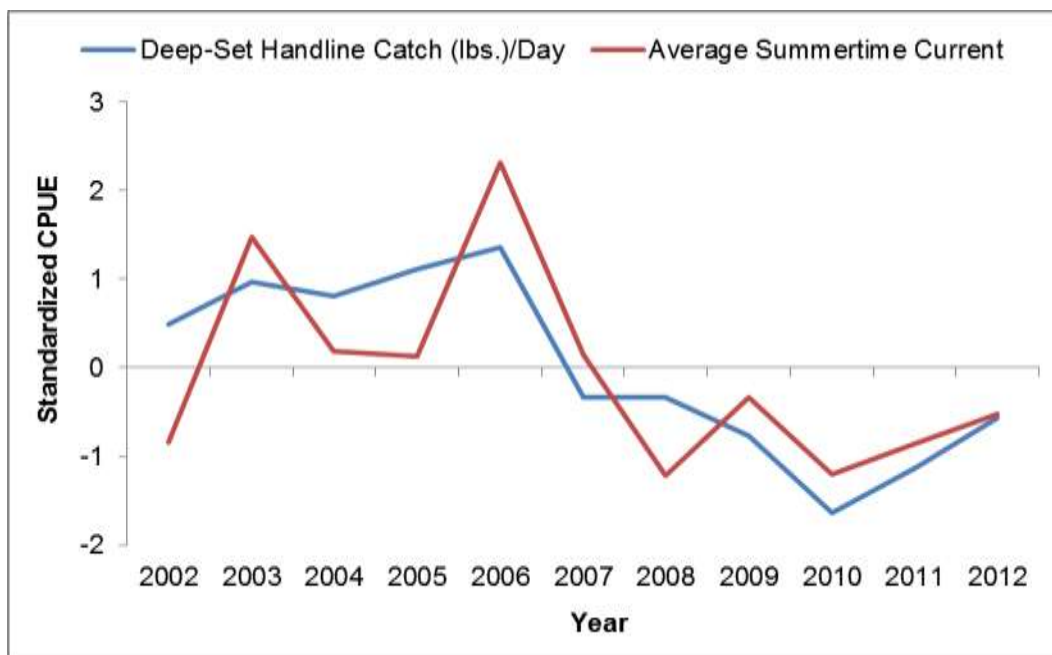


Figure 40. Comparison of standardized MHI Deep-Set Handline CPUE and the average summertime zonal current with a phase lag of two years from 2002-2012 ( $r = 0.748$ )

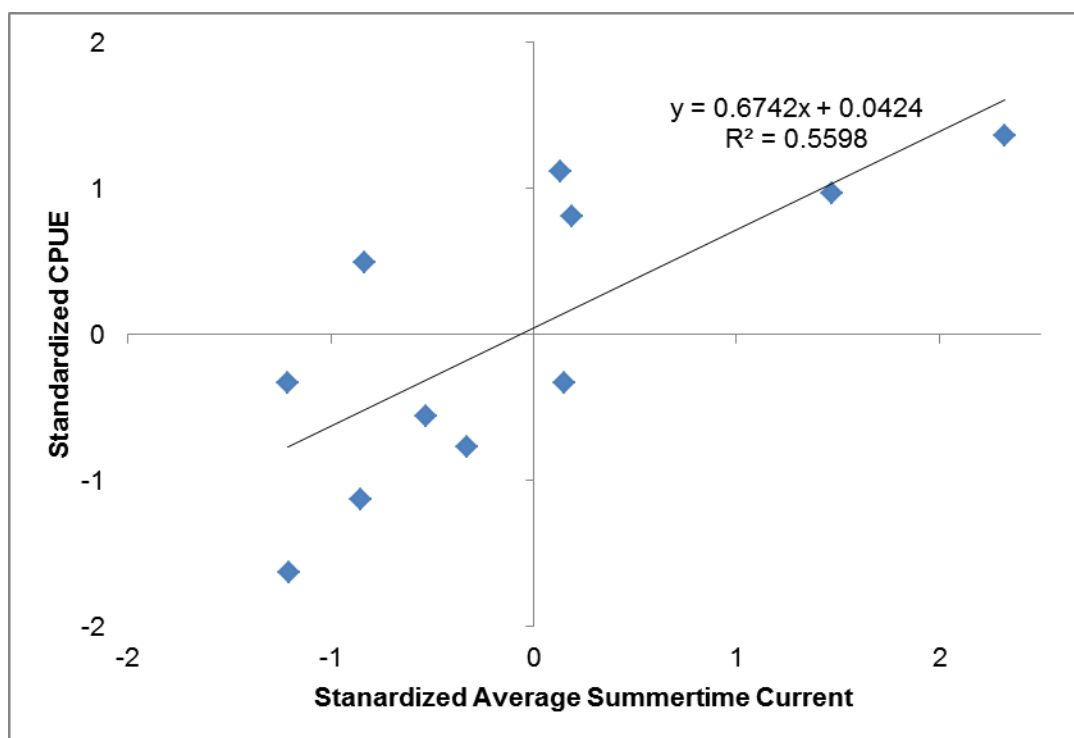


Figure 41. Standardized CPUE for uku from the MHI from 2002-2012 plotted against standardized average summertime zonal current with a phase lag of two years

### 3.4 RECENT RELEVANT ABSTRACTS

In this section, abstracts from primary journal articles published in 2021 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.

**Becker EA, Forney KA, Oleson EM, Bradford AL, Moore JE, Barlow J. 2021. Habitat-based density estimates for cetaceans within the waters of the U.S. Exclusive Economic Zone around the Hawaiian Archipelago. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-116, 38 p. <https://doi.org/10.25923/x9q9-rd73>.**

The Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) 2017 was conducted in waters within the United States (U.S.) Exclusive Economic Zone (EEZ) around the Hawaiian Archipelago (henceforth “Hawaiian EEZ” for brevity) from 6 July through 1 December 2017 (Yano et al. 2018). The primary objective of this line-transect survey was to collect cetacean sighting data to support the derivation of cetacean density estimates using both design-based analyses and habitat modeling techniques. This report summarizes the results of the habitat modeling effort. The design-based estimates are described separately in Bradford et al. (in review).

