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ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT

HAWAII ARCHIPELAGO FISHERY ECOSYSTEM PLAN
2017

Western Pacific Regional Fishery Management Council
1164 Bishop St., Suite 1400
Honolulu, HI 96813
PHONE: (808) 522-8220
FAX: (808) 522-8226
www.wpcouncil.org

The ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT for the HAWAII ARCHIPELAGO FISHERY ECOSYSTEM 2017 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council, NMFS-Pacific Island Fisheries Science Center, Pacific Islands Regional Office, and the Division of Aquatic Resources (HI) Department of Marine and Wildlife Resources (AS), Division of Aquatic and Wildlife Resources (Guam), and Division of Fish and Wildlife (CNMI).

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

Edited By: Marlowe Sabater, Asuka Ishizaki, Rebecca Walker, Sylvia Spalding, and Thomas Remington WPRFMC

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

Hawaii Division of Aquatic Resources: Reginald Kokubun, Hal Koike, and Ryan Okano

NMFS Pacific Islands Fisheries Science Center: Justin Hospital, Ivor Williams, Joe O'Malley, Brett Taylor, Michael Parke, Phoebe Woodworth-Jefcoats, John Marra, Tom Oliver, Frank Parrish, T. Todd Jones, Kirsten Leong, and Minling Pan.

NMFS Pacific Islands Regional Office: Melanie Brown and Sarah Ellgen

Pacific Islands Regional Planning Body: Sarah Pautzke

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EXECUTIVE SUMMARY

As part of its five-year fishery ecosystem plan (FEP) review, the Council identified the annual reports as a priority for improvement. The former annual reports have been revised to meet National Standard regulatory requirements for the Stock Assessment and Fishery Evaluation (SAFE) reports. The purpose of the report 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 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 section of this report presents descriptions of Hawaiian commercial fisheries including deep-7 bottomfish, non-deep-7 bottomfish, coral reef, crustacean, and mollusk and limu management unit species (MUS). The data collection systems for each fishery are 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 for historical fishing parameters, top species catch by gear, and total catch values by gear are also provided. For 2017 catch in Hawaii, none of the evaluated MUS exceeded their associated annual catch limits (ACL), allowable biological catch (ABC) values, or overfishing limits (OFL). Note that ACLs were not specified for Kona crab, non-Deep 7 bottomfish, or coral reef ecosystem management unit species because the National Marine Fisheries Service (NMFS) had recently acquired new information that require additional environmental analyses to support the Council's ACL recommendations for these MUS. Recent average catch for the Main Hawaiian Island Deep 7 bottomfish stock complex (266,550 lbs.) accounted for 87.1% of its prescribed ACL (306,000 lbs.).

In 2017, the Main Hawaiian Island deep-7 bottomfish fishery was characterized by maintaining a decreasing trend in fishing effort and participation relative to measured averages. Though the number of fish caught and the weight also showed a decrease, effort and participation were decreasing such that CPUE for the fishery reflected an increase CPUE relative to short- and long-term averages. The deep 7 catch was mostly from the deep sea handline. The non-deep 7 bottomfish fishery was mostly dominated by uku (*Aprion virescens*) with a smaller contribution from white ulua (*Caranx ignobilis*). The fishery participation and effort were relatively consistent with short-term values and showed a slight increase in comparison with 20-year averages. The total number and pounds of non-Deep 7 bottomfish caught were up overall in 2017. Non-deep 7 species were landed using the deep-sea handline, inshore-handline, and troll method. The deep-sea handline method had interannual increases in participation, effort, catch, and CPUE. The inshore handline showed the same pattern of increasing participation, effort, and catch, though associated CPUE was slightly less. In contrast, while troll with bait had interannual decreases in all evaluated parameters except for CPUE, the comparisons with the short- and long-term averages showed stable effort and participation with increases in catch and CPUE.

The coral reef ecosystem management unit species (CREMUS) finfish fishery, in general, exhibited a decline in fishing participation, effort, and catch from 2016 and decadal averages. The CREMUS fishery is dominated by inshore handline that lands coastal pelagic species, followed by purse seine, lay gill net, and seine net that lands schooling and coastal pelagic species. Inshore handline had relatively low values for effort, participation, catch, and CPUE in

2017. Purse seine also showed a general decrease in the monitored parameters. In contrast, lay gill net had an increase in catch and CPUE in comparison with short- and long-term averages, while effort and participation were slightly lower. Seine net was showing an increase in effort from 2016; though catch and CPUE were on par with short-term averages, they were much less than the values noted for long-term averages an increase in catch and CPUE. The last major gear used was the spear that showed a general decline in 2017 for all monitored parameters.

In 2017, the crustacean fishery showed an overall decline. Considering the crustacean management unit species evaluated, participation and catch in the fishery for deep water shrimp (*Heterocarpus laevigatus*) were not disclosed due to data confidentiality despite having shown an increase in catch and CPUE last year. Kona crab and lobsters statistics were all down in 2017.

Monitoring for invertebrate fisheries for mollusks and limu was generally focused on hand harvest, spear, and inshore handline. Hand picking for invertebrates showed a general decline for opihi and opihi'alina, with an increase for lime kohu. Spearing for day octopus had an increase in effort, participation, catch, and CPUE from last year, though CPUE was on par with short- and long-term averages. Other octopus landed using the inshore handline also showed an increase in CPUE despite the overall decline in effort, participation, and catch values.

Ecosystem considerations were added to the annual SAFE report following the Council's review of its fishery ecosystem plans and revised management objectives. Fishery independent ecosystem survey data, human dimensions, protected species, climate and oceanographic, essential fish habitat, and marine planning information are included in the ecosystem considerations section.

Fishery independent ecosystem survey data was acquired through visual surveys conducted in Main Hawaiian Islands (MHI), Northwest Hawaiian Islands (NWHI), American Samoa, Pacific Remote Island Area, Commonwealth of Northern Mariana Islands, and Guam. This report illustrates the mean fish biomass for the reef areas within these locations. Additionally, the mean reef fish biomass and mean size of fishes (>10 cm) for the MHI and NWHI are presented by sampling year and reef area. Finally, the reef fish population estimates for each study site within MHI and NWHI are provided for hardbottom habitat (0-30 m).

This year for the Main Hawaiian Islands, a section was added showing life history parameters for a handful of species of both coral reef fish and bottomfish. 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

The socioeconomics section outlines the pertinent economic, social, and community information available for assessing the successes and impacts of management measures or the achievements of the Fishery Ecosystem Plan for the Hawaiian Archipelago. It meets the objective "Support Fishing Communities" adopted at the 165th Council meeting; specifically, it identifies the various social and economic groups within the region's fishing communities and their interconnections. The section begins with an overview of the socioeconomic context for the region, and then provides a summary of relevant studies and data for Hawaii, followed by summaries of relevant studies and data for each fishery within the Main Hawaiian Islands, and concludes with relevant socioeconomic data trends including commercial pounds sold, revenues, and prices. There were no new data reported for neither the crustacean nor the precious coral fisheries in the Main Hawaiian Islands. Considering the Hawaiian bottomfish fishery, the price for bottomfish management unit species stayed relatively stable at approximately $6/lb. in 2017 ($7.41/lb. for Deep-7; $4.03/lb. for non-Deep-7), while the most recently calculated average cost of a bottomfish trip was approximately $253. For the coral reef fishery in the area, the price of coral reel management unit species also remained relatively steady at $3.63/lb. in 2017, while the average cost of a spearfishing trip was notably cheaper than bottomfishing in the Main Hawaiian Islands at $159.

The protected species section of this report summarizes information and monitors protected species interactions in fisheries managed under the Hawaii FEP. These fisheries generally have limited impacts to protected species, and currently do not have federal observer coverage. Consequently, this report tracks fishing effort and other characteristics to detect potential changes to the level of impacts to protected species. Fishery performance data contained 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 to indicate that impacts to protected species have changed in recent years.

The climate change section of this report includes indicators of current and changing climate and related oceanic conditions in the geographic areas for which the Western Pacific Regional Fishery Management Council has responsibility. 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 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, as well as provide historical context and recognize patterns and trends. The atmospheric concentration of carbon dioxide (CO_2) trend is increasing exponentially with the time series maximum at 406.53 ppm. The oceanic pH at Station Aloha, in Hawaii has shown a significant linear decrease of -0.0386 pH units, or roughly a 9% increase in acidity ([H+]) since 1989. The year 2017 had relatively low temperature anomalies, with values not surpassing two degree heating weeks in area surrounding the Main Hawaiian Islands. The East Pacific hurricane season saw 18 named storms in 2017, nine of which were hurricanes and four major. The north central Pacific, conversely, had no storms over the course of 2017. This year, the climate change section was updated with information on storm-force winds as well as an additional indicator for precipitation.

The essential fish habitat (EFH) review section of this report is required by the Hawaii Archipelago FEP and National Standard 2 guidelines, and includes cumulative impacts on 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 essential fish habitat review section of 2017 annual SAFE report, a literature review of the life history and habitat requirements for each life stage of four reef-associated crustaceans 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*). The most up to date information on species distribution, fisheries status, and life history are summarized. This section is also meant to address any Council directives toward its Plan Team; however, there were no Plan Team directives in 2017.

The marine planning section of this report tracks 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. In the Hawaii Archipelago, alternative energy development and military activities are those with the highest potential fisheries impact. The Bureau of Ocean Energy Management received four nominations of commercial interest for its Call Areas northwest and south of Oahu, all of which are in the area identification and environmental assessment stage of the leasing process. The Department of Defense is released a draft environmental impact statement regarding activities entitled “Hawaii-Southern California Training and Testing” in October 2017; these activities will likely impact fishing access and fish habitat.

The data integration chapter of this report is still under development. The Council hosted a Data Integration Workshop in late 2016 with a goal of identifying policy-relevant fishery ecosystem relationships. The archipelagic data integration chapter currently explores the potential association between fishery parameters and precipitation, primary productivity, and temperature-derived variables. A contractor has recently completed these analyses, and intial results of exploratory analyses are included for the first time in 2017. The commercial coral reef fisheries of the Main Hawaiian Islands generally showed weak associations with the environmental parameters evaluated. No connection was discovered between sum of the coral reef fisheries in the region with sea surface temperature, though the weke (i.e. goatfish of the family Mullidae) taxa group had a positively-significant statistical relationship with the variable. No general associations were discovered between precipitation and akule or opelu. Lastly, the relationship between the sum of the commercial reef fisheries in the Main Hawaiian Islands and the concentration of fluorometric chlorophyll-*a* integrated over the top 200 meters of the water column was determined to be statistically significant in a negative fashion. In line with these results, the taape taxa group showed the strongest significant relationship with the same environmental variable, also negative. A non-metric multidimensional scaling analysis showed that, while the evaluation was not able to identify any significant levels of association between expanded creel catch data and a swath of environmental parameters, the first axis, responsible for explaining 94% of the variance, showed the strongest relationships with salinity (negative) and pH (positive). In continuing forward with associated analyses and presentation of results for the data integration chapter, the Plan Team suggested several improvements to implement in the coming year: standardizing and correcting values in CPUE time series, incorporating longer stretches of phase lag, completing comparisons on the species-level and by dominant gear types, incorporating local knowledge on shifts in fishing dynamics over the course of the time series, and utilizing the exact environmental data sets presented in the ecosystem consideration chapter of the annual report. Implementation of these suggestions will allow for the preparation of a more finalized version of the data integration chapter in the coming year.

The 2018 Archipelagic Plan Team had the following recommendations with respect to this report:

Regarding the monitoring of the management unit species, the Archipelagic Plan Team recommends the Council to direct staff to work with the Territory fishery agencies to identify and resolve issues with regards to real-time accurate reporting, such as regulatory gaps, and potential solutions, such as mandatory licensing and reporting (e.g. log books).

Regarding the development and improvement of data collection systems in the short term, the Archipelagic Plan Team recommends the Council to support these processes by exploring the options of: a dedicated port sampler to conduct a full census of the bottomfish catch, the improvement and expansion of Commercial Receipt Books, and improvements in the timeliness of the data transcription.

Regarding the carry-over provision of the 2016 National Standard 1, the Archipelagic Plan Team recommends the Council direct staff to explore the application of the carry-over provision in the Council's control rules.

Regarding the evaluation 2017 catch relative to 2017 ACLs, the Archipelagic Plan Team recommends retaining the ACL at 60 lbs. for CNMI slipper lobster. The CNMI slipper lobsters recent three-year average of catch amounting to 130 lbs. exceeded its ACL of 60 lbs. The slipper lobster fishery is tracked through the Commercial Receipt Books. The increase in catch can likely be attributed to the implementation of the Territory Science Initiative, designed to improve the data submitted to the Commercial Receipt Books. In 2017, seven invoices and five fishermen reported the sale of slipper lobsters, which were zeroes in years prior to 2016.

Regarding the improvement of identifying precious coral essential fish habitat, the Archipelagic Plan Team endorses the Plan Team Precious Coral Working Group Report, and they recommend that the Council direct staff to develop an analysis of options to redefine EFH/HAPC for Council consideration for an FEP amendment.

Regarding the research priorities, the Archipelagic Plan Team adopts the changes proposed by the Social Science Planning Committee to the Human Communities section of the Council's MSRA five-year research priorities.

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ACRONYMS AND ABBREVIATIONS

Acronym	**Meaning**
ABC	Acceptable Biological Catch
ACE	Accumulated Cyclone Energy
ACL	Annual Catch Limits
ACT	Annual Catch Target
AM	Accountability Measures
AVHRR	Advanced Very High Resolution Radiometer
BAC-MSY	Biomass Augmented Catch MSY
B_{FLAG}	warning reference point for biomass
BiOp	Biological Opinion
BMUS	Bottomfish Management Unit Species
BOEM	Bureau of Ocean Energy Management
BSIA	Best Scientific Information Available
CFR	Code of Federal Regulations
CMLS	Commercial Marine License System
CMS	coastal and marine spatial
CMUS	Crustacean Management Unit Species
CNMI	Commonwealth of the Northern Mariana Islands
CPUE	Catch Per Unit Effort
CRED	Coral Reef Ecosystem Division
CREMUS	Coral Reef Ecosystem Management Unit Species
DLNR-DAR	Department of Land and Natural Resources-Division of Aquatic Resources
DPS	Distinct Population Segment
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EKE	Eddy kinetic energy
ENSO	El Niño Southern Oscillation
EO	Executive Order
ESA	Endangered Species Act
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
FRS	Fishing Report System
GAC	Global Area Coverage
GFS	global forecast system
HAPC	Habitat Area of Particular Concern
HDAR	Hawaii Division of Aquatic Resources
IBTrACS	International Best Track Archive for Climate Stewardship
LOF	List of Fisheries
LVPA	Large Vessel Prohibited Area
MFMT	Maximum Fishing Mortality Threshold

MHI	Main Hawaiian Island
MMA	marine managed area
MMPA	Marine Mammal Protection Act
MPA	marine protected area
MPCC	Marine Planning and Climate Change
MPCCC	Council's MPCC Committee
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
MUS	management unit species
NCADAC	National Climate Assessment & Development Advisory Committee
NCDC	National Climatic Data Center
NEPA	National Environmental and Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service
NMFS	National Marine Fisheries Service
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWHI	Northwestern Hawaiian Islands
OFL	Overfishing Limits
OFR	Online Fishing Report
ONI	Ocean Niño Index
OR&R	Office of Response and Restoration
OY	Optimum Yield
PacIOOS	Pacific Integrated Ocean Observing System
PCMUS	Precious Coral Management Unit Species
Pelagic FEP	Fishery Ecosystem Plan for the Pacific Pelagic Fisheries
PI	Pacific Islands
PIBHMC	Pacific Island Benthic Habitat Mapping Center
PIFSC	Pacific Island Fisheries Science Center
PIRCA	Pacific Islands Regional Climate Assessment
PIRO	NOAA NMFS Pacific Islands Regional Office
PMUS	pelagic management unit species
POES	Polar Operational Environmental Satellite
PRIA	Pacific Remote Island Areas
RAMP	Reef Assessment and Monitoring Program
RPB	Regional Planning Body
SAFE	Stock Assessment and Fishery Evaluation
SBRM	Standardized Bycatch Reporting Methodologies
SDC	Status Determination Criteria
SEEM	Social, Economic, Ecological, Management uncertainties
SPC	Stationary Point Count
SST	Sea Surface Temperature
TAC	Total Allowable Catch
USACE	United States Army Corps of Engineers

WPacFIN	Western Pacific Fishery Information Network
WPRFMC	Western Pacific Regional Fishery Management Council
WPSAR	Western Pacific Stock Assessment Review

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1 FISHERY PERFORMANCE

1.1 DEEP-7 BMUS

1.1.1 Fishery Descriptions

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

1.1.2 Data Collection Systems

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

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

The data records from fishing reports submitted online by fishers are automatically extracted and exported as daily batch text files from the OFR and uploaded by DLNR-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. The assistant will call the fisher or dealer to clarify any discrepancies. The data supervisor then transfers both fisheries and dealer data to WPacFIN daily where data trends are created and reported weekly to Deep-7 fishery managers and stake holders. A bottomfish newsletter is published for bottomfishers and fish dealers on a quarterly basis.

1.1.2.1 Historical Summary

Table 1. 2017 annual fishing parameters for the Deep-7 bottomfish fishery comparing current values with short-term (10-year) and the long-term (20-year) average Values are for the fishing year.

Fishery	Parameters	2017 Values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
BMUS Deep-7	No. License	339	↓ 20.4%	↓ 19.9%
	Trips	2,327	↓ 19.2%	↓ 23.8%
	No. Caught	65,886	↓ 4.29%	↓ 2.47%
	Lbs. Caught	235,731	↓ 5.11%	↓ 5.24%

1.1.2.2 Species Summary

Table 2. 2017 annual indicators for the Deep-7 bottomfish fishery comparing current estimates with the short-term (10-year) and the long-term (20-year) average. Values are for the fishing year.

Methods	Fishery indicators	2017 values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep-Sea Handline	Opakapaka	132,329 lbs.	↑ 8.40%	↑ 9.01%
	Onaga	45,786 lbs.	↓ 30.6%	↓ 32.5%
	Ehu	23,948 lbs.	↓ 8.05%	↓ 0.55%
	Hapuupuu	7,675 lbs.	↓ 12.5%	↓ 23.3%
	No. Lic.	323	↓ 20.1%	↓ 19.7%
	No. Trips	2,180	↓ 21.2%	↓ 26.3%
	Lbs. Caught	229,469 lbs.	↓ 7.08%	↓ 7.09%
	CPUE	105.3 lbs./trip	↑ 17.0%	↑ 23.8%
Inshore Handline	Opakapaka Ehu Lehi	Insufficient data to report trends		

	Onaga			
	No. Lic. No. Trips Lbs. Caught CPUE	4 4 15 lbs. 3.75 lbs./trip	↓ 60.0% ↓ 78.9% ↓ 97.7% ↓ 86.6%	↓ 63.6% ↓ 80.0% ↓ 97.2% ↓ 82.1%
Palu-ahi	Opakapaka	3,168 lbs.	↑ 243%	↑ 442%
	Ehu	Insufficient data to report trends		
	Lehi	986 lbs.	↑ 1.75%	↑ 45.0%
	Hapuupuu	Insufficient data to report trends		
	No. Lic. No. Trips Lbs. Caught CPUE	23 121 4,484 lbs. 37.1 lbs./trip	0% ↑ 47.6% ↑ 116% ↑ 54.4%	↑ 21.1% ↑ 102% ↑ 233% ↑ 95.1%

1.1.3 Time Series Statistics

1.1.3.1 Commercial Fishing Parameters

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

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

Table 3. Time series of commercial fishermen reports for Deep-7 BMUS fishery (1966-2017). Historical record reported by Fiscal Year from 1966-1993 and by Fishing Year from 1994-2017. July and August 1993 omitted to allow for this change.

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1966	92	1055	413	11018	181629
1967	110	1469	550	16005	231315
1968	121	1193	524	12906	194851
1969	132	1216	532	11409	177381
1970	139	1150	528	8482	158195
1971	167	1254	606	10203	135156
1972	218	1929	831	19833	228375
1973	210	1574	732	16747	169273
1974	264	2161	938	23976	225561
1975	247	2094	903	24052	221385
1976	303	2265	995	23896	250270
1977	338	2722	1173	26872	274298
1978	434	2658	1540	41381	307672
1979	447	2255	1517	32312	273846
1980	461	2853	1435	35096	244219
1981	486	3769	1636	45085	308296
1982	451	3917	1634	46873	329436
1983	539	4875	1890	61857	409241
1984	553	4462	1799	55532	340790
1985	551	5752	2043	88679	484042
1986	605	5748	2256	99886	509121
1987	581	5572	2178	132498	579170
1988	550	6033	2122	136728	566724
1989	564	6253	2231	117599	559293
1990	531	5249	1944	90353	455802
1991	499	4223	1773	68411	334673
1992	488	4508	1846	85693	371245
1993	450	3550	1497	63668	265287
1993	121	374	168	7356	28826
1994	518	3886	1698	84875	318461
1995	525	3921	1706	78159	320940
1996	519	3999	1755	84096	295881
1997	500	4189	1762	83893	307615
1998	520	4119	1733	83781	290083
1999	430	3007	1428	56682	214004
2000	497	3929	1697	84064	311611
2001	457	3572	1550	71433	265755
2002	388	2856	1334	54520	209351
2003	364	2936	1248	62891	246814
2004	331	2649	1138	57386	208743

Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2005	351	2702	1198	61410	241660
2006	352	2266	1051	45427	189550
2007	356	2548	1144	49953	204792
2008	353	2345	1023	49423	196889
2009	476	3266	1473	66836	258335
2010	460	2787	1224	56645	207978
2011	472	3423	1408	74412	273053
2012	479	3079	1520	67956	226704
2013	458	2977	1497	68445	239063
2014	423	3172	1492	90291	311179
2015	410	2886	1413	90793	307075
2016	372	2344	1194	76831	277454
2017	339	2327	1152	65886	235731
10-year avg.	**426**	**2879**	**1338**	**68839**	**248431**
20-year avg.	**423**	**3052**	**1376**	**67554**	**248757**

1.1.4 Top Four Species per Gear Type

1.1.4.1 Deep-sea Handline

The heavy tackle, deep-sea handline gear is the dominant method for this fishery. The opakapaka and onaga are the primary target species, with the latter requiring much more fishing skill. In recent years, bottomfishers have remarked that opakapaka is the preferred target due to less fishing grounds and because it is easier to land for what is now a one-day fishery.

Table 4. HDAR MHI Fiscal Annual Deep-7 Catch (lbs. caught) Summary (1966-2017) by Species and top Gear: Deep-sea handline. Historical record reported by Fiscal Year from 1966-1993 and by Fishing Year from 1994-2017. July and August 1993 omitted to allow for this change.

Year	Opakapaka		Onaga		Ehu		Hapuupuu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	76	70651	34	63965	47	17587	49	11644
1967	96	120888	43	68442	62	18350	60	10624
1968	97	83983	62	69504	68	19864	58	11304
1969	115	85663	48	53839	68	16088	60	10881
1970	114	69538	44	43540	62	15870	64	19842
1971	130	59002	53	39213	78	15255	81	14471
1972	184	117426	71	58673	105	21282	112	16659
1973	175	93197	68	35584	94	14524	117	14828
1974	220	134838	86	43607	113	21113	117	14444
1975	199	114571	94	45016	113	21136	108	23078

1976	224	101618	118	78684	105	21621	140	21236
1977	255	98398	100	82049	144	32530	130	26769
1978	345	149538	135	66124	191	34385	197	27366
1979	306	140303	133	51601	190	20859	184	28053
1980	344	147342	161	29889	183	15836	182	16984
1981	386	193944	153	42659	207	20754	188	16056
1982	370	173803	177	65235	233	24088	189	20854
1983	422	226589	240	71687	277	27450	209	31733
1984	394	153138	239	84602	281	35214	207	26286
1985	437	196016	296	162305	308	40325	250	30960
1986	475	171581	343	194172	368	59768	241	23593
1987	454	254234	287	173638	320	45258	175	27703
1988	445	299861	272	156077	296	41010	194	10039
1989	436	306607	302	142829	318	37110	184	13288
1990	419	209597	307	141419	312	37326	176	13488
1991	385	138285	276	104562	301	32397	169	17217
1992	375	174138	253	95363	308	33331	165	17915
1993	346	138439	194	52703	256	25588	167	15721
1993	85	14511	51	5707	61	3087	35	2120
1994	393	176118	241	71989	287	22658	190	11610
1995	427	179674	236	65906	289	26001	230	15564
1996	417	148425	245	68198	279	31371	223	12017
1997	380	160062	218	61209	266	28676	216	15796
1998	386	146576	250	68984	299	25402	215	12458
1999	325	101755	198	60605	233	19747	179	9908
2000	386	166796	251	72599	283	27600	209	13569
2001	340	127076	253	64661	273	25856	203	15845
2002	288	100796	194	59867	218	17149	165	8676
2003	256	127191	190	69473	214	15768	142	9442
2004	233	87126	185	76754	193	20557	131	8384
2005	249	102641	202	87588	208	21948	131	10548
2006	245	73282	202	74745	206	18327	122	7635
2007	270	82512	202	80629	223	17566	118	6155
2008	271	94145	197	55680	210	17910	133	6729
2009	361	132724	245	59827	295	24649	168	7808
2010	324	102000	251	56166	296	23718	165	8022
2011	367	146934	258	67375	304	24124	175	8002
2012	341	109265	261	55524	321	27276	157	9737
2013	326	98600	246	68383	306	31332	156	10342
2014	324	162369	233	75213	275	30408	161	10667
2015	308	150657	227	78044	269	33058	138	9930

2016	280	136357	201	73792	232	32050	120	10010
2017	263	131329	172	45786	222	23948	127	7675
10-year avg.	**318**	**121154**	**232**	**65949**	**273**	**26045**	**149**	**8774**
20-year avg.	**313**	**120474**	**223**	**67811**	**256**	**24080**	**160**	**10005**

1.1.4.2 Inshore Handline

The inshore handline gear is supposed to be a lighter tackle than the deep-sea handline. The ehu and onaga landings were probably made with the heavier tackle gear, but were reported by fishers as inshore handline. For these cases, in recent years fishers were contacted to verify the gear reported. The fishing report was not amended if the fisher did not respond. The opakapaka and lehi landings were probably fished in shallow water habitat.

Table 5. HDAR MHI Fiscal Annual Deep-7 Catch (Lbs. caught) Summary (1966-2017) by Species and second Gear: Inshore handline. Historical record reported by Fiscal Year from 1966-1993 and by Fishing Year from 1994-2017. July and August 1993 omitted to allow for this change.

Year	**Opakapaka**		**Ehu**		**Lehi**		**Onaga**	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	4	500	4	55	n.d.	n.d.	n.d.	n.d.
1967	n.d.	n.d.	NULL	NULL	n.d.	n.d.	NULL	NULL
1968	NULL	NULL	n.d.	n.d.	NULL	NULL	NULL	NULL
1969	n.d.	n.d.	4	80	NULL	NULL	n.d.	n.d.
1970	n.d.	n.d.	NULL	NULL	4	129	NULL	NULL
1971	4	56	5	26	n.d.	n.d.	6	57
1972	n.d.	n.d.	3	26	n.d.	n.d.	n.d.	n.d.
1973	n.d.	n.d.	3	37	3	32	n.d.	n.d.
1974	n.d.	n.d.	NULL	NULL	n.d.	n.d.	NULL	NULL
1975	12	1318	3	54	6	327	n.d.	n.d.
1976	21	975	9	398	10	387	11	857
1977	40	2552	27	1024	12	473	13	1572
1978	43	1735	28	415	36	943	5	84
1979	100	4644	60	1451	53	1934	19	1406
1980	13	113	9	40	21	712	3	14
1981	18	531	9	39	14	336	5	26
1982	15	111	16	129	19	296	6	84
1983	30	228	24	235	22	360	11	283
1984	16	668	16	154	29	274	14	883
1985	NULL	NULL	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1986	8	267	4	36	5	29	n.d.	n.d.

Year	**Opakapaka**		**Ehu**		**Lehi**		**Onaga**	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1987	13	647	n.d.	n.d.	3	16	NULL	NULL
1988	4	53	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1989	6	291	5	33	NULL	NULL	n.d.	n.d.
1990	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
1991	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1992	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1993	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1993	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1994	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1995	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1996	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1997	3	22	n.d.	n.d.	4	29	n.d.	n.d.
1998	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	NULL	NULL
1999	NULL	NULL	NULL	NULL	n.d.	n.d.	NULL	NULL
2000	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	NULL	NULL
2001	6	80	3	74	NULL	NULL	NULL	NULL
2002	5	51	n.d.	n.d.	NULL	NULL	n.d.	n.d.
2003	7	211	6	191	n.d.	n.d.	n.d.	n.d.
2004	15	824	6	51	3	7	5	90
2005	9	772	5	246	7	68	3	200
2006	6	539	3	21	NULL	NULL	n.d.	n.d.
2007	9	1074	3	430	4	88	n.d.	n.d.
2008	5	268	n.d.	n.d.	3	24	n.d.	n.d.
2009	15	733	4	78	3	111	3	40
2010	14	250	8	172	3	33	4	63
2011	7	242	3	13	n.d.	n.d.	NULL	NULL
2012	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
2013	3	12	NULL	NULL	n.d.	n.d.	NULL	NULL
2014	NULL	NULL	n.d.	n.d.	n.d.	n.d.	NULL	NULL
2015	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2016	n.d.	n.d.	NULL	NULL	n.d.	n.d.	NULL	NULL
2017	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
10 -year avg.	**7**	**335**	**3**	**162**	**n.d.**	**n.d.**	**n.d.**	**n.d.**
20- year avg.	**7**	**308**	**3**	**108**	**n.d.**	**n.d.**	**n.d.**	**n.d.**

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

1.1.4.3 Palu ahi

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

Table 6. HDAR MHI Fiscal Annual Deep-7 Catch (Lbs. caught) Summary (1983-2017) by Species and third Gear: palu ahi. Historical record reported by Fiscal Year from 1966-1993 and by Fishing Year from 1994-2017. July and August 1993 omitted to allow for this change.

Year	**Opakapaka**		**Ehu**		**Lehi**		**Hapuupuu**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1983	n.d.	n.d.	NULL	NULL	3	50	NULL	NULL
1984	3	629	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1985	NULL	NULL	NULL	NULL	n.d.	n.d.	NULL	NULL
1986	10	275	n.d.	n.d.	9	1087	NULL	NULL
1987	6	112	n.d.	n.d.	9	331	NULL	NULL
1988	n.d.	n.d.	n.d.	n.d.	9	165	n.d.	n.d.
1989	3	110	NULL	NULL	4	91	NULL	NULL
1990	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1991	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1992	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1993	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1993	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1994	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1995	n.d.	n.d.	NULL	NULL	6	92	NULL	NULL
1996	4	15	NULL	NULL	12	228	NULL	NULL
1997	3	64	n.d.	n.d.	14	226	NULL	NULL
1998	n.d.	n.d.	NULL	NULL	11	291	NULL	NULL
1999	5	86	NULL	NULL	13	410	NULL	NULL
2000	8	133	NULL	NULL	11	302	NULL	NULL
2001	4	30	NULL	NULL	4	34	NULL	NULL
2002	NULL	NULL	n.d.	n.d.	4	135	n.d.	n.d.
2003	10	298	n.d.	n.d.	12	450	n.d.	n.d.
2004	13	436	n.d.	n.d.	15	717	3	68
2005	11	134	n.d.	n.d.	16	551	n.d.	n.d.
2006	8	680	NULL	NULL	18	782	NULL	NULL

Year	**Opakapaka**		**Ehu**		**Lehi**		**Hapuupuu**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
2007	9	340	n.d.	n.d.	12	539	NULL	NULL
2008	12	1754	3	8	16	1238	3	39
2009	8	1731	5	97	26	1613	n.d.	n.d.
2010	14	272	4	73	20	683	n.d.	n.d.
2011	4	168	n.d.	n.d.	9	218	n.d.	n.d.
2012	18	400	n.d.	n.d.	18	1029	n.d.	n.d.
2013	21	1174	n.d.	n.d.	21	1505	n.d.	n.d.
2014	24	1217	4	24	25	1322	NULL	NULL
2015	16	1491	n.d.	n.d.	19	938	n.d.	n.d.
2016	14	698	n.d.	n.d.	11	598	n.d.	n.d.
2017	17	3168	n.d.	n.d.	19	986	4	122
10-year avg.`	**14**	**923**	**3**	**43**	**18**	**969**	**n.d.**	**n.d.**
20 -year avg.	**11**	**584**	**n.d.**	**n.d.**	**15**	**680**	**n.d.**	**n.d.**

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

1.1.5 Catch Parameters by Gear

The CPUE (lbs. per trip) for the dominant method, deep-sea handline, peaked at the beginning of the time series, and leveled off since the early 1990's and through 2012. Most of the flat CPUE ranging between 71-92 lbs. per trip is attributed to state and federal regulations that removed fishing areas, interim closed season, and quotas on the landings. Recently, CPUE is trending up since 2014; last year it was ~105 lbs. per trip. Fishers are making fewer trips, but landings are larger because the size-weight of the Deep-7 bottomfish is increasing.

Table 7. HDAR MHI Fiscal Annual Deep-7 CPUE by dominant fishing methods (1966-2016). Historical record reported by Fiscal Year from 1966-1993 and by Fishing Year from 1994-2016. July and August 1993 omitted to allow for this change.

Year	**Deep-sea handline**				**Inshore handline**				**Palu ahi**			
	No. Lic.	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic**	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**
1966	86	1012	180165	178.03	10	16	711	44.44	NULL	NULL	NULL	0
1967	107	1449	231014	159.43	4	5	45	9	NULL	NULL	NULL	0
1968	118	1164	194494	167.09	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	0
1969	128	1175	176874	150.53	8	14	234	16.71	NULL	NULL	NULL	0
1970	135	1118	157853	141.19	5	6	161	26.83	NULL	NULL	NULL	0
1971	163	1219	134916	110.68	14	24	185	7.71	NULL	NULL	NULL	0
1972	214	1896	227744	120.12	15	22	182	8.27	NULL	NULL	NULL	0

1973	201	1537	168976	109.94	13	16	117	7.31	NULL	NULL	NULL	0
1974	258	2126	225181	105.92	4	6	61	10.17	NULL	NULL	NULL	0
1975	238	2038	219094	107.5	21	39	1864	47.79	NULL	NULL	NULL	0
1976	270	2028	241655	119.16	50	103	3134	30.43	NULL	NULL	NULL	0
1977	290	2263	255125	112.74	61	195	7428	38.09	NULL	NULL	NULL	0
1978	392	2365	297167	125.65	103	209	3866	18.5	NULL	NULL	NULL	0
1979	379	1901	259999	136.77	171	327	11685	35.73	NULL	NULL	NULL	0
1980	412	2591	235253	90.8	49	92	1038	11.28	NULL	NULL	NULL	0
1981	456	3458	301716	87.25	48	79	1114	14.1	NULL	NULL	NULL	0
1982	429	3688	322688	87.5	58	103	742	7.2	n.d.	n.d.	n.d.	n.d.
1983	501	4571	401606	87.86	90	166	1482	8.93	3	8	64	8
1984	503	4157	330294	79.45	82	148	2535	17.13	5	22	930	42.27
1985	533	5623	481308	85.6	10	13	1024	78.77	n.d.	n.d.	n.d.	n.d.
1986	582	5563	503729	90.55	27	42	790	18.81	12	63	1403	22.27
1987	562	5412	569395	105.21	21	39	887	22.74	13	35	484	13.83
1988	534	5955	564910	94.86	11	15	141	9.4	9	17	262	15.41
1989	536	6155	556924	90.48	20	27	629	23.3	5	12	201	16.75
1990	526	5230	454948	86.99	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	0
1991	492	4205	334546	79.56	4	4	55	13.75	NULL	NULL	NULL	0
1992	483	4485	371088	82.74	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	0
1993	445	3537	265195	74.98	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	0
1993	120	372	28773	77.35			NULL	0	NULL	NULL	NULL	0
1994	511	3864	318157	82.34	6	7	64	9.14	NULL	NULL	NULL	0
1995	516	3897	320634	82.28	n.d.	n.d.	n.d.	n.d.	6	6	105	17.5
1996	507	3952	295248	74.71	5	6	28	4.67	13	21	243	11.57
1997	484	4129	306177	74.15	13	16	128	8	16	23	301	13.09
1998	506	4056	288890	71.23	7	7	69	9.86	11	30	301	10.03
1999	415	2920	213039	72.96	4	4	38	9.5	14	48	496	10.33
2000	492	3885	311032	80.06	6	8	59	7.38	13	30	435	14.5
2001	447	3536	265437	75.07	9	19	178	9.37	6	9	79	8.78
2002	381	2826	208840	73.9	9	14	93	6.64	5	14	199	14.21
2003	345	2844	244718	86.05	14	26	543	20.88	16	49	850	17.35
2004	301	2530	206293	81.54	19	40	1117	27.93	21	72	1271	17.65
2005	319	2596	239409	92.22	21	50	1389	27.78	22	49	803	16.39
2006	323	2155	186274	86.44	11	27	673	24.93	19	61	1464	24
2007	334	2433	201381	82.77	14	46	2291	49.8	16	56	902	16.11
2008	331	2241	192029	85.69	8	15	1494	99.6	20	78	3119	39.99
2009	448	3117	252861	81.12	18	29	1078	37.17	31	105	3943	37.55
2010	421	2660	205699	77.33	25	41	616	15.02	28	67	1352	20.18
2011	449	3330	270282	81.17	9	18	284	15.78	11	33	542	16.42
2012	464	2979	224953	75.51	3	3	19	6.33	23	90	1512	16.8

2013	439	2847	235651	82.77	5	5	21	4.2	32	119	2785	23.4
2014	404	3061	308472	100.77	3	3	26	8.67	31	106	2638	24.89
2015	392	2765	303255	109.68	3	9	156	17.33	24	89	2599	29.2
2016	353	2245	275016	122.5	n.d.	n.d.	n.d.	n.d.	18	73	1366	18.71
2017	323	2180	229469	105.26	4	4	15	3.75	23	121	4484	37.06
10-year avg.	**404**	**2,768**	**246,960**	**90**	**10**	**19**	**665**	**28**	**23**	**82**	**2,076**	**24**
20- year avg.	**402**	**2,958**	**246,985**	**85**	**11**	**20**	**541**	**21**	**19**	**60**	**1,348**	**19**

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

1.2 NON DEEP-7 BMUS

1.2.1 Fishery Descriptions

This species group category is characterized by three jacks: the white/giant ulua (*Caranx ignobilis*), gunkan/black ulua (*Caranx lugubris*), and butaguchi/pig-lip ulua (*Pseudocaranx dentex*). The category is similarly characterized by two snappers: the uku (*Aprion virescens*) and yellowtail kalekale (*Pristipomoides auricilla*). All three jack species have been identified as in the catch records since 1981. Before then, landings for these jacks were reported under the "miscellaneous jack" category, which is summarized in the CREMUS group. The yellowtail kalekale was identified in the catch records starting in 1996. Previously, this species may have been reported as a general kalekale (*Pristipomoides sieboldii*), which is summarized in the Deep-7 BMUS group.

Jacks are predators and found throughout the MHI, although the black ulua and butaguchi are relatively more abundant in the NWHI. In terms of habitat, white ulua prefer nearshore with rocky substrate, embayments, reefs, shallow, and deep waters. Butaguchi ulua forage in deeper waters near the bottom, and gunkan ulua similarly prefer deeper waters off reef slopes. The peak spawning period for white ulua is during new and full moons between May and August. Information here was drawn from Mitchell *et al*., (2005).

1.2.2 Dashboard Statistics

The collection of commercial non-Deep-7 BMUS 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). The non-Deep7 BMUS are reported by commercial fishers on the Monthly Fishing Report or the Net, Trap, Dive Activity Report or the MHI Deep-7 Bottomfish Fishing Trip Report.

Refer to data processing procedures documented in the Deep-7 BMUS section for paper fishing reports and fishing reports filed online. Database assistants and data monitoring associate will enter the paper Monthly Fishing Report information within four weeks, and the Net, Trap, Dive Activity Report and the MHI Deep-7 Bottomfish Fishing Trip Report within two business days.

1.2.2.1 Historical Summary

Table 8. 2017 annual fishing parameters for the non Deep-7 Bottomfish fishery comparing current values with short-term (10-year) and long-term (20-year) averages. Values are for the fiscal year.

Fishery	Parameters	2017 Values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
BMUS Non Deep-7	No. License	412	↓ 7.21%	↑ 0.24%
	Trips	1,952	↓ 2.74%	↑ 10.5%
	No. Caught	16,573	↑ 20.1%	↑ 44.3%
	Lbs. Caught	127,265	↑ 5.38%	↑ 25.3%

1.2.2.2 Species Summary

Table 9. 2017 annual indicators for the non-Deep-7 bottomfish fishery comparing current estimates with short-term (10-year) and long-term (20-year) averages. Values are for the Fiscal Year.

Methods	Fishery indicators	2017 values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Deep-Sea Handline	Uku	76,658 lbs.	↑ 12.6%	↑ 25.7%
	White Ulua	1,356 lbs.	↓ 66.5%	↓ 47.4%
	No. Lic.	187	↓ 7.43%	↓ 8.33%
	No. Trips	858	↓ 2.05%	↑ 2.14%
	Lbs. Caught	78,136 lbs.	↑ 6.70%	↑ 18.2%
	CPUE	91.07 lbs./trip	↑ 8.94%	↑ 15.7%
Inshore Handline	Uku	11,741 lbs.	↑ 1.7%	↑ 14.9%
	White Ulua	1,204 lbs.	↓ 54.6%	↓ 37.9%
	No. Lic.	58	↓ 37.6%	↓ 46.3%
	No. Trips	324	↓ 13.6%	↓ 18.4%
	Lbs. Caught	15,982 lbs.	↓ 7.39%	↑ 7.45%
	CPUE	49.33 lbs./trip	↑ 7.19%	↑ 31.7%
Troll with Bait	Uku	11,777 lbs.	↑ 69.5%	↑ 77.6%
	White Ulua	1,279 lbs.	↓ 27.9%	↓ 19.3%
	No. Lic.	34	↓ 8.11%	N/A
	No. Trips	169	↓ 4.50%	N/A
	Lbs. Caught	13,200 lbs.	↑ 51.1%	N/A
	CPUE	78.11 lbs./trip	↑ 58.2%	N/A

N/A = data unavailable to make a 20-year trend

1.2.3 Time Series Statistics

1.2.3.1 Commercial Fishing Parameters

The most important species in this group category is the uku. Because of the wide habitat range where this species is found it is commonly taken by heavy (deep-sea handline) and light (inshore handline) tackles and troll gear. The white ulua, gunkan ulua, and butaguchi ulua, and yellowtail kalekale were not established as specific species during the entire time series. Refer to discussion in the previous section. Early in the time series up until 1982, the effort and catch trends reflect only uku landings. The White ulua was not widely accepted by markets during the 1990’s because of the ciguatera toxin. Since the implementation of the federal bottomfish fishing year, uku landings have trended upwards. During the first four federal fishing years, the Deep-7 bottomfish fishery was closed because the TAC or ACL was attained. Bottomfish fishers shifted target to uku during the closures, and in recent years this effort is rewarding because of decent market prices.

Table 10. HDAR MHI Fiscal Annual non Deep-7 Bottomfish commercial fishermen reports (1966-2017).

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1966	84	571	278	1297	46816
1967	108	733	366	1911	64215
1968	110	570	317	1222	52352
1969	116	716	377	1554	54139
1970	125	731	394	1576	49794
1971	137	608	356	1712	48418
1972	161	761	441	1369	54139
1973	169	767	472	1897	46578
1974	235	1039	632	3768	72953
1975	213	1041	580	2709	75490
1976	213	934	518	2388	69009
1977	245	1093	612	2643	47094
1978	376	1569	1038	4460	94798
1979	381	1346	1037	4832	82747
1980	361	1483	902	5140	63980
1981	392	2117	1107	7950	95027
1982	389	2021	1120	7945	96144
1983	431	2769	1366	10880	123244
1984	469	2631	1312	14199	164464
1985	467	2112	1157	8905	101889
1986	363	1566	859	6064	83164
1987	366	1586	887	10700	117959
1988	461	2713	1260	15511	201383
1989	509	3317	1621	31063	347700
1990	488	2522	1391	12746	150809
1991	454	2189	1258	12183	144940
1992	409	1812	1072	9399	101683
1993	365	1498	897	6811	76343
1994	386	1515	919	6981	89516
1995	395	1710	954	7961	85106
1996	340	1248	830	7085	73067
1997	448	1901	1144	10147	93482
1998	418	1696	1011	6883	63243
1999	366	1458	916	9639	84116
2000	418	1791	1048	12550	103673
2001	374	1520	924	9392	78113
2002	313	1190	779	8733	82572
2003	329	1223	780	7064	66225

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2004	355	1436	898	7822	76849
2005	381	1557	946	10587	95028
2006	382	1478	912	8926	80867
2007	357	1706	958	9832	96223
2008	384	1815	980	12438	107483
2009	411	1725	1018	11399	97130
2010	457	2019	1167	15007	125417
2011	494	2374	1325	16402	149144
2012	455	2009	1181	13690	124217
2013	493	2113	1274	17378	157798
2014	461	1997	1201	12050	104390
2015	460	2092	1236	14631	123931
2016	457	2174	1238	14931	118960
2017	412	1952	1135	16573	127265
10-year avg.	**444**	**2007**	**1160**	**13800**	**120771**
20-year avg.	**411**	**1766**	**1048**	**11487**	**101594**

1.2.4 Top Two Species per Gear Type

1.2.4.1 Deep-sea Handline

Table 11. HDAR MHI Fiscal Annual non Deep-7 Bottomfish Catch (Lbs. caught) Summary (1966-2017) by Species and top Gear: Deep-sea handline.