**Berger AM, Deroba JJ, Bosley KM, Goethel DR, Langseth BJ, Schueller AM, Hanselman DH. 2021. Incoherent dimensionality in fisheries management: consequences of misaligned stock assessment and population boundaries. ICES Journal of Marine Science. <https://doi.org/10.1093/icesjms/fsaa203>.**

Fisheries policy inherently relies on an explicit definition of management boundaries that delineate the spatial extent over which stocks are assessed and regulations are implemented. However, management boundaries tend to be static and determined by politically negotiated or historically identified population (or multi-species) units, which create a potential disconnect with underlying, dynamic population structure. The consequences of incoherent management and population or stock boundaries were explored through the application of a two-area spatial simulation–estimation framework. Results highlight the importance of aligning management assessment areas with underlying population structure and processes, especially when fishing mortality is disproportionate to vulnerable biomass among management areas, demographic parameters (growth and maturity) are not homogenous within management areas, and connectivity (via recruitment or movement) unknowingly exists among management areas. Bias and risk were greater for assessments that incorrectly span multiple population segments (PSs) compared to assessments that cover a subset of a PS, and these results were exacerbated when there was connectivity between PSs. Directed studies and due consideration of critical PSs, spatially explicit models, and dynamic management options that help align management and population boundaries would likely reduce estimation biases and management risk, as would closely coordinated management that functions across population boundaries.

**Donovan MK, Burkepile DE, Kratochwill C, Shlesinger T, Sully S, Oliver TA, Hodgson G, Freiwald J, van Woesik R. 2021. Local conditions magnify coral loss after marine heatwaves. *Science*. 372(6545):977-80. <https://doi.org/10.1126/science.abd9464>.**

Climate change threatens coral reefs by causing heat stress events that lead to widespread coral bleaching and mortality. Given the global nature of these mass coral mortality events, recent

studies argue that mitigating climate change is the only path to conserve coral reefs. Using a global analysis of 223 sites, we show that local stressors act synergistically with climate change to kill corals. Local factors such as high abundance of macroalgae or urchins magnified coral loss in the year after bleaching. Notably, the combined effects of increasing heat stress and macroalgae intensified coral loss. Our results offer an optimistic premise that effective local management, alongside global efforts to mitigate climate change, can help coral reefs survive the Anthropocene.

**Friedland KD, Smolinski S, Tanaka KR. 2021. Contrasting patterns in the occurrence and biomass centers of gravity among fish and macroinvertebrates in a continental shelf ecosystem. *Ecol Evol.* 11(5). <https://doi.org/10.1002/ece3.7150>.**

The distribution of a group of fish and macroinvertebrates ( $n = 52$ ) resident in the US Northeast Shelf large marine ecosystem were characterized with species distribution models (SDM), which in turn were used to estimate occurrence and biomass center of gravity (COG). The SDMs were fit using random forest machine learning and were informed with a range of physical and biological variables. The estimated probability of occurrence and biomass from the models provided the weightings to determine depth, distance to the coast, and along-shelf distance COG. The COGs of occupancy and biomass habitat tended to be separated by distances averaging 50 km, which approximates half of the minor axis of the subject ecosystem. During the study period (1978–2018), the biomass COG has tended to shift to further offshore positions whereas occupancy habitat has stayed at a regular spacing from the coastline. Both habitat types have shifted their along-shelf distances, indicating a general movement to higher latitude or to the Northeast for this ecosystem. However, biomass tended to occur at lower latitudes in the spring and higher latitude in the fall in a response to seasonal conditions. Distribution of habitat in relation to depth reveals a divergence in response with occupancy habitat shallowing over time and biomass habitat distributing in progressively deeper water. These results suggest that climate forced change in distribution will differentially affect occurrence and biomass of marine taxa, which will likely affect the organization of ecosystems and the manner in which human populations utilize marine resources.

**Gonzalez-Mon B, Bodin Ö, Lindkvist E, Frawley TH, Giron-Nava A, Basurto X, Nenadovic M, Schlüter M. 2021. Spatial diversification as a mechanism to adapt to environmental changes in small-scale fisheries. *Environmental Science & Policy*, 116, pp.246-257.**

Small-scale fisheries' actors increasingly face new challenges, including climate driven shifts in marine resource distribution and productivity. Diversification of target species and fishing locations is a key mechanism to adapt to such changes and maintain fisheries livelihoods. Here we explore environmental and institutional factors mediating how patterns of spatial diversification (i.e., utilization of alternative fishing grounds) and target species diversification change over time. Using small-scale fisheries in Baja California Sur (Mexico) as a case study, we adopt a social-ecological network approach to conduct a spatially explicit analysis of fisheries landings data (2008–2016). This approach quantifies relative patterns of diversification, and when combined with a qualitative analysis of existing literature, enables us to illuminate institutional and environmental factors that may influence diversification strategies. Our results indicate that interannual changes in spatial diversification are correlated with regional oceanographic change, while illustrating the heterogeneity and dynamism of diversification strategies. Rather than acting in isolation, we hypothesize that environmental drivers likely operate in combination with existing fisheries regulations and local socioeconomic context to

mediate spatial diversification. We argue that small-scale fisheries policies need to better account such linkages as we move towards an increasingly variable environment. Overall, our results highlight spatial diversification as a dynamic process and constitute an important step towards understanding and managing the complex mechanisms through which environmental changes affect small-scale fisheries.

**Heneghan RF, Galbraith E, Blanchard JL, Harrison C, Barrier N, Bulman C, Cheung W, Coll M, Eddy TD, Erauskin-Extramiana M, Everett JD, et al. 2021. Disentangling diverse responses to climate change among global marine ecosystem models. *Progress in Oceanography*:102659 <https://doi.org/10.1016/j.pocean.2021.102659>.**

Climate change is warming the ocean and impacting lower trophic level (LTL) organisms. Marine ecosystem models can provide estimates of how these changes will propagate to larger animals and impact societal services such as fisheries, but at present these estimates vary widely. A better understanding of what drives this inter-model variation will improve our ability to project fisheries and other ecosystem services into the future, while also helping to identify uncertainties in process understanding. Here, we explore the mechanisms that underlie the diversity of responses to changes in temperature and LTLs in eight global marine ecosystem models from the Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP). Temperature and LTL impacts on total consumer biomass and ecosystem structure (defined as the relative change of small and large organism biomass) were isolated using a comparative experimental protocol. Total model biomass varied between  $-35\%$  to  $+3\%$  in response to warming, and  $-17\%$  to  $+15\%$  in response to LTL changes. There was little consensus about the spatial redistribution of biomass or changes in the balance between small and large organisms (ecosystem structure) in response to warming, an LTL impacts on total consumer biomass varied depending on the choice of LTL forcing terms. Overall, climate change impacts on consumer biomass and ecosystem structure are well approximated by the sum of temperature and LTL impacts, indicating an absence of nonlinear interaction between the models' drivers. Our results highlight a lack of theoretical clarity about how to represent fundamental ecological mechanisms, most importantly how temperature impacts scale from individual to ecosystem level, and the need to better understand the two-way coupling between LTL organisms and consumers. We finish by identifying future research needs to strengthen global marine ecosystem modelling and improve projections of climate change impacts.

**Hyrenbach KD, Ishizaki A, Polovina J, Ellgen S (Eds.). 2021. The factors influencing albatross interactions in the Hawaii longline fishery: Towards identifying drivers and quantifying impacts. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-122, 163 p. <https://doi.org/10.25923/nb95-gs31>.**

The Hawaii longline fishery has been required to use seabird mitigation measures under the Pacific Pelagic Fishery Management Plan (current Fishery Ecosystem Plan, or FEP) since 2001. In the past decade since the successful implementation of seabird mitigation measures, the fishery has seen a gradual increasing trend in Black-footed (*Phoebastria nigripes*, BFAL) and Laysan (*P. immutabilis*, LAAL) albatross interactions, with higher rates of Black-footed albatross interactions since 2015. A published analysis conducted by Gilman and colleagues (2016) using data from October 2004 to May 2014, indicated that albatross interaction rates significantly increased during years of higher annual mean multivariate El Niño index (MEI), suggesting that oceanographic changes may have contributed to these changes in albatross catch rates. This analysis also showed a significant increasing trend in the number of albatross

attending fishing vessels which may have contributed to the increasing catch rates. Moreover, the higher interaction rates observed during the recent El Niño event (2015–2016) further underscore the potential links between ocean conditions and albatross longline interactions.

**Jardim E, Azevedo M, Brodziak J, Brooks EN, Johnson KF, Klibansky N, Millar CP, Minto C, Mosqueira I, Nash RD, et al. 2021. Operationalizing ensemble models for scientific advice to fisheries management. ICES Journal of Marine Science. <https://doi.org/10.1093/icesjms/fsab010>.**

This paper explores the possibility of using the ensemble modelling paradigm to fully capture assessment uncertainty and improve the robustness of advice provision. We identify and discuss advantages and challenges of ensemble modelling approaches in the context of scientific advice. There are uncertainties associated with every phase in the stock assessment process: data collection, assessment model choice, model assumptions, interpretation of risk, up to the implementation of management advice. Additionally, the dynamics of fish populations are complex, and our incomplete understanding of those dynamics and limited observations of important mechanisms, necessitate that models are simpler than nature. The aim is for the model to capture enough of the dynamics to accurately estimate trends and abundance, and provide the basis for robust advice about sustainable harvests. The status quo approach to assessment modelling has been to identify the “best” model and generate advice from that model, mostly ignoring advice from other model configurations regardless of how closely they performed relative to the chosen model. We discuss and make suggestions about the utility of ensemble models, including revisions to the formal process of providing advice to management bodies, and recommend further research to evaluate potential gains in modelling and advice performance.

**Kaplan IC, Gaichas SK, Stawitz CC, Lynch PD, Marshall KN, Deroba JJ, Masi M, Brodziak JK, Aydin KY, Holsman K, et al. 2021. Management Strategy Evaluation: Allowing the Light on the Hill to Illuminate More Than One Species. *Frontiers in Marine Science*. 8:688. <https://doi.org/10.3389/fmars.2021.624355>.**

Management strategy evaluation (MSE) is a simulation approach that serves as a “light on the hill” (Smith, 1994) to test options for marine management, monitoring, and assessment against simulated ecosystem and fishery dynamics, including uncertainty in ecological and fishery processes and observations. MSE has become a key method to evaluate trade-offs between management objectives and to communicate with decision makers. Here we describe how and why MSE is continuing to grow from a single species approach to one relevant to multi-species and ecosystem-based management. In particular, different ecosystem modeling approaches can fit within the MSE process to meet particular natural resource management needs. We present four case studies that illustrate how MSE is expanding to include ecosystem considerations and ecosystem models as ‘operating models’ (i.e., virtual test worlds), to simulate monitoring, assessment, and harvest control rules, and to evaluate tradeoffs via performance metrics. We highlight United States case studies related to fisheries regulations and climate, which support NOAA’s policy goals related to the Ecosystem Based Fishery Roadmap and Climate Science Strategy but vary in the complexity of population, ecosystem, and assessment representation. We emphasize methods, tool development, and lessons learned that are relevant beyond the United States, and the additional benefits relative to single-species MSE approaches.

**Kasperski S, DePiper GS, Blake S, Colburn LL, Jepson M, Haynie1 AC, Karnauskas M, Leong KM, Lipton D, Masi M, et al. 2021. Assessing the State of Coupled Social-Ecological**

**Modeling in Support of Ecosystem Based Fisheries Management in the U.S. Front. Mar. Sci. <https://doi.org/10.3389/fmars.2021.631400>.**

There has been a proliferation of coupled social-ecological systems (SES) models created and published in recent years. However, the degree of coupling between natural and social systems varies widely across the different coupled models and is often a function of the disciplinary background of the team conducting the research. This manuscript examines models developed for and used by NOAA Fisheries in support of Ecosystem Based Fisheries Management (EBFM) in the United States. It provides resource managers and interdisciplinary scientists insights on the strengths and weaknesses of the most commonly used SES models: end-to-end models, conceptual models, bioeconomic models, management strategy evaluations (MSEs), fisher behavior models, integrated social vulnerability models, and regional economic impact models. These model types are not unique to the literature, but allow us to differentiate between one-way coupled models – where outputs from one model are inputs into a second model of another discipline with no feedback to the first model, and two-way coupled models – where there are linkages between the natural and social system models. For a model to provide useful strategic or tactical advice, it should only be coupled to the degree necessary to understand the important dynamics/responses of the system and to create management-relevant performance metrics or potential risks from an (in)action. However, one key finding is to not wait to integrate! This paper highlights the importance of “when” the coupling happens, as timing affects the ability to fully address management questions and multi-sectoral usage conflicts that consider the full SES for EBFM or ecosystem based management (EBM) more generally.