Fiscal Year	Uku		White ulua	
	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	78	46358	NULL	NULL
1967	101	63303	NULL	NULL
1968	104	51705	NULL	NULL
1969	107	52824	NULL	NULL
1970	115	48645	NULL	NULL
1971	133	48038	NULL	NULL
1972	154	53336	NULL	NULL
1973	161	45817	NULL	NULL
1974	216	72130	NULL	NULL
1975	191	74325	NULL	NULL
1976	166	63048	NULL	NULL
1977	187	36177	NULL	NULL
1978	303	75501	NULL	NULL
1979	248	67218	NULL	NULL
1980	290	57725	NULL	NULL
1981	338	90177	NULL	NULL

Fiscal Year	**Uku**		**White ulua**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1982	355	88334	15	426
1983	368	109638	31	5284
1984	381	134395	49	8369
1985	360	84510	37	3789
1986	267	62839	20	1253
1987	246	61087	15	4466
1988	347	166300	29	3193
1989	422	297514	67	15715
1990	374	121439	63	10686
1991	322	104580	58	7316
1992	281	68668	13	1368
1993	221	54888	9	712
1994	270	69806	12	1333
1995	275	61449	13	501
1996	224	51617	19	2037
1997	250	56910	12	923
1998	228	37599	5	416
1999	215	64511	8	466
2000	252	78851	8	403
2001	205	50998	10	608
2002	176	58177	7	1313
2003	153	41730	28	2120
2004	133	47695	29	1966
2005	160	55707	33	1519
2006	167	46767	29	1415
2007	162	51603	34	4052
2008	167	53056	35	4405
2009	183	65897	40	3462
2010	200	75714	51	4113
2011	234	88939	57	7033
2012	206	65393	42	4319
2013	203	89061	40	5475
2014	174	57181	35	3104
2015	174	69025	30	2603
2016	173	64206	28	1826
2017	182	76658	24	1356
10-year avg.	**188**	**68080**	**39**	**4042**
20-year avg.	**191**	**60988**	**28**	**2579**

1.2.4.2 Inshore Handline

Table 12. HDAR MHI Fiscal Annual non Deep-7 Bottomfish (lbs. caught) Summary (1966-2017) by Species and second Gear: Inshore handline.

Fiscal Year	Uku		White Ulua	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1966	4	50	NULL	NULL
1967	4	554	NULL	NULL
1968	8	345	NULL	NULL
1969	3	24	NULL	NULL
1970	3	20	NULL	NULL
1971	3	25	NULL	NULL
1972	3	12	NULL	NULL
1973	8	47	NULL	NULL
1974	7	158	NULL	NULL
1975	16	331	NULL	NULL
1976	42	2453	NULL	NULL
1977	60	7792	NULL	NULL
1978	134	14348	NULL	NULL
1979	211	12673	NULL	NULL
1980	71	1825	NULL	NULL
1981	67	1198	NULL	NULL
1982	43	582	n.d.	n.d.
1983	45	560	6	182
1984	53	1169	8	1062
1985	4	207	3	91
1986	22	2323	4	147
1987	91	11687	14	537
1988	91	10401	14	661
1989	75	4532	10	415
1990	78	2653	10	297
1991	106	4675	23	973
1992	127	17553	12	864
1993	114	8222	13	552
1994	83	8333	7	169
1995	98	8413	11	436
1996	85	4668	10	926
1997	175	14612	14	1206
1998	173	17614	14	1427
1999	134	10050	12	930
2000	152	14423	11	609

Fiscal Year	Uku		White Ulua	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
2001	142	14844	17	827
2002	94	12229	18	1291
2003	70	6748	24	1458
2004	68	5063	31	1431
2005	80	6980	24	1856
2006	64	9098	20	1275
2007	64	10452	21	1642
2008	67	13079	33	2619
2009	91	9148	36	2446
2010	86	15368	40	3039
2011	102	17679	47	5070
2012	89	20860	31	4594
2013	88	21188	37	2174
2014	78	12968	29	1549
2015	63	11917	23	1353
2016	64	12188	21	1581
2017	44	14741	23	1204
10-year avg.	**80**	**14498**	**32**	**2649**
20-year avg.	**97**	**12832**	**25**	**1940**

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

1.2.4.3 Troll with Bait

The gear code for troll with bait was established in October 2002 when the revised commercial fishing reports were implemented. Previously all troll activities were reported as troll miscellaneous gear.

Table 13. HDAR MHI Fiscal Annual non Deep-7 Bottomfish Catch (lbs. caught) Summary (2003-2017) by Species and third Gear: Troll with Bait.

Fiscal year	Uku		White Ulua	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
2003	19	2270	11	1034
2004	17	5664	8	1365
2005	21	9041	6	1036
2006	17	6361	8	994
2007	12	4842	16	1837
2008	13	13599	14	2090
2009	15	2470	14	1292

Fiscal year	**Uku**		**White Ulua**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
2010	26	5813	12	1493
2011	31	3679	17	2075
2012	26	5315	13	1885
2013	40	6840	16	2482
2014	45	6334	18	2177
2015	45	9004	12	1294
2016	47	11597	16	1125
2017	29	11777	11	1279
10-year avg.	**30**	**6949**	**15**	**1775**
20-year avg.	**27**	**6631**	**13**	**1584**

1.2.4.4 Troll (Misc.)

The troll gear was standardized and reported under specific methods including troll with lure or bait or green stick in October 2002 when the revised commercial fishing reports were implemented. Since then fishers were contacted to verify miscellaneous troll activities on their fishing reports. A fishing report was not amended if the asspcoated fisher did not respond.

Table 14. HDAR MHI Fiscal Annual non Deep-7 Bottomfish Catch (lbs. caught) Summary (1972-2017) by Species and fourth Gear: Troll (misc.). Recent data restricted by confidentiality protocol.

Fiscal Year	**Uku**		**White Ulua**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1972	5	142	NULL	NULL
1973	5	204	NULL	NULL
1974	12	326	NULL	NULL
1975	16	283	NULL	NULL
1976	20	2206	NULL	NULL
1977	26	955	NULL	NULL
1978	20	1374	NULL	NULL
1979	n.d.	n.d.	NULL	NULL
1980	51	1748	NULL	NULL
1981	29	1125	NULL	NULL
1982	27	1329	6	470
1983	29	1429	7	185
1984	42	2563	34	1689
1985	9	380	83	4568
1986	23	634	48	2616
1987	24	1777	15	3731

Fiscal Year	Uku		White Ulua	
	No. License	Lbs. Caught	No. License	Lbs. Caught
1988	29	2877	15	852
1989	49	6196	18	1389
1990	52	3063	17	1978
1991	41	5991	27	2007
1992	38	3867	13	339
1993	24	932	10	872
1994	34	1155	7	553
1995	37	1028	4	261
1996	33	1562	6	327
1997	47	2411	6	556
1998	33	675	5	257
1999	23	1724	4	369
2000	31	1359	7	184
2001	40	2340	9	1129
2002	37	2040	6	476
2003	10	373	3	115
2004	3	43	NULL	NULL
2005	NULL	NULL	n.d.	n.d.
2006	NULL	NULL	NULL	NULL
2007	NULL	NULL	NULL	NULL
2008	NULL	NULL	NULL	NULL
2009	NULL	NULL	NULL	NULL
2010	NULL	NULL	NULL	NULL
2011	NULL	NULL	NULL	NULL
2012	NULL	NULL	NULL	NULL
2013	NULL	NULL	n.d.	n.d.
2014	NULL	NULL	NULL	NULL
2015	NULL	NULL	NULL	NULL
2016	NULL	NULL	NULL	NULL
2017	NULL	NULL	NULL	NULL

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

1.2.5 Catch Parameters by Gear

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

Table 15. Time series of CPUE by dominant fishing methods from non Deep-7 BMUS (1966-2016).

Fiscal Year	Deep-sea handline				Inshore handline				Troll with bait				Troll (misc.)			
	No. Lic.	No. trips	Lbs. Caught	CPUE	No. Lic.	No. trips	Lbs. Caught	CPUE	No. License	No. trips	Lbs. Caught	CPUE	No. License	No. trips	Lbs. Caught	CPUE
1966	78	514	46358	90.19	4	4	50	12.5	NULL	NULL	NULL	0	NULL	NULL	NULL	0
1967	101	683	63303	92.68	4	5	554	110.8	NULL	NULL	NULL	0	n.d.	n.d.	n.d.	n.d.
1968	104	509	51705	101.58	8	13	345	26.54	NULL	NULL	NULL	0	n.d.	n.d.	n.d.	n.d.
1969	107	615	52824	85.89	3	3	24	8	NULL	NULL	NULL	0	n.d.	n.d.	n.d.	n.d.
1970	115	633	48645	76.85	3	4	20	5	NULL	NULL	NULL	0	NULL	NULL	NULL	0
1971	133	548	48038	87.66	3	4	25	6.25	NULL	NULL	NULL	0	NULL	NULL	NULL	0
1972	154	663	53336	80.45	3	3	12	4	NULL	NULL	NULL	0	5	10	142	14.2
1973	161	675	45817	67.88	8	9	47	5.22	NULL	NULL	NULL	0	5	7	204	29.14
1974	216	968	72130	74.51	7	10	158	15.8	NULL	NULL	NULL	0	12	13	326	25.08
1975	191	947	74325	78.48	16	23	331	14.39	NULL	NULL	NULL	0	16	19	283	14.89
1976	166	732	63048	86.13	42	97	2453	25.29	NULL	NULL	NULL	0	20	52	2206	42.42
1977	187	716	36177	50.53	60	211	7792	36.93	NULL	NULL	NULL	0	26	41	955	23.29
1978	303	1097	75501	68.82	134	298	14348	48.15	NULL	NULL	NULL	0	20	41	1374	33.51
1979	248	857	67218	78.43	211	431	12673	29.4	NULL	NULL	NULL	0	n.d.	n.d.	n.d.	n.d.
1980	290	1196	57725	48.27	71	110	1825	16.59	NULL	NULL	NULL	0	51	82	1748	21.32
1981	338	1763	90177	51.15	67	110	1198	10.89	NULL	NULL	NULL	0	29	44	1125	25.57
1982	355	1760	90223	51.26	45	66	603	9.14	NULL	NULL	NULL	0	30	40	1799	44.98
1983	374	2506	115980	46.28	51	74	748	10.11	NULL	NULL	NULL	0	36	46	1614	35.09
1984	397	2246	144502	64.34	58	95	2239	23.57	NULL	NULL	NULL	0	73	108	4252	39.37
1985	378	1853	92057	49.68	8	8	306	38.25	NULL	NULL	NULL	0	91	133	4948	37.2
1986	282	1271	70271	55.29	28	60	2540	42.33	NULL	NULL	NULL	0	63	92	3250	35.33
1987	262	1084	82513	76.12	100	264	12376	46.88	NULL	NULL	NULL	0	35	75	5555	74.07
1988	365	2270	174945	77.07	101	218	11132	51.06	NULL	NULL	NULL	0	43	78	3837	49.19
1989	441	2867	320763	111.88	83	174	4955	28.48	NULL	NULL	NULL	0	62	116	7585	65.39

Fiscal Year	Deep-sea handline				Inshore handline				Troll with bait				Troll (misc.)			
	No. Lic.	No. trips	Lbs. Caught	CPUE	No. Lic.	No. trips	Lbs. Caught	CPUE	No. License	No. trips	Lbs. Caught	CPUE	No. License	No. trips	Lbs. Caught	CPUE
1990	395	2053	139989	68.19	83	232	3136	13.52	NULL	NULL	NULL	0	67	113	5041	44.61
1991	346	1680	125306	74.59	120	259	5679	21.93	NULL	NULL	NULL	0	64	126	7998	63.48
1992	289	1169	72393	61.93	130	445	18434	41.42	NULL	NULL	NULL	0	48	79	4206	53.24
1993	237	911	62746	68.88	122	372	8790	23.63	NULL	NULL	NULL	0	31	68	1804	26.53
1994	282	1086	76244	70.21	85	218	8502	39	NULL	NULL	NULL	0	39	63	1708	27.11
1995	291	1230	72242	58.73	105	298	8886	29.82	NULL	NULL	NULL	0	40	63	1289	20.46
1996	234	811	61442	75.76	92	250	5668	22.67	NULL	NULL	NULL	0	39	67	1889	28.19
1997	268	1033	71884	69.59	179	655	15868	24.23	NULL	NULL	NULL	0	51	91	2966	32.59
1998	238	905	40551	44.81	183	619	19302	31.18	NULL	NULL	NULL	0	39	59	978	16.58
1999	222	782	67218	85.96	140	473	11029	23.32	NULL	NULL	NULL	0	27	44	2093	47.57
2000	258	996	83039	83.37	158	567	15049	26.54	NULL	NULL	NULL	0	36	47	1543	32.83
2001	212	850	55632	65.45	152	464	15707	33.85	NULL	NULL	NULL	0	50	84	3481	41.44
2002	187	697	62685	89.94	106	335	13562	40.48	NULL	NULL	NULL	0	43	71	2536	35.72
2003	173	674	46791	69.42	80	238	8390	35.25	23	65	3333	51.28	13	18	488	27.11
2004	150	644	51079	79.32	85	275	6614	24.05	21	118	7075	59.96	3	3	43	14.33
2005	175	761	60698	79.76	89	313	8904	28.45	22	127	10077	79.35	n.d.	n.d.	n.d.	n.d.
2006	173	691	50233	72.7	71	246	10481	42.61	24	108	7385	68.38	NULL	NULL	NULL	0
2007	169	813	56300	69.25	73	313	12115	38.71	25	137	6719	49.04	NULL	NULL	NULL	0
2008	189	840	60670	72.23	83	334	15869	47.51	21	199	15689	78.84	NULL	NULL	NULL	0
2009	201	899	70006	77.87	109	329	11678	35.5	21	104	3792	36.46	NULL	NULL	NULL	0
2010	217	911	81054	88.97	99	388	18439	47.52	32	142	7306	51.45	NULL	NULL	NULL	0
2011	257	1200	97542	81.29	121	443	22881	51.65	37	136	5827	42.85	NULL	NULL	NULL	0
2012	223	807	70811	87.75	100	465	25724	55.32	29	157	7199	45.85	NULL	NULL	NULL	0
2013	217	861	96085	111.6	105	404	23407	57.94	47	175	8985	51.34	n.d.	n.d.	n.d.	n.d.
2014	184	807	60699	75.22	88	341	14787	43.36	51	222	8511	38.34	NULL	NULL	NULL	0
2015	181	826	72040	87.22	72	335	13328	39.79	48	224	10300	45.98	NULL	NULL	NULL	0

Fiscal Year	**Deep-sea handline**				**Inshore handline**				**Troll with bait**				**Troll (misc.)**			
	No. Lic.	**No. trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. trips**	**Lbs. Caught**	**CPUE**	**No. License**	**No. trips**	**Lbs. Caught**	**CPUE**	**No. License**	**No. trips**	**Lbs. Caught**	**CPUE**
2016	181	789	66362	84.11	72	380	13833	36.4	52	255	11383	44.64	NULL	NULL	NULL	0
2017	187	858	78136	91.07	58	324	15982	49.33	34	169	13200	78.11	NULL	NULL	NULL	0
10-year avg.	**202**	**876**	**73232**	**83.6**	**93**	**375**	**17258**	**46.02**	**37**	**177**	**8739**	**49.37**	**n.d.**	**n.d.**	**n.d.**	**n.d.**
20-year avg.	**204**	**840**	**66107**	**78.7**	**108**	**397**	**14874**	**37.47**	**33**	**156**	**8233**	**52.78**	**26**	**42**	**1415**	**33.69**

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

1.3 CREMUS FINFISH

1.3.1 Fishery Descriptions

There are 66 different specific finfish species in this group. These species represent a total of 12 families including surgeonfish (*Acanthuridae*), jacks (*Carangidae*), squirrelfish (*Holocentridae*), rudderfish (*Kyphosidae*), wrasses (*Labridae*), emperor (*Lethrinidae*), snappers (*Lutjanidae*), mullet (*Mugilidae*), goatfish (*Mullidae*), parrotfish (*Scaridae*), grouper (*Serranidae*), and shark (*Carcharhinidae).*

Overall, the key driver species in this group category is the akule, halalu (juvenile akule), and opelu from the Carangidae family, ta‘ape from the Lutjanidae family, ama‘ama from the Mugilidae family, and miscellaneous weke from the Mullidae family. The dominant gear types are inshore handline, purse seine net (pelagic), lay gill net, and seine net.

1.3.2 Dashboard Statistics

The collection of commercial CREMUS finfish 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). The CREMUS finfish 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.

Refer to data processing procedures documented in the Deep-7 BMUS section for paper fishing reports and fishing reports filed online. Database assistants and the data monitoring associate will enter the paper Monthly Fishing Report information within four weeks, and the Net, Trap, Dive Activity Report and the MHI Deep-7 Bottomfish Fishing Trip Report within two business days.

1.3.2.1 Historical Summary

Table 16. 2017 annual fishing parameters for the CREMUS finfish fishery comparing current values with short-term (10-year) and long-term (20-year) averages.

Fishery	Parameters	2017 Values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
CREMUS Finfish	No. License	601	↓ 20.6%	↓ 25.5%
	Trips	6,043	↓ 28.5%	↓ 32.5%
	No. Caught	1,085,267	↓ 22.5%	↑ 9.32%
	Lbs. Caught	720,182	↓ 29.5%	↓ 41.1%

1.3.2.2 Species Summary

Table 17. 2017 annual indicators for the CREMUS finfish fishery comparing current estimates with the short-term (10-year) and the long-term (20-year) averages.

Methods	Fishery Indicators	2017 values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Inshore Handline	Opelu	22,367 lbs.	↓ 82.8%	↓ 85.0%
	Akule	76,650 lbs.	↓ 15.8%	↓ 32.9%
	Taape	4,408 lbs.	↓ 29.7%	↓ 54.7%
	Ulua	N/A	N/A	N/A
	No. Lic.	180	↓ 43.0%	↓ 55.0%
	No. Trips	1,847	↓ 47.5%	↓ 58.9%
	Lbs. Caught	115,394 lbs.	↓ 52.7%	↓ 61.2%
	CPUE	62.48 lbs./trip	↓ 9.91%	↓ 5.62%
Purse Seine Net	Akule	Insufficient data for species level trends		
	Ulua			
	Kala			
	Taape			
	No. Lic.	3	↓ 40%	↓ 50%
	No. Trips	21	↓ 16.0%	↓ 32.3%
	Lbs. Caught	39,501 lbs.	↓ 61.4%	↓ 71.6%
	CPUE	1,881 lbs./trip	↓ 54.0%	↓ 58.4%
Lay Gill Net	Akule	159,667 lbs.	↑ 13.6%	↑ 13.5%
	Weke	N/A	N/A	N/A
	Amaama	1,081 lbs.	↓ 85.6%	↓ 83.5%
	Kala	10,643 lbs.	↓ 1.01%	↑ 25.3%
	No. Lic.	27	↓ 25.0%	↓ 34.2%
	No. Trips	327	↓ 14.6%	↓ 31.9%
	Lbs. Caught	184,690 lbs.	↑ 2.38%	↓ 0.10%
	CPUE	564.8 lbs./trip	↑ 19.9%	↑ 46.6%
Seine Net	Akule	61,062 lbs.	↑ 12.6%	↓ 67.4%
	Weke	N/A	N/A	N/A
	Taape	20,358 lbs.	↑ 13.0%	↑ 24.0%
	Opelu	N/A	N/A	N/A
	No. Lic.	19	↓ 20.8%	↓ 9.52%
	No. Trips	191	↓ 16.2%	↓ 4.02%
	Lbs. Caught	134,735 lbs.	↓ 8.14%	↓ 49.5%
	CPUE	705.42 lbs./trip	↑ 9.65%	↓ 47.4%
Spear	Uhu	16,036 lbs.	↓ 62.0%	↓ 47.0%
	Palani	8,869 lbs.	↓ 35.6%	↓ 8.88%
	Kala	5,135 lbs.	↓ 51.3%	↓ 31.2%
	Manini	4,412 lbs.	↓ 42.0%	↓ 18.0%
	No. Lic.	65	↓ 35.0%	↓ 36.9%
	No. Trips	666	↓ 43.5%	↓ 31.1%
	Lbs. Caught	53	↓ 53.7%	↓ 34.1%
	CPUE	79.87 lbs./trip	↓ 17.9%	↓ 4.31%

1.3.3 Time Series Statistics

1.3.3.1 Commercial Fishing Parameters

Table 18. Time series of commercial fishermen reports for CREMUS finfish fishery (1966-2017).

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1966	261	6387	1482	329614	1114853
1967	302	7324	1731	325083	1328133
1968	294	6463	1634	302805	1512844
1969	362	7038	1802	411936	1628970
1970	417	7870	2113	371275	1469487
1971	478	7671	2171	304742	1332051
1972	488	8288	2369	318812	1287455
1973	538	7488	2328	352780	1269877
1974	646	8290	2684	353026	1115435
1975	648	8872	2657	427742	1159570
1976	684	9047	2839	353277	1378855
1977	772	10321	3172	423391	1577768
1978	942	8739	3928	461673	1315632
1979	955	6460	4072	462099	1171970
1980	954	9315	3771	536639	1410824
1981	989	11968	3967	495199	1350879
1982	868	10477	3602	269481	1075781
1983	956	12482	4017	339593	1493283
1984	1037	12511	4145	269324	1475465
1985	925	11057	3757	297806	921552
1986	996	11149	3984	272007	848528
1987	1010	11758	3973	350436	994022
1988	1029	11671	4034	268120	960842
1989	1090	12125	4370	336536	1222961
1990	1051	12046	4183	450386	1477667
1991	1059	12079	4151	348003	1341206
1992	1055	12513	4122	443298	1547351
1993	987	10497	3551	208924	1396986
1994	1036	10522	3688	162596	1152157
1995	1038	10543	3626	148510	1397121
1996	1058	11514	3818	178477	1382267
1997	1110	12081	4172	194210	1243396
1998	1097	12313	4111	346507	1953487
1999	1015	10881	3701	251043	1861426
2000	953	11067	3552	353755	1795017

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
2001	889	9845	3292	290579	1516577
2002	808	8378	2972	221654	1064347
2003	736	8347	2700	1181409	1268654
2004	687	8224	2612	1155922	1231904
2005	648	7023	2349	890187	1210960
2006	634	6500	2178	956258	1095354
2007	641	7678	2416	1648856	1301579
2008	646	7534	2438	1664832	1071304
2009	806	8798	3018	1642692	908931
2010	824	9983	3276	1391746	1074816
2011	851	9789	3312	1303543	1187856
2012	779	8972	3031	1324037	947831
2013	793	8515	3011	1204777	932060
2014	761	8083	2920	1195820	883302
2015	761	7655	2877	1181857	912322
2016	699	7316	2730	1345114	923042
2017	601	6043	2365	1085267	720182
10-year avg.	**757**	**8447**	**2908**	**1401234**	**1021039**
20-year avg.	**807**	**8957**	**3036**	**992715**	**1222587**

1.3.4 Top 4 Species per Gear Type

1.3.4.1 Inshore Handline

Table 19. HDAR MHI Fiscal Annual CREMUS finfish Catch (Lbs. caught) Summary (1966-2017) by Species and top Gear: Inshore handline.

Fiscal Year	Opelu		Akule		Taape		Ulua	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	88	89408	110	160301	NULL	NULL	57	4879
1967	109	136450	118	155720	NULL	NULL	64	4863
1968	87	104308	111	174282	NULL	NULL	59	5076
1969	89	128720	134	188541	NULL	NULL	83	5988
1970	100	114741	141	164990	5	534	76	5921
1971	111	97302	158	150492	25	1546	73	3832
1972	140	120995	190	174260	40	1602	104	4957
1973	137	92282	182	147072	48	1822	96	4202
1974	139	89675	202	142495	54	2065	107	4517
1975	143	164833	201	159815	66	3262	91	5461
1976	123	152760	166	126854	58	2844	96	6351

Fiscal Year	Opelu		Akule		Taape		Ulua	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1977	119	122355	138	52421	77	2298	93	4617
1978	156	186552	194	97186	232	18596	182	11917
1979	138	172771	238	109071	244	20643	251	20628
1980	180	246393	226	94969	209	11943	156	9651
1981	195	217082	237	109449	200	13603	180	11898
1982	173	133747	235	97257	242	14386	172	8576
1983	164	114400	322	162519	246	16390	167	6885
1984	207	235467	295	150735	272	17387	215	8003
1985	182	151699	214	101670	191	14188	142	8507
1986	250	193535	224	73529	257	19526	137	6838
1987	289	252473	222	78773	197	16682	159	10156
1988	227	148241	211	82828	226	20170	151	6489
1989	228	142750	207	90862	173	7112	163	10831
1990	227	156300	309	141707	183	8412	118	3820
1991	212	184668	310	203420	250	13989	155	6751
1992	323	227866	372	207980	219	14286	154	16812
1993	243	205254	322	154577	194	12284	121	12166
1994	299	211838	266	133564	204	14430	107	7811
1995	222	176137	245	103124	201	19664	132	12875
1996	344	276576	295	148925	207	14429	103	7196
1997	327	230136	361	179306	255	16995	182	13587
1998	241	159954	350	203059	277	21573	177	22456
1999	208	170547	293	195973	212	17345	142	16322
2000	225	185713	284	185869	193	21144	117	7575
2001	214	185394	239	140482	176	20370	123	14019
2002	194	152356	200	108446	145	11760	112	9591
2003	209	214377	151	107384	115	6835	44	2661
2004	176	163963	145	100022	97	5770	5	171
2005	141	100965	103	83258	89	5212	14	369
2006	140	117589	98	69912	84	4747	n.d	n.d.
2007	187	172586	117	87912	87	4846	n.d	n.d.
2008	140	143692	105	65024	100	6282	3	100
2009	213	178821	154	80157	124	8158	n.d	n.d.
2010	197	159413	171	121585	124	8975	6	195
2011	188	168377	150	90770	114	8368	NULL	NULL
2012	166	117301	162	91604	116	9003	NULL	NULL
2013	172	119257	153	92126	110	6238	NULL	NULL
2014	161	96798	129	79606	88	3612	n.d	n.d.

Fiscal Year	**Opelu**		**Akule**		**Taape**		**Ulua**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
2015	102	80284	128	98014	73	3819	9	230
2016	86	61494	119	100223	57	3058	4	63
2017	51	22367	104	76650	66	4408	NULL	NULL
10-year avg.	**162**	**129816**	**139**	**90984**	**100**	**6274**	**4**	**113**
20-year avg.	**185**	**148967**	**181**	**114178**	**132**	**9725**	**53**	**4872**

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

1.3.4.2 Purse Seine Net (Pelagic)

The purse seine net (pelagic) gear was standardized in October 2002 when the revised fishing reports were implemented. This gear was formerly called the akule or bag net, and is utilized by surrounding a school of fish with a net and drawing the bottom of the net closed to form a bag. In recent years, this method was used by a few highliners to land large volumes of akule. The largest operation ended a several years ago with the vessel being converted to the longline fleet. Recent annual landings may not be available due to data confidentiality. Fishers who use this type of operation where the fish end up being entangled in the mesh will opt to report the method as gill net.

Table 20. HDAR MHI Fiscal Annual CREMUS Finfish Catch (Lbs. caught) Summary (1966-2017) by Species and 2nd Gear: Purse seine net (pelagic).

Fiscal Year	**Akule**		**Ulua (misc.)**		**Kala**		**Taape**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1966	9	430069	n.d.	n.d.	NULL	NULL	NULL	NULL
1967	8	541816	3	10163	n.d.	n.d.	NULL	NULL
1968	19	802810	4	6860	3	5214	NULL	NULL
1969	22	575744	5	14359	5	3822	NULL	NULL
1970	32	764641	n.d.	n.d.	5	3168	NULL	NULL
1971	14	604113	3	1332	3	4500	NULL	NULL
1972	19	527806	n.d.	n.d.	4	335	NULL	NULL
1973	27	563319	4	1919	n.d.	n.d.	NULL	NULL
1974	25	331655	n.d.	n.d.	n.d.	n.d.	NULL	NULL
1975	21	233349	4	341	n.d.	n.d.	n.d.	n.d.
1976	37	136603	3	4607	n.d.	n.d.	n.d.	n.d.
1977	24	369813	NULL	NULL	n.d.	n.d.	NULL	NULL
1978	15	235862	n.d.	n.d.	n.d.	n.d.	NULL	NULL
1979	27	198657	NULL	NULL	n.d.	n.d.	NULL	NULL

Fiscal Year	Akule		Ulua (misc.)		Kala		Taape	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1980	25	271103	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1981	24	100923	NULL	NULL	NULL	NULL	NULL	NULL
1982	18	159716	NULL	NULL	NULL	NULL	NULL	NULL
1983	26	152571	NULL	NULL	NULL	NULL	n.d.	n.d.
1984	31	322873	n.d.	n.d.	3	1028	NULL	NULL
1985	13	46523	n.d.	n.d.	NULL	NULL	NULL	NULL
1986	6	53683	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1987	13	19779	n.d.	n.d.	NULL	NULL	NULL	NULL
1988	12	10660	NULL	NULL	NULL	NULL	NULL	NULL
1989	25	262304	NULL	NULL	NULL	NULL	NULL	NULL
1990	21	105824	n.d.	n.d.	NULL	NULL	NULL	NULL
1991	26	102669	NULL	NULL	NULL	NULL	NULL	NULL
1992	16	47720	NULL	NULL	NULL	NULL	NULL	NULL
1993	8	23160	NULL	NULL	NULL	NULL	NULL	NULL
1994	12	29766	NULL	NULL	NULL	NULL	NULL	NULL
1995	18	294130	NULL	NULL	NULL	NULL	NULL	NULL
1996	14	276916	NULL	NULL	NULL	NULL	NULL	NULL
1997	9	50949	NULL	NULL	NULL	NULL	NULL	NULL
1998	7	27496	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1999	5	55633	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
2000	6	105037	NULL	NULL	NULL	NULL	NULL	NULL
2001	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
2002	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2003	3	286796	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2004	6	276164	NULL	NULL	NULL	NULL	n.d.	n.d.
2005	5	427938	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2006	4	356297	NULL	NULL	NULL	NULL	NULL	NULL
2007	3	374871	NULL	NULL	NULL	NULL	NULL	NULL
2008	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.
2009	4	98213	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2010	8	52604	NULL	NULL	NULL	NULL	NULL	NULL
2011	n.d.	n.d.	NULL	NULL	n.d.	n.d.	n.d.	n.d.
2012	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
2013	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.
2014	NULL	NULL	NULL	NULL	NULL	NULL	n.d.	n.d.
2015	4	23735	NULL	NULL	NULL	NULL	n.d.	n.d.
2016	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.
2017	3	39401	NULL	NULL	NULL	NULL	n.d.	n.d.

Fiscal Year	Akule		Ulua (misc.)		Kala		Taape	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
10-year avg.	**3**	**102526**	**NULL**	**NULL**	**n.d.**	**n.d.**	**n.d.**	**n.d.**
20-year avg.	**4**	**139439**	**n.d.**	**n.d.**	**n.d.**	**n.d.**	**n.d.**	**n.d.**

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

1.3.4.3 Lay Gill Net

The lay gill net gear was standardized in October 2002 when the revised fishing reports were implemented. This gear is defined more like a method in that it is net that captures fish by entangling the fish head in the mesh. Subsequently, most fishers who use mesh net and entangle the fish will report this method.

Table 21. HDAR MHI Fiscal Annual CREMUS Finfish Catch (Lbs. caught) Summary (1966-2017) by Species and 3rd Gear: Lay gill net.

Fiscal Year	Akule		Weke (misc.)		Amaama		Kala	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	9	22711	23	6421	25	14090	9	777
1967	6	14380	26	10865	25	19491	12	2789
1968	13	48949	29	12389	19	16964	9	633
1969	17	37858	43	11405	30	22603	11	2709
1970	17	35368	56	24342	35	14449	19	7326
1971	22	86067	54	16467	36	17357	23	6038
1972	27	104361	49	15346	34	15600	29	10785
1973	35	94435	68	21882	42	13898	24	7127
1974	53	148772	71	23164	41	15358	40	18656
1975	53	188093	61	27097	44	12100	51	15742
1976	35	139046	66	27985	28	11021	46	10705
1977	47	208639	79	24005	35	13304	51	10827
1978	51	144587	87	31425	46	13230	58	16611
1979	33	92734	84	15208	38	15676	45	8606
1980	32	170266	70	37174	39	8369	47	8049
1981	31	173429	73	55584	36	8031	42	6728
1982	22	80563	62	36216	40	6900	39	5362
1983	29	166452	58	32332	33	5723	36	6678
1984	36	142881	62	28323	35	3998	31	2622
1985	22	109702	31	8541	16	2581	19	1383
1986	19	61882	22	6857	17	1773	14	2622

Fiscal Year	**Akule**		**Weke (misc.)**		**Amaama**		**Kala**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1987	13	26469	22	9146	22	3721	13	7782
1988	19	21536	30	8386	17	1296	15	8313
1989	22	33648	43	11727	13	1427	28	4542
1990	26	223344	23	7052	15	2046	11	326
1991	27	114547	30	6467	12	276	21	2481
1992	33	155760	36	8836	14	7820	21	2086
1993	35	158397	34	11727	14	8500	15	2726
1994	30	131655	35	5767	14	5636	26	2396
1995	28	99625	36	10008	16	4658	17	1747
1996	25	109947	36	19069	14	6026	31	7245
1997	27	182017	29	11848	16	4904	25	3779
1998	23	205954	24	6283	10	5469	17	3986
1999	25	198943	22	6960	13	3537	12	1130
2000	23	217039	18	2851	14	2862	15	4291
2001	27	140410	20	2448	11	5759	15	9788
2002	20	42247	14	3875	9	5423	13	8110
2003	20	97978	12	4592	12	7054	15	11198
2004	19	114786	8	2021	11	7089	12	4918
2005	25	135373	7	450	11	8214	14	7841
2006	17	74215	n.d.	n.d.	11	6116	15	7357
2007	15	128642	NULL	NULL	6	8515	11	8193
2008	16	112086	NULL	NULL	10	11905	5	6109
2009	16	59712	3	206	10	8102	9	6123
2010	19	112663	4	1152	12	6038	10	11105
2011	21	169952	n.d.	n.d.	8	6177	12	12392
2012	19	153280	n.d.	n.d.	4	14111	12	10453
2013	23	128601	NULL	NULL	12	5400	10	16716
2014	14	144310	NULL	NULL	11	5802	12	10367
2015	23	206132	NULL	NULL	8	5141	11	13473
2016	19	187154	NULL	NULL	6	3601	6	12364
2017	21	159667	NULL	NULL	4	1081	6	10643
10-year avg.	**19**	**140553**	**n.d.**	**n.d.**	**9**	**7481**	**10**	**10752**
20-year avg.	**21**	**140725**	**11**	**2989**	**10**	**6562**	**13**	**8496**

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

1.3.4.4 Seine Net

The seine net gear was standardized in October 2002 when the revised fishing reports were implemented. This gear is defined as using a net by moving it through the water to surround a school of fish and corralling and trapping them within the walls of the net. Fishers who use this type of operation where the fish end up being entangled in the mesh will opt to report the method as gill net.

Table 22. HDAR MHI Fiscal Annual CREMUS Finfish Catch (Lbs. caught) Summary (1977-2017) by Species and fourth Gear: Seine net.

Fiscal Year	Akule		Weke (misc.)		Taape		Opelu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	n.d.	n.d.	3	5214	NULL	NULL	n.d.	n.d.
1967	n.d.	n.d.	4	4654	NULL	NULL	n.d.	n.d.
1968	n.d.	n.d.	3	683	NULL	NULL	n.d.	n.d.
1969	3	17337	5	3339	NULL	NULL	n.d.	n.d.
1970	n.d.	n.d.	3	1179	NULL	NULL	n.d.	n.d.
1971	n.d.	n.d.	3	1519	NULL	NULL	n.d.	n.d.
1972	n.d.	n.d.	3	383	NULL	NULL	n.d.	n.d.
1973	n.d.	n.d.	3	336	NULL	NULL	n.d.	n.d.
1974	3	14740	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1975	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.
1976	n.d.	n.d.	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1977	5	74825	4	1800	n.d.	n.d.	n.d.	n.d.
1978	n.d.	n.d.	10	21233	4	12207	NULL	NULL
1979	n.d.	n.d.	19	30891	15	17900	n.d.	n.d.
1980	n.d.	n.d.	12	17748	6	7372	n.d.	n.d.
1981	NULL	NULL	8	7508	n.d.	n.d.	NULL	NULL
1982	5	21701	9	14804	6	14106	n.d.	n.d.
1983	6	48543	11	14865	6	14837	n.d.	n.d.
1984	6	41584	5	7539	3	1355	NULL	NULL
1985	4	7548	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1986	n.d.	n.d.	3	8168	n.d.	n.d.	n.d.	n.d.
1987	4	68407	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1988	3	79020	6	8426	3	1165	n.d.	n.d.
1989	n.d.	n.d.	5	2033	n.d.	n.d.	NULL	NULL
1990	10	274936	4	2123	3	451	n.d.	n.d.
1991	12	222235	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1992	13	247721	9	6998	8	14558	NULL	NULL
1993	8	394896	10	12045	5	22492	n.d.	n.d.
1994	7	198718	9	5130	8	12948	NULL	NULL

Fiscal Year	**Akule**		**Weke (misc.)**		**Taape**		**Opelu**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1995	8	252684	6	6072	6	15149	n.d.	n.d.
1996	5	44863	8	9763	6	9248	n.d.	n.d.
1997	9	97418	6	12556	6	6169	n.d.	n.d.
1998	10	698010	6	12103	6	19641	n.d.	n.d.
1999	7	589149	12	13361	8	18275	n.d.	n.d.
2000	9	636089	5	6236	5	13654	NULL	NULL
2001	10	579500	7	8844	6	12386	n.d.	n.d.
2002	4	330385	6	4579	3	4978	n.d.	n.d.
2003	3	53492	6	1670	7	10507	n.d.	n.d.
2004	5	92423	7	1747	13	11169	3	364
2005	4	80927	n.d.	n.d.	9	28648	n.d.	n.d.
2006	6	44799	n.d.	n.d.	13	22816	NULL	NULL
2007	5	75070	NULL	NULL	13	16953	NULL	NULL
2008	6	53194	n.d.	n.d.	11	19307	3	2512
2009	8	71279	NULL	NULL	15	20945	n.d.	n.d.
2010	11	86288	n.d.	n.d.	17	15492	3	1811
2011	8	29822	n.d.	n.d.	13	29445	n.d.	n.d.
2012	9	42285	n.d.	n.d.	12	12186	3	1064
2013	4	19837	n.d.	n.d.	10	18030	n.d.	n.d.
2014	4	18147	NULL	NULL	14	10728	n.d.	n.d.
2015	5	36252	NULL	NULL	11	16408	n.d.	n.d.
2016	10	102076	NULL	NULL	9	19144	NULL	NULL
2017	9	61062	NULL	NULL	13	20358	NULL	NULL
10-year avg.	**7**	**54254**	**n.d.**	**n.d.**	**13**	**18021**	**n.d.**	**n.d.**
20-year avg.	**7**	**187237**	**4**	**4665**	**10**	**16423**	**n.d.**	**n.d.**

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

Table 23. HDAR MHI Fiscal Annual CREMUS Finfish Catch (Lbs. Caught) Summary (1966-2017) by Species and fifth Gear: Spear.

Fiscal Year	**Uhu (misc.)**		**Palani**		**Kala**		**Manini**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1966	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1967	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
1968	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1969	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL

1970	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1971	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1972	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1973	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1974	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1975	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	NULL
1976	6	350	4	96	NULL	NULL	4	23
1977	12	419	3	100	n.d.	n.d.	n.d.	n.d.
1978	47	8843	5	220	n.d.	n.d.	n.d.	n.d.
1979	58	11970	7	241	n.d.	n.d.	3	50
1980	56	12564	25	568	7	169	19	362
1981	50	11173	26	891	10	153	17	340
1982	45	10491	22	885	11	241	17	397
1983	42	16284	23	2992	10	1407	16	979
1984	50	15855	28	3014	13	161	20	563
1985	57	17152	28	1709	24	1259	28	1435
1986	70	23967	36	2026	14	1167	32	1225
1987	69	24905	31	3141	14	792	29	1531
1988	68	35479	30	3366	16	963	30	1595
1989	64	42786	34	6223	25	1016	34	2135
1990	50	20253	24	2133	12	294	27	1292
1991	74	19331	41	3151	26	832	27	582
1992	67	27060	32	2624	22	638	35	771
1993	72	20251	41	4673	26	1059	35	1103
1994	78	31501	44	4665	33	2271	43	1661
1995	94	32250	50	7972	49	5106	51	6281
1996	102	25995	57	7940	46	2925	52	3175
1997	99	20990	45	2094	38	1686	44	2772
1998	90	25193	51	4035	34	2565	47	1873
1999	85	23518	45	3220	37	2357	48	1406
2000	88	22984	45	4530	39	2083	43	2134
2001	78	13914	40	4630	33	2152	41	2847
2002	78	14865	39	3327	43	3502	39	1128
2003	81	14980	43	7605	38	5106	34	6466
2004	63	14265	41	7077	30	6915	30	4949
2005	57	15965	37	13607	26	10391	31	3701
2006	58	16426	37	6952	23	7072	39	4235
2007	64	18122	46	6915	32	5624	45	5827
2008	65	23266	39	9178	26	6347	42	5554
2009	93	31139	63	10792	52	6101	55	5635
2010	77	43112	49	12165	42	7833	42	9714

2011	81	62728	46	19114	38	15299	47	9982
2012	79	66193	44	21736	45	19742	52	11454
2013	84	69873	53	20516	45	18659	45	10532
2014	67	51217	38	14558	32	10619	38	7024
2015	56	31992	33	12320	26	9690	32	4283
2016	42	23749	23	10110	21	5368	26	5950
2017	47	16036	25	8869	24	5135	24	4412
10-year avg.	**71**	**42197**	**43**	**13759**	**36**	**10538**	**43**	**7606**
20-year avg.	**74**	**30253**	**43**	**9733**	**35**	**7460**	**41**	**5378**

1.3.5 Catch Parameters by Gear

The top gear in this category is inshore handline, and the driver species landed are opelu and akule. The CPUE for this year type is relatively flat throughout the time series at approximately 68 lbs. per trip. In recent years, the number of fishers and trips are about half the levels observed in the first 25 years of the time series. The driver species are landed more frequently by the more efficient net methods with higher associated CPUEs.

Table 24. Time series of inshore handline, pelagic purse seine net, and lay gill net CPUE harvesting CREMUS Finfish (1966-2017).

Fiscal Year	Inshore Handline				Purse Seine Net (Pelagic)				Lay Gill Net			
	No. License	No. Trips	Lbs. Caught	CPUE	No. License	No. Trips	Lbs. Caught	CPUE	No. License	No. Trips	Lbs. Caught	CPUE
1966	150	3774	266302	70.56	9	147	430497	2928.55	45	419	49542	118.24
1967	182	4008	309477	77.21	8	146	553059	3788.08	50	458	57619	125.81
1968	158	3793	297015	78.31	20	262	821723	3136.35	44	538	91095	169.32
1969	188	3978	339863	85.44	22	265	598758	2259.46	73	570	84914	148.97
1970	215	4191	300057	71.6	32	312	778068	2493.81	88	701	94010	134.11
1971	266	4082	269197	65.95	14	251	619914	2469.78	100	708	137975	194.88
1972	292	4898	318019	64.93	19	220	531166	2414.39	97	723	158686	219.48
1973	300	4009	262107	65.38	27	249	578496	2323.28	122	850	167162	196.66
1974	347	4125	255203	61.87	25	202	336492	1665.8	151	1140	239854	210.4
1975	344	4498	352409	78.35	22	215	238058	1107.25	144	1230	288651	234.68
1976	312	3993	305383	76.48	38	182	144679	794.94	137	1182	277074	234.41
1977	299	3340	201757	60.41	25	138	370673	2686.04	170	1481	351439	237.3
1978	522	4331	360820	83.31	16	97	237134	2444.68	190	1205	258359	214.41
1979	557	3074	363052	118.1	27	104	198671	1910.3	162	705	161428	228.98
1980	495	4126	385421	93.41	27	228	271488	1190.74	147	1110	280779	252.95
1981	539	5442	371769	68.31	25	208	104009	500.04	140	1345	352970	262.43
1982	512	4526	273897	60.52	18	230	159754	694.58	115	1248	199378	159.76
1983	550	5628	316215	56.19	27	241	153022	634.95	121	1271	279881	220.21
1984	640	6638	438069	65.99	32	251	334178	1331.39	125	1025	225017	219.53
1985	593	5655	306035	54.12	13	56	46551	831.27	57	638	141943	222.48
1986	594	5997	315878	52.67	6	48	54278	1130.79	50	454	84349	185.79
1987	567	6230	385860	61.94	13	36	20258	562.72	47	486	60314	124.1
1988	557	5373	286062	53.24	14	32	11308	353.38	51	454	57236	126.07
1989	546	4890	279454	57.15	26	113	263017	2327.58	73	595	79365	133.39
1990	617	5718	340318	59.52	21	91	105841	1163.09	58	577	245178	424.92

Fiscal Year	Inshore Handline				Purse Seine Net (Pelagic)				Lay Gill Net			
	No. License	No. Trips	Lbs. Caught	CPUE	No. License	No. Trips	Lbs. Caught	CPUE	No. License	No. Trips	Lbs. Caught	CPUE
1991	612	6414	440419	68.67	26	121	102669	848.5	55	532	145638	273.76
1992	663	7115	493187	69.32	16	73	47720	653.7	67	700	192317	274.74
1993	587	6044	403974	66.84	8	27	23160	857.78	71	922	198350	215.13
1994	605	6023	389643	64.69	12	35	29766	850.46	67	747	174593	233.73
1995	589	5626	335008	59.55	18	54	294130	5446.85	72	717	147546	205.78
1996	641	6813	466273	68.44	14	88	276929	3146.92	66	747	201023	269.11
1997	705	7550	472493	62.58	9	27	50949	1887	64	747	237614	318.09
1998	706	7630	444827	58.3	8	35	28328	809.37	52	712	245845	345.29
1999	583	6419	430366	67.05	6	73	62049	849.99	52	674	247793	367.65
2000	571	6891	424637	61.62	7	48	105931	2206.9	42	680	254315	373.99
2001	546	6259	387024	61.83	3	22	4397	199.86	37	616	179294	291.06
2002	477	5270	302263	57.36	NULL	NULL	NULL	0	37	467	92792	198.7
2003	389	4596	348882	75.91	8	22	290257	13193.5	47	551	182279	330.81
2004	326	4006	285912	71.37	12	57	291421	5112.65	43	488	168519	345.33
2005	267	3291	207344	63	8	28	429217	15329.18	49	447	174188	389.68
2006	266	2733	203102	74.31	5	23	356478	15499.04	38	384	110986	289.03
2007	314	3620	277141	76.56	4	16	375211	23450.69	28	327	156379	478.22
2008	284	3306	226571	68.53	6	84	262029	3119.39	31	287	150939	525.92
2009	390	4251	285604	67.19	7	18	101714	5650.78	36	203	86770	427.44
2010	382	4487	308256	68.7	8	22	52804	2400.18	39	328	145384	443.24
2011	365	4099	287173	70.06	n.d.	n.d.	n.d.	n.d.	39	407	217742	534.99
2012	336	3788	237462	62.69	n.d.	n.d.	n.d.	n.d.	33	398	201600	506.53
2013	345	3415	236692	69.31	n.d.	n.d.	n.d.	n.d.	41	441	178374	404.48
2014	283	2923	197882	67.7	n.d.	n.d.	n.d.	n.d.	34	461	186918	405.46
2015	238	2693	198906	73.86	7	34	27818	818.18	39	511	244790	479.04
2016	210	2522	180318	71.5	3	15	16974	1131.6	37	452	231673	512.55
2017	180	1847	115394	62.48	3	21	39501	1881	27	327	184690	564.8

Fiscal Year	**Inshore Handline**				**Purse Seine Net (Pelagic)**				**Lay Gill Net**			
	No. License	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. License**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. License**	**No. Trips**	**Lbs. Caught**	**CPUE**
10-year avg.	**316**	**3519**	**244043**	**69.35**	**5**	**25**	**102219**	**4088.76**	**36**	**383**	**180400**	**471.02**
20-year avg.	**400**	**4492**	**297374**	**66.2**	**6**	**31**	**138971**	**4482.94**	**41**	**480**	**184881**	**385.17**

Table 25. Time series of seine net and spear CPUE harvesting CREMUS Finfish (1966-2017).