**McNamara KE, Westoby R, Chandra A. 2021. Exploring climate-driven non-economic loss and damage in the Pacific Islands. *Current Opinion in Environmental Sustainability*, 50, pp.1-11.**

Non-economic loss and damage induced by climate change in the Pacific Islands region has been reported as fears of cultural loss, deterioration of vital ecosystem services, and dislocation from ancestral lands, among others. This paper undertakes an in-depth systematic review of literature from the frontlines of the Pacific Islands to ascertain the complexities of non-economic loss and damage from climate change. We synthesise knowledge to date on different but inter-connected categories of non-economic loss and damage, namely: human mobility and territory, cultural heritage and Indigenous knowledge, life and health, biodiversity and ecosystem services, and sense of place and social cohesion. Identifying gaps and possibilities for future research agendas is presented. Synthesising knowledge to date and identifying remaining gaps about non-economic loss and damage is an important step in taking stock of what we already know and fostering action and support for addressing loss and damage in the years to come.

**Politikos DV, Rose KA, Curchitser EN, Checkley DM Jr , Rykaczewski RR, Fiechter J. 2021. Climate variation and anchovy recruitment in the California current: a cause-and-effect analysis of an end-to-end model simulation. *Marine Ecology Progress Series*. Volume 680:111-136. <https://doi.org/10.3354/meps13853>.**

Interannual and regime (decadal) scale changes in climate affect the spatial distribution and productivity of marine fish species in numerous ecosystems. We analyzed a historical simulation (1965-2000) from an end-to-end ecosystem model of anchovy population dynamics for the California Current System to untangle the effects of warm versus cool conditions on recruitment. A 3-dimensional coupled hydrodynamic-NPZD (nitrogen-phytoplankton-zooplankton-detritus)

model (ROMS-NEMURO) provided the physical conditions (circulation, temperature) and 3 zooplankton concentrations as inputs to an anchovy full life cycle individual-based model (IBM). Our analysis was focused on isolating the effects of the well-documented El Niño Southern Oscillation signal and 3 climate regimes on spawning habitat, development, and survival of eggs and yolk-sac larvae, growth and survival of larvae and juveniles, and ultimately recruitment of anchovy. The major drivers of lowered recruitment success in warm years and in warmer regimes were reduced survival and growth rates of eggs and larvae that resulted from the poleward shift of adults in response to warmer temperatures prior to spawning. Three model-data comparisons showed the model deviated from empirically derived values of annual recruitment success but agreed with data for annual mean latitude of egg distributions and predicted larval consumption rates versus measured zooplankton concentrations. More effort is needed to improve certain biological aspects of the IBM so that it can replicate empirically estimated recruitment fluctuations. Overall, the altered responses of anchovy to changing climate in the California Current domain illustrate the benefit of the present mechanistic approach to infer how anchovy may respond under future ecosystem conditions.

**Smith JA, Tommasi D, Welch H, Hazen EL, Sweeney J, Brodie S, Muhling B, Stohs SM, Jacox MG. 2021. Comparing Dynamic and Static Time-Area Closures for Bycatch Mitigation: A Management Strategy Evaluation of a Swordfish Fishery. *Frontiers in Marine Science*. 8:272. <https://doi.org/10.3389/fmars.2021.630607>.**

Time-area closures are a valuable tool for mitigating fisheries bycatch. There is increasing recognition that dynamic closures, which have boundaries that vary across space and time, can be more effective than static closures at protecting mobile species in dynamic environments. We created a management strategy evaluation to compare static and dynamic closures in a simulated fishery based on the California drift gillnet swordfish fishery, with closures aimed at reducing bycatch of leatherback turtles. We tested eight operating models that varied swordfish and leatherback distributions, and within each evaluated the performance of three static and five dynamic closure strategies. We repeated this under 20 and 50% simulated observer coverage to alter the data available for closure creation. We found that static closures can be effective for reducing bycatch of species with more geographically associated distributions, but to avoid redistributing bycatch the static areas closed should be based on potential (not just observed) bycatch. Only dynamic closures were effective at reducing bycatch for more dynamic leatherback distributions, and they generally reduced bycatch risk more than they reduced target catch. Dynamic closures were less likely to redistribute fishing into rarely fished areas, by leaving open pockets of lower risk habitat, but these closures were often fragmented which would create practical challenges for fishers and managers and require a mobile fleet. Given our simulation's catch rates, 20% observer coverage was sufficient to create useful closures and increasing coverage to 50% added only minor improvement in closure performance. Even strict static or dynamic closures reduced leatherback bycatch by only 30–50% per season, because the simulated leatherback distributions were broad and open areas contained considerable bycatch risk. Perfect knowledge of the leatherback distribution provided an additional 5–15% bycatch reduction over a dynamic closure with realistic predictive accuracy. This moderate level of bycatch reduction highlights the limitations of redistributing fishing effort to reduce bycatch of broadly distributed and rarely encountered species, and indicates that, for these species, spatial management may work best when used with other bycatch mitigation approaches. We recommend future research explores methods for considering model uncertainty in the spatial and temporal resolution of dynamic closures.

**Syddall V, Thrush S, Fisher K, 2021. Transdisciplinary analysis of Pacific tuna fisheries: A research framework for understanding and governing oceans as social-ecological systems. *Marine Policy*, 134, p.104783.**

Western and Central Pacific (WCP) tuna fisheries are faced with complex and interlinked social and ecological challenges including high seas management issues, setting sustainable limits, human rights violations, and illegal, unreported, and unregulated (IUU) activities. However, strong but narrow disciplinary science persist to dominate governance. Effective governance across complex multi-scale systems in the WCP tuna fishery requires a more integrated understanding of social-ecological systems (SES). Transdisciplinary problem solving informed by participatory, social-ecological resilience research, and political ecology has the potential to reveal complicated interactions and connections across ocean SES networks. Social-Ecological-Oceans Systems Framework (SECO) was developed to capture the breadth and depth of the system and address interactions and connections between separate system components. SECO develops a practical integrated approach using accessible methods for addressing a large complex ocean system such as the WCP tuna fisheries. The framework offers a rapid transdisciplinary assessment and opens space for their deeper transdisciplinary analyses. This exploratory framework, as the WCP tuna case example shows, starts to reveal issues at scales that are not likely to be addressed by the strong single disciplinary approaches to governance now prevailing. The transdisciplinary research approach was developed to be responsive to diverse participants' knowledge, including local communities, scientists (social and biophysical), industry experts, economists, and fisheries managers. SECO was applied to place-specific studies, Suva, Fiji and Honiara and Gizo, Solomon Islands in the WCP tuna fishery. This validated SECO to ensure robustness and reliability

**Tanaka KR, Van Houtan KS, Mailander E, Dias BS, Galginitis C, O'Sullivan J, Lowe CG, Jorgensen SJ. 2021. North Pacific warming shifts the juvenile range of a marine apex predator. *Scientific Reports*. 11:3373. <https://doi.org/10.1038/s41598-021-82424-9>.**

During the 2014–2016 North Pacific marine heatwave, unprecedented sightings of juvenile white sharks (*Carcharodon carcharias*) emerged in central California. These records contradicted the species established life history, where juveniles remain in warmer waters in the southern California Current. This spatial shift is significant as it creates potential conflicts with commercial fisheries, protected species conservation, and public safety concerns. Here, we integrate community science, photogrammetry, biologging, and mesoscale climate data to describe and explain this phenomenon. We find a dramatic increase in white sharks from 2014 to 2019 in Monterey Bay that was overwhelmingly comprised of juvenile sharks < 2.5 m in total body length. Next, we derived thermal preferences from 22 million tag measurements of 14 juvenile sharks and use this to map the cold limit of their range. Consistent with historical records, the position of this cold edge averaged 34° N from 1982 to 2013 but jumped to 38.5° during the 2014–2016 marine heat wave. In addition to a poleward shift, thermally suitable habitat for juvenile sharks declined 223.2 km<sup>2</sup> year<sup>-1</sup> from 1982 to 2019 and was lowest in 2015 at the peak of the heatwave. In addition to advancing the adaptive management of this apex marine predator, we discuss this opportunity to engage public on climate change through marine megafauna.

**Timmers MA, Jury CP, Vicente J, Bahr KD, Webb MK, Toonen RJ. 2021. Biodiversity of coral reef cryptobiota shuffles but does not decline under the combined stressors of ocean**

**warming and acidification. Proceedings of the National Academy of Sciences. Volume 118: Issue 39. <https://doi.org/10.1073/pnas.2103275118>.**

Although climate change is expected to decimate coral reefs, the combined impacts of ocean-warming and acidification on coral reef biodiversity remains largely unmeasured. Here, we present a two-year mesocosm experiment to simulate future ocean acidification and ocean-warming to quantify the impacts on species richness, community composition, and community structure. We find that species richness is equivalent between the dual-stressor and present-day treatments but that the community shuffles, undoubtedly altering ecosystem function. However, our ability to predict the outcomes of such community shuffling remains limited due to the critical knowledge gap regarding ecological functions, life histories, and distributions for most members of the cryptobenthic community that account for the majority of the biodiversity within these iconic ecosystems.

**Whitney JL, Gove JM, McManus MA, Smith KA, Lecky J, Neubauer P, Phipps JE, Contreras EA, Kobayashi DR, Asner GP. 2021. Surface slicks are pelagic nurseries for diverse ocean fauna. Scientific Reports. 11(1):1-8. <https://doi.org/10.1038/s41598-021-81407-0>.**

Most marine animals have a pelagic larval phase that develops in the coastal or open ocean. The fate of larvae has profound effects on replenishment of marine populations that are critical for human and ecosystem health. Larval ecology is expected to be tightly coupled to oceanic features, but for most taxa we know little about the interactions between larvae and the pelagic environment. Here, we provide evidence that surface slicks, a common coastal convergence feature, provide nursery habitat for diverse marine larvae, including > 100 species of commercially and ecologically important fishes. The vast majority of invertebrate and larval fish taxa sampled had mean densities 2–110 times higher in slicks than in ambient water. Combining in-situ surveys with remote sensing, we estimate that slicks contain 39% of neustonic larval fishes, 26% of surface-dwelling zooplankton (prey), and 75% of floating organic debris (shelter) in our 1000 km<sup>2</sup> study area in Hawai‘i. Results indicate late-larval fishes actively select slick habitats to capitalize on concentrations of diverse prey and shelter. By providing these survival advantages, surface slicks enhance larval supply and replenishment of adult populations from coral reef, epipelagic, and deep-water ecosystems. Our findings suggest that slicks play a critically important role in enhancing productivity in tropical marine ecosystems.

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**APPENDIX A: LIST OF SPECIES****HAWAII MANAGEMENT UNIT SPECIES****1. MHI Deep-7 Bottomfish Multi-Species Stock Complex (FSSI)**

| <b>DAR Species Code</b> | <b>Species Name</b>        | <b>Scientific Name</b>             |
|-------------------------|----------------------------|------------------------------------|
| 19                      | pink snapper (‘ōpakapaka)  | <i>Pristipomoides filamentosus</i> |
| 22                      | longtail snapper (onaga)   | <i>Etelis coruscans</i>            |
| 21                      | squirrelfish snapper (ehu) | <i>Etelis carbunculus</i>          |
| 15                      | sea bass (hapu‘upu‘u)      | <i>Epinephelus quernus</i>         |
| 97                      | snapper (gindai)           | <i>Pristipomoides zonatus</i>      |
| 17                      | pink snapper (kalekale)    | <i>Pristipomoides sieboldii</i>    |
| 58                      | silver jaw jobfish (lehi)  | <i>Aphareus rutilans</i>           |

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

| <b>DAR Species Code</b> | <b>Species Name</b> | <b>Scientific Name</b>  |
|-------------------------|---------------------|-------------------------|
| 20                      | gray jobfish (uku)  | <i>Aprion virescens</i> |