Fiscal Year	**Seine Net**				**Spear**			
	No. License	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. License**	**No. Trips**	**Lbs. Caught**	**CPUE**
1966	5	31	18394	593.35	NULL	NULL	NULL	0
1967	4	91	74956	823.69	n.d.	n.d.	n.d.	n.d.
1968	6	83	30244	364.39	NULL	NULL	NULL	0
1969	7	119	89370	751.01	NULL	NULL	NULL	0
1970	5	81	36905	455.62	NULL	NULL	NULL	0
1971	3	74	29123	393.55	NULL	NULL	NULL	0
1972	3	64	6789	106.08	NULL	NULL	NULL	0
1973	4	35	20873	596.37	n.d.	n.d.	n.d.	n.d.
1974	4	32	19948	623.38	NULL	NULL	NULL	0
1975	3	4	5246	1311.5	n.d.	n.d.	n.d.	n.d.
1976	3	36	358799	9966.64	15	39	1287	33
1977	11	65	89655	1379.31	23	51	1319	25.86
1978	11	97	63475	654.38	70	318	16631	52.3
1979	30	162	91355	563.92	74	327	19001	58.11
1980	13	52	37893	728.71	78	394	26011	66.02
1981	10	54	15921	294.83	72	552	28336	51.33
1982	18	116	82967	715.23	57	495	27562	55.68
1983	21	116	290269	2502.32	62	455	34102	74.95

Fiscal Year	Seine Net				Spear			
	No. License	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. License**	**No. Trips**	**Lbs. Caught**	**CPUE**
1984	14	75	62692	835.89	71	491	30171	61.45
1985	8	21	15389	732.81	82	800	45158	56.45
1986	6	64	37930	592.66	90	716	48877	68.26
1987	6	110	112255	1020.5	92	770	53505	69.49
1988	11	101	100070	990.79	92	833	69271	83.16
1989	9	63	35218	559.02	92	792	78910	99.63
1990	15	118	283108	2399.22	82	628	44447	70.78
1991	13	94	240900	2562.77	99	749	47338	63.2
1992	20	186	298547	1605.09	96	895	54082	60.43
1993	20	277	464809	1678.01	96	751	49072	65.34
1994	15	109	238403	2187.18	115	875	61625	70.43
1995	14	129	300961	2333.03	132	1094	75764	69.25
1996	15	162	99743	615.7	143	1047	58782	56.14
1997	17	146	139146	953.05	140	802	40931	51.04
1998	17	198	755425	3815.28	128	912	50731	55.63
1999	20	188	643390	3422.29	119	861	47853	55.58
2000	13	130	667234	5132.57	115	822	50685	61.66
2001	18	116	613925	5292.46	110	673	38805	57.66
2002	10	65	361127	5555.8	108	637	35665	55.99
2003	15	166	138804	836.17	105	672	47636	70.89
2004	23	229	195862	855.29	80	696	47247	67.88
2005	17	238	200324	841.7	78	752	57827	76.9
2006	21	219	151261	690.69	82	729	51233	70.28
2007	24	215	187849	873.72	96	882	57313	64.98
2008	23	209	144626	691.99	81	989	64845	65.57
2009	28	276	164758	596.95	128	1332	82441	61.89
2010	33	335	190900	569.85	110	1505	119727	79.55
2011	23	294	149084	507.09	109	1522	169297	111.23

Fiscal Year	Seine Net				Spear			
	No. License	No. Trips	Lbs. Caught	CPUE	No. License	No. Trips	Lbs. Caught	CPUE
2012	24	177	109493	618.6	109	1458	185632	127.32
2013	18	173	98394	568.75	114	1417	187608	132.4
2014	23	193	105467	546.46	101	1026	123958	120.82
2015	21	165	117859	714.3	86	966	86790	89.84
2016	20	178	167564	941.37	63	675	66797	98.96
2017	19	191	134735	705.42	65	666	53194	79.87
10-year avg.	**24**	**228**	**146678**	**643.32**	**100**	**1178**	**114565**	**97.25**
20-year avg.	**21**	**199**	**266702**	**1340.21**	**103**	**967**	**80713**	**83.47**

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

1.4 CRUSTACEAN

1.4.1 Fishery Descriptions

This species group is comprised of the *Heterocarpus* deep water shrimps (*H. laevigatus* and *H. ensifer*), spiny lobsters (*Panulirus marginatus* and *P. Penicillatus*), slipper lobsters (*Scyllaridae haanii* and *S. squammosus*), kona crab (*Ranina ranina*), kuahonu crab (*Portunus Sanguinolentus*), Hawaiian crab (*Podophthalmus vigil*), Opaelolo (*Penaeus marginatus*), and ‘a‘ama crab (*Grapsus tenuicrustatus*). The main gear types used are shrimp traps, loop nets, miscellaneous traps, and crab traps.

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 Online Fishing Report system (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.

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 associates will enter the paper Monthly Fishing Report information within four weeks, and the Net, Trap, Dive Activity Report and the MHI Deep-7 Bottomfish Fishing Trip Report within two business days.

1.4.2.1 Historical Summary

Table 26. 2017 annual fishing parameters for the Crustacean fishery comparing current estimates with the short-term (10-year) and the long-term (20-year) averages.

Fishery	Parameters	2017 Values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Long-Term Avg. (20-year)
Crustacean	No. License	38	↓ 45.7%	↓ 60.0%
	Trips	473	↓ 35.0%	↓ 33.9%
	No. Caught	75,551	↓ 62.4%	↓ 35.9%
	Lbs. Caught	30,608	↓ 51.3%	↓ 54.3%

1.4.2.2 Species Summary

Table 27. 2017 annual indicators for the Crustacean fishery comparing current estimates with the short-term (10-year) and the long-term (20-year) averages.

Methods	Fishery indicators	2017 values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Short-Term Avg. (20-year)
Shrimp trap	*H. laevigatus*	N/A	N/A	N/A
	No. Lic.	N/A	N/A	N/A
	No. Trips	N/A	N/A	N/A
	Lbs. Caught	N/A	N/A	N/A

	CPUE	N/A	N/A	N/A
Loop net	Kona crab	1,691 lbs.	↓ 77.1%	↓ 85.9%
	No. Lic.	17	↓ 50.0%	↓ 66.0%
	No. Trips	36	↓ 72.9%	↓ 78.4%
	Lbs. Caught	1,691 lbs.	↓ 77.2%	↓ 86.0%
	CPUE	46.97 lbs./trip	↓ 15.6%	↓ 34.9%
Hand grab (lobster)	Green spiny	3,575 lbs.	↓ 54.6%	N/A
	Red spiny	3,713 lbs.	↓ 60.1%	N/A
	No. Lic.	12	↓ 36.8%	↓ 55.6%
	No. Trips	156	↓ 36.3%	↓ 34.2%
	Lbs. Caught	4,710 lbs.	↓ 53.0%	↓ 48.0%
	CPUE	30.19 lbs./trip	↓ 26.2%	↓ 21.0%

1.4.3 Time Series Statistics

1.4.3.1 Commercial Fishing Parameters

Table 28. Time series of commercial fishermen reports for Crustacean fishery (1966-2017).

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1966	64	805	234	12042	33264
1967	74	759	259	3814	38359
1968	56	592	205	2313	40873
1969	84	817	268	4580	56873
1970	75	886	269	13514	82730
1971	94	1248	352	67103	104014
1972	92	1070	319	3479	119988
1973	77	942	293	2485	107373
1974	113	911	321	14124	80283
1975	109	1123	320	10047	89689
1976	125	1041	337	9784	74056
1977	125	1199	381	10999	64335
1978	138	781	403	10678	68289
1979	115	472	309	7596	42366
1980	111	487	257	5216	24689
1981	117	631	290	6480	27641
1982	111	740	325	4370	30683
1983	121	865	354	12732	38359
1984	170	1251	436	12867	238819
1985	160	1357	440	14086	110456
1986	160	1000	431	9078	53374
1987	173	1048	422	12804	51870
1988	124	806	300	7807	48713

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1989	106	596	249	3984	74013
1990	122	747	278	7526	377734
1991	132	845	324	10311	123992
1992	148	935	339	13526	77038
1993	129	831	319	7729	86093
1994	130	821	323	6627	100993
1995	140	856	383	6715	117203
1996	172	1016	405	8980	119882
1997	159	785	365	11909	79349
1998	157	945	388	13987	80900
1999	157	802	365	14865	242736
2000	149	782	345	18691	53546
2001	128	615	280	14616	34803
2002	113	576	275	14717	32919
2003	96	495	221	48737	35703
2004	85	499	195	49743	36308
2005	82	737	188	75462	97915
2006	74	789	193	83508	146245
2007	59	577	174	92091	41580
2008	67	727	200	159459	67074
2009	83	761	212	160505	59563
2010	78	872	235	169993	70786
2011	93	766	246	141811	60222
2012	73	667	212	145928	40785
2013	65	758	214	253962	69715
2014	66	870	206	534365	100880
2015	59	677	176	205650	65574
2016	56	613	189	147321	53563
2017	38	473	139	75551	30608
10-year avg.	**70**	**728**	**206**	**201099**	**62897**
20-year avg.	**95**	**715**	**244**	**117861**	**73470**

1.4.4 Top 4 Species per Gear Type

1.4.4.1 Shrimp Trap

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

Table 29. HDAR MHI Fiscal Annual Crustacean Catch (Lbs. caught) Summary (1987-2017) by species and Top Gear: Shrimp trap.

Fiscal Year	Laevigatus		Ensifer		Opaelolo	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	NULL	NULL	NULL	NULL	NULL	NULL
1967	NULL	NULL	NULL	NULL	NULL	NULL
1968	NULL	NULL	NULL	NULL	NULL	NULL
1969	NULL	NULL	NULL	NULL	NULL	NULL
1970	NULL	NULL	NULL	NULL	NULL	NULL
1971	NULL	NULL	NULL	NULL	NULL	NULL
1972	NULL	NULL	NULL	NULL	NULL	NULL
1973	NULL	NULL	NULL	NULL	NULL	NULL
1974	NULL	NULL	NULL	NULL	NULL	NULL
1975	NULL	NULL	NULL	NULL	NULL	NULL
1976	NULL	NULL	NULL	NULL	NULL	NULL
1977	NULL	NULL	NULL	NULL	NULL	NULL
1978	NULL	NULL	NULL	NULL	NULL	NULL
1979	NULL	NULL	NULL	NULL	NULL	NULL
1980	NULL	NULL	NULL	NULL	NULL	NULL
1981	NULL	NULL	NULL	NULL	NULL	NULL
1982	NULL	NULL	NULL	NULL	NULL	NULL
1983	NULL	NULL	NULL	NULL	NULL	NULL
1984	NULL	NULL	NULL	NULL	NULL	NULL
1985	NULL	NULL	NULL	NULL	NULL	NULL
1986	NULL	NULL	NULL	NULL	NULL	NULL
1987	3	1796	n.d.	n.d.	n.d.	n.d.
1988	n.d.	n.d.	3	1568	NULL	NULL
1989	n.d.	n.d.	n.d.	n.d.	NULL	NULL
1990	5	341780	n.d.	n.d.	NULL	NULL
1991	n.d.	n.d.	NULL	NULL	NULL	NULL
1992	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1993	n.d.	n.d.	NULL	NULL	NULL	NULL
1994	4	47737	n.d.	n.d.	NULL	NULL
1995	6	69962	n.d.	n.d.	n.d.	n.d.
1996	4	67077	n.d.	n.d.	n.d.	n.d.
1997	8	32564	n.d.	n.d.	n.d.	n.d.
1998	7	21157	n.d.	n.d.	n.d.	n.d.

Fiscal Year	**Laevigatus**		**Ensifer**		**Opaelolo**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1999	5	185139	n.d.	n.d.	NULL	NULL
2000	3	11770	n.d.	n.d.	NULL	NULL
2001	4	6307	n.d.	n.d.	n.d.	n.d.
2002	n.d.	n.d.	NULL	NULL	NULL	NULL
2003	3	4284	n.d.	n.d.	NULL	NULL
2004	n.d.	n.d.	NULL	NULL	NULL	NULL
2005	4	51996	n.d.	n.d.	NULL	NULL
2006	5	99718	n.d.	n.d.	NULL	NULL
2007	n.d.	n.d.	n.d.	n.d.	NULL	NULL
2008	n.d.	n.d.	n.d.	n.d.	NULL	NULL
2009	n.d.	n.d.	n.d.	n.d.	NULL	NULL
2010	n.d.	n.d.	n.d.	n.d.	NULL	NULL
2011	n.d.	n.d.	n.d.	n.d.	NULL	NULL
2012	4	6854	n.d.	n.d.	NULL	NULL
2013	5	12759	n.d.	n.d.	NULL	NULL
2014	10	47764	5	927	NULL	NULL
2015	7	27163	3	21	NULL	NULL
2016	5	27009	n.d.	n.d.	NULL	NULL
2017	n.d.	n.d.	n.d.	n.d.	NULL	NULL
10-year avg.	**4**	**13846**	**n.d.**	**n.d.**	**NULL**	**NULL**
20-year avg.	**4**	**27964**	**n.d.**	**n.d.**	**n.d.**	**n.d.**

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

1.4.4.2 Loop Net

The driver species for this gear is the kona crab with the kuahonu (i.e. white) crab comprising a large portion of the bycatch. The levels of fishing effort and landings have gradually declined since 2000. The State has established and amended several regulations on the taking and sale of kona crab. In addition to long-standing restrictions for minimum size, berried females, and season closure, the added prohibition of harvesting females hurt fishing effort and may have discouraged them from further participation. Another factor that impacted the decline in kona crab landings was the retirement of a long-time highline fisher several years ago.

Table 30. HDAR MHI Fiscal Annual Crustacean Catch (Lbs. caught) Summary (1966 - 2016) by species and 2nd Gear: Loop net.

Fiscal Year	**Kona Crab**		**Kuahonu Crab**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**

Fiscal Year	**Kona Crab**		**Kuahonu Crab**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1966	21	10029	NULL	NULL
1967	30	17444	NULL	NULL
1968	25	26419	NULL	NULL
1969	28	35939	NULL	NULL
1970	29	35033	NULL	NULL
1971	38	42977	NULL	NULL
1972	40	69328	NULL	NULL
1973	32	62455	NULL	NULL
1974	49	39121	NULL	NULL
1975	58	23996	NULL	NULL
1976	50	23195	n.d.	n.d.
1977	33	15966	NULL	NULL
1978	60	28582	NULL	NULL
1979	51	24674	NULL	NULL
1980	39	8162	NULL	NULL
1981	47	12102	NULL	NULL
1982	48	8291	NULL	NULL
1983	48	9009	NULL	NULL
1984	58	12904	NULL	NULL
1985	71	20846	NULL	NULL
1986	80	27200	NULL	NULL
1987	62	16310	NULL	NULL
1988	47	12475	NULL	NULL
1989	32	11790	4	668
1990	32	16118	NULL	NULL
1991	44	22789	NULL	NULL
1992	71	34291	NULL	NULL
1993	66	25305	n.d.	n.d.
1994	70	23770	NULL	NULL
1995	77	22763	NULL	NULL
1996	88	30581	NULL	NULL
1997	86	28893	n.d.	n.d.
1998	82	28611	n.d.	n.d.
1999	90	25417	n.d.	n.d.
2000	84	16908	n.d.	n.d.
2001	61	10035	n.d.	n.d.
2002	64	11372	n.d.	n.d.
2003	51	11755	3	17
2004	49	12685	n.d.	n.d.

Fiscal Year	**Kona Crab**		**Kuahonu Crab**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
2005	51	11750	n.d.	n.d.
2006	38	9143	3	58
2007	33	5653	n.d.	n.d.
2008	35	13136	3	14
2009	43	7519	3	15
2010	39	11449	3	12
2011	49	10609	n.d.	n.d.
2012	41	8149	n.d.	n.d.
2013	28	9551	n.d.	n.d.
2014	29	2999	3	19
2015	24	2293	n.d.	n.d.
2016	23	2512	n.d.	n.d.
2017	17	1690	n.d.	n.d.
10-year avg.	**34**	**7389**	**n.d.**	**n.d.**
20-year avg.	**50**	**12023**	**n.d.**	**n.d.**

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

1.4.4.3 Crab Trap

The gear code for crab trap was established in 1985. Prior to 1985 all trap activities were reported under miscellaneous traps. The driver species for this gear is the kuahonu crab. Throughout the time series, there has been a small group of fishers participating in this fishery numbering no more than eight in a year. There is a market demand for kuahonu crab and the landings have been trending upwards .r the past eight years (except for 2015, which remains undisclosed due to data confidentiality).

Table 31. HDAR MHI Fiscal Annual Crustacean Catch (Lbs. caught) Summary (1966-2017) by species and 4th Gear: Crab trap.

Fiscal Year	**Kuahonu Crab**		**Kona Crab**		**Samoan Crab**		**Spiny Lobster**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1966	3	5399	NULL	NULL	n.d.	n.d.	12	2683
1967	5	4070	NULL	NULL	NULL	NULL	9	2180
1968	4	2757	NULL	NULL	n.d.	n.d.	9	1714
1969	8	2488	n.d.	n.d.	4	305	14	4142
1970	7	19012	n.d.	n.d.	n.d.	n.d.	8	1983
1971	11	42507	n.d.	n.d.	NULL	NULL	11	1878
1972	8	39091	n.d.	n.d.	n.d.	n.d.	12	2886

1973	8	34095	NULL	NULL	n.d.	n.d.	10	3945
1974	11	28858	n.d.	n.d.	NULL	NULL	14	3969
1975	11	52730	n.d.	n.d.	NULL	NULL	13	2599
1976	11	29457	n.d.	n.d.	NULL	NULL	10	1619
1977	10	10024	n.d.	n.d.	n.d.	n.d.	14	4382
1978	7	17015	n.d.	n.d.	n.d.	n.d.	14	5383
1979	3	3409	NULL	NULL	NULL	NULL	12	2139
1980	5	1590	3	2099	n.d.	n.d.	15	4303
1981	5	2054	NULL	NULL	n.d.	n.d.	11	2372
1982	5	2693	n.d.	n.d.	NULL	NULL	12	4937
1983	3	2832	n.d.	n.d.	NULL	NULL	16	4639
1984	5	3167	n.d.	n.d.	NULL	NULL	19	11279
1985	6	7437	n.d.	n.d.	n.d.	n.d.	22	9347
1986	n.d.	n.d.	NULL	NULL	NULL	NULL	3	465
1987	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	3	179
1988	n.d.	n.d.	n.d.	n.d.	NULL	NULL	n.d.	n.d.
1989	NULL	NULL	NULL	NULL	NULL	NULL	n.d.	n.d.
1990	NULL	NULL	NULL	NULL	NULL	NULL	n.d.	n.d.
1991	n.d.	n.d.	NULL	NULL	n.d.	n.d.	n.d.	n.d.
1992	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	NULL
1993	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1994	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
1995	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
1996	n.d.	n.d.	n.d.	n.d.	NULL	NULL	NULL	NULL
1997	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
1998	n.d.	n.d.	NULL	NULL	n.d.	n.d.	3	95
1999	n.d.	n.d.	NULL	NULL	NULL	NULL	3	20
2000	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2001	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2002	n.d.	n.d.	NULL	NULL	NULL	NULL	n.d.	n.d.
2003	n.d.	n.d.	NULL	NULL	n.d.	n.d.	NULL	NULL
2004	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2005	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2006	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2007	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2008	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2009	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2010	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2011	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2012	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2013	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL

2014	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2015	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2016	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
2017	NULL	NULL	NULL	NULL	4	1138	NULL	NULL

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

1.4.4.4 Hand/grab for crustaceans

DLNR-DAR standardized the gear/method definitions for hand/grab in October 2002. For the harvesting of crustaceans/lobsters by hand, the "diving" gear code had been used. It is defined as "Fishing while swimming free dive (skin diving) or swimming with the assistance of compressed gases (SCUBA, rebreathers, etc.). Examples are lobster or namako diving. Does not include diving with a spear (see spearfishing), a net (see various nets), or for limu or opihi (see handpicking). Typical species: various marine species."

Table 32. HDAR MHI Fiscal Annual Crustacean Catch (Lbs. caught) Summary (1966-2017) by species and Fourth Gear: Hand/Grab.

Fiscal Year	Green Spiny Lobster		Spiny Lobster		Red Spiny Lobster		A'ama / Black Crab		Slipper Lobster	
	No. Lic.	Lbs. Caught	No. Lic.	Lbs. Caught	No. Lic.	Lbs. Caught	No. Lic.	Lbs. Caught	No. Lic.	Lbs. Caught
1966	NULL	NULL	4	177	NULL	NULL	NULL	NULL	NULL	NULL
1967	NULL	NULL	3	179	NULL	NULL	NULL	NULL	NULL	NULL
1968	NULL	NULL	n.d.	n.d.	NULL	NULL	NULL	NULL	NULL	NULL
1969	NULL	NULL	5	261	NULL	NULL	NULL	NULL	NULL	NULL
1970	NULL	NULL	7	1062	NULL	NULL	NULL	NULL	n.d.	n.d.
1971	NULL	NULL	7	264	NULL	NULL	NULL	NULL	n.d.	n.d.
1972	NULL	NULL	10	505	NULL	NULL	NULL	NULL	NULL	NULL
1973	NULL	NULL	7	267	NULL	NULL	NULL	NULL	NULL	NULL
1974	NULL	NULL	18	767	NULL	NULL	NULL	NULL	n.d.	n.d.
1975	NULL	NULL	6	252	NULL	NULL	NULL	NULL	NULL	NULL
1976	NULL	NULL	7	617	NULL	NULL	NULL	NULL	NULL	NULL
1977	NULL	NULL	11	657	NULL	NULL	NULL	NULL	n.d.	n.d.
1978	NULL	NULL	19	630	NULL	NULL	NULL	NULL	3	111
1979	NULL	NULL	19	764	NULL	NULL	NULL	NULL	4	73
1980	NULL	NULL	14	708	NULL	NULL	NULL	NULL	n.d.	n.d.
1981	NULL	NULL	11	160	NULL	NULL	NULL	NULL	NULL	NULL
1982	NULL	NULL	4	264	NULL	NULL	NULL	NULL	NULL	NULL
1983	NULL	NULL	6	484	NULL	NULL	NULL	NULL	NULL	NULL
1984	NULL	NULL	7	344	NULL	NULL	NULL	NULL	NULL	NULL
1985	NULL	NULL	11	487	NULL	NULL	NULL	NULL	NULL	NULL
1986	NULL	NULL	25	2877	NULL	NULL	n.d.	n.d.	n.d.	n.d.

1987	NULL	NULL	35	3208	NULL	NULL	9	385	3	54
1988	NULL	NULL	33	4369	NULL	NULL	8	840	3	66
1989	NULL	NULL	24	3084	NULL	NULL	5	226	n.d.	n.d.
1990	NULL	NULL	36	3997	NULL	NULL	NULL	NULL	NULL	NULL
1991	NULL	NULL	39	2904	NULL	NULL	NULL	NULL	6	31
1992	NULL	NULL	33	3543	NULL	NULL	NULL	NULL	n.d.	n.d.
1993	NULL	NULL	23	1268	NULL	NULL	NULL	NULL	n.d.	n.d.
1994	NULL	NULL	24	799	NULL	NULL	NULL	NULL	n.d.	n.d.
1995	NULL	NULL	27	2359	NULL	NULL	NULL	NULL	3	26
1996	NULL	NULL	51	6504	NULL	NULL	NULL	NULL	5	81
1997	NULL	NULL	39	5119	NULL	NULL	NULL	NULL	5	58
1998	NULL	NULL	37	8878	NULL	NULL	NULL	NULL	3	25
1999	NULL	NULL	39	6596	NULL	NULL	NULL	NULL	n.d.	n.d.
2000	NULL	NULL	44	8480	NULL	NULL	NULL	NULL	8	83
2001	NULL	NULL	41	7212	NULL	NULL	NULL	NULL	n.d.	n.d.
2002	NULL	NULL	36	9998	NULL	NULL	NULL	NULL	6	38
2003	12	4667	15	1036	24	5396	n.d.	n.d.	n.d.	n.d.
2004	15	4577	n.d.	n.d.	24	6782	3	146	NULL	NULL
2005	14	10023	4	167	19	10263	n.d.	n.d.	NULL	NULL
2006	17	9381	5	387	22	9647	n.d.	n.d.	n.d.	n.d.
2007	12	8645	n.d.	n.d.	15	8990	n.d.	n.d.	n.d.	n.d.
2008	15	7657	n.d.	n.d.	15	7834	NULL	NULL	n.d.	n.d.
2009	18	10695	n.d.	n.d.	21	11149	n.d.	n.d.	n.d.	n.d.
2010	18	10302	n.d.	n.d.	21	14088	n.d.	n.d.	n.d.	n.d.
2011	21	9702	NULL	NULL	26	11479	n.d.	n.d.	NULL	NULL
2012	15	8176	NULL	NULL	20	10350	NULL	NULL	n.d.	n.d.
2013	16	8843	NULL	NULL	18	10429	NULL	NULL	NULL	NULL
2014	10	6594	n.d.	n.d.	12	9329	NULL	NULL	n.d.	n.d.
2015	12	7983	NULL	NULL	15	8971	n.d.	n.d.	NULL	NULL
2016	8	4739	NULL	NULL	9	5250	n.d.	n.d.	NULL	NULL
2017	8	3575	NULL	NULL	9	3713	n.d.	n.d.	n.d.	n.d.

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

1.4.5 Catch Parameters by Gear

Table 33. Time series of CPUE by dominant fishing methods from Crustaceans (1966-2017).

Fiscal Year	Shrimp Trap				Kona Crab Net (Loop)				Hand/Grab				Crab Trap			
	No. Lic.	No. Trips	Lbs. Caught	CPUE	No. Lic.	No. Trips	Lbs. Caught	CPUE	No. Lic.	No. Trips	Lbs. Caught	CPUE	No. Lic.	No. Trips	Lbs. Caught	CPUE
1966	NULL	NULL	NULL	0	21	178	10029	56.34	4	8	177	22.13	n.d.	n.d.	n.d.	n.d.
1967	NULL	NULL	NULL	0	30	185	17444	94.29	3	4	179	44.75	6	76	2758	36.29
1968	NULL	NULL	NULL	0	25	167	26419	158.2	n.d.	n.d.	n.d.	n.d.	4	96	2624	27.33
1969	NULL	NULL	NULL	0	28	232	35939	154.91	5	16	261	16.31	11	132	4095	31.02
1970	NULL	NULL	NULL	0	29	195	35033	179.66	7	31	1075	34.68	11	73	2384	32.66
1971	NULL	NULL	NULL	0	38	241	42977	178.33	7	16	265	16.56	6	133	3211	24.14
1972	NULL	NULL	NULL	0	40	259	69328	267.68	10	35	505	14.43	9	120	3560	29.67
1973	NULL	NULL	NULL	0	32	230	62455	271.54	7	13	267	20.54	9	66	1354	20.52
1974	NULL	NULL	NULL	0	49	199	39121	196.59	18	49	772	15.76	7	83	2130	25.66
1975	NULL	NULL	NULL	0	58	233	23996	102.99	6	12	252	21	11	141	2694	19.11
1976	NULL	NULL	NULL	0	50	205	23256	113.44	7	22	617	28.05	30	159	5047	31.74
1977	NULL	NULL	NULL	0	33	133	15966	120.05	12	33	723	21.91	43	383	16237	42.39
1978	NULL	NULL	NULL	0	60	227	28582	125.91	22	39	741	19	16	120	3799	31.66
1979	NULL	NULL	NULL	0	51	188	24674	131.24	20	34	837	24.62	21	102	6396	62.71
1980	NULL	NULL	NULL	0	40	101	8192	81.11	15	21	732	34.86	21	98	2779	28.36
1981	NULL	NULL	NULL	0	47	143	12102	84.63	11	20	160	8	15	73	2419	33.14
1982	NULL	NULL	NULL	0	48	163	8291	50.87	4	7	264	37.71	16	54	1534	28.41
1983	NULL	NULL	NULL	0	48	148	9305	62.87	6	18	496	27.56	22	93	3730	40.11
1984	NULL	NULL	NULL	0	58	178	12904	72.49	7	17	344	20.24	29	81	2182	26.94
1985	NULL	NULL	NULL	0	71	309	20846	67.46	11	19	487	25.63	16	69	1149	16.65
1986	NULL	NULL	NULL	0	80	302	27200	90.07	29	122	2976	24.39	13	56	755	13.48
1987	5	26	3481	133.88	62	158	16310	103.23	48	219	3774	17.23	9	20	358	17.9
1988	3	44	12934	293.95	47	179	12475	69.69	41	247	5518	22.34	6	7	352	50.29
1989	n.d.	n.d.	n.d.	n.d.	33	140	12458	88.99	29	160	3338	20.86	7	14	312	22.29

Fiscal Year	Shrimp Trap				Kona Crab Net (Loop)				Hand/Grab				Crab Trap			
	No. Lic.	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**
1990	5	87	343102	3943.7	32	130	16118	123.98	36	142	3997	28.15	18	78	1233	15.81
1991	n.d.	n.d.	n.d.	n.d.	44	161	22789	141.55	40	179	2935	16.4	12	77	1785	23.18
1992	n.d.	n.d.	n.d.	n.d.	71	316	34291	108.52	33	141	3556	25.22	11	23	524	22.78
1993	n.d.	n.d.	n.d.	n.d.	66	309	25306	81.9	23	80	1277	15.96	12	14	269	19.21
1994	4	75	49505	660.07	70	245	23770	97.02	25	68	824	12.12	9	31	446	14.39
1995	7	103	74697	725.21	77	296	22763	76.9	28	148	2415	16.32	7	26	412	15.85
1996	5	190	70386	370.45	88	329	30581	92.95	52	289	6586	22.79	5	13	114	8.77
1997	9	99	34009	343.53	86	278	28895	103.94	39	200	5184	25.92	n.d.	n.d.	n.d.	n.d.
1998	8	82	21537	262.65	82	307	28632	93.26	38	272	8903	32.73	4	7	173	24.71
1999	5	111	186400	1679.2	90	258	25425	98.55	39	186	6604	35.51	5	9	50	5.56
2000	3	72	11798	163.86	84	195	16914	86.74	45	264	8573	32.47	n.d.	n.d.	n.d.	n.d.
2001	6	64	6436	100.56	61	151	10067	66.67	43	193	7273	37.68	n.d.	n.d.	n.d.	n.d.
2002	n.d.	n.d.	n.d.	n.d.	64	179	11382	63.59	37	194	10036	51.73	5	12	53	4.42
2003	3	50	4748	94.96	51	165	11772	71.35	33	175	6600	37.71	3	4	65	16.25
2004	n.d.	n.d.	n.d.	n.d.	49	158	12690	80.32	28	234	7001	29.92	n.d.	n.d.	n.d.	n.d.
2005	4	67	54379	811.63	51	170	11815	69.5	24	300	10512	35.04	NULL		NULL	0
2006	5	163	103857	637.16	38	160	9201	57.51	23	274	10095	36.84	n.d.	n.d.	n.d.	n.d.
2007	n.d.	n.d.	n.d.	n.d.	33	133	5657	42.53	16	275	9128	33.19	3	20	177	8.85
2008	n.d.	n.d.	n.d.	n.d.	35	221	13150	59.5	16	191	8354	43.74	9	94	1356	14.43
2009	n.d.	n.d.	n.d.	n.d.	43	168	7534	44.85	24	271	11329	41.8	5	109	1475	13.53
2010	n.d.	n.d.	n.d.	n.d.	39	209	11461	54.84	24	361	14422	39.95	4	60	1756	29.27
2011	n.d.	n.d.	n.d.	n.d.	49	190	10622	55.91	30	268	11539	43.06	5	82	1300	15.85
2012	4	95	7140	75.16	41	128	8154	63.7	21	267	10421	39.03	5	57	906	15.89
2013	5	150	12972	86.48	28	106	9554	90.13	19	233	10452	44.86	5	61	1309	21.46
2014	10	316	48691	154.09	29	59	3017	51.14	14	234	9350	39.96	n.d.	n.d.	n.d.	n.d.
2015	7	228	27184	119.23	24	64	2319	36.23	18	191	9230	48.32	5	31	493	15.9
2016	5	171	27041	158.13	23	49	2525	51.53	12	158	5499	34.8	7	36	811	22.53

Fiscal Year	**Shrimp Trap**				**Kona Crab Net (Loop)**				**Hand/Grab**				**Crab Trap**			
	No. Lic.	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic.**	**No. Trips**	**Lbs. Caught**	**CPUE**
2017	n.d.	n.d.	n.d.	n.d.	17	36	1691	46.97	12	156	4710	30.19	5	52	1140	21.92
10-year avg.	**4**	**116**	**14804**	**127.62**	**34**	**133**	**7402**	**55.65**	**19**	**245**	**10025**	**40.92**	**5**	**58**	**1016**	**17.52**
20-year avg.	**4**	**97**	**28955**	**298.51**	**50**	**167**	**12040**	**72.1**	**27**	**237**	**9052**	**38.19**	**4**	**33**	**561**	**17**

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

NULL = no available data

1.5 MOLLUSK AND LIMU

1.5.1 Fishery Descriptions

This species category is comprised of algae including miscellaneous *Gracilaria spp*., limu kohu (*Asparagopsis taxiformis*), limu manauea (*Gracilaria coronopifolia*), ogo (*G. parvispora*), limu wawaeiole (*U. fasciata*), mollusks including clam (*Tapes phililippinarum*), he’e (*Octopus cyanea*), he’e pu loa (*O. ornatus*), other octopus (*Octopus spp*.), hihiwai (*Theodoxus spp*.), opihi ‘alina (yellowfoot, *Cellana sandwicensis*), opihi makaiauli (black foot, *C. exarata*), opihi (*Cellana spp*.), and pupu (top shell).

The top gears for this species group category are handpicked, spear, and inshore handline.

1.5.2 Dashboard Statistics

The collection of commercial Mollusk and Limu 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). The Mollusk and Limu landings are reported by commercial fishers in the Monthly Fishing Report or the Net, Trap, Dive Activity Report.

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 associates are to enter the paper Monthly Fishing Report information within four weeks, and the Net, Trap, Dive Activity Report within two business days.

1.5.2.1 Historical Summary

Table 34. 2017 annual fishery parameters for the Mollusk and Limu fishery comparing current estimates with the short-term (10-year) and the long-term (20-year) averages.

Fishery	Parameters	2017 Values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Short-Term Avg. (20-year)
Mollusk and Limu	No. License	75	↓ 42.3%	↓ 50.3%
	Trips	791	↓ 53.1%	↓ 58.5%
	No. Caught	65,318	↑ 178%	↑ 295%
	Lbs. Caught	28,980	↓ 51.1%	↓43.8%

1.5.2.2 Species Summary

Table 35. 2017 annual indicators for the Mollusk and Limu fishery comparing current estimates with the short-term (10-year) and the long-term (20-year) averages.

Methods	Fishery indicators	2017 values	2017 Comparative Trends	
			Short-Term Avg. (10-year)	Short-Term Avg. (20-year)
Hand pick	Opihi	1,659 lbs.	↓ 39.7%	↓ 68.4%
	Opihi’alina	7,380 lbs.	↓ 48.7%	↓ 41.4%
	Wawaaeiole	N/A	N/A	N/A

	Limu kohu	4,887 lbs.	↑ 21.2%	↑ 52.0%
	No. Lic.	22	↓ 51.1%	↓ 60.0%
	No. Trips	301	↓ 56.6%	↓ 67.0%
	Lbs. Caught	13,938 lbs.	↓ 50.3%	↓ 42.9%
	CPUE	46.31 lbs./trip	↑ 14.6%	↑ 72.4%
Spear	Octopus (misc.)	207 lbs.	↓ 7.17%	↓ 96.5%
	He’e day tako	11,672 lbs.	↓ 52.7%	N/A
	No. Lic.	37	↓ 41.3%	↓ 45.6%
	No. Trips	382	↓ 48.2%	↓ 47.7%
	Lbs. Caught	11,879 lbs.	↓ 52.3%	↓ 41.1%
	CPUE	31.1 lbs./trip	↓ 7.77%	↑ 12.7%
Inshore handline	Octopus (misc.)	N/A	N/A	N/A
	He’e day tako	2,505 lbs.	↓ 51.9%	↓ 50.6%
	No. Lic.	14	↓ 33.3%	↓ 50.0%
	No. Trips	51	↓ 72.6%	↓ 76.3%
	Lbs. Caught	2,505 lbs.	↓ 52.8%	↓ 57.4%
	CPUE	49.12 lbs./trip	↑ 72.1%	↑ 79.5%

1.5.3 Time Series Statistics

1.5.3.1 Commercial Fishing Parameters

Table 36. Time series of commercial fishermen reports for the Mollusk and Limu fishery (1966-2017).

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1966	43	435	195	2070	23044
1967	75	996	293	2764	44221
1968	52	651	220	2177	33000
1969	71	831	257	1797	72176
1970	98	1075	338	3683	83503
1971	103	1133	374	3321	85479
1972	111	1265	406	1491	129860
1973	119	1363	429	2499	125317
1974	145	1400	484	67955	103763
1975	136	1292	452	2588	91532
1976	127	1234	423	16005	90835
1977	169	1632	595	5053	133804
1978	180	1119	577	20070	89918
1979	186	738	598	4563	58359
1980	195	1135	562	4730	48302
1981	153	1376	479	3554	36955
1982	128	972	371	1954	26604
1983	138	867	386	3036	24502
1984	194	1688	607	7895	57637

Fiscal Year	No. License	Trips	No. Reports	No. Caught	Lbs. Caught
1985	160	1837	501	4761	50425
1986	204	2022	670	7001	57333
1987	247	2526	785	8153	71628
1988	211	2106	596	8489	58079
1989	208	2134	610	6494	47015
1990	165	1649	510	3424	29992
1991	175	1551	535	3966	30730
1992	206	1796	613	4775	38103
1993	195	1887	564	5575	41109
1994	192	1866	602	5524	41601
1995	186	2033	600	4536	55517
1996	212	2136	632	5745	41700
1997	207	1832	606	5407	38267
1998	224	2253	718	8324	43896
1999	214	1972	714	5625	35968
2000	190	2306	722	8036	44732
2001	185	2384	685	6534	52219
2002	183	2308	682	6252	48262
2003	150	2264	606	21658	46540
2004	131	2092	544	15049	44820
2005	103	2185	448	8585	46550
2006	124	1702	447	10301	37217
2007	112	1485	432	15036	33332
2008	126	1451	460	10510	37506
2009	135	1737	500	18247	57779
2010	151	1945	576	16664	66268
2011	149	2150	617	29644	67042
2012	147	1945	587	50022	70837
2013	144	1951	624	21237	78325
2014	132	1748	564	19182	72963
2015	121	1335	452	22631	56162
2016	81	1101	352	31643	51315
2017	75	791	319	65318	28980
10-year avg.	**130**	**1687**	**518**	**23486**	**59230**
20-year avg.	**151**	**1908**	**567**	**16531**	**51539**

1.5.4 Top Four Species per Gear Type

1.5.4.1 Handpick

The top gear for this group category is handpick or gleaning. Fishers typically use their hands to gather seaweed or an instrument such as a knife to harvest opihi from the shoreline. Two specific species codes were established in 2002 for opihi. They are the yellow foot and black foot species. Prior to 2002, all opihi species were reported under opihi (misc.). The specific limu species were established in 1985. Prior to 1985, all seaweed species were reported under limu miscellaneous. When the revised fishing reports were implemented in October 2002, DAR launched an outreach campaign to inform fishers to report specific opihi and limu species.

Table 37. HDAR MHI Fiscal Annual Mollusk & Limu Catch Summary (1966-2017) by Hand pick.

Fiscal Year	Opihi		Opihi'alina		Wawaeiole		Limu kohu	
	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	13	13989	NULL	NULL	NULL	NULL	NULL	NULL
1967	40	36000	NULL	NULL	NULL	NULL	NULL	NULL
1968	26	22994	NULL	NULL	NULL	NULL	NULL	NULL
1969	36	23818	NULL	NULL	NULL	NULL	NULL	NULL
1970	41	20446	NULL	NULL	NULL	NULL	NULL	NULL
1971	46	17229	NULL	NULL	NULL	NULL	NULL	NULL
1972	44	16689	NULL	NULL	NULL	NULL	NULL	NULL
1973	46	17169	NULL	NULL	NULL	NULL	NULL	NULL
1974	51	19558	NULL	NULL	NULL	NULL	NULL	NULL
1975	46	14277	NULL	NULL	NULL	NULL	NULL	NULL
1976	47	18090	NULL	NULL	NULL	NULL	NULL	NULL
1977	54	10494	NULL	NULL	NULL	NULL	NULL	NULL
1978	51	14267	NULL	NULL	NULL	NULL	NULL	NULL
1979	51	14146	NULL	NULL	NULL	NULL	NULL	NULL
1980	48	8435	NULL	NULL	NULL	NULL	NULL	NULL
1981	33	7231	NULL	NULL	NULL	NULL	NULL	NULL
1982	28	6050	NULL	NULL	NULL	NULL	NULL	NULL
1983	32	4765	NULL	NULL	NULL	NULL	NULL	NULL
1984	28	5708	NULL	NULL	NULL	NULL	NULL	NULL
1985	27	4850	NULL	NULL	n.d.	n.d.	n.d.	n.d.
1986	61	10607	NULL	NULL	6	4238	9	2119
1987	88	16748	NULL	NULL	12	5661	23	5373
1988	70	11989	NULL	NULL	6	6254	14	2313
1989	67	11914	NULL	NULL	3	1260	13	2600
1990	56	7848	NULL	NULL	4	1441	12	3319
1991	55	7618	NULL	NULL	4	1954	24	3180
1992	55	9271	NULL	NULL	9	1982	13	1354
1993	38	5587	NULL	NULL	6	2529	14	1709
1994	40	9879	NULL	NULL	5	820	21	3101
1995	50	13462	NULL	NULL	7	1086	19	2868
1996	52	14012	NULL	NULL	6	1879	14	2592

Fiscal Year	**Opihi**		**Opihi'alina**		**Wawaeiole**		**Limu kohu**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**	**No. License**	**Lbs. Caught**
1997	45	10291	NULL	NULL	6	2346	17	3547
1998	55	11886	NULL	NULL	n.d.	n.d.	23	2999
1999	43	12028	NULL	NULL	n.d.	n.d.	9	1832
2000	35	10338	NULL	NULL	5	3129	16	1608
2001	31	12385	NULL	NULL	5	7328	15	1941
2002	28	12847	NULL	NULL	6	3550	10	2351
2003	21	5145	15	7300	4	2694	10	2606
2004	14	1709	15	8685	n.d.	n.d.	12	3179
2005	5	278	10	8240	n.d.	n.d.	7	1728
2006	7	403	11	8364	n.d.	n.d.	7	2163
2007	11	939	14	6487	5	2158	12	1480
2008	12	372	25	6993	5	4834	9	3061
2009	12	2782	19	14866	9	4013	12	3120
2010	22	5348	28	19521	7	5317	14	4243
2011	14	2984	18	16183	5	5458	10	4643
2012	12	3418	30	15129	6	10643	10	5454
2013	6	1958	18	16475	8	18864	9	4895
2014	7	4902	19	23479	5	2058	9	4659
2015	11	2574	19	14390	3	348	12	5065
2016	5	2180	15	9722	n.d.	n.d.	7	3492
2017	10	1658	15	7380	NULL	NULL	11	4877
10-year avg.	**11**	**2750**	**21**	**14373**	**5**	**5373**	**11**	**4023**
20-year avg.	**20**	**5241**	**18**	**12595**	**5**	**4092**	**12**	**3209**

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

1.5.4.2 Spear

For the secondary gear, spear, the driver species is octopus. There are two specific species for octopus to distinguish the day species (*O. cyanea*) from night (*O. ornatus*); these species were established in 2002. Prior to 2002, all octopus species were reported as “miscellaneous octopus”. When the revised fishing reports were implemented in October 2002, DAR launched an outreach campaign to ask fishers to report specific octopus species. Because the use of spear may or may not include SCUBA apparatus by definition, it is possible that the introduction of SCUBA may have increased fishing power and contributed to the overall increase in octopus landings. It should be noted that the miscellaneous opihi and limu species taken by this gear type are probably reporting discrepancies. Starting in 2002, fishers were contacted to verify the potential discrepancy, with the report remaining unchanged if there was no response.

Table 38. HDAR MHI Fiscal Annual Mollusk & Limu Catch Summary (1966-2017) by Spear.

Fiscal Year	Octopus (misc.)		He'e (Day tako)	
	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	15	4704	NULL	NULL
1967	20	6573	NULL	NULL
1968	15	5622	NULL	NULL
1969	18	4809	NULL	NULL
1970	27	4609	NULL	NULL
1971	30	5548	NULL	NULL
1972	38	9003	NULL	NULL
1973	41	7358	NULL	NULL
1974	54	9234	NULL	NULL
1975	59	9637	NULL	NULL
1976	51	7237	NULL	NULL
1977	58	12594	NULL	NULL
1978	81	14793	NULL	NULL
1979	81	13712	NULL	NULL
1980	74	16100	NULL	NULL
1981	54	11130	NULL	NULL
1982	45	7131	NULL	NULL
1983	44	6605	NULL	NULL
1984	66	13298	NULL	NULL
1985	63	10544	NULL	NULL
1986	89	14814	NULL	NULL
1987	73	20881	NULL	NULL
1988	68	13547	NULL	NULL
1989	71	15351	NULL	NULL
1990	52	6881	NULL	NULL
1991	58	7293	NULL	NULL
1992	71	9354	NULL	NULL
1993	71	10973	NULL	NULL
1994	75	12252	NULL	NULL
1995	74	11505	NULL	NULL
1996	94	11663	NULL	NULL
1997	89	14233	NULL	NULL
1998	100	17594	NULL	NULL
1999	94	11668	NULL	NULL
2000	84	18924	NULL	NULL

Fiscal Year	Octopus (misc.)		He'e (Day tako)	
	No. License	Lbs. Caught	No. License	Lbs. Caught
2001	80	18857	NULL	NULL
2002	73	15002	NULL	NULL
2003	48	11536	33	5340
2004	17	1012	51	12592
2005	20	2144	45	13028
2006	4	630	56	11489
2007	n.d.	n.d.	47	12472
2008	NULL	NULL	62	14420
2009	5	133	68	21865
2010	8	141	63	22351
2011	n.d.	n.d.	75	27910
2012	4	74	66	29521
2013	13	678	69	28045
2014	4	468	61	29875
2015	6	173	55	29358
2016	5	251	33	30688
2017	8	207	33	11672
10-year avg.	**6**	**223**	**60**	**24667**
20-year avg.	**35**	**5980**	**56**	**20652**

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

1.5.4.3 Inshore Handline

Another popular method used to harvest octopus, especially the daytime species, is using a cowrie shell dragged by handline along the bottom. This gear is also reported as “inshore handline”. It should be noted that miscellaneous hihiwai and limu species taken by this gear type are probably reporting discrepancies. Starting in 2002, fishers were contacted to verify the potential discrepancy, with the report remaining unchanged if there was no response.

Table 39. HDAR MHI Fiscal Annual Mollusk & Limu Catch Summary (1966-2017) by Inshore handline.

Fiscal Year	Octopus (misc.)		He'e (day tako)	
	No. License	Lbs. Caught	No. License	Lbs. Caught
1966	6	139	NULL	NULL
1967	7	117	NULL	NULL
1968	4	83	NULL	NULL
1969	5	43	NULL	NULL
1970	6	423	NULL	NULL

Fiscal Year	Octopus (misc.)		He'e (day tako)	
	No. License	Lbs. Caught	No. License	Lbs. Caught
1971	6	69	NULL	NULL
1972	8	249	NULL	NULL
1973	12	482	NULL	NULL
1974	15	400	NULL	NULL
1975	12	254	NULL	NULL
1976	9	459	NULL	NULL
1977	13	340	NULL	NULL
1978	29	1920	NULL	NULL
1979	43	3927	NULL	NULL
1980	47	5377	NULL	NULL
1981	49	5003	NULL	NULL
1982	35	2914	NULL	NULL
1983	39	6090	NULL	NULL
1984	56	14503	NULL	NULL
1985	46	7914	NULL	NULL
1986	43	10429	NULL	NULL
1987	44	12402	NULL	NULL
1988	46	17047	NULL	NULL
1989	33	5390	NULL	NULL
1990	30	3893	NULL	NULL
1991	25	5635	NULL	NULL
1992	45	6322	NULL	NULL
1993	44	8729	NULL	NULL
1994	41	5333	NULL	NULL
1995	30	4566	NULL	NULL
1996	37	7315	NULL	NULL
1997	40	4468	NULL	NULL
1998	46	6874	NULL	NULL
1999	46	5798	NULL	NULL
2000	41	6264	NULL	NULL
2001	40	5966	NULL	NULL
2002	42	7653	NULL	NULL
2003	31	6442	7	735
2004	12	1021	22	5994
2005	12	1099	14	4832
2006	n.d.	n.d.	23	7416
2007	NULL	NULL	15	7156
2008	NULL	NULL	13	3960
2009	NULL	NULL	19	7399

Fiscal Year	**Octopus (misc.)**		**He'e (day tako)**	
	No. License	**Lbs. Caught**	**No. License**	**Lbs. Caught**
2010	n.d.	n.d.	16	4622
2011	NULL	NULL	27	5427
2012	n.d.	n.d.	19	4500
2013	7	312	25	5476
2014	6	153	19	5903
2015	5	232	24	3341
2016	3	297	14	4259
2017	NULL	NULL	14	2505
10-year avg.	**4**	**174**	**19**	**5204**
20-year avg.	**21**	**2915**	**18**	**5073**

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

1.5.5 Catch Parameters by Gear

Table 40. Time series of CPUE by dominant gear from Mollusk and Limu (1966-2017).

Fiscal Year	**Handpicked**				**Spear**				**Inshore Handline**			
	No. Lic	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic**	**No. Trips**	**Lbs. Caught**	**CPUE**
1966	13	172	14584	84.79	15	131	4704	35.91	6	16	139	8.69
1967	41	783	36210	46.25	20	128	6573	51.35	7	15	117	7.8
1968	26	454	23766	52.35	16	120	5813	48.44	4	6	83	13.83
1969	37	415	23968	57.75	18	101	4809	47.61	5	8	43	5.38
1970	43	401	21089	52.59	27	126	4609	36.58	6	21	423	20.14
1971	48	372	17980	48.33	30	196	5548	28.31	6	9	69	7.67
1972	45	273	18519	67.84	38	209	9003	43.08	8	15	249	16.6
1973	47	275	19462	70.77	41	235	7358	31.31	12	37	482	13.03
1974	54	389	24946	64.13	54	302	9234	30.58	15	28	400	14.29
1975	49	363	17553	48.36	60	322	9709	30.15	12	18	254	14.11
1976	47	304	18283	60.14	51	287	7237	25.22	9	25	459	18.36
1977	54	247	10518	42.58	58	450	12854	28.56	13	20	340	17
1978	52	222	14375	64.75	82	430	14803	34.43	29	77	1920	24.94
1979	51	183	14174	77.45	81	335	13712	40.93	43	83	3927	47.31
1980	48	199	8435	42.39	77	415	16860	40.63	47	139	5377	38.68
1981	33	199	7231	36.34	54	394	11130	28.25	49	187	5003	26.75
1982	28	156	6054	38.81	45	284	7154	25.19	35	156	2914	18.68
1983	33	154	4871	31.63	47	298	6891	23.12	39	210	6090	29
1984	29	135	5760	42.67	66	478	13543	28.33	60	409	15484	37.86
1985	27	170	5600	32.94	63	494	10607	21.47	46	296	7914	26.74
1986	82	891	25441	28.55	89	582	14879	25.57	43	392	10429	26.6
1987	126	1373	32771	23.87	74	694	21164	30.5	44	387	12402	32.05

Fiscal Year	**Handpicked**				**Spear**				**Inshore Handline**			
	No. Lic	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic**	**No. Trips**	**Lbs. Caught**	**CPUE**	**No. Lic**	**No. Trips**	**Lbs. Caught**	**CPUE**
1988	95	1113	25112	22.56	68	482	13547	28.11	46	463	17047	36.82
1989	100	1414	24568	17.37	72	530	15565	29.37	33	175	5390	30.8
1990	95	1212	18718	15.44	52	279	6881	24.66	30	143	3893	27.22
1991	102	1108	17336	15.65	58	307	7293	23.76	25	123	5635	45.81
1992	101	1068	17354	16.25	71	496	9354	18.86	45	201	6322	31.45
1993	86	1056	14088	13.34	71	451	10973	24.33	44	323	8729	27.02
1994	90	1115	17676	15.85	75	537	12252	22.82	41	185	5333	28.83
1995	91	1293	20693	16	74	526	11505	21.87	30	170	4566	26.86
1996	87	991	21487	21.68	94	850	11663	13.72	37	251	7315	29.14
1997	85	921	18884	20.5	89	660	14268	21.62	40	215	4468	20.78
1998	90	1046	17975	17.18	100	920	17594	19.12	46	242	6874	28.4
1999	82	952	17610	18.5	94	738	11668	15.81	46	245	5798	23.67
2000	80	1054	18559	17.61	84	986	18924	19.19	41	229	6264	27.35
2001	74	1276	27040	21.19	80	863	18857	21.85	40	211	5966	28.27
2002	68	1354	24731	18.27	73	698	15002	21.49	43	210	7665	36.5
2003	55	1298	22055	16.99	60	686	16876	24.6	33	248	7176	28.94
2004	45	1299	23713	18.25	54	496	13633	27.49	23	264	7015	26.57
2005	33	1294	21018	16.24	49	572	15171	26.52	20	275	5931	21.57
2006	39	742	16279	21.94	57	604	12119	20.06	23	300	7434	24.78
2007	43	540	12479	23.11	49	627	12505	19.94	15	250	7156	28.62
2008	50	640	17369	27.14	62	561	14453	25.76	13	169	3960	23.43
2009	49	723	27177	37.59	70	725	21998	30.34	19	233	7399	31.76
2010	64	923	36790	39.86	65	698	22641	32.44	17	216	4655	21.55
2011	45	973	32765	33.67	75	880	27918	31.73	27	208	5427	26.09
2012	57	795	36136	45.45	69	907	29616	32.65	20	193	4533	23.49
2013	43	824	43556	52.86	77	871	28723	32.98	30	219	5788	26.43
2014	39	683	35643	52.19	63	800	30343	37.93	25	183	6056	33.09
2015	34	487	22463	46.13	59	680	29531	43.43	27	103	3572	34.68
2016	21	336	15431	45.93	36	620	30939	49.9	16	87	4556	52.37
2017	22	301	13938	46.31	37	382	11879	31.1	14	51	2505	49.12
10-year avg.	**45**	**694**	**28047**	**40.41**	**63**	**738**	**24889**	**33.72**	**21**	**186**	**5310**	**28.55**
20-year avg.	**55**	**909**	**24417**	**26.86**	**68**	**730**	**20150**	**27.6**	**28**	**215**	**5885**	**27.37**

1.6 PRECIOUS CORALS FISHERY

1.6.1 Fishery Descriptions

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

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

1.6.2 Dashboard Statistics

Future reports will include data as resources allow.

1.6.3 Other Statistics

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

1.7 HAWAII MARINE RECREATIONAL FISHING SURVEY

1.7.1 Fishery Descriptions

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

DAR manages the collection of both commercial and non-commercial fishery dependent information in both state and federal waters. Regulatory actions in federal waters are typically proposed by NMFS based largely on stock assessments produced by PIFSC staff. Proposed regulations in federal waters are then generally agreed upon by NMFS, DAR, and WPRFMC. These three agencies coordinate management in federal waters to simplify the regulations for the fishing public, prevent overfishing, and manage the fisheries for long-term sustainability. This shared management responsibility is necessary due to the overlap of various fisheries in both state and federal waters. The information in this report is largely based on the data collected by DAR.

1.7.2 Non-Commercial Data Collection Systems

Two independent and complementary surveys were re-initiated in Hawaii in collaboration with NOAA Fisheries' Marine Recreational Fishery Statistics Surveys (MRFSS) since 2001. The Hawaii Marine Recreational Fishing Survey (HMRFS) follows the traditional MRFSS on-site Access Point Angler Intercept Survey (APAIS) used to collect non-commercial finfish catch information for shore and private boat fishing modes (Figure 1). The charter boat mode is covered by the State of Hawaii's Commercial Marine License (CML) system whereby all crew members working on charter boats are lawfully required to annually purchase a CML and report catch and trip statistics on a monthly basis to DAR. A local contractor currently conducts the Coastal Household Telephone Survey (CHTS) which utilizes a random-digit-dial sampling method of landline telephones to collect non-commercial effort information for both shore and private boat fishing modes. As of 2017, HMRFS consists of 13 field surveyors (one on Kauai, one on Maui, one on Molokai, six on Oahu, and four on the Big Island), one data manager, and one project manager. A more detailed description of the current sampling and estimation procedures can be found in Ma and Ogawa (2016).

1.7.2.1 Shore-Based Fishing Effort Prediction Model

Hawaii’s coastal terrain varies from sandy beaches to rocky boulders, and people fish accordingly using different type of gears. For effective fishery management, it is helpful to know these spatial varitatations in fishing effort along the shoreline. HMRFS has been colleting non-commercial fishing effort from 98 sites in Hawaii covering differing habitat types (Figure 1). The survey collects both boat-based and shore-based fishing effort, but for this model, we only used the shore-based fishing effort data. We combined the shoreline fishing data with 36 spatially explicit environmental variables that potentially affect fishing effort (Table 40) and created a prediction model using boosted regression tree analysis (BRT; Friedman *et al*., 2000).

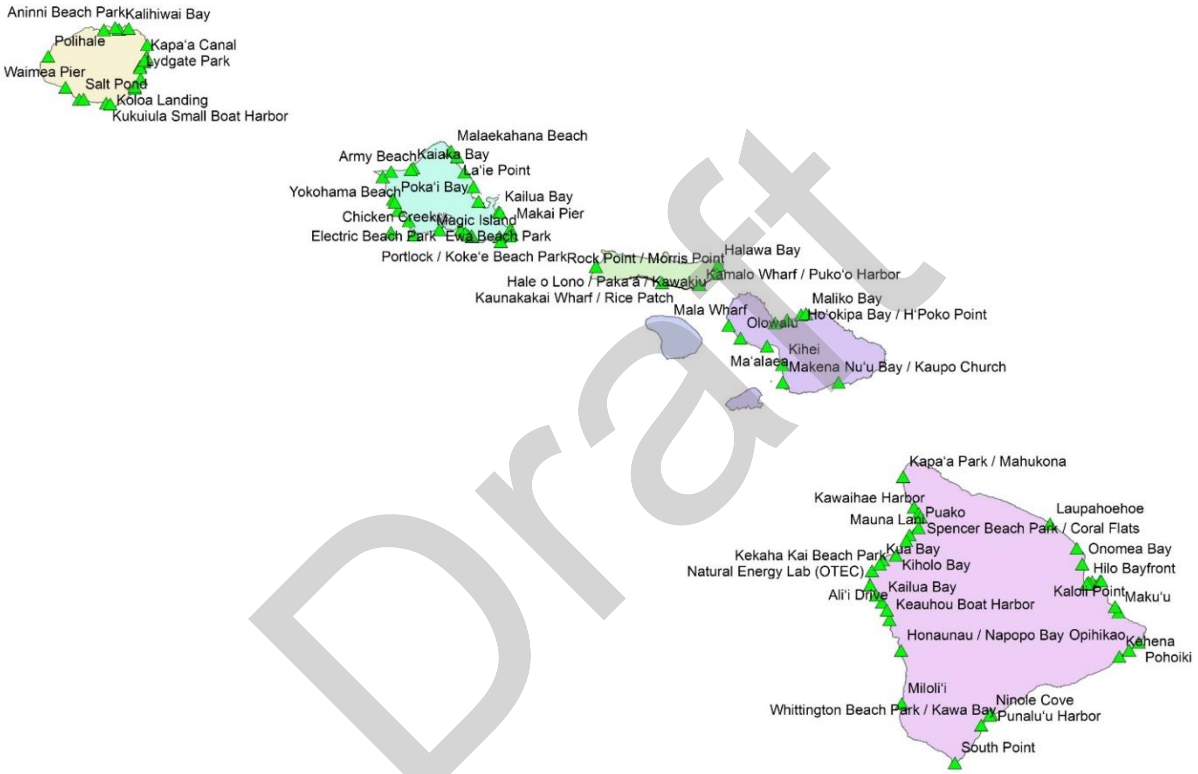

Figure 1. Access point angler intercept survey sites for the main Hawaiian islands.

Table 41. List of environmental variables used to create the fishing effort prediction model.

Variable Category	Variable	No. of sites w/ variable	Description	Layer Type	Data Source
Anthropogenic Impact	Accessibility	71	12 classifications scoring the ease of access (combination of access road type and distance to	Point	Joey Lecky (OTP)

			shore)		
	Distance to Humans	71	Sum of human population (from 2010 census blocks) in 15km radius (# of people)	60m * 60m raster	Marine Biogeographic Assessment of the Main Hawaiian Islands, Chapter 4 (NCCOS)
Oceanographic Variables	Island	71	Each island as independent factors	polygon	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	Wave Power	71	Mean wave power (wave height x wave period) derived from a 10-year hindcast model (kilowatts per meter)	60m * 60m raster	Marine Biogeographic Assessment of the Main Hawaiian Islands, Chapter 4 (NCCOS)
	Slope of Slope	71	Maximum rate of change in seafloor slope between each grid cell and its neighbors (degrees)	60m * 60m raster	Marine Biogeographic Assessment of the Main Hawaiian Islands, Chapter 4 (NCCOS)
	Depth	71	Seafloor depth from 5m grid resolution bathymetry synthesis (meters)	60m * 60m raster	Marine Biogeographic Assessment of the Main Hawaiian Islands, Chapter 4 (NCCOS)
	Max Slope 240	71	Maximum rate of change in seafloor depth between each grid cell and its 240m neighborhood (degrees)	60m * 60m raster	Marine Biogeographic Assessment of the Main Hawaiian Islands, Chapter 4 (NCCOS)
Productivity	Predicted Biomass_g	71	Total biomass predicted from boosted regression tree models (g/m^2)	60m * 60m raster	Marine Biogeographic Assessment of the Main Hawaiian Islands, Chapter 4 (NCCOS)
Habitat	Unknown	19	Seafloor geomorphology delineated as unknown	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Spur and Groove	0	Seafloor geomorphology delineated as spur and groove	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Scatter Coral Rock	5	Seafloor geomorphology delineated as scattered coral/rock	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Sand	41	Seafloor geomorphology delineated as sand	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Rubble	3	Seafloor geomorphology delineated as rubble	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Rock and boulder	34	Seafloor geomorphology delineated as rock/boulder	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Pavement with Sand Channels	2	Seafloor geomorphology delineated as sand channels	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Pavement	33	Seafloor geomorphology delineated as pavement	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)

	Mud	11	Seafloor geomorphology delineated as mud	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Individual Patch Reef	0	Seafloor geomorphology delineated as individual patch reef	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Artificial Habitat	15	Seafloor geomorphology delineated as artificial	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Aggregated Patch Reef	0	Seafloor geomorphology delineated as aggregated patch reef	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
	Aggregate Reef	9	Seafloor geomorphology delineated as aggregate reef	Polygon	Benthic Habitat Map for Main Hawaiian Islands (NCCOS)
Shoreline	8C Sheltered RipRap	9	Sheltered coastline with rip rap	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	8B Sheltered Man Made	14	Sheltered coastline with man-made structure	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	8A Sheltered Rocky	4	Sheltered coastline with rocky habitat	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	6B RipRap	13	Coastline with rip rap.	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	6A Gravel Beaches	20	Coastline with gravel beach	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	5 Mixed Sand Gravel	13	Coastline with sand and gravel beaches	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	4 Coarse Grained Sand	33	Coastline with grainy sand beaches	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	3A Fine to Medium Sand	10	Coastline with fine to medium grain sand beaches	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	2B Scarps Steep Sloped Muddy	0	Coastline with exposed scarps and steep slopes in clay	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	2A Exposed Wave	15	Coastline with exposed wave-cut platforms in bedrock	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)

	1B Exposed Solid ManMade	16	Coastline with exposed solid man-made structures	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	1A Exposed Rocky Shores	22	Coastline with exposed rocky cliffs	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	10C Swamps	0	Coastline with freshwater swamps	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	10D Scrub Shrub Wetland	5	Coastline with mangroves	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	10A Saltwater Marsh	7	Coastline with salt and brackish water marsh	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)
	10B Freshwater Marsh	0	Coastline with freshwater marsh	Polyline	Hawaii ESI: Hydro (NOAA National Ocean Service, Office of Response and Restoration)

1.7.2.1.1 Methods

First, the coastline was divided into small, equilateral hexagons of 300 m (Figure 2). These hexagons delineate the spatial extent of each shoreline survey effort.

Figure 2. Example of 300 m hexagons overlaid over the island of Oahu. Green stars indicate a survey site within the area.

Each of the 36 environmental raster layers was overlayed with this hexagon layer and the raster value that fell within each hexagon was averaged using the raster calculator in ArcGIS 10.0. Annual fishing effort was calculated for each hexagon that contained a shoreline survey site for each gear type. In the end, there were 71 hexagons that contained both the survey site (hence the fishing effort information) and environment variable information. These 71 hexagons were used to fit the BRT model to examine the associations between environmental variables and annual fishing effort for the three common gear types (rod and reel, spear, and thrownet). We further used BRT to predict and map the distributions of fishing effort occurring in individual hexagons for all the coastlines along the main Hawaiian Islands using the environmental variables. BRT stems from machine learning and improves the standard regression tree modelling by adding a stochastic component to the model (Friedman *et al*., 2000). All BRT analyses were carried out in R using the GBM package developed by Ridgeway (2010) and supplemented with functions from Elith *et al.* (2008).

1.7.2.1.2 Results

Important environmental predictors for all three gear types were rugosity (measured in max slope) and mean distance to humans (Table 41). Other factors that were commonly important were wave power, rocky boulder/pavement habitat, depth, and fish abundance (measured in biomass) in the water. Islands of Kahoolawe, Lanai, Molokai, and Niihau had to be removed from our prediction model due to the low number or absence of survey sites. The total fishing effort predicted was 8,007,030 gear hours from the model for rod and reel (Figure 3), 319,140 gear hours for spear fishing (Figure 4), and 188,010 gear-hours for throw net (Figure 5) for the combined remaining islands of Kauai, Oahu, Maui, and Hawaii.

Table 42. Top 10 environmental variables showing the relative influence (percentage) on fishing effort (gear-hours) from the boosted regression tree (BRT) models for each selected gear type across the main Hawaiian Islands. The spatial predictions derived from models are shown in Figures 3 though 5.

Variable Categories	Environmental Variable	Rod	ThrowNet	Spear
Oceanographic	Island	21.86	24.09	6.41
Oceanographic	Max Slope	11.17	15.19	20.00
Anthropogenic	Mean Distance to Human	8.80	7.93	17.55
Habitat	Rock and Boulder	1.45	16.35	11.88
Oceanographic	Mean Wave Power	8.14	9.64	11.59
Productivity	Biomass (g/m^2)	18.43	3.70	4.63
Oceanographic	Mean Depth (m)	7.27	2.45	6.26
Habtiat	Pavement	12.46	0.64	2.01
Oceanographic	MeanSlopeOfSlope	2.52	4.53	7.90
Habitat	Sand	2.74	4.58	3.16
Coastline	Coarse Grained Sand Beac	0.54	2.04	4.94
Habitat	Mean Percent Coral	0.27	3.71	1.13
Coastline	6A Gravel Beaches	2.92	1.93	0.19
Anthropogenic	Accessibility	0.47	1.75	0.63

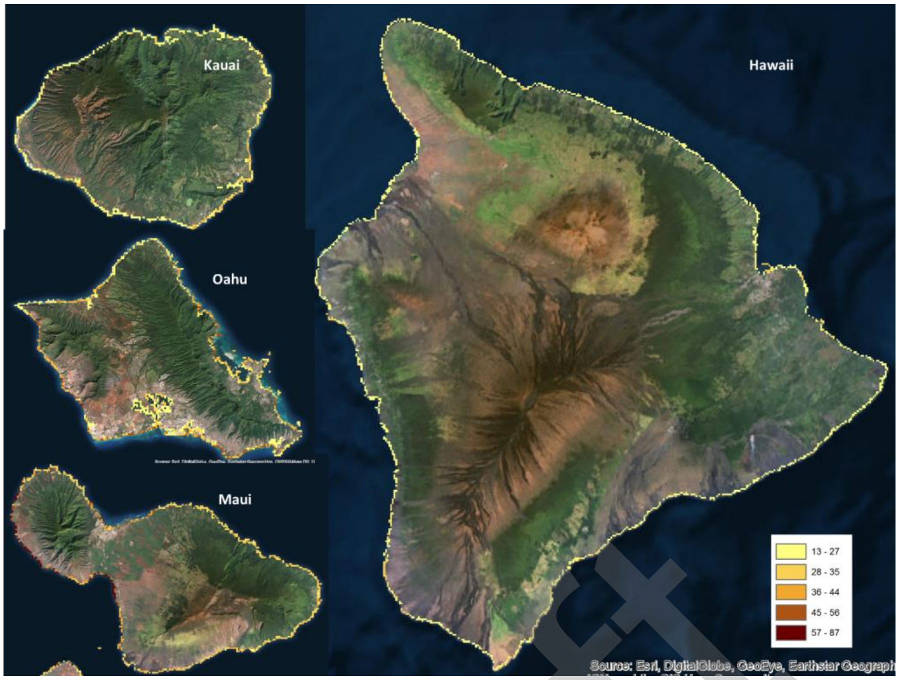

Figure 3. Fishing effort in gear-hours predicted for *rod-and-reel* fishing by a boosted regression tree model for the islands of Kauai, Oahu, Maui, and Hawaii.

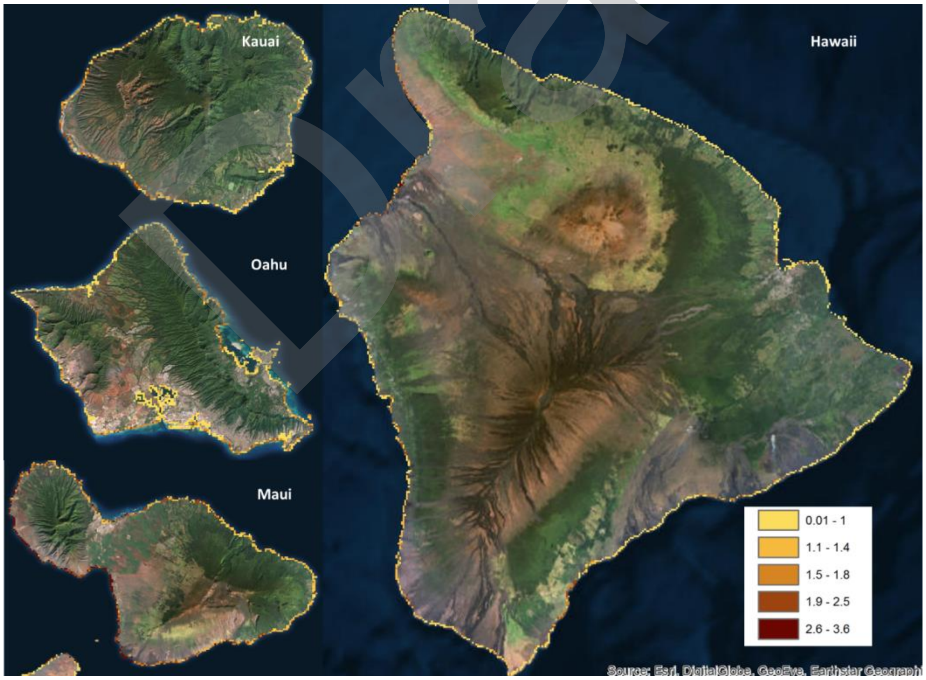

Figure 4. Fishing effort in gear-hours predicted for *spear fishing* by a boosted regression tree model for the islands of Kauai, Oahu, Maui, and Hawaii.

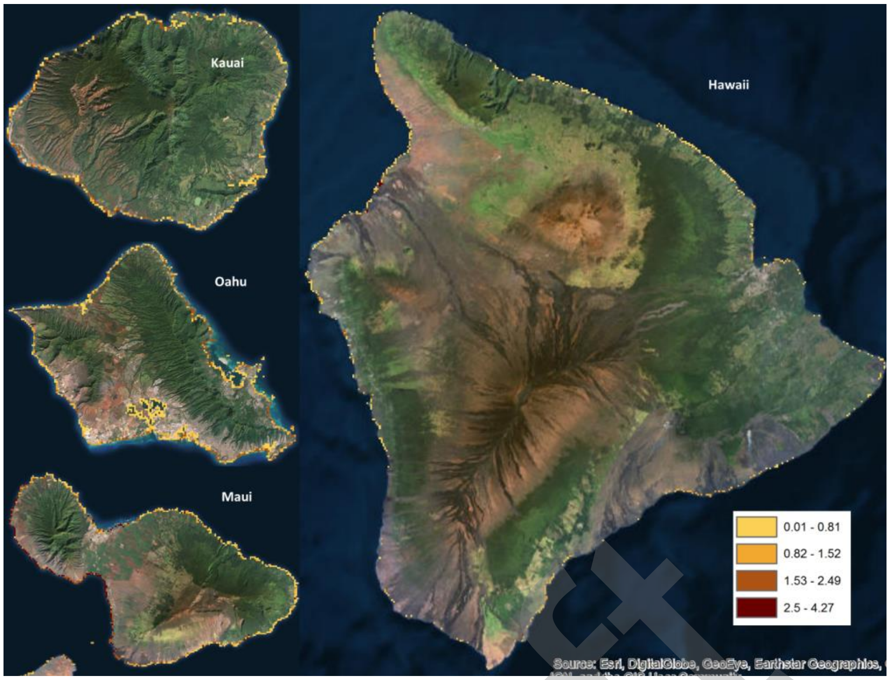

Figure 5. Fishing effort in gear-hours predicted for *throw net fishing* by a boosted regression tree model for the islands of Kauai, Oahu, Maui, and Hawaii.

1.7.2.1.3 Discussion

The ability to spatially predict fishing effort is critical for spatial management plans. The BRT analyses show promise as a predictor of effort because the estimate was similar to that of the fishing effort estimate from the phone survey currently conducted by MRIP. Observational data from HMRFS allows the estimates to be spatially explicit and further allow estimation of CPUE and species catch composition by each gear type. This gives more detailed information on fishing effort than just total statewide fishing effort and catch that MRIP currently provides. The detailed information allows the state to explore wider management options that could be more efficient and easier to enforce. For example, being able to see fishing effort by gear type allows the state to look into gear restrictions, and spatially explicit information allows the state to look into fishery management area options.

We plan to further use BRT to estimate CPUE and catch along the coastline, to see if a gear-type restriction at specific areas would be as efficient at conserving species of concern as current statewide regulations. A current challenge is the low number of survey sites on remote access areas especially on Lanai, Niihau, and Molokai. The predictions for these areas are not as reliable as predictions made on other areas of the coastline. Future creel survey projects could target these hard-to-access sites and further improve the precision of the predictions.

1.8 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.

1.8.1 Special Coral Reef Ecosystem Permit

Regulations require the special coral reef ecosystem fishing permit for anyone fishing for coral reef ecosystem management unit species (MUS) in a low-use 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 ecosystem MUS while fishing for bottomfish MUS, crustacean MUS, 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 ecosystem MUS caught in a low-use MPA.

1.8.2 Main Hawaiian Islands Non-commercial Bottomfish

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

1.8.3 Western Pacific Precious Coral

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

1.8.4 Western Pacific Crustaceans Permit

Regulations require a permit for the owner of a U.S. fishing vessel used to fish for lobster or deepwater shrimp in the EEZ around American Samoa, Guam, Hawaii, and the Pacific Remote Islands Areas, and in the EEZ seaward of 3 nautical miles of the shoreline of the Northern Mariana Islands.

Table 43 provides the number of permits issued to Hawaii FEP fisheries between 2007 and 2017. Historical data are from the PIFSC, and 2017 data are from the PIRO Sustainable Fisheries Division permits program as of January 5, 2018.

Table 43. Number of federal permits by Hawaii FEP Fishery from 2007-2017.

Year	Special Coral reef ecosystem	MHI Non-commercial Bottomfish	Precious Coral	Crustacean Shrimp	Crustacean Lobster
2007			2		2
2008		76	1		2
2009		91	2		3
2010		28	2		3
2011	1	19	2		
2012	1	11	2	2	1
2013		3	1	5	2
2014		3	1	7	2
2015		2	1	5	2
2016	1	1	1	4	1
2017	1	1	1	6	1

1.9 STATUS DETERMINATION CRITERIA

1.9.1 Bottomfish and Crustacean Fishery

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

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

In addition to the thresholds MFMT and MSST, a warning reference point, B_{FLAG}, is specified at some point above the MSST to provide a trigger for consideration of management action prior to B_{FLAG} reaching the threshold. MFMT, MSST, and B_{FLAG} are specified as indicated in Table 44.

Table 44. Overfishing threshold specifications for Hawaiian bottomfish and NWHI lobsters Note that the MFMT listed here only applies to Hawaiian bottomfish, not NWHI lobsters.

MFMT	MSST	B_{FLAG}
$F(B) = \frac{F_{MSY} B}{c\, B_{MSY}}$ for $B \le c\, B_{MSY}$ $F(B) = F_{MSY}$ for $B > c\, B_{MSY}$	$c\, B_{MSY}$	B_{MSY}
where c = max (1-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_{AVE}, where E_{AVE} 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 particular species within the complex has a mortality rate that leads to excessive depletion. In order to accomplish this, a secondary set of reference points is specified to evaluate stock status with respect to recruitment overfishing. A secondary "recruitment overfishing" control rule is specified to control fishing mortality with respect to that status. The rule applies only to those component stocks (species) for which adequate data are available. The ratio of a current spawning stock biomass proxy (SSB_{Pt}) to a given reference level ($SSBP_{REF}$) is used to determine if individual stocks are experiencing recruitment overfishing. SSBP is CPUE scaled by percent mature fish in the catch. When the ratio $SSBP_t/SSBP_{REF}$, or the "SSBP ratio" (SSBPR) for any species drops below a certain limit ($SSBPR_{MIN}$), that species is considered to be recruitment overfished and management measures will be implemented to reduce fishing mortality on that species. The rule applies only when the SSBP ratio drops below the $SSBPR_{MIN}$, but it will continue to apply until the ratio achieves the "SSBP ratio recovery target" ($SSBPR_{TARGET}$), which is set at a level no less than $SSBP_{RMIN}$. These two reference points and their associated recruitment overfishing control rule, which prescribe a target fishing mortality rate ($F_{RO-REBUILD}$) as a function of the SSBP ratio, are specified as indicated in Table 45. Again, E_{MSY} is used as a proxy for F_{MSY}.

Table 45. Recruitment overfishing control rule specifications for the bottomfish management unit species in Hawaii.

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

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

1.9.2 Coral Reef Fishery

Available biological and fishery data are poor for all coral reef ecosystem management unit species in the Hawaiian Islands. There is scant information on the life histories, ecosystem dynamics, fishery impact, community structure changes, yield potential, and management reference points for many coral reef ecosystem species. Additionally, total fishing effort cannot be adequately partitioned between the various management unit species (MUS) for any fishery or area. Biomass, maximum sustainable yield, and fishing mortality estimates are not available for any single MUS. Once these data are available, fishery managers can establish limits and reference points based on the multi-species coral reef ecosystem as a whole.

The MSY control rule should be applied to the individual species in a multi-species stock when possible. When this is not possible, MSY may be specified for one or more species; these values can be used as indicators for the multi-species stock's MSY.

Individual species that are part of a multi-species complex will respond differently to an OY-determined level of fishing effort (F_{OY}). Thus, for a species complex that is fished at F_{OY}, managers still must track individual species' mortality rates in order to prevent species-specific population declines that would lead to depletion.

For the coral reef fishery, the multi-species complex as a whole is used to establish limits and reference points for each area. Available data for a particular species are used to evaluate the status of individual MUS stocks in order to prevent recruitment overfishing when possible. When better data and the appropriate multi-species stock assessment methodologies become available, all stocks will be evaluated independentlywithout proxy.

1.9.2.1 Establishing Reference Point Values

Standardized values of catch per unit effort (CPUE) and effort (E) are used to establish limit and reference point values, which act as proxies for relative biomass and fishing mortality, respectively. Limits and reference points are calculated in terms of $CPUE_{MSY}$ and E_{MSY} included in Table 46.

Table 46. Status determination criteria for the coral reef management unit species using CPUE-based proxies

Value	Proxy	Explanation
MaxFMT (F_{MSY})	E_{MSY}	0.91 $CPUE_{MSY}$
F_{OY}	0.75 E_{MSY}	suggested default scaling for target
B_{MSY}	$CPUE_{MSY}$	operational counterpart
B_{OY}	1.3 $CPUE_{MSY}$	simulation results from Mace (1994)
MinSST	0.7 $CPUE_{MSY}$	suggested default (1-M)B_{MSY} with M=0.3*
B_{FLAG}	0.91 $CPUE_{MSY}$	suggested default (1-M)B_{OY} with M=0.3*

When reliable estimates of E_{MSY} and $CPUE_{MSY}$ are not available, they are generated from time series of catch and effort values, standardized for all identifiable biases using the best available analytical tools. $CPUE_{MSY}$ is calculated as one-half a multi-year moving average reference CPUE ($CPUE_{REF}$).

1.9.3 Current Stock Status

1.9.3.1 Deep-7 Bottomfish Management Unit Species Complex

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

Generally, data are only available on commercial landings by species and catch-per-unit-effort (CPUE) for the multi-species complexes as a whole. The assessment utilized a state-space surplus production model with explicit process and observation error terms (Meyer and Millar, 1999). Determinations of overfishing and overfished status can then be made by comparing current biomass and harvest rates to MSY level reference points. To date, the main Hawaiian island Deep-7 bottomfish complex is not subject to overfishing and is not overfished (Table 47).

Table 47. Stock assessment parameters for the main Hawaiian island Deep-7 complex (Boggs memo 3/3/2015).

Parameter	Value	Notes	Status
MSY	0.404 ± 0.156	Expressed in million lbs. (± std. error)	
H_{2013}	3.8 ± 1.4	Expressed in percentage	
H_{MSY}	6 ± 2.1	Expressed in percentage (± std. error)	
H/H_{MSY}	0.627		No overfishing occurring
B_{2013}	13.34 ± 5.397	Expressed in million lbs.	
B_{MSY}	14.51 ± 4.267	Expressed in million lbs. (± std. error)	
B/ B_{MSY}	0.930		Not overfished

1.9.3.2 Coral reef

The application of the SDCs for the management unit species in the coral reef fisheries is limited due to various challenges. First, the thousands of species included in the coral reef MUS makes the SDC and status determination impractical. Second, the CPUE derived from the creel survey is based on the fishing method and there is no species-specific CPUE information available. In order to allocate the fishing method level CPUE to individual species, the catch data (the value of catch is derived from CPUE hence there is collinearity) will have to be identified to species level and CPUE will be parsed out by species composition. The third challenge is that there is very little species-level identification applied to the creel surveys. There has been no attempt to estimate MSY for the coral reef MUS until the 2007 re-authorization of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) that requires the Council to specify ACLs for species in the FEPs.

For ACL specification purposes, MSYs in the coral reef fisheries are determined by using the Biomass-Augmented Catch-MSY approach (Sabater and Kleiber, 2014). This method estimates MSY using plausible combination rates of population increase (denoted by *r*) and carrying capacity (denoted by *k*) assumed from the catch time series, resilience characteristics (from FishBase), and biomass from existing underwater census surveys done by the Pacific Island Fisheries Science Center. This method was applied to species complexes grouped by taxonomic families. The most recent MSY estimates are found in Table 48. The SSC utilized the MSYs for the coral reef MUS complexes as the OFLs.

Table 48. Best available MSY estimates for the coral reef MUS in Hawaii

Fishery	Management Unit Species	MSY (lbs)
Coral Reef Ecosystem	*Selar crumenopthalmus* – akule	1,150,800
	Decapterus macarellus – opelu	538,000

	Acanthuridae-surgeonfish	445,500
	Carangidae-jacks	185,100
	Carcharhinidae-reef sharks	12,400
	Crustaceans-crabs	43,100
	Holocentridae-squirrelfish	159,800
	Kyphosidae - rudderfish	122,800
	Labridae – wrasse	229,200
	Lethrinidae - emperors	39,600
	Lutjanidae-snappers	359,300
	Mollusk-turbo snails, octopus, etc.	50,300
	Mugilidae-mullets	24,600
	Mullidae-goatfish	195,700
	Scaridae-parrotfish	271,500
	Serranidae - groupers	141,300
	All other CREMUS combined	540,800

1.9.3.3 Crustacean

The application of the SDCs for the crustacean MUS is limited to the NWHI lobster stock. Previous studies conducted in the main Hawaiian Islands estimated the MSY for spiny lobsters at approximately 15,000 – 30,000 lobsters per year of 8.26 cm carapace length or longer (WPFMC 1983). There are insufficient data to estimate MSY values for MHI slipper lobsters. MSY for deepwater shrimp is estimated for the MHI at 40 kg/nm^2 (Tagami and Ralston, 1988).

A stock assessment model was developed in 2014 in an attempt to understand and determine the status of the Kona crab stock in the MHI (Thomas, 2011). This assessment utilized a non-equilibrium generalized production model (using the Stock-Production Model Incorporating Covariate –ASPIC statistical routine) to estimate parameters needed to determine stock status. Based on this, the Kona crab stock is overfished (possibly rebuilding), but not experiencing overfishing (Table 49)

Table 49. Stock assessment parameters for the Kona crab stock (Thomas *et al*., 2015).

Parameter	Value	Notes	Status
MSY	40,400	Expressed in lbs	
H_{2007}		Expressed in percentage	
H_{MSY}	0.2534	Expressed in percentage (± std error)	
H/H_{MSY}	0.9218		No overfishing occurring
B_{2007}		Expressed in million pounds	
B_{MSY}	159,500	Expressed in lbs	
B/ B_{MSY}	0.1810		Overfished

For ACL-specification purposes, MSY for spiny lobsters are determined by using the Biomass-Augmented Catch-MSY approach (Sabater and Kleiber, 2014). This method estimates MSY using plausible combination rates of population increase (denoted by *r*) and carrying capacity (denoted by *k*) assumed from the catch time series, resilience characteristics (from FishBase), and biomass from existing underwater census surveys done by the Pacific Island Fisheries Science Center. This method was applied to species complexes grouped by taxonomic families. The most recent MSY estimates are found in Table 50.

Table 50. Best available MSY estimates for the crustacean MUS in Hawaii.

Fishery	**Management Unit Species**	**MSY (lbs.)**
Crustacean	Deepwater shrimp	598,328
	Spiny lobsters	20,400
	Slipper lobsters	None
	Kona crab	40,400

SOURCE: Deepwater shrimp MSY – Tagami and Ralston, 1988; Spiny lobster MSY – WPRFMC, 2014; Kona crab – Thomas, 2011.

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

1.10.1 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 and NMFS, 2011). The process starts with the use of the best scientific information available (BSIA) in the form of, but not limited to, stock assessments, published paper, reports, or available data. This information is classified into the different Tiers in the control rule ranging from Tier 1 (most information available, typically an assessment) to Tier 5 (catch-only information). The control rules are applied to the BSIA. Tiers 1 to 3 would involve conducting a Risk of Overfishing Analysis (denoted by P*) to quantify the scientific uncertainties around the assessment to specify the Acceptable Biological Catch (ABC). This would lower the ABC from the over-fishing limit (OFL) (MSY-based). A Social, Ecological, Economic, and Management (SEEM) Uncertainty Analysis is performed to quantify the uncertainties from the SEEM factors. The buffer is used to lower the ACL from the ABC. For Tier 4 - which consists of stocks with MSY estimates but no active fisheries - the control rule is 91% of MSY. For Tier 5 which has catch-only information, the control rule is a third reduction in the median catch depending on the qualitative evaluation on what the stock status is based on expert opinion. ACL specification can choose from a variety of method including the above mentioned SEEM analysis or a percentage buffer (% reduction from ABC based on expert opinion) or the use of an Annual Catch Target. Specifications are done on an annual basis but the Council normally specifies a multi-year specification.

The Accountability Measure for the coral reef and bottomfish fisheries in Hawaii is an overage adjustment. The ACL is downward adjusted with the amount of overage from the ACL based on a three-year running average.

1.10.2 Current OFL, ABC, ACL, and recent catch

The most recent multiyear specification of OFL, ABC, and ACL for the some coral reef species complex, non-Deep-7, crustaceans, and precious coral fisheries was completed in the 160th Council meeting from June 25 to 27, 2014. The specification covers fishing years 2015, 2016, 2017, and 2018 for the coral reef MUS complexes. The fisheries for deep sea corals remain inactive. ACLs were not specified for Kona crab, non-Deep 7 bottomfish, or coral reef ecosystem MUS because NMFS has recently acquired new information that require additional environmental analyses to support the Council’s ACL recommendations for these MUS (50 CFR Part 665). A P* and SEEM analysis was performed for this multiyear specification (NMFS 2015a).