**3. Seamount groundfish Complex (non-FSSI)**

| <b>DAR Species Code</b> | <b>Species Name</b> | <b>Scientific Name</b>       |
|-------------------------|---------------------|------------------------------|
| 140                     | Armorhead           | <i>Pentaceros wheeleri</i>   |
| 141                     | Alfonsin            | <i>Beryx splendens</i>       |
| None                    | Ratfish/butterfish  | <i>Hyperoglyphe japonica</i> |

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

| <b>DAR Species Code</b> | <b>Species Name</b> | <b>Scientific Name</b>   |
|-------------------------|---------------------|--------------------------|
| 708                     | deepwater shrimp    | <i>Heterocarpus</i> spp. |

|     |                            |                          |
|-----|----------------------------|--------------------------|
| 709 | deepwater shrimp (ensifer) | <i>Heterocarpus</i> spp. |
|-----|----------------------------|--------------------------|

#### 5. Crustacean Kona crab Complex (non-FSSI)

| DAR Species Code | Species Name | Scientific Name      |
|------------------|--------------|----------------------|
| 701              | Kona crab    | <i>Ranina ranina</i> |

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

| DAR Species Code | Species Name | Scientific Name           |
|------------------|--------------|---------------------------|
| 860              | Black Coral  | <i>Antipathes griggi</i>  |
| 860              | Black Coral  | <i>Antipathes grandis</i> |
| 860              | Black Coral  | <i>Myriopathes ulex</i>   |

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

| DAR Species Code | Species Name | Scientific Name                                         |
|------------------|--------------|---------------------------------------------------------|
| 871              | Pink coral   | <i>Pleurocorallium secundum</i>                         |
| 873              | Red coral    | <i>Hemicorallium laauense</i>                           |
| 881              | Gold Coral   | <i>Kulamanamana haumea</i> (prev. <i>Gerardia</i> spp.) |
| 892              | Bamboo coral | <i>Acanella</i> spp.                                    |

### MONITORED ECOSYSTEM COMPONENT SPECIES

#### 1. Species Selected for Monitoring by DLNR-DAR

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

| <b>DAR Species Code</b> | <b>Species Name</b>         | <b>Scientific Name</b>   |
|-------------------------|-----------------------------|--------------------------|
| 74                      | brown chub (nenu)           | <i>Kyphosus bigibbus</i> |
| 87/88/96                | parrotfish (uhu)            | Scaridae                 |
| 114                     | bluestripe snapper (ta‘ape) | <i>Lutjanus kasmira</i>  |
| 716/717/718             | lobster                     | Miscellaneous            |
| 724                     | limpets (‘opihi)            | <i>Cellana</i> spp.      |
| 726                     | day octopus (day tako)      | <i>Octopus cyanea</i>    |

## 2. Species Monitored by Trophic, 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 “Piscivore”.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

| <b>Family</b> | <b>Scientific Name</b>           | <b>Trophic Group</b> | <b>Functional Group</b> |
|---------------|----------------------------------|----------------------|-------------------------|
| Scaridae      | <i>Scarus forsteni</i>           | H                    | Parrotfish              |
| Scaridae      | <i>Scarus tricolor</i>           | H                    | Parrotfish              |
| Scaridae      | <i>Scarus xanthopleura</i>       | H                    | Parrotfish              |
| Scaridae      | <i>Hipposcarus longiceps</i>     | H                    | Parrotfish              |
| Scaridae      | <i>Scarus altipinnis</i>         | H                    | Parrotfish              |
| Scaridae      | <i>Chlorurus perspicillatus</i>  | H                    | Parrotfish              |
| Scaridae      | <i>Scaridae</i>                  | H                    | Parrotfish              |
| Scaridae      | <i>Scarus rubroviolaceus</i>     | H                    | Parrotfish              |
| Scaridae      | <i>Chlorurus microrhinos</i>     | H                    | Parrotfish              |
| Scaridae      | <i>Cetoscarus ocellatus</i>      | H                    | Parrotfish              |
| Scaridae      | <i>Scarus ghobban</i>            | H                    | Parrotfish              |
| Scaridae      | <i>Chlorurus</i> sp.             | H                    | Parrotfish              |
| Scaridae      | <i>Scarus</i> sp.                | H                    | Parrotfish              |
| Scaridae      | <i>Bolbometopon muricatum</i>    | Cor                  | Parrotfish              |
| Lutjanidae    | <i>Lutjanus fulvus</i>           | MI                   | Snappers                |
| Lutjanidae    | <i>Lutjanus kasmira</i>          | MI                   | Snappers                |
| Lutjanidae    | <i>Lutjanus gibbus</i>           | MI                   | Snappers                |
| Lutjanidae    | <i>Lutjanus monostigma</i>       | Pisc                 | Snappers                |
| Lutjanidae    | <i>Macolor macularis</i>         | Pk                   | Snappers                |
| Lutjanidae    | <i>Aphareus furca</i>            | Pisc                 | Snappers                |
| Lutjanidae    | <i>Macolor niger</i>             | Pk                   | Snappers                |
| Lutjanidae    | <i>Macolor</i> sp.               | Pk                   | Snappers                |
| Lutjanidae    | <i>Lutjanus bohar</i>            | Pisc                 | Snappers                |
| Lutjanidae    | <i>Lutjanus argentimaculatus</i> | MI                   | Snappers                |
| Lutjanidae    | <i>Aprion virescens</i>          | 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                                |
|-------------------------|--------------------------------------------------------------------------------|--------------------|-------------|------------------------------|-------------------------------------------|
| <b>Seabirds</b>         |                                                                                |                    |             |                              |                                           |
| Laysan Albatross        | <i>Phoebastria immutabilis</i>                                                 | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                          |
| Black-Footed Albatross  | <i>Phoebastria nigripes</i>                                                    | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                          |
| Short-Tailed Albatross  | <i>Phoebastria albatrus</i>                                                    | Endangered         | N/A         | Breeding visitor in the NWHI | 35 FR 8495, 65 FR 46643, Pyle & Pyle 2009 |
| Northern Fulmar         | <i>Fulmarus glacialis</i>                                                      | Not Listed         | N/A         | Winter resident              | Pyle & Pyle 2009                          |
| Kermadec Petrel         | <i>Pterodroma neglecta</i>                                                     | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Herald Petrel           | <i>Pterodroma arminjoniana</i>                                                 | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Murphy's Petrel         | <i>Pterodroma ultima</i>                                                       | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Mottled Petrel          | <i>Pterodroma inexpectata</i>                                                  | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Juan Fernandez Petrel   | <i>Pterodroma externa</i>                                                      | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Hawaiian Petrel         | <i>Pterodroma sandwichensis</i> ( <i>Pterodroma phaeopygia sandwichensis</i> ) | Endangered         | N/A         | Breeding visitor in the MHI  | 32 FR 4001, Pyle & Pyle 2009              |
| White-Necked Petrel     | <i>Pterodroma cervicalis</i>                                                   | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Bonin Petrel            | <i>Pterodroma hypoleuca</i>                                                    | Not Listed         | N/A         | Breeding visitor in the NWHI | Pyle & Pyle 2009                          |
| Black-Winged Petrel     | <i>Pterodroma nigripennis</i>                                                  | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Cook Petrel             | <i>Pterodroma cookii</i>                                                       | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Stejneger Petrel        | <i>Pterodroma longirostris</i>                                                 | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Pycroft Petrel          | <i>Pterodroma pycrofti</i>                                                     | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Bulwer's Petrel         | <i>Bulweria bulwerii</i>                                                       | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                          |
| Flesh-Footed Shearwater | <i>Ardenna carneipes</i>                                                       | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Wedge-Tailed Shearwater | <i>Ardenna pacifica</i>                                                        | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                          |
| Buller's Shearwater     | <i>Ardenna bulleri</i>                                                         | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |
| Sooty Shearwater        | <i>Ardenna grisea</i>                                                          | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                          |