At the 171st Council meeting in Pago Pago American Samoa from October 17 to 19, 2017, the Council specified new ACLs for five coral reef fish species and four species complexes. There was one assessed species (*Monotaxis grandoculis*) that currently represents the family Lethrinidae where the ACL had been retained. This new specification was based on the benchmark assessment of 27 coral reef fish species in the main Hawaiian Islands. This is a multi-year specification covering fishing year 2018, 2019, and 2020. A P* analysis was performed for this multiyear specification. There were only five species of the 27 species assessed that the SSC deemed adequate for a single species harvest limit specification. The rest of the species were grouped on a family level and the assessed species were treated as indicator species for the family. The indicator species for Family Acanthuridae are *Acanthurus dussumieri* (palani), *Naso lituratus* (umaumalei), *N. brevirostris* (kala lolo), *N. unicornis* (kala), *A. blochii* (pualu), and *N. hexacanthus* (kala lolo). The indicator species for Family Carangidae are *Caranx melampygus* (omilu), *C. ignobilis* (ulua aukea), and *Carangoides orthogrammus* (ulua). The indicator species for Family Mullidae are *Parupeneus insularis* (munu), *P. cyclostomus* (moano), *Mulloidichthys vanicolensis* (weke'ula), *M. flavolineatus* (weke'a), and *M. pfluegeri* (weke nono). Finally, the indicator species for Family Scaridae are *Scarus dubius* (lauia), *S. psittacus* (uhu), *S. rubroviolaceus* (uhu ele'ele), *Chlorurus spilurus* (uhu), *Chlorurus perspicillatus* (uhu uliuli), and *Calotomus carolinus* (ponuhunuhu).

ACLs were not specified for Kona crab, non-Deep 7 bottomfish, or coral reef ecosystem MUS because NMFS has recently acquired new information that require additional environmental analyses to support the Council's ACL recommendations for these MUS (50 CFR Part 665). The ACL described in Table 50 are the Council recommended ACLs from the 171st meeting.

The most recent multiyear specification of OFL, ABC, and ACL for the main Hawaiian island Deep-7 bottomfish complex was completed at the 163rd meeting in June of 2015. The specification covers fishing year 2015-2016, 2016-2017, and 2017-2018. This multi-year specification utilized a phased-in approach (Slow-up, Fast-down) to alleviate the impact of a sudden drop of the new catch limit. Note that the MHI Deep 7 stock complex operates based on Fishing Year, and is currently still open. Recent average catch for the MHI Deep 7 Bottomfish stock complex (266,550 lbs.) accounted for 87.1% of its prescribed ACL (306,000 lbs.; Table 51). A P* and SEEM analysis was also performed for this multiyear specification (NMFS 2015b).

Table 51. Hawaii ACL table with 2017 catch (lbs.).

Fishery	Management Unit Species	OFL	ABC	ACL	Catch
Bottomfish	MHI Deep-7 stock complex	352,000	326,000	326,000	266,550
	Aprion virescens – uku	N.A.	N.A.	N.A.	10,340
Crustaceans	Deepwater shrimp	N.A.	250,773	250,773	16,139
	Spiny lobster	20,400	15,800	15,000	4,945
	Slipper lobster	N.A.	280	280	N.A.
	Kona crab	N.A.	N.A.	N.A.	1,993
Precious coral	Auau channel black coral	8,250	7,500	5,512	N.A.F.
	Makapuu bed-pink coral	3,307	3,009	2,205	N.A.F.
	Makapuu bed-bamboo coral	628	571	551	N.A.F.
	180 fathom bank-pink coral	734	668	489	N.A.F.
	180 fathom bank-bamboo coral	139	126	123	N.A.F.
	Brooks bank-pink coral	1,470	1,338	979	N.A.F.
	Brooks bank-bamboo coral	280	256	245	N.A.F.
	Kaena point bed-pink coral	220	201	148	N.A.F.
	Kaena point bed-bamboo coral	42	37	37	N.A.F.
	Keahole bed-pink coral	220	201	148	N.A.F.
	Keahole bed-bamboo coral	42	37	37	N.A.F.

	Precious coral in HI exploratory area	N.A.	2,205	2,205	N.A.F.
Coral Reef Ecosystem	*S. crumenopthalmus* – akule	N.A.	N.A.	N.A.	389,844
	D. macarellus – opelu	N.A.	N.A.	N.A.	181,473
	Lutjanus kasmira – taape	N.A.	N.A.	N.A.	N.A.
	L. fulvus – toau	N.A.	N.A.	N.A.	N.A.
	Parupeneus porphyreus – kumu	N.A.	N.A.	N.A.	N.A.
	Cephalopholis argus – roi	N.A.	N.A.	N.A.	N.A.
	Acanthuridae-surgeonfish	N.A.	N.A.	N.A.	78,076
	Carangidae-jacks	N.A.	N.A.	N.A.	42,340
	Carcharhinidae-reef sharks	N.A.	N.A.	N.A.	2,500
	Crustaceans-crabs	N.A.	N.A.	N.A.	21,237
	Holocentridae-squirrelfish	N.A.	N.A.	N.A.	48,637
	Kyphosidae - rudderfish	N.A.	N.A.	N.A.	13,336
	Labridae - wrasse	N.A.	N.A.	N.A.	7,175
	Lethrinidae - emperors	N.A.	N.A.	N.A.	2,808
	Lutjanidae-snappers	N.A.	N.A.	N.A.	39,333
	Mollusk-snails, octopus, etc.	N.A.	N.A.	N.A.	30,658
	Mugilidae-mullets	N.A.	N.A.	N.A.	4,834
	Mullidae-goatfish	N.A.	N.A.	N.A.	61,184
	Scaridae-parrotfish	N.A.	N.A.	N.A.	33,902
	Serranidae - groupers	N.A.	N.A.	N.A.	1,327
	All other CREMUS combined	N.A.	N.A.	N.A.	13,823

Note:
* MHI Deep-7 bottomfish is still ongoing for Fishing Year 2017-2018; data as of 08/31/2017.
***Cheilinus undulatus* and *Bolbometopon muricatum* are species not present in Hawaii.

The catch shown in Table 51 takes the average of the recent three years as recommended by the Council at its 160th meeting to avoid large fluctuations in catch due to data quality and outliers. "N.A.F." indicates no active fisheries as of date.

1.11 BEST SCIENTIFIC INFORMATION AVAILABLE

1.11.1 Main Hawaiian Island Deep-7 Bottomfish Fishery

1.11.1.1 Stock assessment benchmark

In 2011, NOAA's Pacific Islands Fisheries Science Center (PIFSC) completed a stock assessment for the MHI Deep-7 bottomfish fishery (2011 stock assessment) using data through 2010 (Brodziak *et al*., 2011). The 2011 stock assessment used similar commercial fishery data as in a 2008 assessment update (Brodziak *et al*., 2009), but includes a modified treatment of unreported catch and catch per unit effort (CPUE) standardization, as well as new research information on the likely life history characteristics of bottomfish (A. Andrews, PIFSC, unpublished 2010 research) in response to recommendations from the Western Pacific Stock Assessment Review (WPSAR) of the 2008 update (Stokes, 2009). Additionally, while the 2008 assessment considered the entire assemblage of Hawaii BMUS on an archipelagic basis (NWHI and MHI), the 2010 assessment focused solely on the Deep-7 bottomfish stock complex in the MHI.

To address the unreported catch issue, the 2011 assessment included four scenarios of unreported catch developed from available information. The four scenarios are labeled in order of magnitude from the highest (Scenario 1) to the lowest (Scenario 4) estimates of unreported catch.

- Catch Scenario 1: Unreported catch is two times commercial reported catch
- Catch Scenario 2: Unreported catch equals the commercial reported catch
- Catch Scenario 3: Unreported catch is one-fifth the commercial reported catch
- Catch Scenario 4: There is no unreported catch

According to the 2011 assessment the Catch Scenario 2 is the baseline (i.e., most plausible scenario) because it used the best available information on unreported to reported catch ratios estimated for individual MHI Deep-7 bottomfish species.

To determine the appropriate CPUE, the 2011 assessment included three scenarios to represent changes in fishing power of the fleet that targets Deep-7 bottomfish for commercial catch. CPUE is used in stock assessments as an index of relative stock abundance. Standardizing CPUE from different anglers over different areas and over many years helps to minimize the effects that could bias CPUE as an index of stock abundance.

- CPUE Scenario 1: Negligible change in bottomfish fishing power through time.
- CPUE Scenario 2: Moderate change in bottomfish fishing power through time. Specifically, this scenario assumed that: (i) there was no change in fishing power during 1949-1970; (ii) fishing power increased at a rate of 0.25 percent per year during 1971-1980; fishing power increased at a rate of 0.5 percent per year during 1981-1990; (iii) fishing power increased at a rate of 0.25 percent per year during 1991-2000; and (iv) fishing power did not change during 2001-2010.
- CPUE Scenario 3: Substantial change in bottomfish fishing power through time. Specifically, this scenario assumed that a substantial change in fishing power scenario

had occurred since the 1950s with an average increase in fishing power of roughly 1.2 percent per year.

According to the 2011 assessment, CPUE Scenario 1 is the baseline (i.e., most plausible scenario) because it represented the best scientific information about the efficiency of the Deep-7 bottomfish fishing fleet through time, and because it did not include ad hoc assumptions about changes in fishing power for the deep handline fishery that has traditionally harvested the Deep-7 bottomfish complex.

Based on the Catch 2/CPUE 1 scenario combination, the 2011 assessment estimates a maximum sustainable yield (MSY) of 417,000 lbs. for the MHI Deep-7 bottomfish stock complex. The 2011 stock assessment also included projection results of a range of commercial catches of Deep-7 bottomfish that would produce probabilities of overfishing ranging from 0 percent to 100 percent and at five percent intervals (Table 19.1 in Brodziak *et al*., 2011). Under the Catch 2/CPUE 1 scenario combination, the catch limit associated with a 50 percent probability of overfishing is 383,000 lbs. of MHI Deep-7 bottomfish. Therefore, while the long-term MSY for the fishery is 417,000 lbs., the OFL for fishery is 383,000 lbs.

1.11.1.1.1 Findings of an Independent Peer Review

In January 2011, PIFSC contracted the Center for Independent Experts (CIE) to provide three independent experts to review a draft of the 2011 stock assessment and prepare a report of their independent findings and recommendations, and whether the 2011 stock assessment is the best scientific information available for management purposes. In general, the CIE review panel found that the 2011 stock assessment was scientifically sound, and applied appropriate modeling approaches and methods given data limitations. In addition, each reviewer provided recommendations on how to improve the next assessment particularly with respect to providing credible CPUE standardization. The reports of the CIE reviewers are available on the PIFSC website at http://www.pifsc.noaa.gov/do/peer_reviews/.

1.11.1.2 Stock assessment updates

In 2014, the PIFSC completed a draft 2014 stock assessment update for the MHI Deep-7 bottomfish fishery (2014 stock assessment), using data through fishing year 2013 (Brodziak *et al*., 2014). The 2014 stock assessment update uses the previous 2011 stock assessment's methods for data analysis, modeling, and stock projections, with one improvement--it included the State of Hawaii's CML data as a variable to standardize CPUE over time. The State began issuing CMLs uniquely and consistently to individuals through time starting in 1994. Therefore, beginning in 1994 the CML number assigned to an individual has remained the same. The 2014 stock assessment included individual CMLs in the CPUE standardization for that year onward. This improvement is highly significant, resulting in a two-fold increase in the explanatory power (R^2) of the CPUE standardization and a substantial decrease in the Akaike information criterion value of the CPUE standardization, which now explains over 50% of the variation in observed CPUE over time. Additionally, in the three additional years (2011-2013) covered by the 2014 assessment, the biomass of the Deep-7 species and the exploitation rate were about the same as in the preceding three years. Therefore, the updated estimates of the values for management (i.e., MSY, OFL, probability of overfishing etc.) are not a result of any significant change in biomass or exploitation rate, but are due to better estimation of the values provided by the previous assessment.

Based on the revised CPUE standardization method and three years of additional catch data, the 2014 stock assessment update re-estimates MSY to be 415,000 lbs., which is similar to the previous MSY estimate of 417,000 lbs. reported in the 2011 stock assessment. The 2014 stock assessment also included projection results of a range of commercial catches of Deep-7 bottomfish that would produce probabilities of overfishing ranging from 0 percent to 100 percent and at five percent intervals (Table 15 in Brodziak *et al*., 2014). Based on a maximum potential harvest of 325,000 lb of MHI Deep-7 bottomfish in the then-ongoing 2013-14 fishing year, the 2014 stock assessment estimated an OFL of 316,000 lbs., which is 67,000 lbs. less than the OFL estimate in the 2011 stock assessment. These updated estimates of MSY and OFL are not the result of any significant change in biomass or exploitation rate, but are due to better estimations resulting from the revised CPUE standardization method.

1.11.1.2.1 Findings of an Independent Peer Review

In December 2014, PIFSC again contracted the CIE to provide three independent experts to review the 2014 stock assessment and prepare a report of their independent findings and recommendations, and to assist NMFS in determining whether the 2014 stock assessment is the best scientific information available for management purposes. In summary, the CIE panel found that including individual CML data as a variable to standardize CPUE over time was an improvement over the method used in the 2011 stock assessment. However, the CIE panel had strong reservations regarding the quality of input catch data and CPUE index of abundance used in both the 2011 and 2014 stock assessments. Specifically, the panel raised concern about the historical pre-1990 data for CPUE calculation and estimates of unreported catch. Given the concerns with the incomplete effort information, the CIE panel concluded that the 2014 stock assessment had serious flaws that compromised its utility for management. In particular, the CIE panel noted that because the 2014 stock assessment was an update only, and required improvements in the index and the population model, the science reviewed in the 2014 stock assessment is not considered the best available. The reports of the CIE reviewers are available on NMFS website at http://www.st.nmfs.noaa.gov/science-quality-assurance/cie-peer-reviews/cie-review-2015.

1.11.1.3 Current best available scientific information

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

On March 3, 2015, PIFSC outlined reasons why the fisheries data in the 2014 assessment produced results that the CIE panel advised was not ready for management application, and identified two ways in which the fisheries data can be improved for future application in the new CPUE standardization method.

1. Although catch per day fished is the best available CPUE that is available continuously over the whole time series, it may not be the best available over the most recent time series. If the time series is to be split with CPUE issues addressed differently before and after the split, one could also analyze and include detailed effort data that has been collected only for the last dozen years. This data could strongly influence recent trends. This was not seen by PIFSC as work that could be done as a simple update in 2014, because it is a complex undertaking.

   The use of CPUE defined as catch per day fished is subject to great criticism, and one way to address this is by using details on hours and numbers of lines and hooks used by fishermen over the last dozen years. Only inexplicit, undescribed differences among fishermen linked through time were applied to the recent stanza in the 2014 CPUE standardization. Using the recent effort detail would still allow differences between individual fishermen to be standardized, and also allow changes in effort details through time to be addressed. Both were factors of great concern to the reviewers. Differences among areas and seasons and other such factors that can be applied throughout the whole time series have remained part of the CPUE standardization in both 2011 and 2014.

2. Further efforts could be made to apply the CPUE standardization to account for differences among fishermen to more data using various exploratory methods and other data sets. The 2014 assessment overlooked a compilation of confidential non-electronic records held by the State of Hawaii that may help to link fisher's identities back through an earlier stanza of time.

Although the CIE panel noted the improvement in catch rate standardization in the 2014 stock assessment compared to 2011, it had strong reservations regarding the input catch data in both stock assessments, However, PIFSC cannot improve the assessment for MHI Deep-7 bottomfish in the ways described above in short order because it is a complex undertaking. Although catch per day fished may not be the best available CPUE data that can be used in the superior split-stanza CPUE standardization (i.e. after 1994), it is the best available CPUE data that is available over the entire time series, and thus appropriate for use in the 2011 assessment approach, which does not utilize a split-stanza CPUE standardization approach. Therefore, NMFS believes that a much simpler update of the 2011 assessment using data from the three most recent years available (i.e., 2011, 2012 and 2013) provides the best scientific information available for management. Applying this updated data, NMFS revised the MSY for MHI Deep-7 bottomfish from 417,000 lb to 404,000 lb and the OFL from 383,000 lb 352,000 lb. These values do not reflect a drastic change in stock status from the information considered by the Council, and the proposed ACL of 346,000 lb remains below the revised OFL of 352,000 lb.

1.11.2 Non-Deep-7 Bottomfish Fishery

1.11.2.1 Stock assessment benchmark

There is no benchmark stock assessment for the non-Deep-7 bottomfish. A previous attempt to determine sustainability of the non-Deep-7 bottomfish stock was done in conjunction with the assessment of the MHI Deep-7 bottomfish stocks. In 2011, NMFS Pacific Islands Fisheries Science Center completed a stock assessment for the Deep-7 bottomfish stock complex using data from 1949-2010 and produced stock projection results of a range of commercial catches of Deep-7 bottomfish that would produce probabilities of overfishing ranging from zero percent to 100 percent, and at five-percent intervals in fishing year 2011-12, and in 2012-13 (Brodziak *et al*., 2011, Table 19.1 and shown in Appendix C). The 2011 stock assessment used similar commercial fishery data as in the previous 2008 stock assessment that assessed the entire Hawaii multi-species bottomfish stock complex as a whole (Brodziak *et al*., 2009); however, the 2011 assessment includes a modified treatment of unreported catch and CPUE standardization, as well as new research information on the likely life history characteristics of Deep-7 bottomfish (A. Andrews, PIFSC, unpublished 2010 research).

According to the 2011 bottomfish stock assessment, the Catch 2/CPUE 1 scenario combination represents the best approximation (with a 40 percent probability) of the true state of the bottomfish fishery and Deep-7 bottomfish population dynamics. Under the Catch 2/CPUE 1 scenario combination, the long-term MSY of the MHI Deep-7 bottomfish stock complex is estimated to be 417,000 lbs. The assessment model also estimates that the commercial catch associated with a 50 percent probability of overfishing the MHI Deep-7 bottomfish complex in fishing year 2011-12 and again in fishing year 2012-13 is 383,000 lbs. Therefore, while the long-term MSY for the Deep-7 bottomfish fishery is 417,000 lb, the overfishing limit (OFL) for the 2011-12 and 2012-13 fishing years is estimated to be 383,000 lbs.

The 2011 MHI Deep-7 bottomfish stock assessment does not include an evaluation of stock status or the risk of overfishing for any of the remaining BMUS in the MHI. Therefore, biological reference points, including estimates of MSY and OFL for the MHI non-Deep-7 bottomfish are unknown. However, the stock assessment projection results for the MHI Deep-7 bottomfish stock complex can be used to develop an OFL proxy for the MHI non-Deep-7 bottomfish stock complex, and a range of commercial non-Deep-7 bottomfish catches that would produce probabilities of overfishing ranging from zero percent to 100 percent. This approach relies on the assumption that population dynamics, catchability and other parameters of the non-Deep-7 bottomfish are similar in relative scale to the Deep-7 bottomfish (Brodziak, pers. com. March 31, 2011). In general, MHI non-Deep-7 bottomfish are coral reef associated species and are more productive compared to MHI Deep-7 bottomfish. However, non-Deep-7 bottomfish are also harvested by a greater range of gear methods, which results in levels, and rates of exploitation that have not been assessed quantitatively or qualitatively in any previous stock assessment.

While a separate stock assessment for MHI non-Deep-7 bottomfish is the preferred approach, until one is produced, estimating a proxy for OFL and probabilities of overfishing for this stock complex based on projection results for MHI Deep-7 bottomfish is an appropriate approach given the fact that only catch data are available for the non-Deep-7 stock complex. Additionally, this catch data indicate that reported commercial catches of MHI Deep-7 bottomfish in proportion to the total reported commercial catches of all MHI bottomfish (Deep-7 + non-Deep-7) are relatively stable over time as reported in Tables 5 (estimates of total Deep-7 catches) and Table 6 (estimates of total bottomfish catches) contained in Brodziak *et al*. (2011). Therefore, reported commercial catches of MHI non-Deep-7 bottomfish in proportion to total reported commercial catches of all MHI bottomfish are also stable over time.

Table 52 summarizes the average proportion of the reported commercial catches (C) of MHI Deep-7 bottomfish relative to the total reported commercial catches of all MHI bottomfish for three time periods: (1) 1949-2010; (2) 2000-2009; and 2008-2010 as presented in Tables 5 and 6 in Brodziak *et al*. (2011). The proportion of MHI Deep-7 catch (PDEEP7) to the total MHI bottomfish catch is also provided and is calculated using the following equation:

PDEEP7(t) = CDEEP7(t) / C Total BMUS(t)

These three time periods were chosen because they reflect the nature of the Hawaii bottomfish fishery over (1) the entire available catch history; (2) the recent decade; and (3) three recent years when the fishery operated under a catch limit system. The results summarized in Table 52 clearly demonstrate that the proportion of Deep-7 to the total reported commercial catches of all MHI bottomfish (Deep-7 + non-Deep-7) has been relatively stable over time with ranges from 67 percent to 72 percent. Conversely, this demonstrates the proportion of non-Deep-7 bottomfish to the total MHI bottomfish catch ranged from 33 percent to 28 percent.

Table 52. Proportion of reported commercial catches of MHI Deep-7 and total reported commercial MHI bottomfish catch over time under Catch 2/CPUE 1 scenario

	t = 1949-2010	**t = 2000-2009**	**t = 2008-2010**
Catch of Deep-7 bottomfish[1]	281.3	234.3	221.5
Catch of Total BMUS[2]	422.1	325.3	330.7
Proportion of Deep-7 (P_{DEEP7})	0.666	0.720	0.700

Notes:
[1] Source: Table 5 in Brodziak *et al*., (2011).
[2] Source: Table 6 in Brodziak *et al*., (2011).

Because two Hawaii BMUS, taape *(Lutjanus kasmira)* and kahala (*Seriola dumerili),* are specifically excluded from the NMFS Hawaii bottomfish stock assessment parameters, their catch information is not included in the total bottomfish estimates used in Table 6 of Brodziak *et al*. (2011).

To estimate an OFL proxy for the MHI non-Deep-7 bottomfish stock complex and a range of commercial non-Deep-7 bottomfish catches that would produce probabilities of overfishing ranging from zero percent to 100 percent, the commercial catch values for MHI Deep-7 bottomfish associated with Catch 2/ CPUE Scenario 1 as presented in Table 19.1 of Brodziak *et al*., (2011), and shown in Appendix C can be divided by the P_{DEEP7} values in Table 52 above. The results of this calculation will derive the total commercial catch equivalent of all MHI bottomfish (Deep-7 + non-Deep-7) and the corresponding probabilities of overfishing all MHI bottomfish.

To derive the level of catch that would produce the corresponding probability of overfishing for MHI non-Deep-7 bottomfish (excluding taape and kahala), the level of catch for MHI Deep-7 bottomfish is simply subtracted from the level of catch for all MHI bottomfish.

Table 53 summarizes the results of this calculation for the time period 1949-2010. This time period is identical to the time period used to produce stock projection results for the Deep-7 stock complex and is the baseline for impact analyses.

Table 53. Commercial catch (in1000 pounds) of MHI Deep-7 BMUS, MHI non-Deep-7 BMUS and all MHI BMUS combined that would produce probabilities of overfishing from 0 through 99% based on 1949-2010 catch data (P_{DEEP7} = 0.666)

Probability of Overfishing[1]	**Catch of MHI Deep-7 BMUS**[1]	**Catch of All MHI BMUS** *(Deep-7 + non-Deep-7)*[2]	**Catch of MHI non-Deep-7 BMUS**[2]
0	11	17	6
5	147	221	74
10	197	296	99
15	229	344	115
20	255	386	131
25	277	415	138
30	299	449	150
35	319	479	160
40	341	512	171
45	361	542	181
50	383	575	192
55	407	611	204
60	429	644	215
65	455	683	228
70	481	722	241
75	513	779	266
80	549	824	275
85	597	896	299
90	665	998	333
95	783	1176	393
99	1001	1503	502

Notes:

[1] Source: Table 19.1 in Brodziak *et al*., (2011)

[2] Excludes Hawaii BMUS taape *(Lutjanus kasmira)* and kahala (*Seriola dumerili).*

Based on

Table 53 above, the catch limit associated with a 50 percent probability of overfishing the MHI Deep-7 bottomfish complex in fishing year 2011-12 and again in fishing year 2012-13 is 383,000 lbs. The catch limit associated with a 50 percent probability of overfishing the MHI non-Deep-7 bottomfish complex in fishing year 2012 and again in 2013 is 192,000 lbs. and is the OFL proxy.

These estimates will continue to apply in future fishing years until a new Deep-7 stock assessment update and associated stock projection analysis is conducted or a separate non-Deep-7 assessment is prepared.

1.11.2.2 Stock assessment updates

The initial method described above was abandoned in 2014. Estimates of MSY and OFL for non-Deep-7 bottomfish in the MHI are based on a modeling approach that uses catch data from local resource management agencies as described in Section 1.2; together with a measure of population growth (*r*), carrying capacity (*k*), and biomass data from NMFS PIFSC underwater fish census surveys (Williams, 2010). This model, termed the "Biomass Augmented Catch-MSY" model is described in detail in Sabater and Kleiber (2014). In summary, the model creates annual biomass projections from a set of *r* and *k* combinations that would not result in biomass that would exceed the carrying capacity or the stock being depleted. The assumption behind the biomass can be informed by augmenting the model with an independent source of biomass information.

The Biomass Augmented Catch-MSY model is based on the Catch-MSY model developed by Martell and Froese (2013), but differs in that it incorporates biomass data. Application of the model provides the very first model-based estimate of MSY for MHI non-Deep-7 bottomfish. In addition to estimates of MSY, the Biomass Augmented Catch-MSY model also generates a range of catches that if realized, would result in a probability of exceeding MSY ranging from five to 50 percent.

Because of the large number of possible combinations of *r* and *k* values available to estimate MSY using the Biomass Augmented Catch-MSY model, the model explored two methods to define the most meaningful and most likely (most plausible) range of *r* and *k* combinations. Method A allows for only a very narrow range of starting *r* and *k* values, while method B allows for a broad range of starting *r* and *k* values, with each method providing different MSY estimates and associated probability of overfishing projections. In reviewing the two methods, the SSC at its 114th meeting held March 11-13, 2014, determined the resulting MSY estimates from method B be used for management decisions because this method provides a more complete range of most likely *r* and *k* combinations compared to method A. The 114th SSC also found that method B also yielded *r* and *k* density plots that generally correspond better to the estimates of MSY than the method A approach.

Based on the method B approach, the Biomass Augmented Catch-MSY model estimates MSY for MHI non-Deep-7 bottomfish to be 265,000 lbs. However, catch projection results generated from the model estimates the level of catch associated with a 50 percent probability of exceeding MSY to be 259,200 lbs. Consistent with National Standard 1 guidelines (74 FR 3178, January 9, 2011), the Council at its 160th meeting, set OFL for MHI non-Deep-7 bottomfish equal to the level of catch associated with a 50 percent probability of exceeding MSY.

In February 2017, PIFSC released the final species level assessment for the main Hawaiian Islands (Nadon, 2017). This assessment covers 27 species of reef fishes, three of which are non-Deep 7 bottomfish: *Caranx ignobilis*, *Aprion virescens*, and *Lutjanus kasmira*.

This assessment utilized a different approach compared to the existing model used for the FY2015-2018 specification. It used life history information and a length-based approach to obtain stock status based on spawning potential ratio (SPR) rather than MSY. When life history information is not available for a species, a data-poor approach is used to simulate life history parameters based on known relationships (Nadon and Ault, 2016). Fishery independent size composition and abundance data from diver surveys were combined with fishery dependent catch estimates to calculate current fishing mortality rates (*F*), spawning potential ratios (SPR), SPR-based sustainable fishing rates (F30; F resulting in SPR = 30%), and catch levels corresponding to these sustainable rates (C30). 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 C30, was obtained by combining F30 estimates with current population biomass estimates derived directly from diver surveys or indirectly from the total catch. The overfishing limits (OFL) corresponding to a 50% risk of overfishing was defined as the median of the C30 distribution.

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

1.11.3 Coral reef fishery

1.11.3.1 Stock assessment benchmark

Coral Reef Ecosystem Management Unit Species Complex-Level Assessment

The first attempt to use a model-based approach in assessing the coral reef MUS complexes was done in 2014 using a biomass-based population dynamics model (Sabater and Kleiber 2014) for the purpose of improving the ACL specification for these stocks. This model was based on the original Martell and Froese (2012) model but was augmented with biomass information to relax the assumption behind carrying capacity. It estimates MSY based on a range of rate of population growth (*r*) and carrying capacity (*k*) values. The best available information for the complex level coral reef stock assessment is as follows:

Input data: The catch data was derived commercial marine license reports.

Model: Biomass Augmented Catch MSY approach based on the original catch-MSY model (Martell and Froese, 2012; Sabater and Kleiber, 2014).

Fishery independent source for biomass: biomass density from the Rapid Assessment and Monitoring Program of NMFS-CREP was expanded to the hard bottom habitat from 0-30 m (Williams, 2010).

This model had undergone a CIE review in 2014 (Cook, 2014; Haddon, 2014; Jones, 2014). This was the basis for the P* analysis that determined the risk levels to specify ABCs. This model was used for the multi-year specification for fishing year 2015-2018.

Coral Reef Ecosystem Management Unit Species Species-Level Assessment

In February 2017, PIFSC released the final species level assessment for the main Hawaiian Islands (Nadon, 2017). This assessment covers 27 species of reef fishes, 24 of which are CREMUS: *Acanthurus blochii*, *Acanthurus dussumieri*, *Naso brevirostris*, *Naso hexacanthus, Naso lituratus, Naso unicornis, Carangoides orthogrammus*, *Caranx melampygus*, *Lutjanus fulvus*, *Mulloidichthys flavolineatus*, *Mulloidichthys pfluegeri*, *Mulloidichthys vanicolensis*, *Parupeneus cyclostomus, Parupeneus insularis, Parupeneus porphyreus*, *Calotomus carolinus*, *Chlorurus perspecillatus*, *Chlorurus spilurus*, *Scarus dubius*, *Scarus psittacus*, *Scarus rubroviolaceus*, *Cephalopholis argus*, *Monotaxis grandoculis*, and *Myripristis berndti*.

This assessment utilized a different approach compared to the existing model used for the FY2015-2018 specification. It used life history information and a length-based approach to obtain stock status based on spawning potential ratio (SPR) rather than MSY. When life history information is not available for a species, a data-poor approach is used to simulate life history parameters based on known relationships (Nadon and Ault, 2016). Fishery independent size composition and abundance data from diver surveys were combined with fishery dependent catch estimates to calculate current fishing mortality rates (*F*), spawning potential ratios (SPR), SPR-based sustainable fishing rates (F30; F resulting in SPR = 30%), and catch levels corresponding to these sustainable rates (C30). 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 C30, was obtained by combining F30 estimates with current population biomass estimates derived directly from diver surveys or indirectly from the total catch. The overfishing limits (OFL) corresponding to a 50% risk of overfishing was defined as the median of the C30 distribution.

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

1.11.3.2 Stock assessment updates

No updates available for the coral reef MUS complex.

1.11.3.3 Other information available

Approximately every five years PIFSC administers a socioeconomic survey to small boat fishermen in Hawaii. This survey consists of about 60 questions regarding a variety of topics, including fishing experiences, market participation, vessels and gear, demographics and household income, and fishermen perspectives. The survey requests participants to identify which MUS they primarily targeted during the previous 12 months, by percentage of trips. Full reports of these surveys can be found at the PIFSC Socioeconomics webpage (Hospital and Beavers, 2011).

PIFSC and the Council conducted a workshop with various stakeholders in CNMI to identify factors and quantify uncertainties associated with the social, economic, ecological, and management of the coral reef fisheries (Sievanen and McCaskey, PIFSC internal report). This was the basis for the SEEM analysis that determined the risk levels to specify ACLs for all areas.

1.11.4 Crustacean fishery

1.11.4.1 Stock assessment benchmark

Spiny Lobsters: There is no benchmark stock assessment for any of the crustacean MUS. The first attempt to use a model-based approach in assessing the crustacean MUS complexes, particularly spiny lobsters, was done in 2014 using a biomass-based population dynamics model (Sabater and Kleiber 2014) for the purpose of improving the ACL specification for these stocks. This model was based on the original Martell and Froese (2012) model but was augmented with biomass information to relax the assumption behind carrying capacity. It estimates MSY based on a range of rate of population growth (*r*) and carrying capacity (K) values. The best available information for the coral reef stock assessment is as follows:

Input data: The catch data was derived from the commercial marine license report.

Model: Biomass Augmented Catch MSY approach based on the original catch-MSY model (Martell and Froese 2012; Sabater and Kleiber 2014).

Fishery independent source for biomass: There is no fishery independent data collection for crustaceans

This model had undergone a CIE review in 2014 (Cook, 2014; Haddon, 2014; Jones, 2014). This was the basis for the P* analysis that determined the risk levels to specify ABCs.

Slipper Lobsters: There has been no attempt to conduct an assessment of the slipper lobster stock. The best attempt to come up with a yield estimate was to use the 75th percentile of the entire catch time series. This follows recommendations from the ORCS Working Group for data poor species (Berkson *et al*., 2011).

Deep-water Shrimp: The deep water shrimp (*Heterocarpus laevigatus* and *H. ensifer*) initial resource assessment was conducted in the late 1980s by Ralston and Tagami (1988). 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 stock assessment model was developed in 2014 in an attempt to understand and determine the status of the Kona crab stock in the main Hawaiian Islands (Thomas *et al.*, 2015). This assessment utilized a non-equilibrium generalized production model (using the Stock-Production Model Incorporating Covariate –ASPIC statistical routine) to estimate parameters needed to determine stock status. Based on this, the Kona crab stock is overfished (possibly rebuilding) but not experiencing overfishing.

This assessment had undergone a CIE desktop review in December 2015 (Hall, 2015). The review concluded that the assessment had utilized the appropriate model and used the data and assumptions correctly making the assessment best available. However, the reviewer also cautioned that there are large uncertainties associated with the results which could change dramatically with the changes in the non-commercial catch assumptions and effects of the State of Hawaii's female release regulations. PIFSC agreed that further work is needed to provide advice on the current status of the population in more recent years. This was included in the list of stocks that PIFSC will conduct a benchmark assessment on in the future. To date, the best available information is based on the 75th percentile of the entire catch time series as a proxy for sustainable yield levels.

1.11.4.2 Stock assessment updates

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

1.11.4.3 Best Scientific Information Available

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

- Spiny lobsters – Sabater and Kleiber (2014).
- Slipper lobsters – WPRFMC (2011) – cite non-fin-fish EA.
- Deepwater shrimp – Ralston and Tagami (1988).
- Kona crabs – Lennon *et al.*, (2015) – cite non-fin-fish EA.

1.12 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 on the basis of 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 in the coral reef and 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 and coral reef fish MUS complexes is defined to be the level of harvest equal to the ACL consistent with the goals and objectives of the Fishery Ecosystem Plans 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 F_{MSY}. There are situations when the long-term means around MSY are going to be lower than ACLs especially if the stock is known to be productive or relatively pristine or lightly fished. One can have catch levels and catch rates exceeding that of MSY over short-term enough to lower the biomass to a level around the estimated MSY and still not jeopardize the stock. This situation is true for the territory bottomfish multi-species complex.

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 54 summarizes the harvest extent and harvest capacity information for Hawaii in 2015

Table 54. Proportion of harvest extent, defined as the proportion of fishing year landing relative to the ACL or OY, and the harvest capacity, defined as the remaining portion of the ACL or OY that can potentially be harvested in a given fishing year in the MHI.

Fishery	Management Unit Species	ACL	Catch	Harvest extent (%)	Harvest capacity (%)
Bottomfish	MHI Deep-7 stock complex	326,000	266,550	81.8	18.2
	MHI Non-Deep 7 stock complex	N.A.	127,265	N.A.	N.A.
Crustaceans	Deepwater shrimp	250,773	16,139	6.4	93.6

	Spiny lobster	15,000	6,617	44.1	55.9
	Slipper lobster	280	0	0.0	100.0
	Kona crab	N.A.	1,993	N.A.	N.A.
Precious coral	Auau channel-black coral	5,512	N.A.F.	N.A.	N.A.
	Makapuu bed-pink coral	2,205	N.A.F.	N.A.	N.A.
	Makapuu bed-bamboo coral	551	N.A.F.	N.A.	N.A.
	180 fathom bank-pink coral	489	N.A.F.	N.A.	N.A.
	180 fathom bank-bamboo coral	123	N.A.F.	N.A.	N.A.
	Brooks bank-pink coral	979	N.A.F.	N.A.	N.A.
	Brooks bank-bamboo coral	245	N.A.F.	N.A.	N.A.
	Kaena point bed-pink coral	148	N.A.F.	N.A.	N.A.
	Kaena point bed-bamboo coral	37	N.A.F.	N.A.	N.A.
	Keahole bed-pink coral	148	N.A.F.	N.A.	N.A.
	Keahole bed-bamboo coral	37	N.A.F.	N.A.	N.A.
	Precious coral in HI exploratory area	2,205	N.A.F.	N.A.	N.A.
Coral Reef Ecosystem	*S. crumenopthalmus*-akule	N.A.	389,844	N.A.	N.A.
	D. macarellus-opelu	N.A.	181,473	N.A.	N.A.
	Acanthuridae-surgeonfish	N.A.	78,076	N.A.	N.A.
	Carangidae-jacks	N.A.	42,340	N.A.	N.A.
	Carcharhinidae-reef sharks	N.A.	2,500	N.A.	N.A.
	Crustaceans-crabs	N.A.	21,237	N.A.	N.A.
	Holocentridae-squirrelfish	N.A.	48,637	N.A.	N.A.
	Kyphosidae - rudderfish	N.A.	13,336	N.A.	N.A.
	Labridae - wrasse	N.A.	7,175	N.A.	N.A.
	Lethrinidae - emperors	N.A.	2,808	N.A.	N.A.
	Lutjanidae-snappers	N.A.	39,333	N.A.	N.A.
	Mollusk-turbo snails, octopus, giant clam	N.A.	30,658	N.A.	N.A.
	Mugilidae-mullets	N.A.	4,834	N.A.	N.A.
	Mullidae-goatfish	N.A.	61,184	N.A.	N.A.
	Scaridae-parrotfish	N.A.	33,902	N.A.	N.A.
	Serranidae - groupers	N.A.	1,327	N.A.	N.A.
	All other CREMUS combined	N.A.	13,823	N.A.	N.A.

1.13 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions PIRO has taken since the April 2016 Joint FEP Plan Team meeting, as reported to the 166rd to 168th Western Pacific Fishery Management Council meetings held June 2016, October 2016, and March 2017.

April 7, 2016. Final 2015-16 Annual Catch Limits and Accountability Measures. **Main Hawaiian Islands Deep 7 Bottomfish**. NMFS specified an annual catch limit (ACL) of 326,000 lbs. for Deep 7 bottomfish in the main Hawaiian Islands (MHI) for the 2015-16 fishing year. As an accountability measure (AM), if the ACL is projected to be reached, NMFS would close the commercial and non-commercial fisheries for MHI Deep 7 bottomfish for the remainder of the fishing year. The ACL and AM specifications support the long-term sustainability of Hawaii bottomfish. The specifications were effective May 9, 2016.

April 21, 2016. NMFS announced that the Secretary of Commerce approved Amendment 4 to the Fishery Ecosystem Plan for the Hawaiian Archipelago. In Amendment 4, the Council revised the essential fish habitat and habitat areas of particular concern for 14 species of bottomfish and three species of seamount groundfish in the Hawaiian Archipelago. The action considers the best available scientific, commercial, and other information about the fisheries, and supports the long-term sustainability of fishery resources.

January 18, 2017. Final 2016-17 Annual Catch Limit and Accountability Measures. **Main Hawaiian Islands (MHI) Deep 7 Bottomfish**. In this final rule, NMFS specifies an annual catch limit (ACL) of 318,000 lbs. of Deep 7 bottomfish in the MHI for the 2016-17 fishing year. As an accountability measure (AM), if the ACL is projected to be reached, NOAA Fisheries would close the commercial and non-commercial fisheries for MHI Deep 7 bottomfish for the remainder of the fishing year. The ACL and AM support the long-term sustainability of Hawaii bottomfish. The final specifications are effective from February 17, 2017, through August 31, 2017.

January 18, 2017 (82 FR 5517). **Pacific Island 2016 Annual Catch Limits and Accountability Measures**. NMFS proposed annual catch limits (ACLs) for Pacific Island bottomfish, crustacean, precious coral, and coral reef ecosystem fisheries, and accountability measures (AMs) to correct or mitigate any overages of catch limits. The proposed ACLs and AMs would be effective for fishing year 2016. The fishing year for each fishery begins on January 1 and ends on December 31, except for precious coral fisheries, which begin July 1 and end on June 30 the following year. Although the 2016 fishing year has ended for most stocks, NMFS evaluates 2016 catches against the 2016 ACLs when data become available in mid-2017. The proposed ACLs and AMs support the long-term sustainability of fishery resources of the U.S. Pacific Islands. The comment period ended February 2, 2017.

January 23, 2017. **2017 NWHI lobster harvest guideline**. NMFS establishes the annual harvest guideline for the commercial lobster fishery in the Northwestern Hawaiian Islands for calendar year 2017 at zero lobsters.

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2 ECOSYSTEM CONSIDERATIONS

2.1 FISHERY ECOSYSTEM

2.1.1 Regional Reef Fish Biomass

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data (details of survey program below) between 2009 and 2015.

Category:
- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:
- ✓ American Samoa
- ✓ Guam
- ✓ Commonwealth of Northern Mariana Islands
- ✓ Main Hawaiian Islands
- ✓ Northwest Hawaiian Islands
- ✓ Pacific Remote Island Areas

Spatial Scale:
- ✓ Regional
- ☐ Archipelagic
- ☐ Island
- ☐ Site

Data Source: Data used to generate biomass estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods are described in detail elsewhere (http://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_15-07.pdf), but in brief 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 (http://www.fishbase.org), 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.

Rationale: Reef fish biomass (i.e. the weight of fish per unit area) has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime.

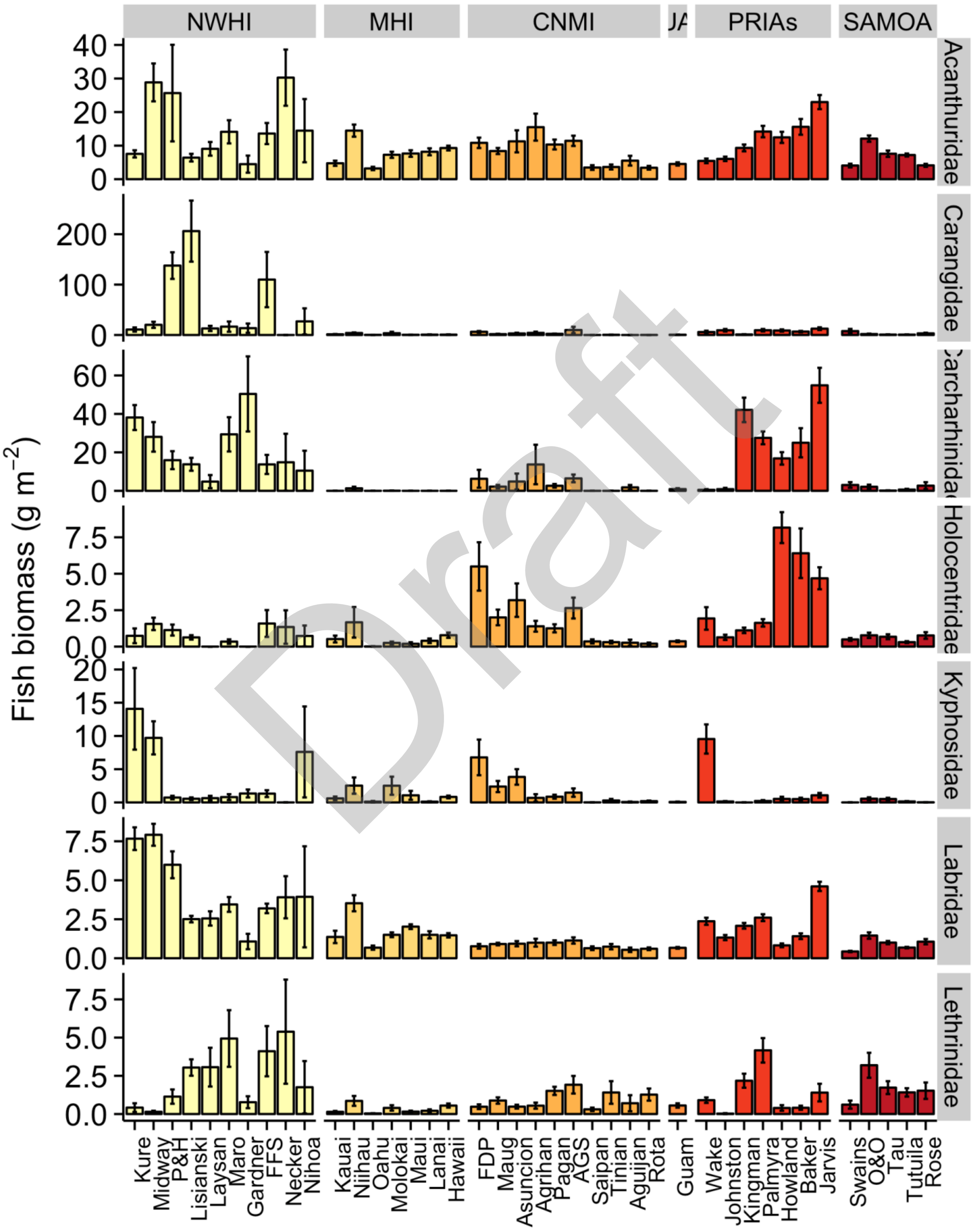
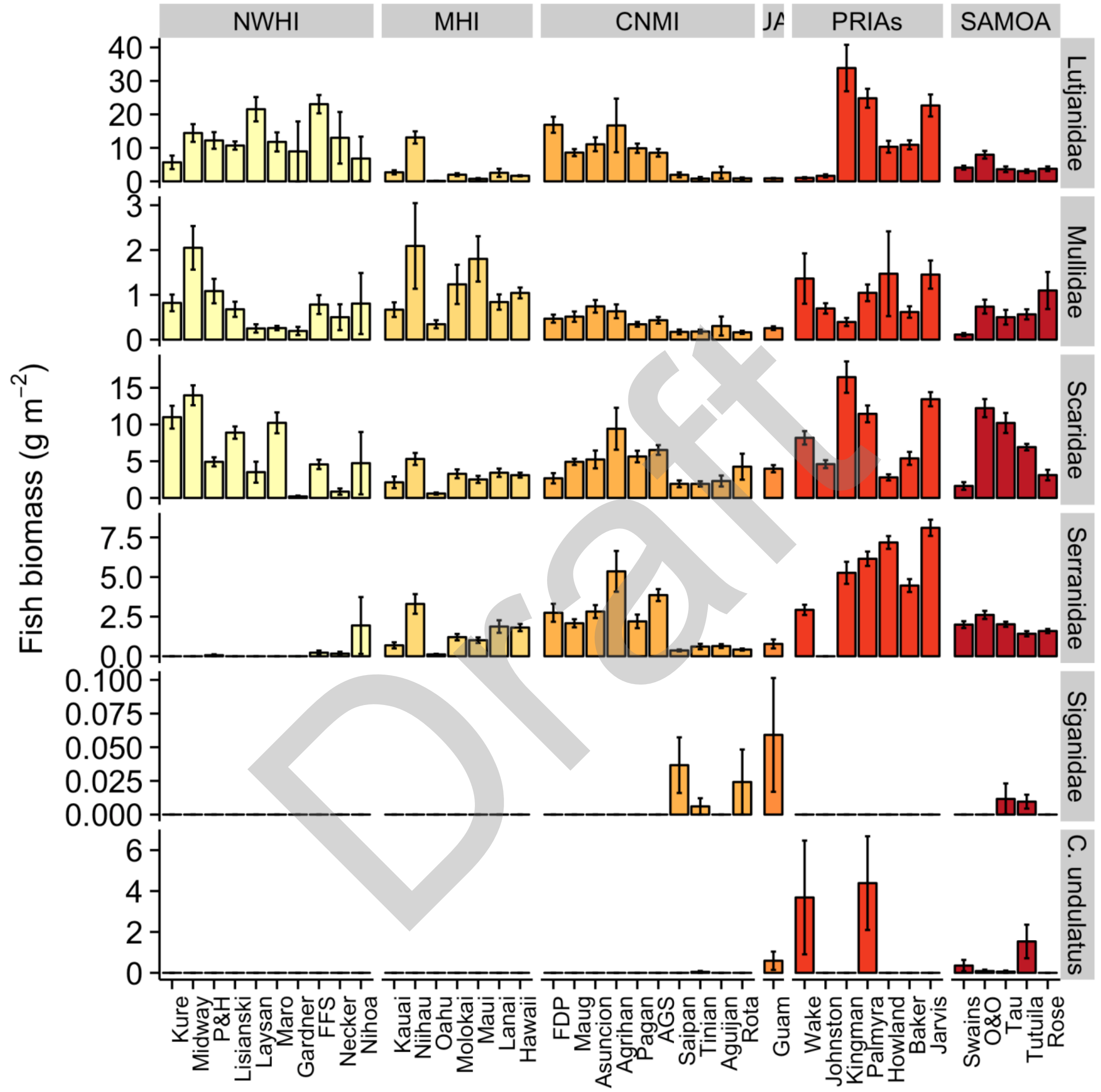


Figure 6. Mean fish biomass (g/m^2 ± standard error) of Coral Reef Management Unit Species (CREMUS) grouped by U.S. Pacific reef area from the years 2009-2015. Islands are ordered within region by latitude. Figure continued from previous page.



2.1.2 Main Hawaiian Islands Reef Fish Biomass

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data (details of survey program below) between 2009 and 2015.

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

- ☐ American Samoa
- ☐ Guam
- ☐ Commonwealth of Northern Mariana Islands
- ✓ Main Hawaiian Islands
- ☐ Northwest Hawaiian Islands
- ☐ Pacific Remote Island Areas

Scale:

- ☐ Regional
- ☐ Archipelagic
- ✓ Island
- ☐ Site

Data Source: Data used to generate biomass estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2.1.1).

Rationale: Reef fish biomass (i.e. the weight of fish per unit area) 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.

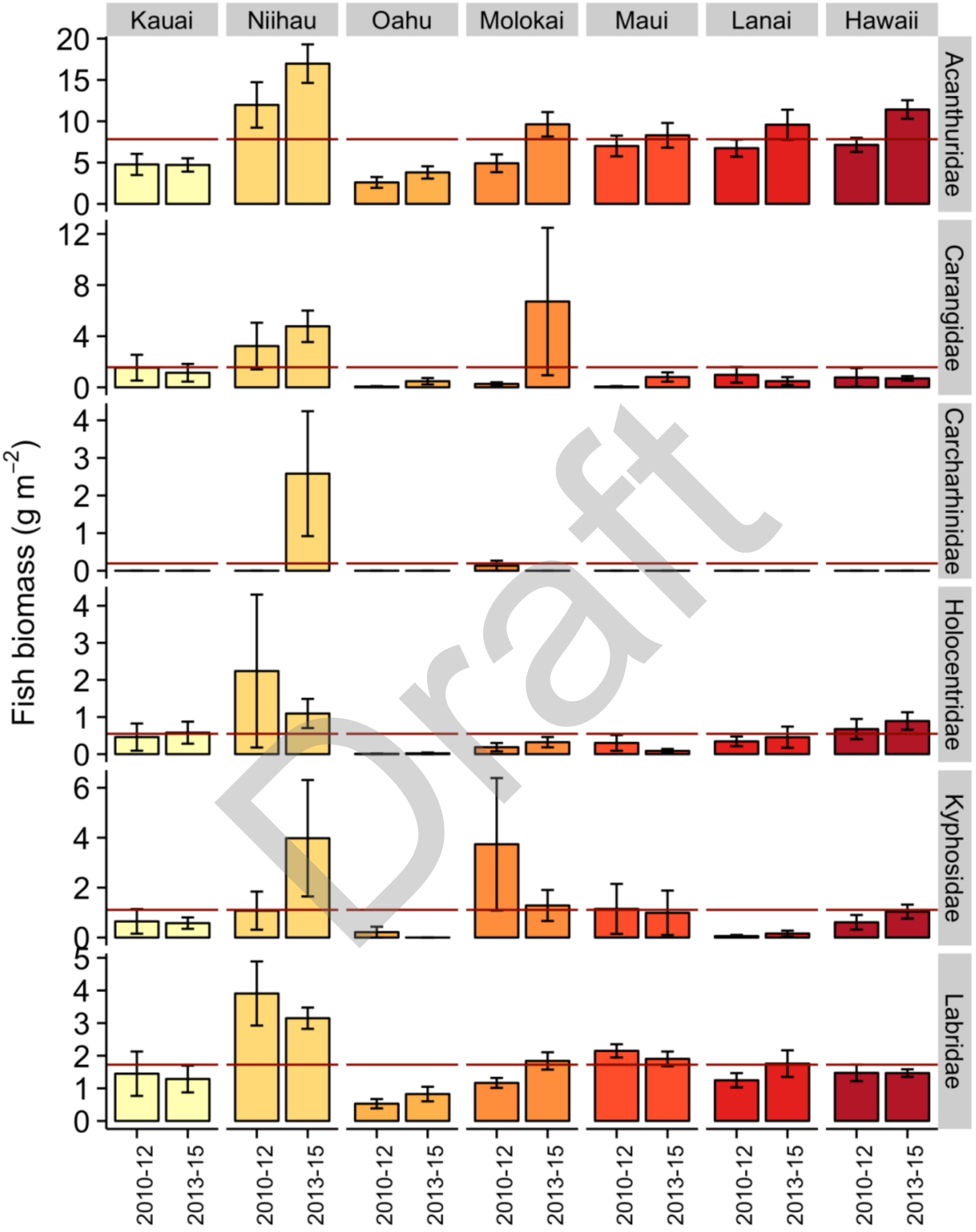
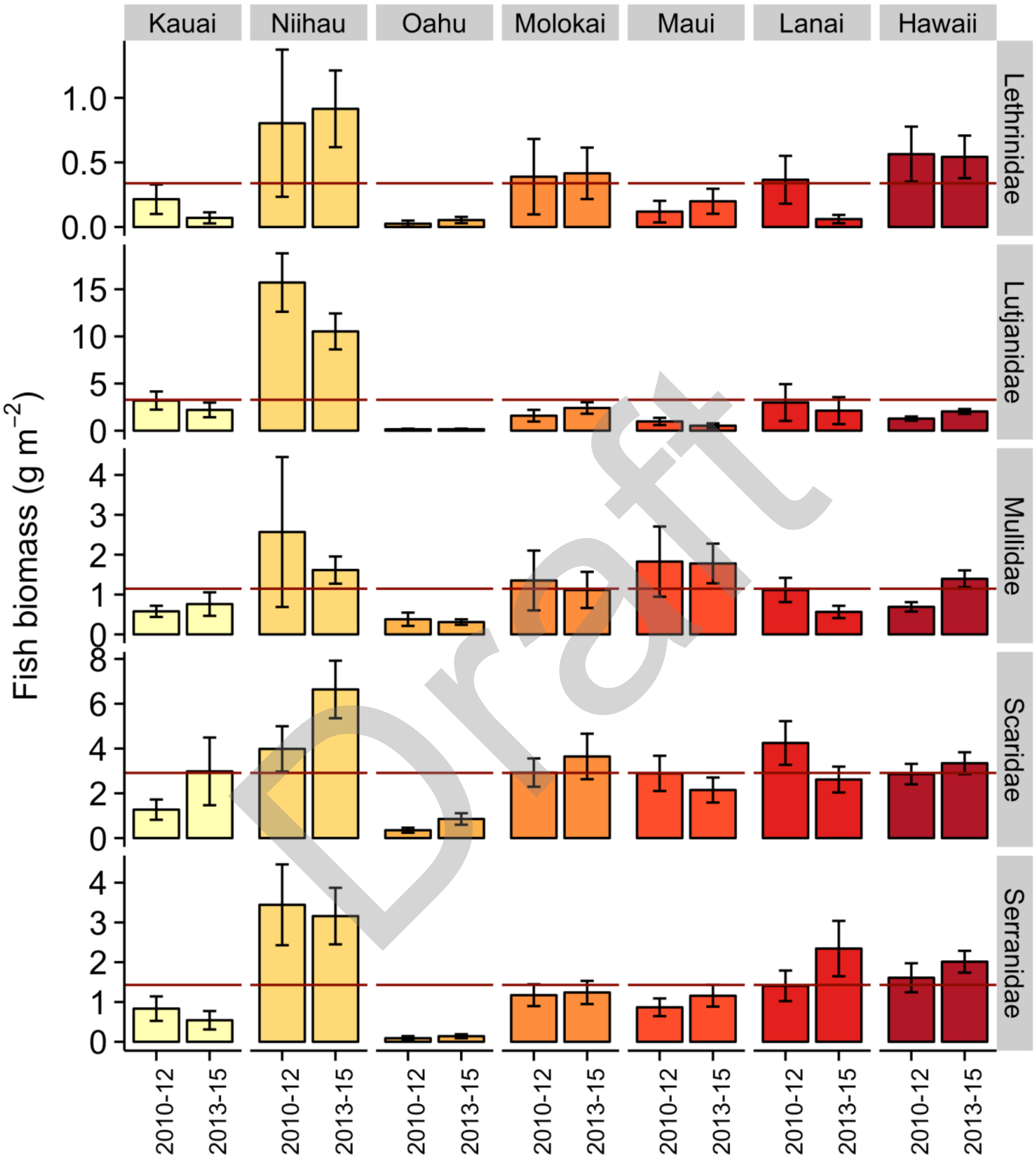


Figure 7. Mean fish biomass (g/m^2 ± standard error) of MHI CREMUS from the years 2009-2015. The MHI mean estimates are represented by the red line. Figure continued from previous page.


Kauai
Niihau
Oahu
Molokai
Maui
Lanai
Hawaii
Lethrinidae
Lutjanidae
Mullidae
Scaridae
Serranidae
Fish biomass (g m^{-2})
0.0
0.5
1.0
0
5
10
15
0
1
2
3
4
0
2
4
6
8
0
1
2
3
4
2010-12
2013-15

2.1.3 Archipelagic Mean Fish Size

Description: 'Mean fish size' is the mean size of reef fishes >10 cm TL (i.e. excluding small fishes) derived from visual survey data (details of survey program below) between 2009 and 2015.

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

- ☐ Regional
- ☐ American Samoa
- ☐ Guam
- ☐ Commonwealth of Northern Mariana Islands
- ✓ Main Hawaiian Islands
- ☐ Northwest Hawaiian Islands
- ☐ Pacific Remote Island Areas

Scale:

- ☐ Regional
- ☐ Archipelagic
- ✓ Island
- ☐ Site

Data Source: Data used to generate biomass estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2.1.1). Fishes smaller than 10 cm TL are excluded so that the fish assemblage measured more closely reflects fishes that are potentially fished, and so that mean sizes are not overly influenced by variability in space and time of recent recruitment.

Rationale: Mean size is important as it is widely used as an indicator of fishing pressure. A fishery can sometimes preferentially target large individuals, and can also the number of fishes reaching older (and larger) size classes. Large fishes contribute disproportionately to community fecundity and can have important ecological roles; for example, excavating bites by large parrotfishes probably have a longer lasting impact on reef benthos than bites by smaller fishes.

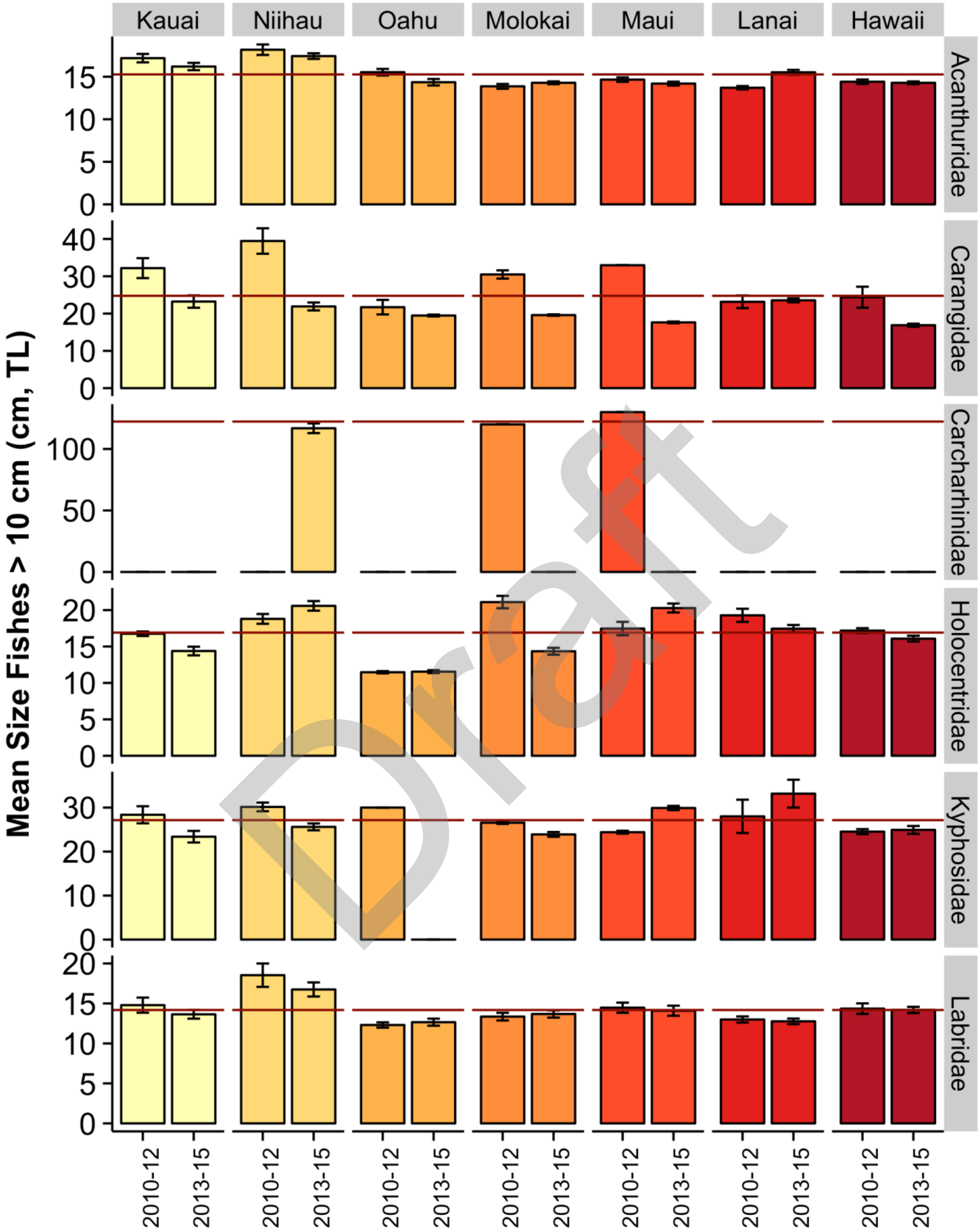
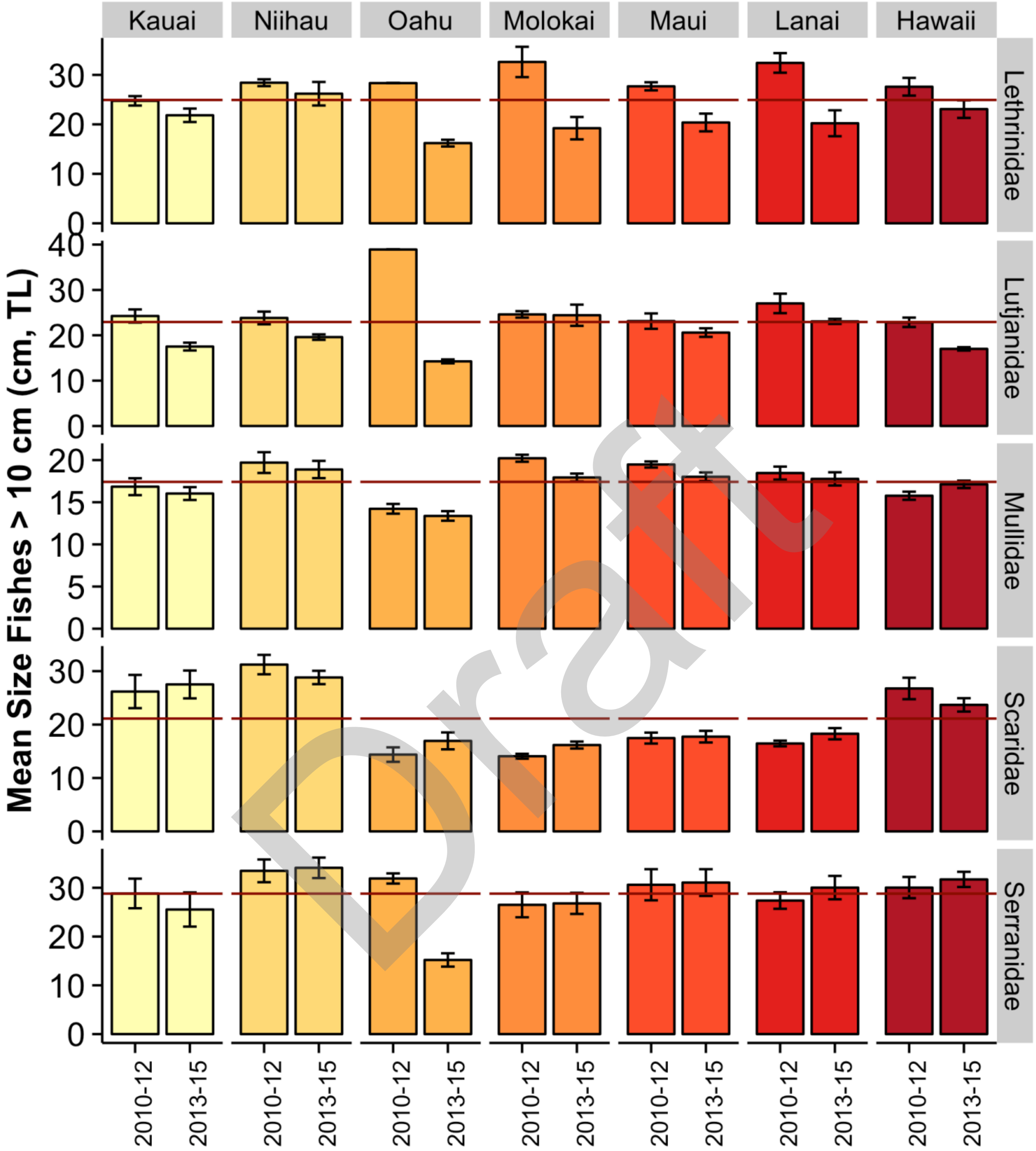


Figure 8. Mean fish size (cm, TL ± standard error) of MHI CREMUS from the years 2009-2015. The MHI mean estimates are plotted for reference (red line). Figure continued from previous page.


Kauai
Niihau
Oahu
Molokai
Maui
Lanai
Hawaii
Lethrinidae
Lutjanidae
Mullidae
Scaridae
Serranidae
Mean Size Fishes > 10 cm (cm, TL)
0
10
20
30
40
5
15
2010-12
2013-15

2.1.4 Reef Fish Population Estimates

Description: ‘Reef fish population estimates’ are calculated by multiplying mean biomass per unit area by estimated hardbottom area in a consistent habitat across all islands (specifically, the area of hardbottom forereef habitat in < 30 meters of water).

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

- ☐ Regional
- ☐ American Samoa
- ☐ Guam
- ☐ Commonwealth of Northern Mariana Islands
- ✓ Main Hawaiian Islands
- ☐ Northwest Hawaiian Islands
- ☐ Pacific Remote Island Areas

Scale:

- ☐ Regional
- ☐ Archipelagic
- ✓ Island
- ☐ Site

Data Source: Data used to generate mean size estimates come from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2.1.1). Those estimates are converted to population estimates by multiplying biomass (g/m^2) per island by the estimated area of hardbottom habitat <30 meters deep at the island, which is the survey domain for the monitoring program that biomass data comes from. Measures of estimated habitat area per island are derived from GIS bathymetry and NOAA Coral Reef Ecosystems Program habitat maps. Many reef fish taxa are present in other habitats than is surveyed by the program, and some taxa likely have the majority of their populations in deeper water. Additionally, fish counts have the potential to be biased by the nature of fish response to divers. Curious fishes, particularly in locations where divers are not perceived as a threat, will tend to be overestimated by visual survey, while skittish fishes will tend to be undercounted. It is also likely that numbers of jacks and sharks in some locations, such as the NWHI are overestimated by visual survey. Nevertheless, the data shown here are consistently gathered across space and time.

Rationale: These data have utility in understanding the size of populations from which fishery harvests are extracted.

Table 55. Reef fish population estimates for MHI CREMUS in 0-30 m hardbottom habitat only. *N* is number of sites surveyed per island.

			ESTIMATED POPULATION BIOMASS (metric Tonnes) in SURVEY DOMAIN OF <30m HARDBOTTOM					
ISLAND	Total Area of reef (Ha)	N	Acanthuridae	Carangidae	Carcharhinids	Holocentridae	Kyphosidae	Labridae
Kauai	18,127.1	82	859.6	242.3	-	94.0	111.0	247.7
Niihau	9,265.8	90	1,341.0	370.6	119.6	154.5	234.2	326.9
Oahu	25,118.8	171	804.5	67.1	-	3.8	27.3	170.0
Molokai	12,730.3	147	925.7	444.2	8.5	32.4	319.7	191.4
Maui	11,122.2	140	851.3	47.8	-	21.6	118.9	225.3
Lanai	3,003.7	88	245.3	22.0	-	12.0	3.3	45.1
Hawaii	16,839.8	198	1,563.1	123.6	-	132.0	139.0	247.7
TOTAL	**96,207.6**	**916**	**6,590.5**	**1,317.6**	**128.1**	**450.4**	**953.3**	**1,454.1**

ISLAND	Total Area of reef (Ha)	N	Lethrinidae	Lutjanidae	Mullidae	Scaridae	Serranidae
Kauai	18,127.1	82	25.9	489.0	121.3	385.2	124.6
Niihau	9,265.8	90	79.6	1,215.9	193.8	492.0	305.9
Oahu	25,118.8	171	9.9	36.9	86.5	151.3	29.0
Molokai	12,730.3	147	51.3	254.3	157.1	418.1	153.5
Maui	11,122.2	140	17.7	84.0	200.5	280.0	112.6
Lanai	3,003.7	88	6.4	76.7	25.2	103.0	56.3
Hawaii	16,839.8	198	93.2	279.9	175.5	522.2	305.0
TOTAL	**96,207.6**	**916**	**284.0**	**2,436.8**	**959.8**	**2,351.9**	**1,087.0**

Note (1): No Siganidae, *Bolbometopon muricatum* or *Cheilinus undulatus* were observed in MHI

2.1.5 Northwestern Hawaiian Islands Reef Fish Biomass

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data (details of survey program below) between 2009 and 2015.

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

- ☐ American Samoa
- ☐ Guam
- ☐ Commonwealth of Northern Mariana Islands
- ☐ Main Hawaiian Islands
- ✓ Northwest Hawaiian Islands
- ☐ Pacific Remote Island Areas

Scale:

- ☐ Regional
- ☐ Archipelagic
- ✓ Island
- ☐ Site

Data Source: Data used to generate biomass estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2.1.1).

Rationale: Reef fish biomass (i.e. the weight of fish per unit area) 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.

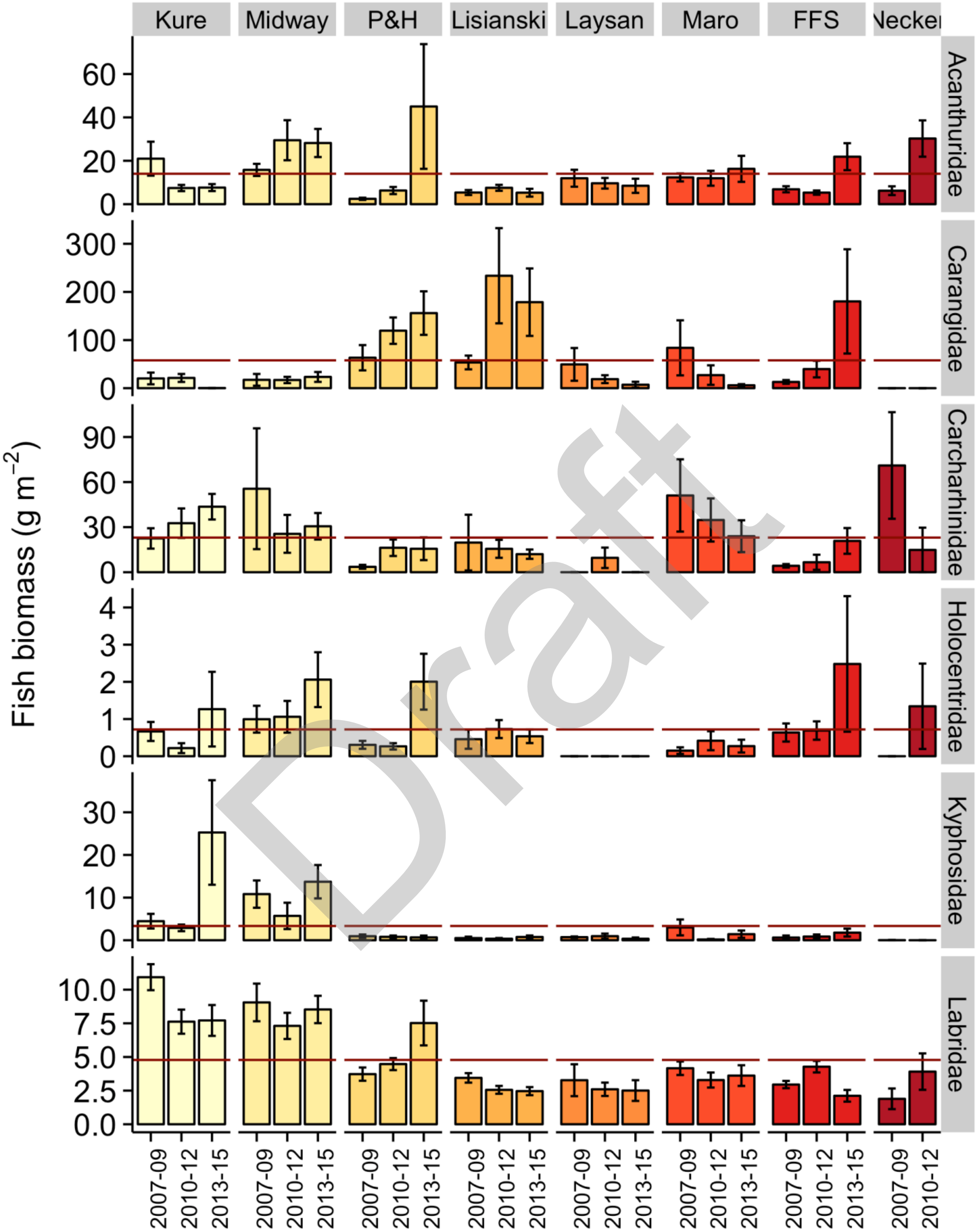
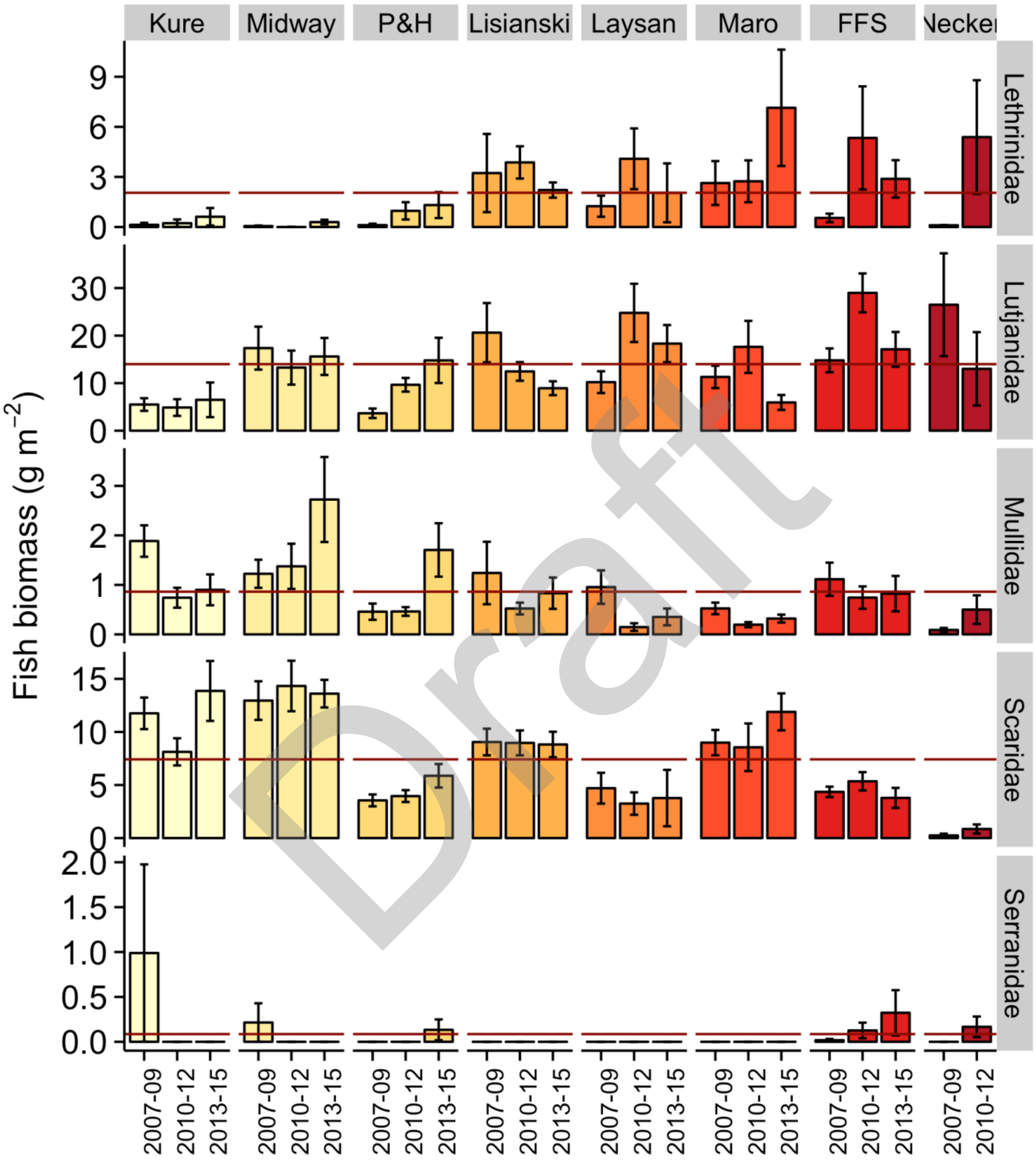


Figure 9. Mean fish biomass (g/m^2 ± standard error) of NWHI CREMUS from the years 2009-2015. The NWHI mean estimates are represented by the red line. Data from Nihoa and Gardner Pinnacles are removed, as data are very limited. Figure continued on next page.


Kure
Midway
P&H
Lisianski
Laysan
Maro
FFS
Necker
Lethrinidae
Lutjanidae
Mullidae
Scaridae
Serranidae
Fish biomass (g m−2)
0
3
6
9
0
10
20
30
0
1
2
3
0
5
10
15
0.0
0.5
1.0
1.5
2.0
2007-09
2010-12
2013-15

2.1.6 Archipelagic Mean Fish Size

Description: 'Mean fish size' is mean size of reef fishes > 10 cm TL (i.e. excluding small fishes) derived from visual survey data (details of survey program below) between 2009 and 2015.

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

- ☐ Regional
- ☐ American Samoa
- ☐ Guam
- ☐ Commonwealth of Northern Mariana Islands
- ☐ Main Hawaiian Islands
- ✓ Northwest Hawaiian Islands
- ☐ Pacific Remote Island Areas

Scale:

- ☐ Regional
- ☐ Archipelagic
- ✓ Island
- ☐ Site

Data Source: Data used to generate biomass estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2.1.1). Fishes smaller than 10 cm TL are excluded so that the fish assemblage measured more closely reflects fishes that are potentially fished, and so that mean sizes are not overly influenced by variability in space and time of recent recruitment.

Rationale: Mean size is important as it is widely used as an indicator of fishing pressure. A fishery can sometimes preferentially target large individuals, and can also the number of fishes reaching older (and larger) size classes. Large fishes contribute disproportionately to community fecundity and can have important ecological roles; for example, excavating bites by large parrotfishes probably have a longer lasting impact on reef benthos than bites by smaller fishes.

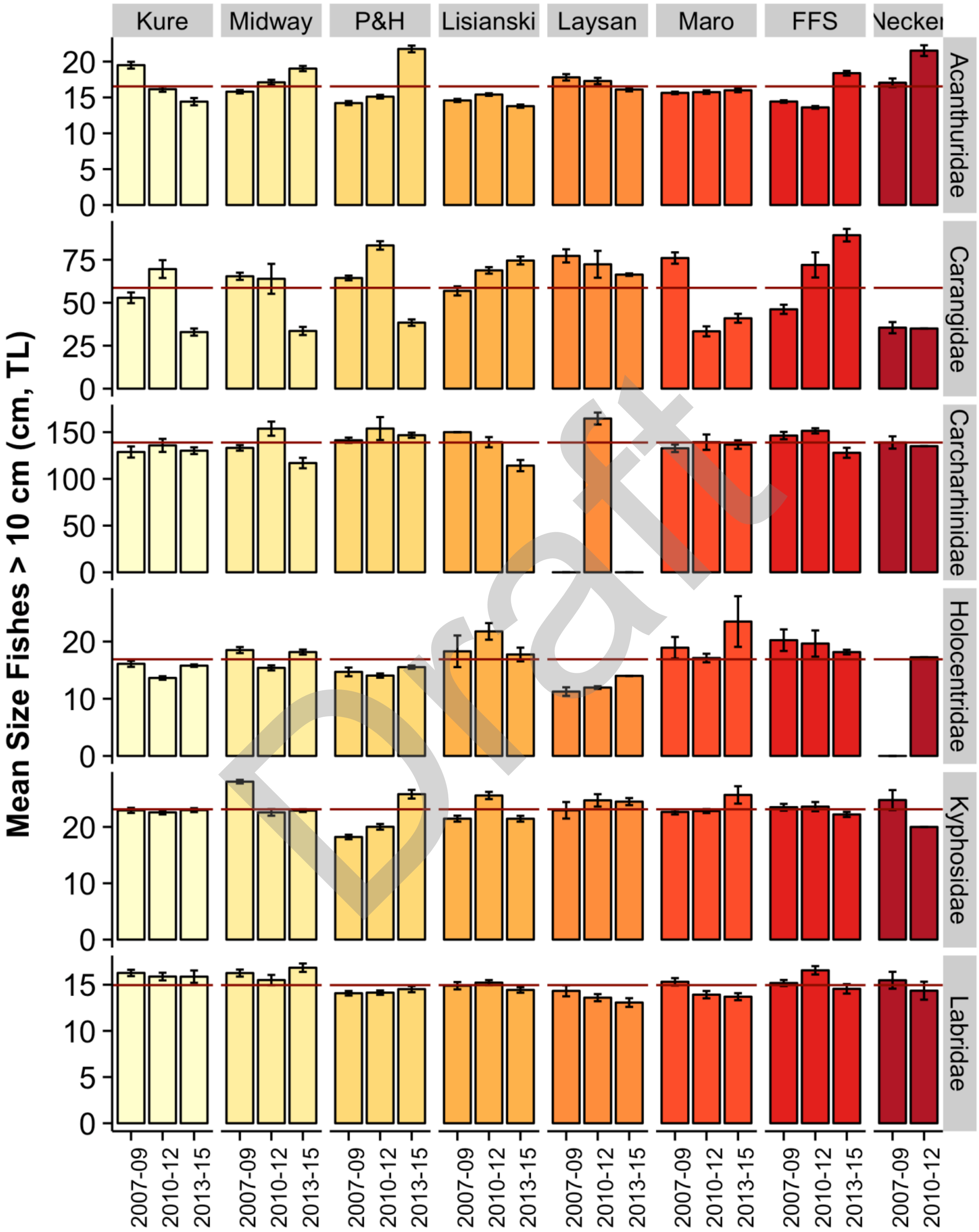
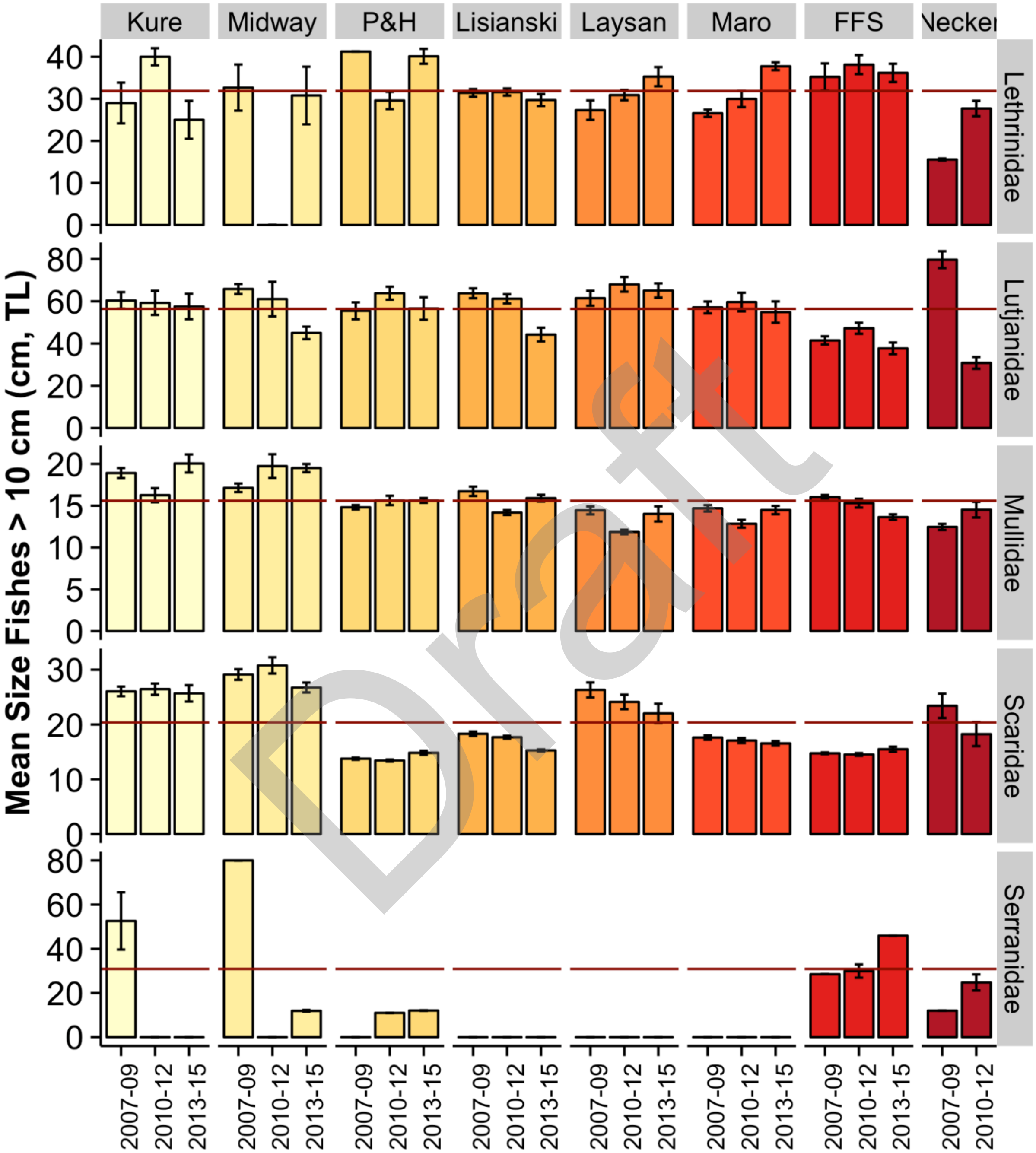


Figure 10. Mean fish size (cm, TL ± standard error) of NWHI CREMUS from the years 2009-2015. The NWHI mean estimates are plotted for reference (red line). Nihoa and

Gardner Pinnacles are removed, as data are very limited. Figure continued from previous page.



2.1.7 Reef Fish Population Estimates

Description: ‘Reef fish population estimates’ are calculated by multiplying mean biomass per unit area by estimated hardbottom area in a consistent habitat across all islands (specifically, the area of hardbottom forereef habitat in < 30 meters of water).

Category:

✓ Fishery independent
☐ Fishery dependent
☐ Biological

Timeframe: Triennial

Jurisdiction:

☐ Regional
☐ American Samoa
☐ Guam
☐ Commonwealth of Northern Mariana Islands
☐ Main Hawaiian Islands
✓ Northwest Hawaiian Islands
☐ Pacific Remote Island Areas

Scale:

☐ Regional
☐ Archipelagic
✓ Island
☐ Site

Data Source: Data used to generate mean size estimates come from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section **Error! eference source not found.**). Those estimates are converted to population estimates by multiplying biomass (g/m^2) per island by the estimated area of hardbottom habitat <30 meters deep at the island, which is the survey domain for the monitoring program that biomass data comes from. Measures of estimated habitat area per island are derived from GIS bathymetry and NOAA Coral Reef Ecosystems Program habitat maps. Many reef fish taxa are present in other habitats than is surveyed by the program, and some taxa likely have the majority of their populations in deeper water. Additionally, fish counts have the potential to be biased by the nature of fish response to divers. Curious fishes, particularly in locations where divers are not perceived as a threat, will tend to be overestimated by visual survey, while skittish fishes will tend to be undercounted. It is also likely that numbers of jacks and sharks in some locations, such as the NWHI are overestimated by visual survey. Nevertheless, the data shown here are consistently gathered across space and time.

Rationale: These data have utility in understanding the size of populations from which fishery harvests are extracted.

Table 56. Reef fish population estimates for NWHI CREMUS in 0-30 m hardbottom habitat only. *N* is number of sites surveyed per island.

			Estimated population biomass (metric tonnes) in survey domain of < 30 m hard bottom					
Island	**Total area of reef (Ha)**	***N***	**Acanthuridae**	**Carangidae**	**Carcharhinids**	**Holocentridae**	**Kyphosidae**	**Labridae**
Kure	3,699.4	53	279.0	399.3	1,410.2	27.4	521.0	283.6
Midway	4,995.6	78	1,440.5	1,008.2	1,401.5	77.9	485.2	395.6
Pearl & Hermes	17,812.1	113	4,570.0	24,530.7	2,839.1	202.2	130.7	1,067.8
Lisianski	30,954.9	105	1,985.5	63,822.4	4,268.3	196.1	171.6	776.7
Laysan	3,399.6	31	307.8	441.5	162.9	-	22.0	86.7
Maro	34,192.6	42	4,827.9	5,676.8	10,040.6	117.7	274.1	1,179.6
Gardner	31,733.2	12	1,423.4	4,315.8	15,991.0	-	426.3	340.7
French Frigate	27,797.4	85	3,781.5	30,580.0	3,814.6	440.9	367.8	888.5
Necker	636.6	8	192.6	0.1	94.4	8.6	0.0	24.9
Nihoa	409.9	8	59.3	110.9	43.0	3.0	31.1	16.1
TOTAL	**155,631**	**535**	**21,137.0**	**146,910.5**	**35,152.7**	**1,262.1**	**2,597.5**	**5,499.4**

Island	**Total area of reef (Ha)**	***N***	**Lethrinidae**	**Lutjanidae**	**Mullidae**	**Scaridae**	**Serranidae**
Kure	3,699.4	53	15.5	210.2	30.4	406.7	-
Midway	4,995.6	78	7.3	721.3	102.4	697.8	-
Pearl & Hermes	17,812.1	113	203.1	2,176.3	193.1	875.3	11.9
Lisianski	30,954.9	105	941.3	3,311.5	209.6	2,752.9	-
Laysan	3,399.6	31	104.2	732.6	8.5	119.3	-
Maro	34,192.6	42	1,689.0	4,028.1	88.3	3,495.6	-
Gardner	31,733.2	12	245.6	2,839.8	61.5	64.4	1.3
French Frigate	27,797.4	85	1,142.2	6,407.8	217.5	1,269.8	62.5
Necker	636.6	8	34.3	82.8	3.2	5.5	1.1
Nihoa	409.9	8	7.2	27.9	3.3	19.4	8.0
TOTAL	**155,631**	**535**	**4,815.7**	**20,907.9**	**1,028.0**	**11,024.8**	**94.6**

Note: No Siganidae, *Bolbometopon muricatum,* or *Cheilinus undulatus* were observed in NWHI.