| Common Name              | Scientific Name                                                    | ESA Listing Status | MMPA Status | Occurrence                   | References                       |
|--------------------------|--------------------------------------------------------------------|--------------------|-------------|------------------------------|----------------------------------|
| Short-Tailed Shearwater  | <i>Ardenna tenuirostris</i>                                        | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                 |
| Christmas Shearwater     | <i>Puffinus nativitatis</i>                                        | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Newell's Shearwater      | <i>Puffinus newelli</i><br>( <i>Puffinus auricularis newelli</i> ) | Threatened         | N/A         | Breeding visitor             | 40 FR 44149,<br>Pyle & Pyle 2009 |
| Wilson's Storm-Petrel    | <i>Oceanites oceanicus</i>                                         | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                 |
| Leach's Storm-Petrel     | <i>Oceanodroma leucorhoa</i>                                       | Not Listed         | N/A         | Winter resident              | Pyle & Pyle 2009                 |
| Band-Rumped Storm-Petrel | <i>Oceanodroma castro</i>                                          | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Tristram Storm-Petrel    | <i>Oceanodroma tristrami</i>                                       | Not Listed         | N/A         | Breeding visitor in the NWHI | Pyle & Pyle 2009                 |
| White-Tailed Tropicbird  | <i>Phaethon lepturus</i>                                           | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Red-Tailed Tropicbird    | <i>Phaethon rubricauda</i>                                         | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Masked Booby             | <i>Sula dactylatra</i>                                             | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Brown Booby              | <i>Sula leucogaster</i>                                            | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Red-Footed Booby         | <i>Sula sula</i>                                                   | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Great Frigatebird        | <i>Fregata minor</i>                                               | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Lesser Frigatebird       | <i>Fregata ariel</i>                                               | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Laughing Gull            | <i>Leucophaeus atricilla</i>                                       | Not Listed         | N/A         | Winter resident in the MHI   | Pyle & Pyle 2009                 |
| Franklin Gull            | <i>Leucophaeus pipixcan</i>                                        | Not Listed         | N/A         | Migrant                      | Pyle & Pyle 2009                 |
| Ring-Billed Gull         | <i>Larus delawarensis</i>                                          | Not Listed         | N/A         | Winter resident in the MHI   | Pyle & Pyle 2009                 |
| Herring Gull             | <i>Larus argentatus</i>                                            | Not Listed         | N/A         | Winter resident in the NWHI  | Pyle & Pyle 2009                 |
| Slaty-Backed Gull        | <i>Larus schistisagus</i>                                          | Not Listed         | N/A         | Winter resident in the NWHI  | Pyle & Pyle 2009                 |
| Glaucous-Winged Gull     | <i>Larus glaucescens</i>                                           | Not Listed         | N/A         | Winter resident              | Pyle & Pyle 2009                 |
| Brown Noddy              | <i>Anous stolidus</i>                                              | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Black Noddy              | <i>Anous minutus</i>                                               | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Blue-Gray Noddy          | <i>Procelsterna cerulea</i>                                        | Not Listed         | N/A         | Breeding visitor in the NWHI | Pyle & Pyle 2009                 |
| White Tern               | <i>Gygis alba</i>                                                  | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Sooty Tern               | <i>Onychoprion fuscatus</i>                                        | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Gray-Backed Tern         | <i>Onychoprion lunatus</i>                                         | Not Listed         | N/A         | Breeding visitor             | Pyle & Pyle 2009                 |
| Little Tern              | <i>Sternula albifrons</i>                                          | 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             | <i>Sternula antillarum</i>      | Not Listed                             | N/A         | Breeding visitor in the NWHI                                                                                                                                                                                                             | Pyle & Pyle 2009                                                              |
| Arctic Tern            | <i>Sterna paradisaea</i>        | Not Listed                             | N/A         | Migrant                                                                                                                                                                                                                                  | Pyle & Pyle 2009                                                              |
| South Polar Skua       | <i>Stercorarius maccormicki</i> | Not Listed                             | N/A         | Migrant                                                                                                                                                                                                                                  | Pyle & Pyle 2009                                                              |
| Pomarine Jaeger        | <i>Stercorarius pomarinus</i>   | Not Listed                             | N/A         | Winter resident in the MHI                                                                                                                                                                                                               | Pyle & Pyle 2009                                                              |
| Parasitic Jaeger       | <i>Stercorarius parasiticus</i> | Not Listed                             | N/A         | Migrant                                                                                                                                                                                                                                  | Pyle & Pyle 2009                                                              |
| Long-Tailed Jaeger     | <i>Stercorarius longicaudus</i> | Not Listed                             | N/A         | Migrant                                                                                                                                                                                                                                  | Pyle & Pyle 2009                                                              |
| <b>Sea turtles</b>     |                                 |                                        |             |                                                                                                                                                                                                                                          |                                                                               |
| Green Sea Turtle       | <i>Chelonia mydas</i>           | 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       | <i>Chelonia mydas</i>           | 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 DSLF fishery. | 43 FR 32800, 81 FR 20057, WPRFMC 2009, Clifton et al. 1982, Karl & Bowen 1999 |
| Hawksbill Sea Turtle   | <i>Eretmochelys imbricata</i>   | Endangered <sup>a</sup>                | N/A         | Small population foraging around Hawaii and low level nesting on Maui and Hawaii 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 | <i>Dermochelys coriacea</i>     | Endangered <sup>a</sup>                | 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  | <i>Caretta caretta</i>          | 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   | <i>Lepidochelys olivacea</i>   | 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                                                                 |
| <b>Marine mammals</b>     |                                |                                                                                                                               |               |                                                                                                                                                                |                                                                                                       |
| Blainville's Beaked Whale | <i>Mesoplodon densirostris</i> | 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                | <i>Balaenoptera musculus</i>   | 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        | <i>Tursiops truncatus</i>      | 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             | <i>Balaenoptera edeni</i>      | Not Listed                                                                                                                    | Unknown       | Common in Hawaiian Islands.                                                                                                                                    | Bradford et al. 2013                                                                                  |
| Common Dolphin            | <i>Delphinus delphis</i>       | Not Listed                                                                                                                    | N/A           | Found worldwide in temperate and subtropical seas.                                                                                                             | Perrin et al. 2009                                                                                    |
| Cuvier's Beaked Whale     | <i>Ziphius cavirostris</i>     | 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           | <i>Phocoenoides dalli</i>      | Not Listed                                                                                                                    | Non-strategic | Range across the entire north Pacific Ocean.                                                                                                                   | Hall 1979                                                                                             |
| Dwarf Sperm Whale         | <i>Kogia sima</i>              | 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        | <i>Pseudorca crassidens</i>    | 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 | <i>Pseudorca crassidens</i>      | 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 Hawaii 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          | <i>Balaenoptera physalus</i>     | Endangered                            | Strategic     | Infrequent sightings in Hawaii 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   | <i>Lagenodelphis hosei</i>       | 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 | <i>Neomonachus schauinslandi</i> | Endangered <sup>a</sup>               | Strategic     | Endemic tropical seal. Occurs throughout the archipelago. MHI population spends some time foraging in federal waters during the day.                                                                                                                                                                                                                                                                                                            | 41 FR 51611, Baker et al. 2011                                                                                       |
| Humpback Whale     | <i>Megaptera novaeangliae</i>    | Delisted Due to Recovery (Hawaii 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 & Antinaja 1977, Rice & Wolman 1978 |
| Killer Whale       | <i>Orcinus orca</i>              | 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      | <i>Indopacetus pacificus</i>      | 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          | <i>Peponocephala electra</i>      | 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                 | <i>Balaenoptera acutorostrata</i> | Not Listed         | Non-strategic | Occur seasonally around Hawai'i.                                                                                                     | Barlow 2003, Rankin & Barlow 2005                                                               |
| Pantropical Spotted dolphin | <i>Stenella attenuata</i>         | 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          | <i>Feresa attenuata</i>           | Not Listed         | Non-strategic | Small resident population.                                                                                                           | McSweeney et al. 2009                                                                           |
| Pygmy Sperm Whale           | <i>Kogia breviceps</i>            | Not Listed         | Non-strategic | Rare, found in nearshore waters.                                                                                                     | Baird et al. 2013                                                                               |
| Risso's Dolphin             | <i>Grampus griseus</i>            | Not Listed         | Non-strategic | Found in tropical to warm-temperate waters worldwide. Uncommon in Hawai'i.                                                           | Perrin et al. 2009                                                                              |
| Rough-Toothed Dolphin       | <i>Steno bredanensis</i>          | Not Listed         | Non-strategic | Found in tropical to warm-temperate waters worldwide. Present throughout Hawaii and in offshore waters.                              | Perrin et al. 2009, Baird et al. 2013, Barlow 2006, Bradford et al. 2013                        |
| Sei Whale                   | <i>Balaenoptera borealis</i>      | 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    | <i>Globicephala macrorhynchus</i> | Not Listed         | Non-strategic | Commonly observed around MHI and present around NWHI.                                                                                | Shallenberger 1981, Bradford et al. 2013, Baird et al. 2013                                     |
| Sperm Whale                 | <i>Physeter macrocephalus</i>     | 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             | <i>Stenella longirostris</i>      | 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, Andrews et al. 2010 |