2.2 LIFE HISTORY AND LENGTH-DERIVED PARAMETERS

2.2.1 MHI Coral Reef Ecosystem – Reef Fish Life History

2.2.1.1 Age & Growth and Reproductive Maturity

Description: Age determination is based on counts of yearly growth marks (annuli) and/or daily growth increments (DGIs) internally visible within transversely-cut thin sections of sagittal otoliths. Validated age determination, particularly for long-lived (≥30 years) fish, is based on an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally-based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. The relation between age and fish length is evaluated by fitting this data to a von Bertalanffy growth function based on statistical analyses. The resulting von Bertalanffy growth function predicts the pattern of growth over time for that particular species. This function typically uses three coefficients (L_∞, k, and t_0) which together characterize the shape of the length-at-age growth relationship.

Length at reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved then subsequently 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 3- or 4-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 50% sex reversal ($A\Delta_{50}$) is typically derived by referencing the von Bertalanffy growth function 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 ($A\Delta_{50}$).

Category:

- ☐ Fishery independent
- ☐ Fishery dependent
- ✓ Biological

Timeframe: N/A

Jurisdiction:

- ☐ American Samoa
- ☐ Guam
- ☐ Commonwealth of Northern Mariana Islands
- ✓ Main Hawaiian Islands
- ✓ Northwest Hawaiian Islands
- ☐ Pacific Remote Island Areas

Spatial Scale:

- ☐ Regional
- ✓ Archipelagic
- ☐ Island
- ☐ Site

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. Refer to the "Reference" column in Table 1 for specific details on data sources by species.

Parameter definitions:

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

L_∞ (asymptotic length) – One of three coefficients of the von Bertalanffy growth function (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 mean maximum length and not the observed maximum length.

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

t_0 (hypothetical age at length zero) – One of three coefficients of the VBGF whose measure is highly influenced by the other two VBGF coefficients (k and L_∞) and typically assumes a negative value when specimens representing early growth phases (0+ to 1+ ages) are not available for age determination.

M (natural mortality) – this is a measure of mortality rate for a fish stock not under the influence of fishing pressure 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 two VBGF coefficients (k and L_{∞}) or by calculating the value of the slope from a regression fit to a declining catch curve (regression of the natural logarithm of abundance versus age class) derived from fishing an unfished or lightly fished population.

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

$A\Delta_{50}$ (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.

L_{50} (length at which 50% of a fish species are capable of spawning) – Length (usually in terms of fork 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 & growth.

$L\Delta_{50}$ (length of sex switching) – Length (usually in terms of fork 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 & growth.

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 fish resources in Hawaii is 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 57. Available age, growth, and reproductive maturity information for coral reef species targeted for life history sampling (otoliths and gonads) in the Hawaiian Archipelago. Parameter estimates are for females unless otherwise noted (F=females, M=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm fork length (FL); k in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications (d) are denoted in "Reference" column.

Species	**Age, growth, and reproductive maturity parameters**								**Reference**
	T_{max}	L_∞	k	t_0	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Calotomus carolinus	4[d]				1.3[d]	3.2 [d]	24[d]	37[d]	DeMartini *et al*. (2017), DeMartini and Howard (2016)
Chlorurus perspicillatus	19[d]	53.2[d]	0.23[d]	-1.48[d]	3.1[d]	7 [d]	34[d]	46[d]	DeMartini *et al*. (2017), DeMartini and Howard (2016)
Chlorurus spilurus	11[d]	34.4[d]	0.40[d]	-0.13[d]	1.5[d]	4 [d]	17[d]	27[d]	DeMartini *et al*. (2017), DeMartini and Howard (2016)
Scarus psittacus	6[d]	32.7[d]	0.49[d]	-0.01[d]	1[d]	2.4 [d]	14[d]	23[d]	DeMartini *et al*. (2017), DeMartini and Howard (2016)
Scarus rubroviolaceus	19[d]	53.5[d]	0.41[d]	0.12[d]	2.5[d]	5 [d]	35[d]	47[d]	DeMartini *et al*. (2017), DeMartini and Howard (2016)
Naso unicornis	54[d]	47.8[d]	0.44[d]	-0.12[d]					Andrews *et al*. (2016)

Notes:

[a] signifies estimate pending further evaluation in an initiated and ongoing study.

[b] signifies a preliminary estimate taken from ongoing analyses.

[c] signifies an estimate documented in an unpublished report or draft manuscript.

[d] signifies an estimate documented in a finalized report or published journal article (including in press).

2.2.2 MHI Bottomfish Ecosystem – Bottomfish Life History

2.2.2.1 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, particularly for long-lived (≥30 years) fish, is based on an environmental signal (bomb radiocarbon ^{14}C) produced during previous atmospheric thermonuclear testing in the Pacific and incorporated into the core regions of sagittal otolith and other aragonite-based calcified structures such as hermatypic corals. This technique relies on developing a regionally-based aged coral core reference series for which the rise, peak, and decline of ^{14}C values is available over the known age series of the coral core. Estimates of fish age are determined by projecting the ^{14}C otolith core values back in time from its capture date to where it intersects with the known age ^{14}C coral reference series. The relation between age and fish length is evaluated by fitting this data to a von Bertalanffy growth function based on statistical analyses. The resulting von Bertalanffy growth function predicts the pattern of growth over time for that particular species. This function typically uses three coefficients (L_∞, k, and t_0) which together characterize the shape of the length-at-age growth relationship.

Length at reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved then subsequently 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 ($\boldsymbol{L_{50}}$). 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 3- or 4-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 50% sex reversal ($A\Delta_{50}$) is typically derived by referencing the von Bertalanffy growth function for that species and using the corresponding $\boldsymbol{L_{50}}$ 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 ($A\Delta_{50}$).

Category:

☐ Fishery independent
☐ Fishery dependent
✓ Biological

Timeframe: N/A

Jurisdiction:

☐ American Samoa
☐ Guam
☐ Commonwealth of Northern Mariana Islands
✓ Main Hawaiian Islands
✓ Northwest Hawaiian Islands
☐ Pacific Remote Island Areas

Spatial Scale:

☐ Regional
✓ Archipelagic
☐ Island
☐ Site

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. Refer to the "Reference" column in Table 1 for specific details on data sources by species.

Parameter definitions:

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

L_∞ (asymptotic length) – One of three coefficients of the von Bertalanffy growth function (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 mean maximum length and not the observed maximum length.

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

t_0 (hypothetical age at length zero) – One of three coefficients of the VBGF whose measure is highly influenced by the other two VBGF coefficients (k and L_∞) and typically assumes a negative value when specimens representing early growth phases (0+ to 1+ ages) are not available for age determination.

***M* (natural mortality)** – this is a measure of mortality rate for a fish stock not under the influence of fishing pressure 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 two VBGF coefficients (*k* and L_∞) or by calculating the value of the slope from a regression fit to a declining catch curve (regression of the natural logarithm of abundance versus age class) derived from fishing an unfished or lightly fished population.

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

$A\Delta_{50}$ (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.

L_{50} (length at which 50% of a fish species are capable of spawning) – Length (usually in terms of fork 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 & growth.

$L\Delta_{50}$ (length of sex switching) – Length (usually in terms of fork 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 & growth.

<u>Rationale</u>: 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 fish resources in Hawaii is 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 58. Available age, growth, and reproductive maturity information for bottomfish species targeted for life history sampling (otoliths and gonads) in the Hawaiian Archipelago. Parameter estimates are for females unless otherwise noted (F=females, M=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm fork length (FL); k in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications (^{d}) are denoted in "Reference" column.

Species	**Age, growth, and reproductive maturity parameters**									**Reference**
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Aphareus rutilans							NA		NA	
Aprion virescens	31^b	77.1^b	0.37^b	-0.51^b	X^a		NA	$42.5\text{-}47.5^d$	NA	Everson *et al*. (1989); O'Malley *et al*. (in prep.)
Etelis carbunculus	X^a	X^a	X^a	X^a	X^a		NA	23.4^d	NA	Nichols *et al*. (in prep); DeMartini *et al*. (2017)
Etelis coruscans	X^a	X^a	X^a	X^a		X^a	NA	X^a	NA	Andrews *et al*. (in prep); Reed *et al*. (in prep.)
Hyporthodus quernus	X^a	X^a	X^a	X^a				58.0^d	89.5^d	Andrews *et al*. (in prep); DeMartini *et al*. (2017)
Pristipomoides filamentosus	42^d	67.5^d	0.24^d	-0.29^d			NA	40.7^d	NA	Andrews *et al*. (2012)
Pristipomoides sieboldii							NA	23.8^d	NA	DeMartini (2017)
Pristpomoides zonatus							NA		NA	

Notes:

[a] signifies estimate pending further evaluation in an initiated and ongoing study.

[b] signifies a preliminary estimate taken from ongoing analyses.

[c] signifies an estimate documented in an unpublished report or draft manuscript.

[d] signifies an estimate documented in a finalized report or published journal article (including in press).

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2.3 SOCIOECONOMICS

This section outlines the pertinent economic, social, and community information available for assessing the successes and impacts of management measures or the achievements of Fishery Ecosystem Plan for the Hawaii Archipelago (Western Pacific Regional Fishery Management Council, 2016). It meets the objective “Support Fishing Communities” adopted at the 165th Council meeting; specifically, it identifies the various social and economic groups within the region’s fishing communities and their interconnections. The section begins with an overview of the socioeconomic context for the region, and then provides a summary of relevant studies and data for Hawaii, followed by summaries of relevant studies and data for each fishery within the Hawaiian archipelago.

In 1996, the Magnuson-Stevens Fishery Conservation and Management Act’s National Standard 8 (NS8) specified that conservation and management measures take into account the importance of fishery resources to fishing communities, to provide for their sustained participation in fisheries and to minimize adverse economic impacts, provided that these considerations do not compromise the achievement of conservation. Unlike other regions of the U.S., the settlement of the Western Pacific region was intimately tied to the sea (Figure 11), which is reflected in local culture, customs, and traditions.

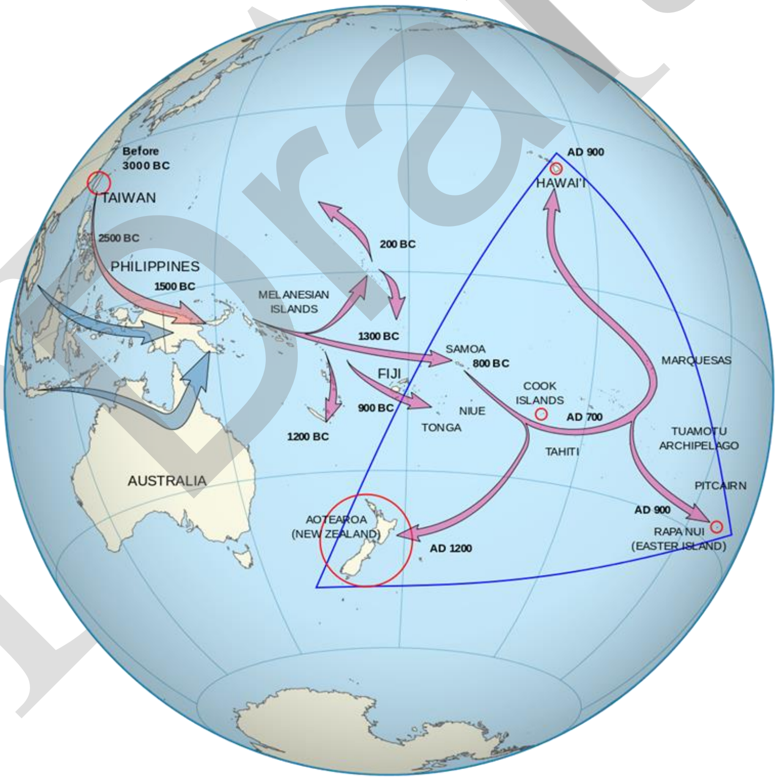

Figure 11. Settlement of the Pacific Islands, courtesy Wikimedia Commons https://commons.wikimedia.org/wiki/File:Polynesian_Migration.svg.

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

2.3.1 Response to Previous Council Recommendations

At its 165th meeting held in Honolulu, Hawaii, the Council approved modifications to the FEP objectives, one of which is to identify the various social and economic groups within the region's fishing communities and their interconnections in support of fishing communities themselves. This chapter meets this objective.

At its 166th meeting held in Tumon, Guam, the Council directed staff to develop a brief report identifying data sources, quality, and coverage for each required socioeconomic parameter in the annual SAFE reports as resources permit. This report should also identify the quality and coverage of this data, as well as any gaps. This data synthesis was conducted and used to guide the development of this chapter with further input and guidance from the Council Social Science Planning Committee and Archipelagic Plan Team.

The Council also directed the Plan Team to consider for future Annual/SAFE reports:

- To include the human perspective, the importance of the community, and the extended cultural and social values of fishing in the dashboard summary format. This chapter is the first effort at including the importance of community and extended cultural and social values into a SAFE report in this region.
- To include enhanced information on social, economic, and cultural impacts of a changing climate and increased pressure on the ocean and its resources. PIFSC developed a Regional Action Plan and Climate Science Strategy as a first step in providing this information (Polovina *et al*., 2016).

2.3.2 Introduction

The geography and overall history of the Hawaiian Archipelago, including indigenous culture and current demographics and description of fishing communities is described in the Fishery Ecosystem Plan for the Hawaii Archipelago (Western Pacific Regional Fishery Management Council, 2009). Over the past decade, a number of 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 fish ponds, some of which date back thousands of years are still used today. The Native Hawaiian land and marine tenure system, known as ahupuaʻa-based management, divided the islands into large parcels called moku, which are reflected in modern political boundaries (Census County Districts).

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

Today, fishing continues to play a central role in the local Hawaiian culture, diet, and economy. In 2012, an estimated 486,000 people were employed in marine-related businesses in Hawaiʻi, with the level of commercial fishing-related employment well above the national average (Richmond *et al*., 2015). The Fisheries Economics of the United States 2014 report found that the seafood industry (including the commercial harvest sector, seafood processors and dealers, seafood wholesalers and distributors, importers, and seafood retailers) generated $743 million in sales impacts and approximately 10,000 full and part-time jobs that year (NMFS, 2016). Recreational anglers took 1.4 million fishing trips, and 1,061 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*., 2010; Davidson *et al*., 2012). In addition, studies have shown that seafood is eaten frequently, at least once a week by most, and at least once a month by almost all respondents (National Coral Reef Monitoring Program, 2016). Fresh seafood is the most popular type of seafood purchased, and while most is purchased at markets or restaurants, a sizeable amount is reported as caught by friends, neighbors, or extended family (National Coral Reef Monitoring Program, 2016; Davidson *et al*., 2012).

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

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

2.3.3 People who Fish

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

The Hawaii small boat pelagic fleet was studied in 2007-2008 (hereafter, referred to as the 2008 study), following a design last utilized in 1997 (Hospital *et al*., 2011). Because respondents also targeted insular fish, the study is included in this report. Their work was updated in 2014 by Chan and Pan (2017) for the small boat fleet in general. Both studies found that the small boat fleet is predominantly owner-operated and a male dominated activity (98% of respondents were male in both studies). The ethnic composition was predominantly Asian (45% in 2008, 41% in 2014) and White (23% in 2008, 26% in 2014), which is similar to the demographics of the state population as a whole. In 2014, proportionally more Native Hawaiians and Pacific Islanders responded to the survey than are represented in the general population (18% vs. 10%). In addition, the majority of 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 59.

Table 59. Catch disposition by fisherman self-classification (from Chan and Pan, 2017).

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

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

The 2008 study was also the first attempt to quantify the scale of unsold fish that was shared within community networks. For commercial fishermen, trips where no fish are sold (30.5%) were nearly equal to trips where profit was made (30.9%). In addition, 97% of survey respondents indicated they participated in fish sharing networks with friends and relatives, and more than 62% considered the fish they catch as an important food source for their family. Community networks were also present in the outlets where fish were sold, which included the United Fishing Agency (UFA) auction in Honolulu, dealers/wholesalers, markets/stores, restaurants, roadside, but also sales to friends, neighbors, and coworkers. The 2014 study also documented 27% of sales to friends, neighbors, or coworkers and corroborated the importance of giving away fish for all self-classification categories (Table 59). 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 motor boat (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.

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

2.3.4 Costs of Fishing

Past research has documented the costs of fishing in Hawaii (Hamilton and Huffman, 1998; 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 60 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 60. Hawaii small boat costs for bottomfish and reef fish trips in 2014.

Cost Category	Bottomfish handline		Reef Fish (spear)	
	$ per trip	% of total trip cost	$ per trip	% of total trip cost
Fuel	134.24	53%	86.26	54%
Non-fuel	118.34	47%	72.68	46%
Total cost	252.58	100%	158.94	100%

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

2.3.5 Bottomfish

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

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

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

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

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

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

2.3.5.1 Commercial Participation, Landings, Revenues, Prices

This section will describe trends in commercial participation, landings, revenues, and prices, as data allows, for the Hawaii bottomfish fishery. Figure 12 shows the trend of number of fishers with sales for Hawaii bottomfish 2008-2017. Figure 13 shows percent of fishers with BMUS sales, 2008-2017.

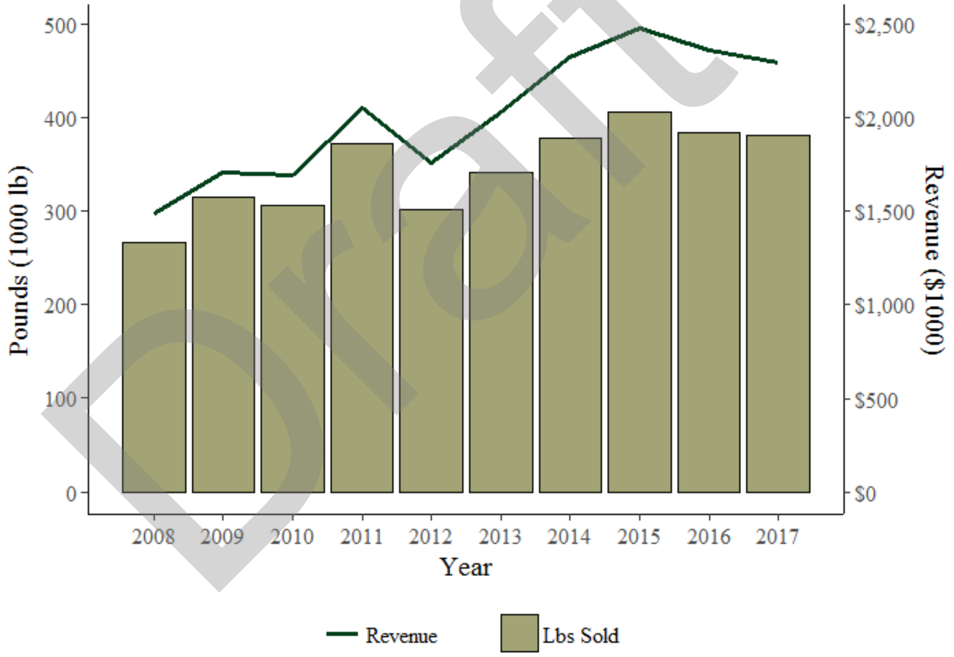

Figure 14 shows the pounds sold and revenue of BMUS of Hawaii bottomfish fishery, 2008-2017. Supporting data for the three figures are presented in Table 61. Figure 15 presents the fish price trends for deep 7 and Non-deep 7 of Hawaii bottomfish fishery, 2007-2017. Supporting data for Figure 15 are presented in Table 62.

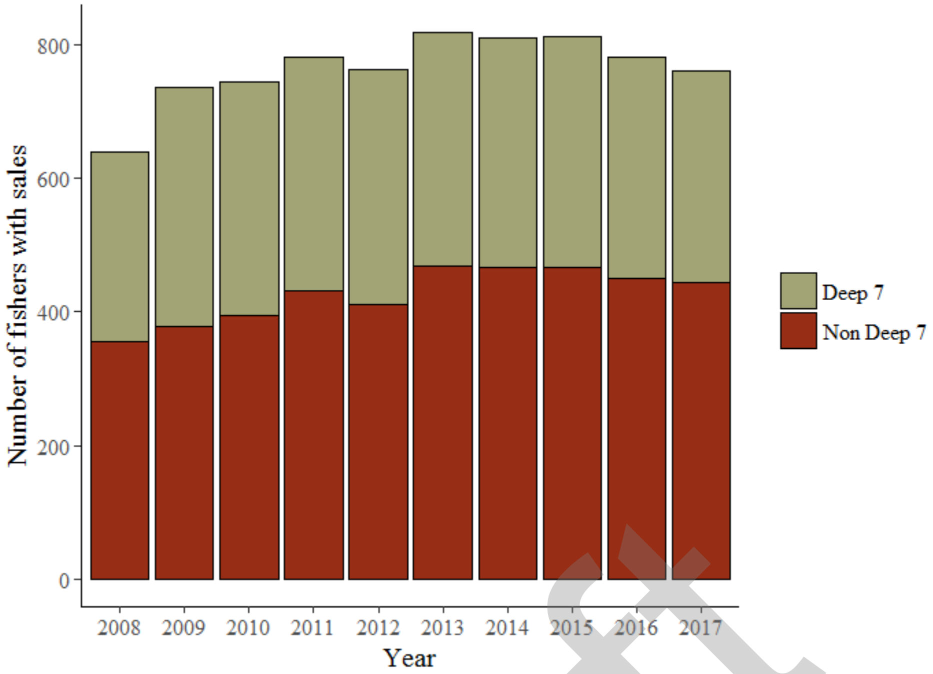

Figure 12. Fishers with sales in the Hawaii bottomfish fishery from 2008-2017.

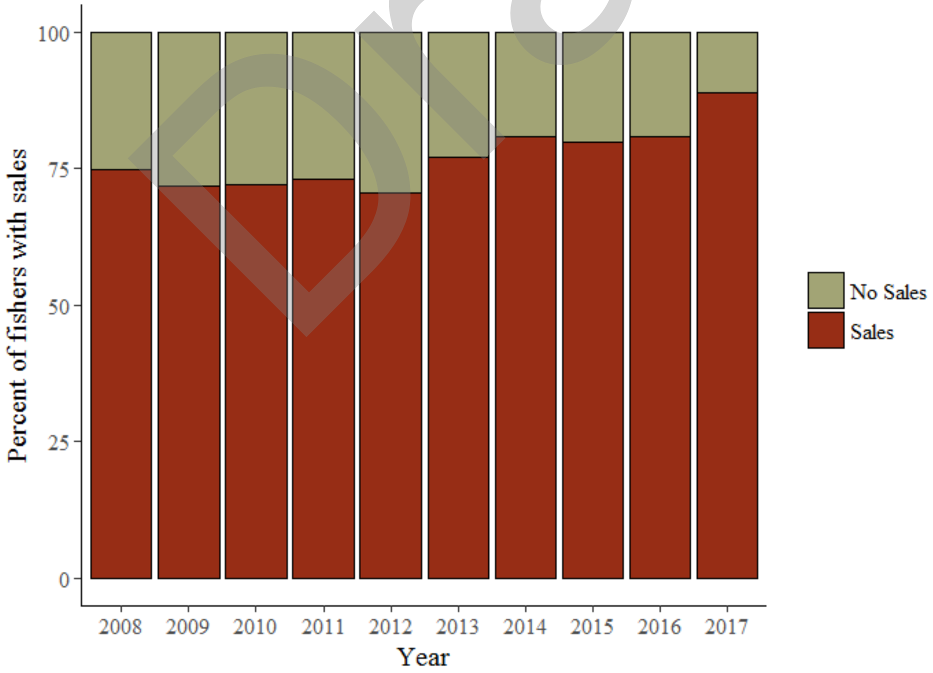

Figure 13. Percent of fishers with BMUS sales from 2008-2017. Data from WPacFIN.

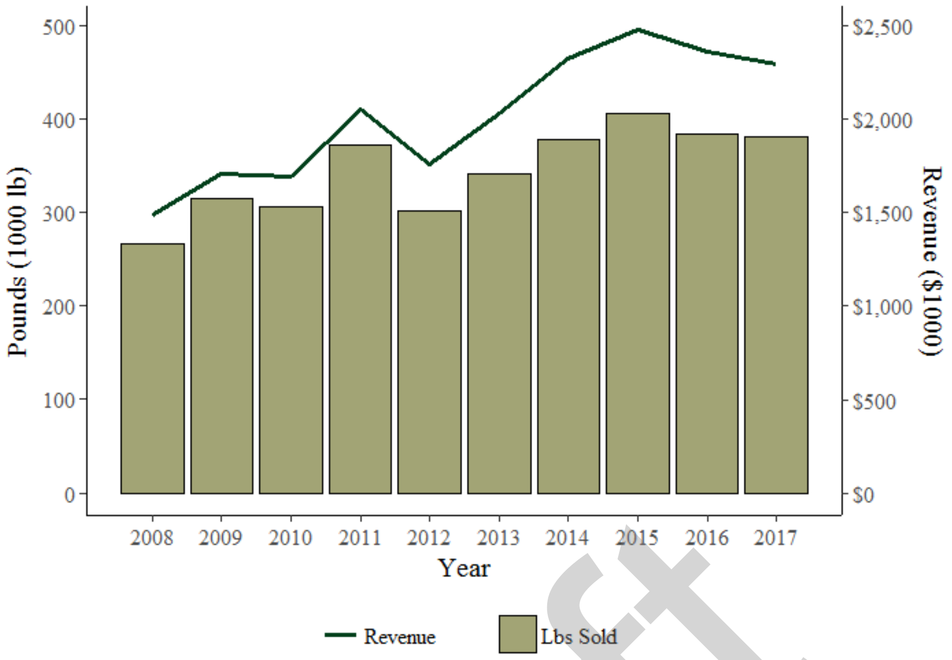

Figure 14. Pounds sold and revenue of BMUS in the Hawaii bottomfish fishery from 2008-2017 (adjusted to 2017 dollars).

Table 61. Commercial landings and revenue information of the Hawaii bottomfish fishery from 2008-2017.

Year	Estimated pounds sold (lb)	Estimated revenue ($)	Estimated revenue ($ adjusted)	# of fishers in dealer	# of fishers in HDAR	% of fishers sold fish	Fish price ($)	Fish price ($ adjusted)	CPI adjustor
2008	266,722	1,250,899	1,494,824	476	636	75%	4.69	5.60	1.195
2009	314,177	1,440,892	1,688,725	550	765	72%	4.59	5.38	1.172
2010	306,128	1,462,737	1,686,536	566	785	72%	4.78	5.51	1.153
2011	372,273	1,840,418	2,068,630	569	779	73%	4.94	5.56	1.124
2012	301,958	1,615,047	1,757,171	559	793	70%	5.35	5.82	1.088
2013	340,932	1,893,305	2,020,156	623	808	77%	5.55	5.93	1.067
2014	377,372	2,199,838	2,314,230	602	744	81%	5.83	6.13	1.052
2015	405,513	2,372,883	2,465,425	606	759	80%	5.85	6.08	1.039
2016	384,512	2,304,786	2,350,882	575	712	81%	5.99	6.11	1.020
2017	381,183	2,292,822	2,292,822	555	625	89%	6.02	6.02	1

Data source: PIFSC WPacFIN from HDAR data.

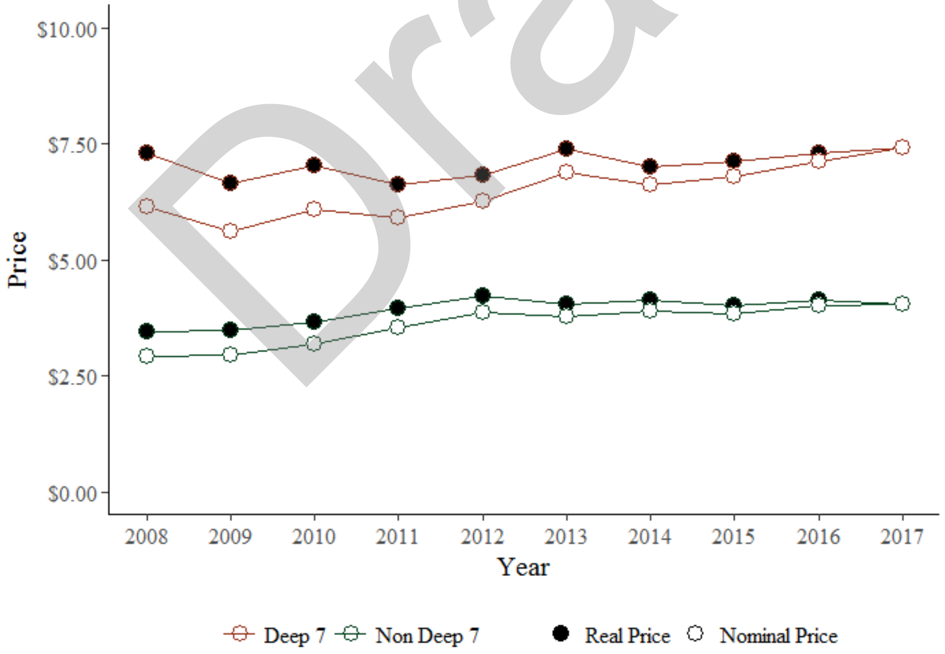

Figure 15. Fish prices of Deep 7 and Non-Deep7 in the Hawaii bottomfish fishery from 2008-2017.

Table 62. Fish sold, revenue, and price information of Deep 7 and Non-Deep7 of Hawaii bottomfish fishery from 2008-2017.

Year	Deep 7 pounds sold (lb)	Deep 7 revenue ($)	Non-Deep 7 pounds sold (lb)	Non-Deep 7 revenue ($)	Deep 7 price ($)	Deep 7 price ($ adjusted)	Non-Deep 7 price ($)	Non-deep 7 price ($ adjusted)	CPI adjustor
2008	147,316	1,079,454	119,406	415,370	6.13	7.33	2.91	3.48	1.196
2009	193,175	1,272,043	121,001	416,682	5.62	6.58	2.94	3.44	1.171
2010	169,884	1,188,754	136,244	497,781	6.07	7.00	3.17	3.65	1.153
2011	219,958	1,462,691	152,316	605,939	5.91	6.65	3.54	3.98	1.125
2012	187,672	1,277,158	114,286	480,013	6.26	6.81	3.86	4.20	1.088
2013	195,272	1,435,630	145,660	584,526	6.89	7.35	3.76	4.01	1.067
2014	267,533	1,863,420	109,839	450,810	6.62	6.97	3.90	4.10	1.053
2015	275,548	1,946,131	129,965	519,294	6.80	7.06	3.85	4.00	1.038
2016	245,083	1,779,794	139,429	571,087	7.12	7.26	4.01	4.10	1.020
2017	223,394	1,656,466	157,789	636,357	7.41	7.41	4.03	4.03	1

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

2.3.5.2 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). The PIFSC Socioeconomics Program has used this framework to evaluate select regional fisheries; specifically, the Hawaii Longline, American Samoa Longline, and Main Hawaiian Islands (MHI) Deep 7 bottomfish fisheries. These indicators include metrics related to catch, effort, and revenues. This section will present revenue and pounds kept performance metrics of; (a) fishery revenue per vessel (per CML) and Gini coefficient, (b) revenue per-day-at-sea and pounds kept per-day-at-sea.

The performance index presented included any trip that catches one or more of the Deep 7 and non-Deep 7 bottomfish species in main Hawaiian Islands. 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. 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. The 2016 fishing year is defined by September 1, 2016 through August 31, 2017.

3. The weight of the kept catch, 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, estimated as the weight of the kept catch times the annual average price per pound.

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

Trends in fishery revenue per vessel and Gini coefficient are shown Figure 16 while trends in (b) revenue per-day-at-sea and pounds kept per-day-at-sea are shown in Figure 17. In these figures "fishery" revenues refers all BMUS species catch and revenues and excludes other species (such as pelagic caught in the same trips). Supporting data are provided in Table 63.

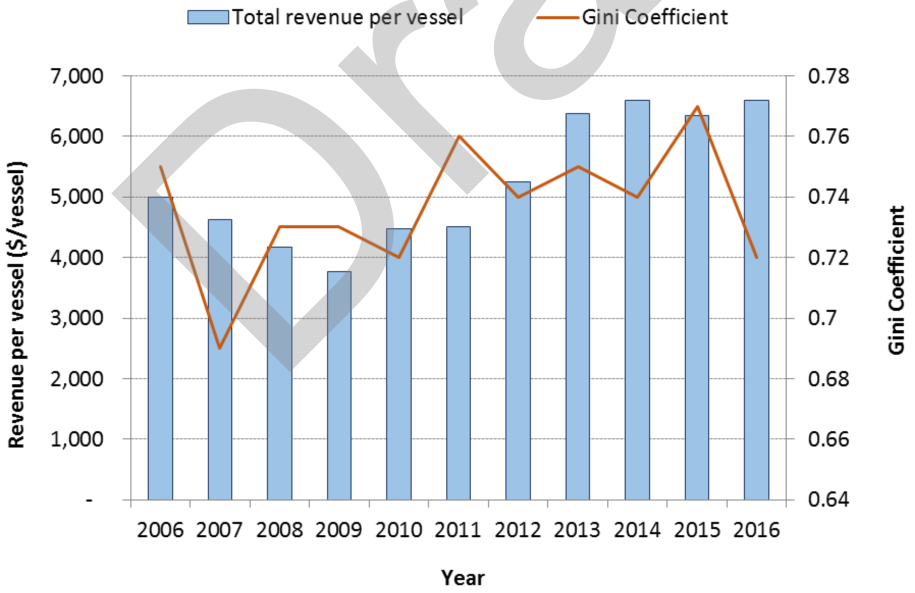

Figure 16. Trends in fishery revenue per vessel and Gini coefficient, 2006-2016 (Adjusted to 2016 dollars) Data sourced from Tier 1 data request.

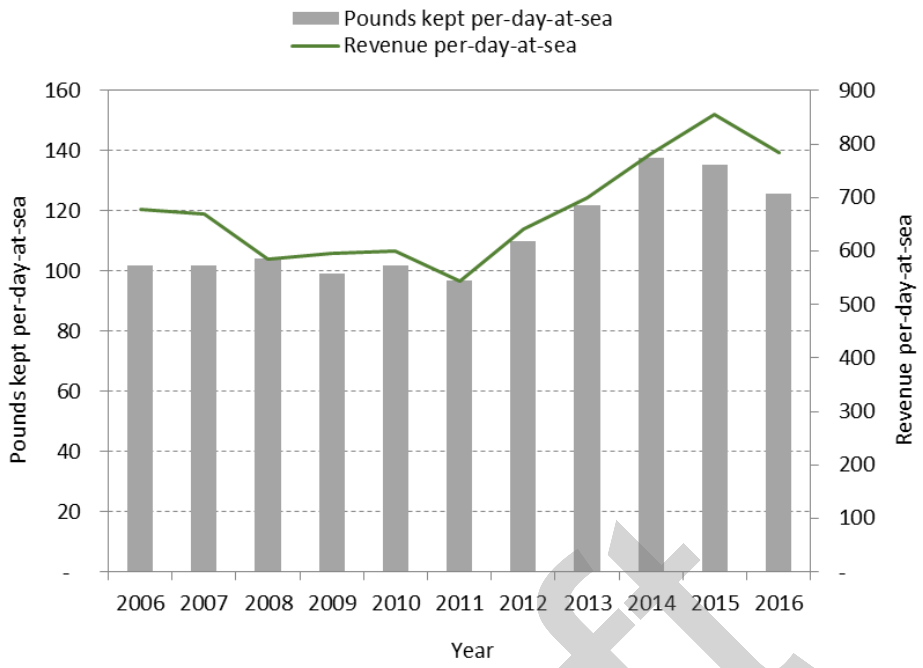

Figure 17. Revenue per-day-at-sea and pounds kept per-day-at-sea from 2006-2016 (adjusted to 2016 dollars).

Table 63. Hawaii Bottomfish Fishery Economic Performance Measures (Revenue and Pounds Kept per Vessel and per Day at Sea).

Year	Revenue per Vessel	Revenue per Vessel ($ adjusted)	Gini Coefficient	Pounds Kept per-day-at-sea	Revenue per-day-at-sea	Revenue per-day-at-sea ($adjusted)	CPI Adjutor
2007	3,822	4,621	69%	102	669	809	1.209
2008	3,602	4,175	73%	104	585	678	1.159
2009	3,260	3,758	73%	99	596	687	1.153
2010	3,960	4,471	72%	102	600	678	1.129
2011	4,147	4,516	76%	97	545	593	1.089
2012	4,936	5,247	74%	110	640	681	1.063
2013	6,101	6,376	75%	122	700	732	1.045
2014	6,409	6,602	74%	138	782	805	1.030
2015	6,215	6,340	77%	136	855	872	1.020
2016	6,598	6,598	72%	126	784	784	1

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

2.3.6 Reef Fish

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

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

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

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

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

With respect to management strategies, at least half of respondents agreed with all the presented management strategies, which ranged from catch limits, to gear restrictions, to enforcement, and 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.

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

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

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

2.3.6.1 Commercial Participation, Landings, Revenues, Prices

This section will describe trends in commercial participation, landings, revenues, and data allows, for the Hawaii coral reef fish fishery. Figure 18 shows the trend of number of fishers with sales for Hawaii coral reef fish fishery 2008-2017. Figure 19 shows percent of fishers with CREMUS sales, 2008-2017. Figure 20 shows the pounds sold and revenue of CREMUS of Hawaii coral reef fish fishery, 2008-2017. Figure 21 shows that prices of nominal and adjusted prices of CREMUS of Hawaii coral reef fishery, 2008-2017. Supporting data for the four figures on the Hawaii coral reef fishery are presented in

Table 64.

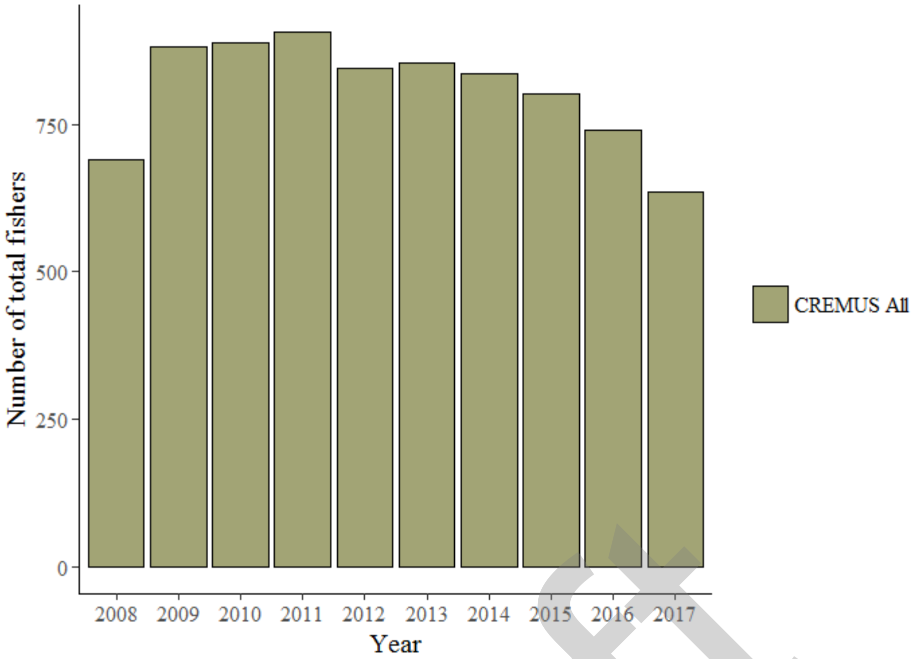

Figure 18. Fishers with sales in the Hawaii coral reef fishery from 2008-2017.

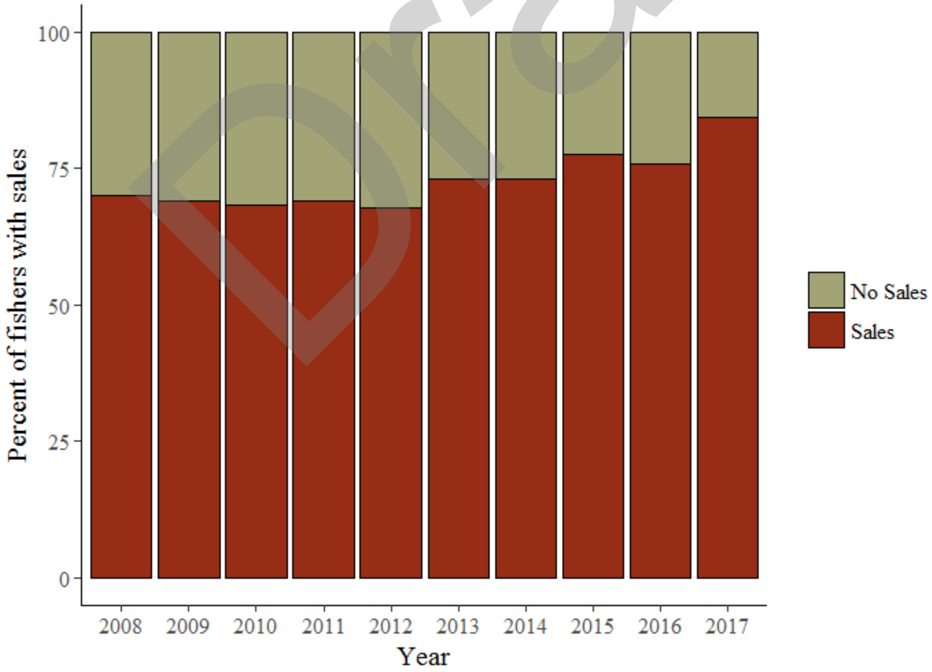

Figure 19. Percent of fishers with sales in the Hawaii coral reef fishery from 2008-2017.

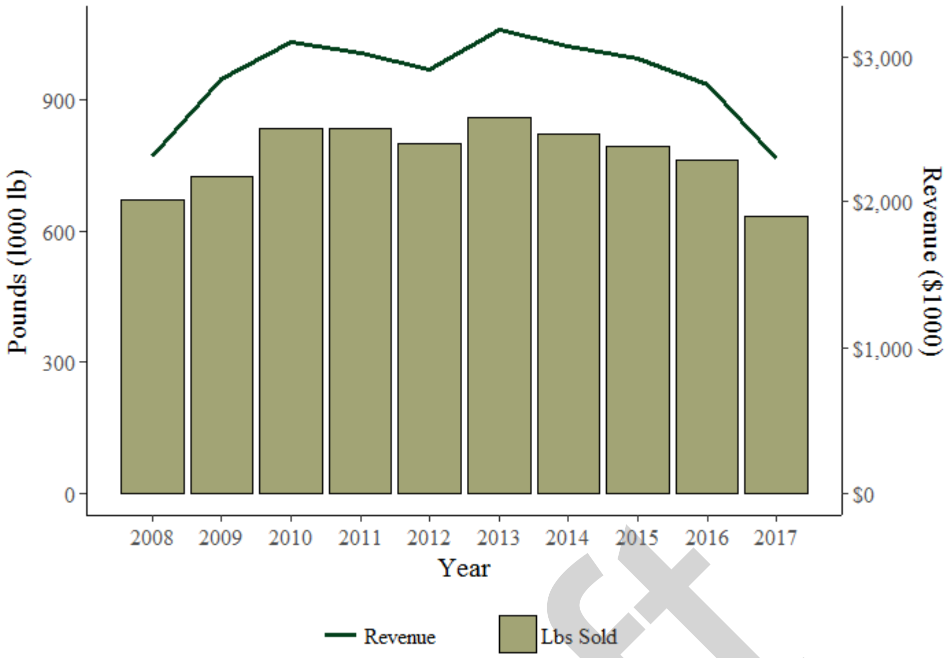

Figure 20. Pounds sold and revenue of Hawaii coral reef fishery from 2008-2017.

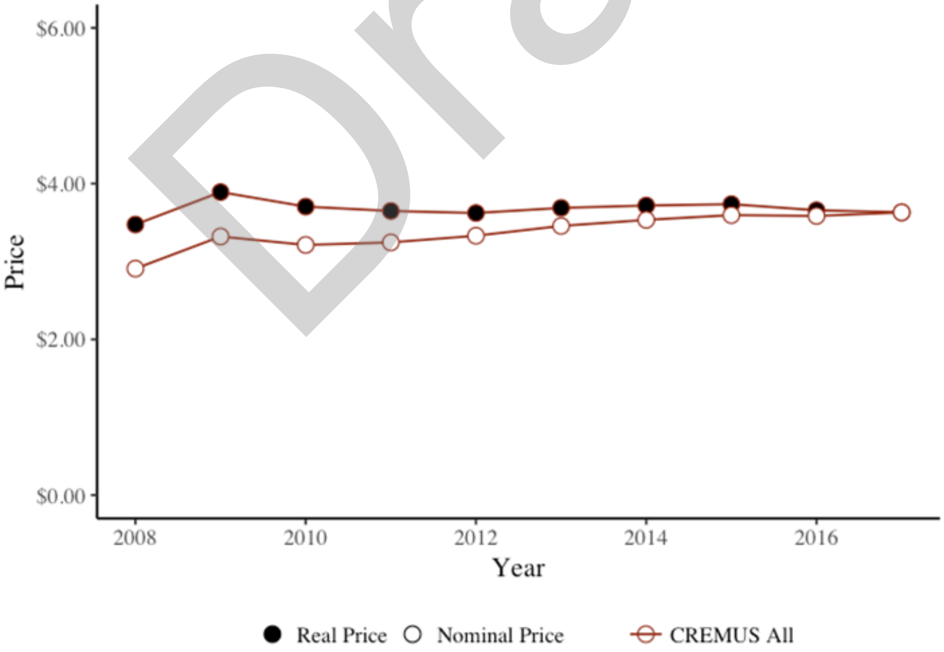

Figure 21. Prices of CREMUS of Hawaii coral reef fishery from 2008-2017.

Table 64. Commercial landings and revenue information of Hawaii coral reef fish fishery from 2008- 2017.