| Common Name          | Scientific Name                | ESA Listing Status                 | MMPA Status   | Occurrence                                                                                                                                                                        | References                                                              |
|----------------------|--------------------------------|------------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Striped Dolphin      | <i>Stenella coeruleoalba</i>   | Not Listed                         | Non-strategic | Found in tropical to warm-temperate waters throughout the world                                                                                                                   | Perrin et al. 2009                                                      |
| <b>Elasmobranchs</b> |                                |                                    |               |                                                                                                                                                                                   |                                                                         |
| Giant manta ray      | <i>Manta birostris</i>         | 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     | <i>Carcharhinus longimanus</i> | 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 | <i>Sphyrna lewini</i>          | 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 | <i>Sphyrna lewini</i>          | 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 |

<sup>a</sup> 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<sup>a</sup>

| Common Name               | Scientific Name                  | ESA Listing Status | Critical Habitat                                                                                                                                                                                                                                                                                                        | References                            |
|---------------------------|----------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Hawksbill Sea Turtle      | <i>Eretmochelys imbricata</i>    | Endangered         | None in the Pacific Ocean.                                                                                                                                                                                                                                                                                              | 63 FR 46693                           |
| Leatherback Sea Turtle    | <i>Dermochelys coriacea</i>      | 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        | <i>Neomonachus schauinslandi</i> | 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 | <i>Eubalaena japonica</i>        | 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. |  |
|--|--|--|-------------------------------------------------------------------------------------------------------|--|

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

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