Year	Estimated pounds sold (lb)	Estimated revenue ($)	Estimated revenue ($ adjusted)	# of fishers in dealer reports	# of fishers in HDAR reports	% of fishers sold fish	Fish price ($)	Fish price ($ adjusted)	CPI adjustor
2008	670,261	1,948,943	2,328,987	482	689	70%	2.91	3.47	1.195
2009	725,712	2,409,713	2,824,184	608	881	69%	3.32	3.89	1.172
2010	834,636	2,682,050	3,092,404	606	888	68%	3.21	3.71	1.153
2011	834,092	2,707,734	3,043,493	626	907	69%	3.25	3.65	1.124
2012	800,856	2,666,503	2,901,155	572	844	68%	3.33	3.62	1.088
2013	861,579	2,978,297	3,177,843	623	853	73%	3.46	3.69	1.067
2014	823,509	2,910,882	3,062,248	611	836	73%	3.53	3.72	1.052
2015	794,064	2,855,600	2,966,968	623	802	78%	3.60	3.74	1.039
2016	763,805	2,739,340	2,794,127	561	740	76%	3.59	3.66	1.020
2017	633,152	2,299,004	2,299,004	535	635	84%	3.63	3.63	1

Data source: PIFSC WPacFIN from HDAR data.

2.3.7 Crustaceans

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

2.3.8 Precious Corals

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

2.3.9 Ongoing Research and Information Collection

Social indicators are being compiled, in accordance with a national project to describe and evaluate community well-being in terms of social, economic, and psychological welfare (https://www.st.nmfs.noaa.gov/humandimensions/social-indicators/index). In 2017, a web-based tool is being developed to compile relevant socioeconomic data into a "Community Snapshot" by Census County Division. In addition, an external review of the Economics and Human Dimensions Program was undertaken (PIFSC, 2017). Recommendations will help focus and prioritize a strategic research agenda.

2.3.10 Relevant PIFSC Economics and Human Dimensions Publications: 2016

Chan, H.L. and Pan, M., 2017. Economic and social characteristics of the Hawaii small boat fishery 2014. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-63, 97 p. https://doi.org/10.7289/V5/TM-PIFSC-63.

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Pacific Islands Fisheries Science Center (PIFSC) Socioeconomics Program, 2017. Potential Economic Impacts of the Papahānaumokuākea Marine National Monument Expansion. Pacific Islands Fisheries Science Center, PIFSC Internal Report, IR-17-06, 14p.

Pacific Islands Fisheries Science Center (PIFSC), 2017. Hawaii Community Snapshot Tool. https://www.pifsc.noaa.gov/socioeconomics/hawaii-community-snapshots.php.

2.3.11 References

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Memo., NOAA-TM-NMFS-PIFSC-20, 19 p. + Appendix. https://www.pifsc.noaa.gov/library/pubs/tech/NOAA_Tech_Memo_PIFSC_20.pdf.

Hospital, J. and Beavers, C., 2011. Management of the main Hawaiian Islands bottomfish fishery: fishers' attitudes, perceptions, and comments. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96822-2396. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-11-06, 46 p. + Appendices. https://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_11-06.pdf

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2.4 PROTECTED SPECIES

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

2.4.1 Indicators for Monitoring Protected Species Interactions in the Hawai`i FEP Fisheries

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

2.4.1.1 FEP Conservation Measures

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

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

2.4.1.2 ESA Consultations

Hawai`i FEP fisheries are covered under the following consultations under section 7 of the ESA, through which NMFS has determined that these fisheries are not likely to jeopardize or adversely affect any ESA-listed species or critical habitat in the Hawai`i Archipelago (Table 65).

In January 2018, oceanic whitetip sharks and giant manta rays were listed under the ESA (83 FR 4153 and 83 FR 2916, respectively). NMFS will reinitiate consultation for those two species for the applicable fisheries if NMFS determines that effects are likely. There is no record of giant manta ray incidental catches in Hawaiian non-longline fisheries, and NMFS is reviewing catch data on oceanic white tip shark incidental catch in these fisheries.

Table 65. Summary of ESA consultations for Hawai`i FEP Fisheries.

Fishery	**Consultation date**	**Consultation type**[a]	**Outcome**[b]	**Species**
Bottomfish	3/18/2008	BiOp	NLAA	Loggerhead sea turtle, leatherback sea turtle, olive ridley sea turtle, green 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)
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)
Coral reef ecosystem (Kona Kanpachi Special Coral Reef Ecosystem Fishing Permit only)	9/19/2013	LOC (USFWS)	NLAA	Short-tailed albatross, Hawaiian petrel, Newell's shearwater
	9/25/2013	LOC	NLAA	Loggerhead sea turtle (North Pacific DPS), leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, North Pacific right whale, sei whale, sperm whale, Hawaiian monk seal, false killer whale (MHI insular DPS)

Fishery	**Consultation date**	**Consultation type**[a]	**Outcome**[b]	**Species**
Crustacean	12/5/2013	LOC	NLAA	Loggerhead sea turtle (North Pacific DPS), leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, North Pacific right whale, sei whale, sperm whale, Hawaiian monk seal, false killer whale (MHI insular DPS)
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)
All fisheries	3/1/2016	LOC	NLAA	Hawaiian monk seal critical habitat

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

Bottomfish Fishery

In a March 18, 2008 Biological Opinion (BiOp) covering MHI bottomfish fishery, NMFS determined that the MHI bottomfish fishery is not likely to jeopardize the green 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 MHI insular false killer whale distinct population segment under the ESA. In a modification to the 2008 BiOp dated August 7, 2013, NMFS determined that commercial and non-commercial bottomfish fisheries in the MHI are not likely to adversely affect MHI insular false killer whale because of the spatial separation between the species and bottomfishing activities, the low likelihood of collisions, and the lack of observed or reported fishery interactions were among other reasons.

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

Crustacean Fishery

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

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 listed species under USFWS's exclusive jurisdiction (i.e., seabirds) and listed species shared with NMFS (i.e., sea turtles).

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

Precious Coral Fishery

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

2.4.1.3 Non-ESA Marine Mammals

The MMPA requires NMFS to annually publish a List of Fisheries (LOF) that classifies commercial fisheries in one of three categories based on the level of mortality and serious injury of marine mammals associated with that fishery. According to the 2018 LOF (83 FR 5349, February 7, 2018), the bottomfish (HI bottomfish handline), precious coral (HI black coral diving), coral fish (HI spearfishing), and crustacean (HI crab trap, lobster trap, shrimp trap, crab net, Kona crab loop net, lobster diving) fisheries are classified as Category III fisheries (i.e. a remote likelihood of or no known incidental mortality and serious injury of marine mammals).

2.4.2 Status of Protected Species Interactions in the Hawai`i FEP Fisheries

Bottomfish Fishery

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

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

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

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

Crustacean, Coral Reef, and Precious Coral Fisheries

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

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, 2016).

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

2.4.3 Identification of Emerging Issues

Several ESA-listed species are being evaluated for critical habitat designation (Table 66). If critical habitats are designated, they will be included in this SAFE report and impacts from FEP-managed fisheries will be evaluated under applicable mandates.

Table 66. Candidate ESA species, and ESA-listed species being evaluated for critical habitat designation.

Species		**Listing process**			**Post-listing activity**	
Common name	**Scientific name**	**90-day finding**	**12-month finding / Proposed rule**	**Final rule**	**Critical Habitat**	**Recovery Plan**
Oceanic whitetip shark	*Carcharhinus longimanus*	Positive (81 FR 1376, 1/12/2016)	Positive, threatened (81 FR 96304, 12/29/2016)	Listed as Threatened (83 FR 4153, 1/30/18)	Not determinable because of insufficient data (83 FR 4153, 1/30/18)	TBA
Pacific bluefin tuna	*Thunnus orientalis*	Positive (81 FR 70074, 10/11/2016)	Not warranted (82 FR 37060, 8/8/17)	N/A	N/A	N/A
Giant manta ray	*Manta birostris*	Positive (81 FR 8874, 2/23/2016)	Positive, threatened (82 FRN 3694, 1/12/2017)	Listed as Threatened (83 FR 2916, 1/22/18)	Not determinable because of insufficient data (83 FR 2916, 1/22/18)	TBA
Reef manta ray	*Manta alfredi*	Positive (81 FR 8874, 2/23/2016)	Not warranted (82 FRN 3694, 1/12/2017)	N/A	N/A	N/A
False killer whale (MHI Insular DPS)	*Pseudorca crassidens*	Positive (75 FR 316, 1/5/2010)	Positive, endangered (75 FR 70169, 11/17/2010)	Listed as endangered (77 FR 70915, 11/28/2012)	Critical habitat maps proposed (82 FR 51186, 11/3/17), comment period closed 1/2/18, final rule expected 7/1/2018	In development, public comment expected 2018
Green sea turtle	*Chelonia mydas*	Positive (77 FR 45571, 8/1/2012)	Identification of 11 DPSs, endangered and threatened (80 FR 15271, 3/23/2015)	11 DPSs listed as endangered and threatened (81 FR 20057, 4/6/2016)	In development, proposal expected TBA[a]	TBA

[a] NMFS and USFWS have been tasked with higher priorities regarding sea turtle listings under the ESA, and do not anticipate proposing green turtle critical habitat designations in the immediate future.

2.4.4 Identification of Research, Data, and Assessment Needs

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

- Improve the precision of commercial and non-commercial fisheries data to improve understanding of potential protected species impacts.
- Define and evaluate innovative approaches to derive robust estimates of protected species interactions in insular fisheries.
- Update analysis of fishing-gear related strandings of Hawai`i green turtles.

2.4.5 References

Kobayashi, D. and Kawamoto, K., 1995. Evaluation of shark, dolphin, and monk seal interactions with NWHI bottomfishing activity: A comparison of two time periods and an estimate of economic impacts. *Fisheries Research*, *23*, pp. 11-22.

Nitta, E. 1999. Draft: Summary report: Bottomfish observer trips in the Northwestern Hawaiian Islands, October 1990 to December 1993. Honolulu, Hawaii, NMFS Pacific Islands Area Office, Pacific Islands Protected Species Program.

WPFRMC, 2009. Fishery Ecosystem Plan for the Hawaii Archipelago. WPFRMC, Honolulu, Hawaii, 286 p.

WPRFMC, 2017. Annual Stock Assessment and Fishery Evaluation Report: Hawaii Archipelago Fishery Ecosystem Plan 2016. WPFRMC, Honolulu, Hawaii, 533 p.

2.5 CLIMATE AND OCEANIC INDICATORS

2.5.1 Introduction

Beginning with the 2015 Annual Report, we have included a chapter on indicators of current and changing climate and related oceanic conditions in the geographic areas for which the Western Pacific Regional Fishery Management Council has responsibility. There are a number of 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:

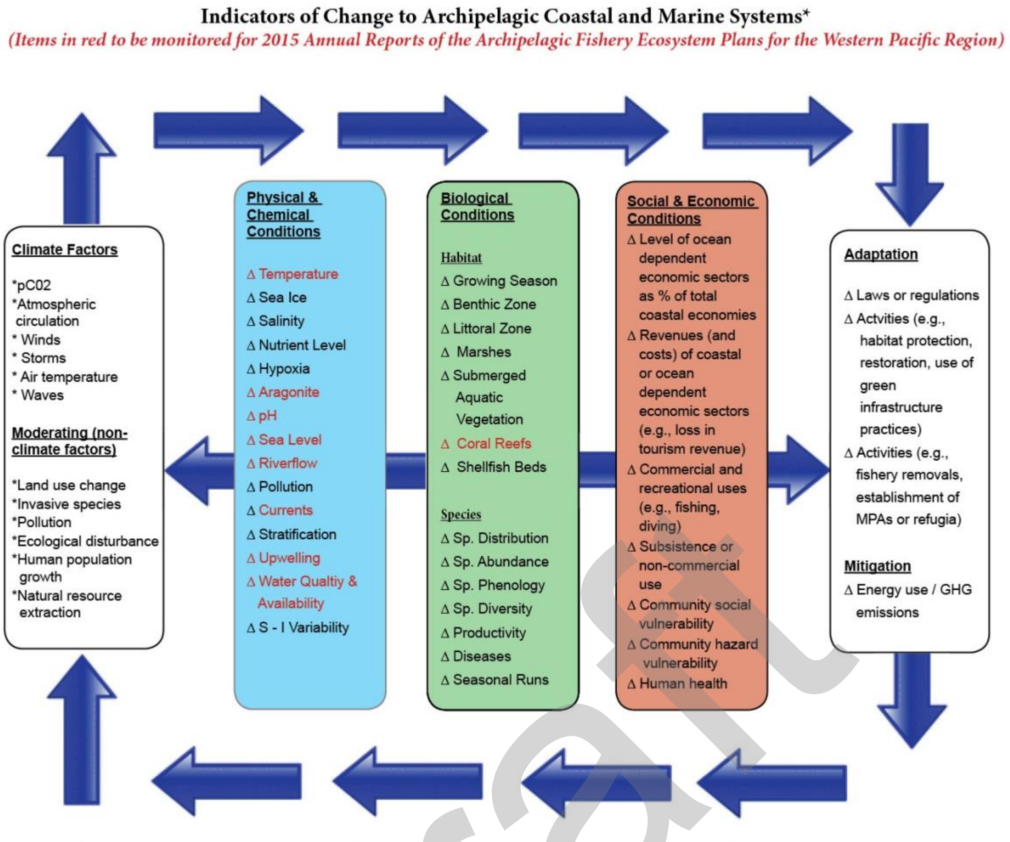
- Emerging scientific and community understanding of the impacts of changing climate conditions on fishery resources, the ecosystems that sustain those resources and the communities that depend upon them;
- Recent Federal Directives including the 2010 implementation of a National Ocean Policy that identified Resiliency and Adaptation to Climate Change and Ocean Acidification as one of nine National priorities; the development of a Climate Science Strategy by the National Marine Fisheries Service (NMFS) in 2015 and the ongoing development of Pacific Regional Climate Science program
- The Council's own engagement with the National Oceanic and Atmospheric Administration (NOAA) as well as jurisdictional fishery management agencies in American Samoa, the Commonwealth of the Northern Mariana Islands, Guam and Hawaii as well as fishing industry representatives and local communities in those jurisdictions; and
- Deliberations of the Council's Marine Planning and Climate Change Committee.

Starting with the 2015 Report, the Council and its partners have provided continuing descriptions of changes in a series of climate and oceanic indicators that will grow and evolve over time as they become available and their relevance to Western Pacific fishery resources becomes clear.

2.5.2 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:



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

Figure 22. Simplified representation of the climate and non-climate stressors in the coastal and marine ecosystems.

As described in the 2014 NCADAC report, the conceptual model represents 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 2015 Annual Report; the specific indicators used in the Report are listed in Section 2.4. Other indicators will be added over time as datasets become available and understanding of the nature 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 that will enable the Council and its partners to move from observations and correlations to understanding the specific nature of interactions and developing capabilities to predict future changes of importance in developing, evaluating, and adapting ecosystem-fishery plans in the Western Pacific Region.

2.5.3 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.

Beginning with the 2015 report on Western Pacific Pelagic resources, the Council has included the following climate and oceanic indicators:

Atmospheric Carbon Dioxide (at Mauna Loa Observatory) – Increasing atmospheric CO_2 is a primary measure of anthropogenic climate change.

Ocean pH (at Station ALOHA) – Ocean pH provides a measure of ocean acidification. Increasing ocean acidification limits the ability of marine organisms to build shells and other hard structures.

Oceanic Niño Index (ONI) – Sea surface temperature anomaly from Niño 3.4 region (5°N - 5°S, 120° - 170°W). This index is used to determine the phase of the El Niño – Southern Oscillation (ENSO), which has implications across the region affecting migratory patterns of key commercial fish stocks which, in turn, affect the location, safety and costs of commercial fishing.

Pacific Decadal Oscillation (PDO) – Like ENSO, the PDO reflects changes between periods of persistently warm or persistently cool ocean temperatures, but over a period of 20 – 30 years versus 6 – 18 months for ENSO event. The climatic finger prints of the PDO are most visible in the Northeastern Pacific, but secondary signatures exist in the tropics.

Sea Surface Temperature –Monthly sea surface temperature and anomaly blended from three data sources covering 1985-2017: Pathfinder v 5.0, the Global Area Coverage, and the GOES-POES dataset from both the AVHRR instrument aboard the NOAA Polar Operational Environmental Satellite (POES) and the Geostationary Operational Environmental Satellite (GOES). Sea surface temperature is one of the most directly observable measures we have for tracking increasing ocean temperature.

Sea Surface Temperature Anomaly – Sea surface temperature anomaly highlights long term trends. Filtering out seasonal cycle, and showing the current year relative to past years, sea surface temperature anomaly provides context on one of the most directly observable measures we have for tracking increasing ocean temperature.

Coral Thermal Stress Exposure – In tropical coastal habitats, one tangible impact of high temperature anomalies is the possibility of mass coral bleaching. To help gauge the history and impact of thermal stress on coastal corals, we present a satellite-derived metric called Degree Heating Weeks.

Chlorophyll-A – Monthly chlorophyll-a spanning 2002-2017 from the MODIS sensor aboard the NASA Aqua satellite. Chlorophyll-A is derived from ocean color, and is a proxy for the amount of phytoplankton in the seawater. Combined with temperature, it can give an index of primary production.

Chlorophyll-Anomaly – Deviation from seasonal and inter-annual chlorophyll-a (chl-A) patterns can provide a means of assessing the relative distinctiveness of 2017, as well as how chl-A varies over time.

Heavy Weather (Tropical Cyclones & Storm Force Winds) -- Measures of tropical cyclone occurrence, strength, and energy. Percentage occurrence of winds > 34 knots. Tropical cyclones and high winds may have the potential to significantly impact fishing operations.

Rainfall – Rainfall has been proposed as a potentially important correlate for the catch of some nearshore species, especially nearshore pelagics.

Sea Level (Sea Surface Height) and Anomaly – 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. NOTE that no water level gauges are available in PRIA so only regional information on this Indicator is included.

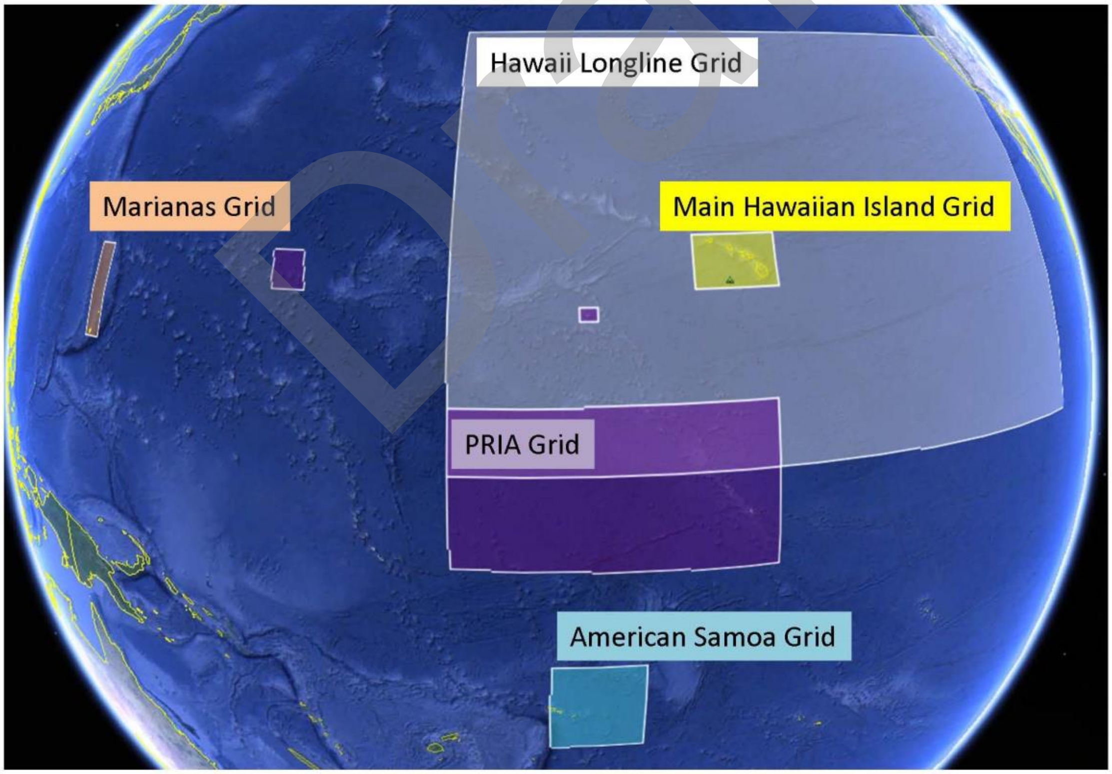


Figure 23. Regional spatial grids representing the scale of the climate change indicators being monitored.

Table 67. Climate and Ocean Indicator Summary.

Indicator	Definition and Rationale	Indicator Status
Atmospheric Concentration of Carbon Dioxide (CO_2)	Atmospheric concentration CO_2 at Mauna Loa Observatory. Increasing atmospheric CO_2 is a primary measure of anthropogenic climate change.	Trend: increasing exponentially 2017: time series mean 406.53 ppm
Oceanic pH	Ocean surface pH at Station ALOHA. Ocean pH provides a measure of ocean acidification. Increasing ocean acidification limits the ability of marine organisms to build shells and other hard structures.	Trend: pH is decreasing at a rate of 0.039 pH units per year, equivalent to 0.4% increase in acidity per year
Oceanic Niño Index (ONI)	Sea surface temperature anomaly from Niño 3.4 region (5°N - 5°S, 120° - 170°W). This index is used to determine the phase of the El Niño – Southern Oscillation (ENSO), which has implications across the region, affecting migratory patterns of key commercial fish stocks which in turn affect the location, safety, and costs of commercial fishing.	2017: ENSO Neutral
Pacific Decadal Oscillation (PDO)	PDO can be thought of as a long-lived, multi-decadal ENSO cycle that has well-documented fishery implications related to ocean temperature and productivity.	2017: positive (warm) from Jan – June, negative (cool) from Jul – Dec
Sea Surface Temperature* (SST)	Satellite remotely-sensed sea surface temperature. SST is projected to rise, and impacts phenomena ranging from winds to fish distribution.	SST in waters surrounding most of PRIA ranged between 27-30° C with 2017 showing anomalies dependent on latitude: along the equator, 2017 showed a negative anomaly, while at ~4 deg N, the 2017 anomaly moves positive.
Coral Thermal Bleaching Exposure (DHW)	Satellite remotely-sensed metric of time and temperature above thresholds relevant for coral bleaching. Metric used is Degree Heating Weeks (DHW).	The equatorial PRIA showed prolonged, substantial DHW stress in 2015-2016, in which DHW values exceeded the range in which mass mortality is expected (DHW>8). Wake Atoll showed more regular, but less prolonged heating events ('14, '15, '17).
Chlorophyll-A (Chl-A)	Satellite remotely-sensed chlorophyll-a. Chl-A is projected to drop over much of the central Pacific, and is directly linked ecosystem productivity.	The Chl-A around the PRIA ranges from 0.08 to 0.35 mg/m^3, with 2017 showing a near-zero and spatially

		variable anomaly.
Tropical Cyclones	Measures of tropical cyclone occurrence, strength, and energy. Tropical cyclones have the potential to significantly impact fishing operations.	Eastern Pacific, 2017: 31 storms, a level slightly lower than average.
		South Pacific, 2017: 6 storms, low – lowest since 2012.
		Central Pacific, 2017: 0 storms. Very low.
Rainfall/Precipitation	CMAP re-analysis of CPC Precipitation Data	2017 showed negative anomalies in rainfall.
Sea Level/Sea Surface Height	Monthly mean sea level time series, including extremes. Data from satellite altimetry & in situ tide gauges. 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.	Although varying over time the monthly mean sea level trend is increasing.

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

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

Status: Atmospheric CO_2 is increasing exponentially. In 2017, the annual mean concentration of CO_2 was 406.53 ppm. In 1959, the first year of the time series, it was 315.97 ppm. The annual mean passed 350 ppm in 1988 and 400 ppm in 2015.

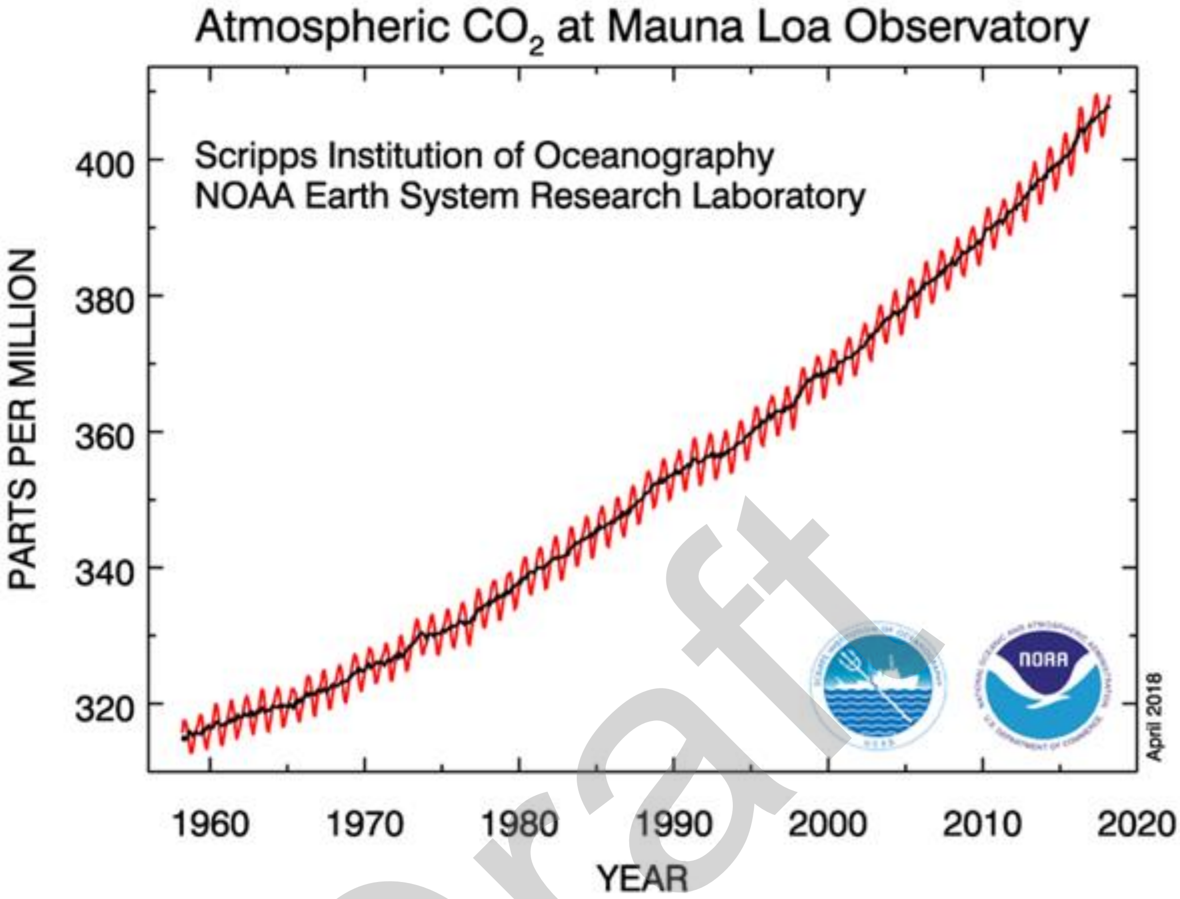


Figure 24. Monthly mean atmospheric carbon dioxide at Mauna Loa Observatory, Hawai`i. Note: The red line shows monthly averages and the black line shows seasonally corrected data.

Description: Monthly mean atmospheric carbon dioxide (CO_2) 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_2 emissions from fossil fuel burning. Carbon dioxide remains in the atmosphere for a very long time, and emissions from any location mix throughout the atmosphere in about one year. The annual oscillations at Mauna Loa, Hawai`i are due to the seasonal imbalance between the photosynthesis and respiration of plants on land. During the summer growing season photosynthesis exceeds respiration and CO_2 is removed from the atmosphere, whereas outside the growing season respiration exceeds photosynthesis and CO_2 is returned to the atmosphere. The seasonal cycle is strongest in the northern hemisphere because of this hemisphere’s larger land mass.

Timeframe: Annual, monthly

Region/Location: Mauna Loa, Hawai`i but representative of global atmospheric carbon dioxide concentration

Data Source: “Full Mauna Loa CO_2 record” available at https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html. Data from additional monitoring stations, including the Tutuila, American Samoa station are available at https://www.esrl.noaa.gov/gmd/dv/iadv/.

Measurement Platform: *In-situ* station

References:

Keeling, C.D., Bacastow, R.B., Bainbridge, A.E., Ekdahl, C.A., Guenther, P.R., Waterman, L.S., 1976. Atmospheric carbon dioxice variations at Mauna Loa Observator, Hawaii. *Tellus*, *28*, pp. 538-551.

Thoning, K.W., Tans, P.P., Komhyr, W.D., 1989. Atmospheric carbon dioxide at Mauna Loa Observatory 2. Analysis of the NOAA GMCC data, 1974-1985. *Journal of Geophysical Research*, *94*, pp. 8549-8565.

2.5.3.2 Oceanic pH

Rationale: Ocean 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 (indicated by lower oceanic pH) limits the ability of marine organisms to build shells and other hard structures. Recent research has shown that pelagic organisms such 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: Oceanic pH has shown a significant linear decrease of 0.0369 pH units, or roughly an 8.9% increase in acidity, over the nearly 30 years spanned by this time series. Additionally, the highest pH value reported for the most recent year (8.0846) is roughly equal to the lowest pH value reported in the first year of the time series (8.0845).

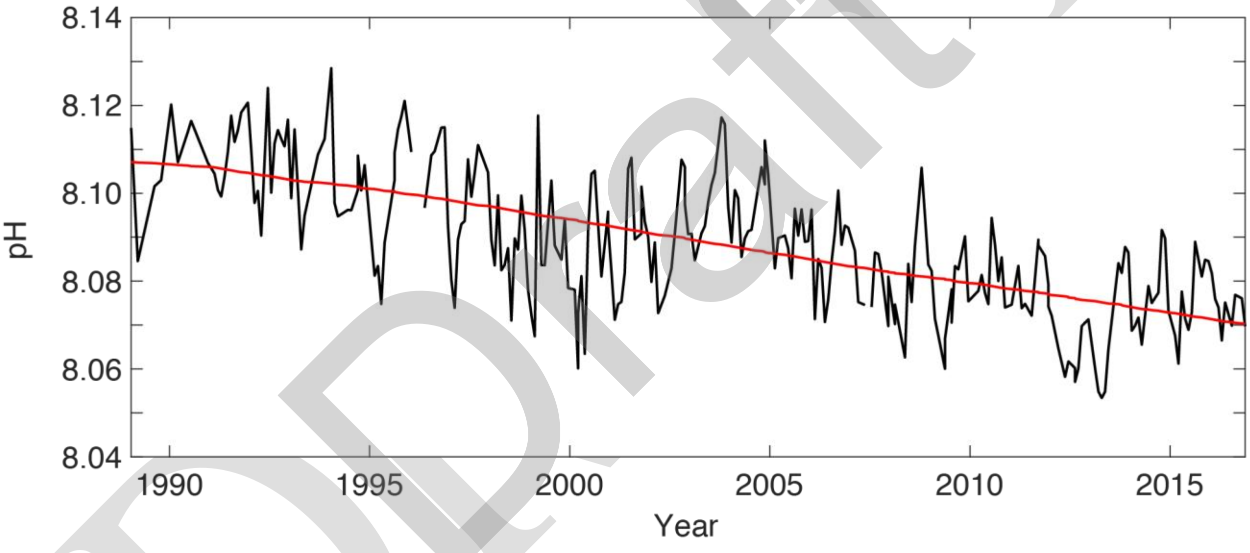


Figure 25. pH Trend at Station ALOHA, 1989 – 2016. **Note: Measured pH values are plotted in black. The linear fit to this time series is shown in red.**

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 2016 (2017 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. 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

Data Source: Hawai`i Ocean Time-series at http://hahana.soest.hawaii.edu/hot/. The Hawai`i Ocean Time-series is maintained by the University of Hawai`i's School for Ocean and Earth Science and Technology.

Measurement Platform: *In-situ* station

References:

An overview of the relationship between acidity and pH can be found at: http://www.pmel.noaa.gov/co2/story/A+primer+on+pH

A detailed description of how HOT determines pH can be found at: http://hahana.soest.hawaii.edu/hot/methods/ph.html

Methods for calculating pH from TA and DIC can be found at: https://www.soest.hawaii.edu/oceanography/faculty/zeebe_files/CO2_System_in_Seawater/csys.html

Fabry, V.J., Seibel, B.A., Feely, R.A., Orr, J.C., 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Marine Science*, 65, pp. 414-432.

Feely, R.A., Alin, S.R., Carter, B., Bednarsek, N., Hales, B., Chan, F., Hill, T.M., Gaylord, B., Sanford, E., Byrne, R.H., Sabine, C.L., Greeley, D., Juranek, L., 2016. Chemical and biological impacts of ocean acidification along the west coast of North America. *Estuarine, Coastal and Shelf Science, 183,* pp. 260-270. doi: 10.1016/j.ecss.2016.08.043.

2.5.3.3 Oceanic Niño Index

Rationale: The ENSO cycle is known to have impacts on Pacific fisheries targeting species including but not limited to tuna. The ONI focuses on ocean temperature, which has the most direct effect on these fisheries.

Status: The ONI was neutral in 2017.

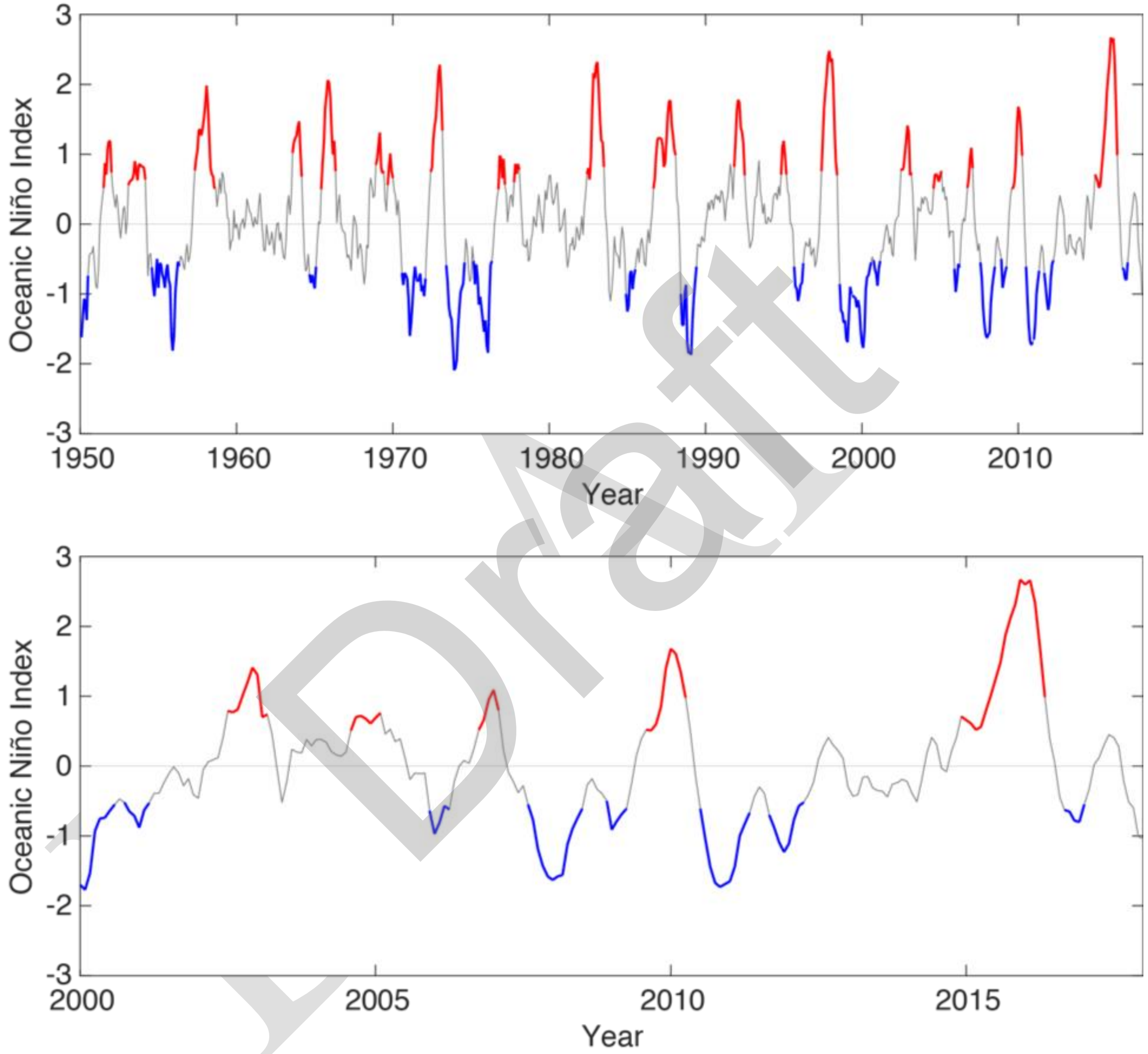


Figure 26. Oceanic Niño Index, 1950-2017 and 2000–2017. Note: Monthly time series of the Oceanic Niño Index for 1950 – 2017 (top) and 2000 – 2017 (bottom). El Niño periods are highlighted in red. La Niña periods are highlighted in blue.

Description: The three-month running mean of ERSST .v4 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 ± 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 this Pacific basin oscillation is measured using the Southern Oscillation Index.

Timeframe: Every three months

Region/Location: Niño3.4 region: 5°S – 5°N, 120° – 170°W

Data Source: NOAA NCEI at https://www.ncdc.noaa.gov/teleconnections/enso/indicators/sst.php.

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

References:

A full description of ENSO and its global impacts can be found at: https://www.climate.gov/news-features/understanding-climate/el-ni%C3%B1o-and-la-ni%C3%B1a-frequently-asked-questions

2.5.3.4 Pacific Decadal Oscillation

Rationale: The Pacific Decadal Oscillation (PDO) was initially named by a 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 – 30 years versus 6 – 18 months for ENSO event. The climatic finger prints of the PDO are most visible in the Northeastern Pacific, but secondary signatures exist in the tropics.

Status: The PDO was positive, or warm, from January through June of 2017. For the remainder of the year, the PDO was negative, or cool. It remains to be seen whether the negative conditions during the second half of the year represent a short-term fluctuation or a true phase change.

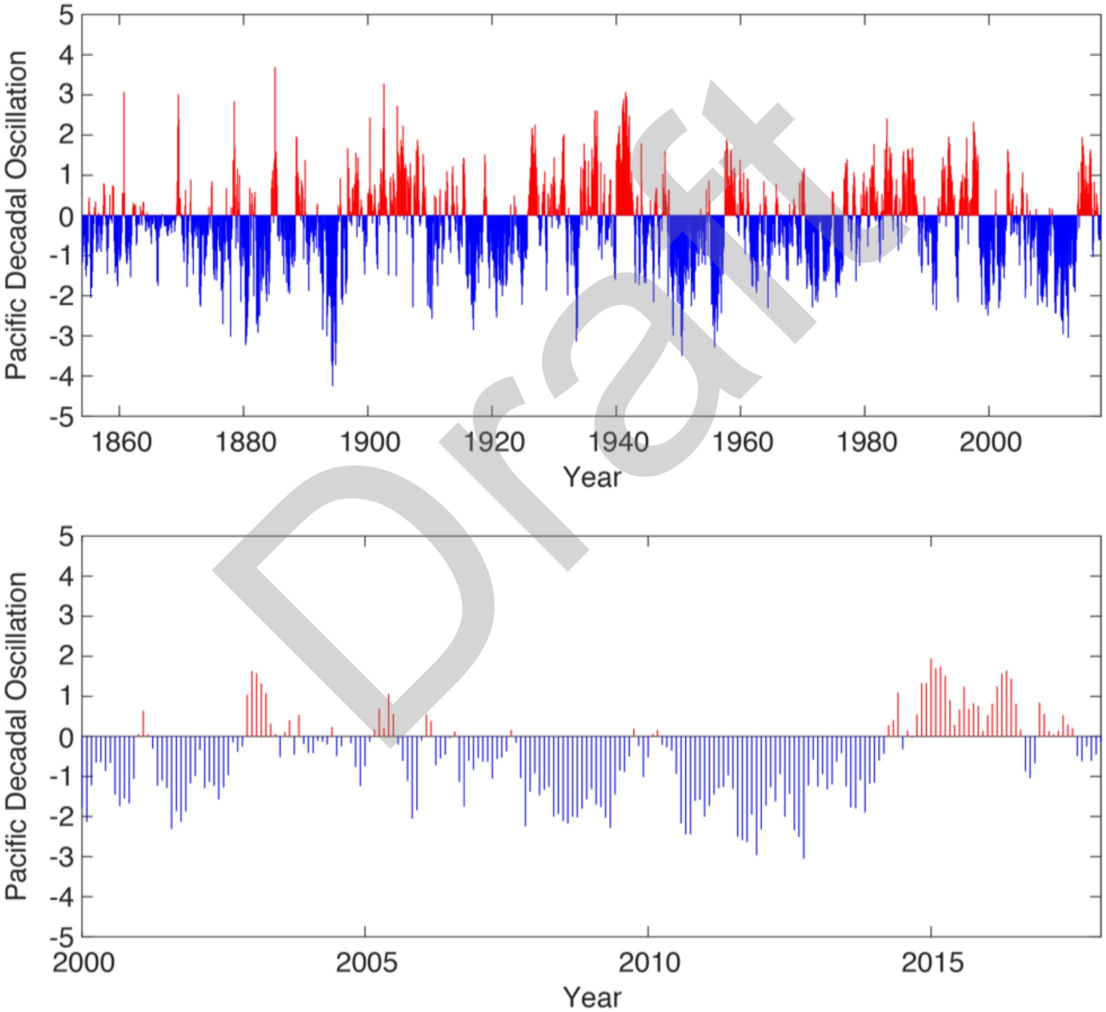


Figure 27. Pacific Decadal Oscillation, 1854–2017 and 2000–2017. Note: Monthly values of the Pacific Decadal Oscillation for 1854 – 2017 (top) and 2000 – 2017 (bottom). Positive, or warm, phases are plotted in red. Negative, or cool, phases are plotted in blue.

Description: The Pacific Decadal Oscillation (PDO) is often described as a long-lived El Niño-like pattern of Pacific climate variability. As seen with the better-known El Niño – Southern Oscillation (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 sea surface temperatures (SSTs) are anomalously cool in the interior North Pacific and warm along the North American coast, and when sea level pressures are below average in the North Pacific, the PDO has a positive value. When the climate anomaly 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.

The National Centers for Environmental Information (NCEI) PDO index is based on NOAA's extended reconstruction of SST (ERSST .v4).

Description inserted from https://www.ncdc.noaa.gov/teleconnections/pdo/.

Timeframe: Annual, monthly

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

Data Source: NOAA NCEI at https://www.ncdc.noaa.gov/teleconnections/pdo/. NCEI is responsible for hosting and providing access to one of the most significant archives on Earth, with comprehensive oceanic, atmospheric, and geophysical data.

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

References:

Mantua, N., 2000: The Pacific Decadal Oscillation. Available at http://research.jisao.washington.edu/pdo/. Accessed Feb. 2017.

2.5.3.5 Sea Surface Temperature & Anomaly

Description: Monthly sea surface temperature from 1982-2017, stitched together from three sources: (1) for 1982-2009 we use the Pathfinder v 5.0 dataset – a reanalysis of historical data from the Advanced Very High Resolution Radiometer (AVHRR); (2) to span 2010-2012 we use the AVHRR Global Area Coverage (GAC) dataset, and (3) data from 2013 to present we use the GOES-POES dataset, (see below for details). Both Pathfinder and GOES-POES provide 0.05º spatial resolution, while GAC provides 0.1º. A monthly climatology was generated across the entire period (1982-2017) to provide both a 2017 spatial anomaly, and an anomaly time series.

Short Descriptions:

Text from the OceanWatch Central Pacific Node:

(1) The NOAA/NASA AVHRR Pathfinder v5 and v5.1 sea-surface temperature dataset is a reanalysis of historical AVHRR data that have been improved using extensive calibration, validation and other information to yield a consistent research quality time series for global climate studies. At 0.05 degrees per pixel (approximately 4 km/pixel), this dataset provides a global spatial coverage ranging from October 1981 - 2009. Our data holdings include descending passes (nighttime).

(2) The Advanced Very High Resolution Radiometer (AVHRR) satellite sensors onboard the NOAA POES (Polar-orbiting Operational Environmental Satellites) satellite constellation have been collecting sea-surface temperature (SST) measurements since 1981. This dataset combines the NOAA/NASA AVHRR Pathfinder v4.1 dataset (January 1985 - January 2003) and the AVHRR Global Area Coverage (GAC) dataset (January 2003 - present) to provide a long time series of SST. These datasets are reduced-resolution legacy datasets and will be discontinued by NOAA in 2016. The dataset is composed of SST measurements from descending passes (nighttime). 3-day composites are only available for GAC, from 2003 - 2016.

(3) The GOES-POES dataset is a blended product, combining SST information from the Geostationary Operational Environmental Satellites (GOES) and the Polar-orbiting Operational Environmental Satellites (POES). This global SST analysis provides a daily gap-free map of the foundation sea surface temperature, generating high density SST data and improving the monitoring of small scale dynamic features in the coastal coral reef environment.

Technical Summary:

Pathfinder v5 & GAC datasets: Text from: https://podaac-www.jpl.nasa.gov/dataset/ AVHRR_PATHFINDER_L3_SST_MONTHLY_NIGHTTIME_V5

The 4 km Advanced Very High Resolution Radiometer (AVHRR) Pathfinder Version 5 sea surface temperature (SST) dataset is a reanalysis of historical AVHRR data that have been improved using extensive calibration, validation and other information to yield a consistent research quality time series for global climate studies. This SST time series represents the longest continual global ocean physical measurement from space. Development of the Pathfinder dataset is sponsored by the NOAA National Oceanographic Data Center (NODC) in collaboration with the University of Miami Rosensteil School of Marine and Atmospheric

Science (RSMAS) while distribution is a collaborative effort between the NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) and the NODC. From a historical perspective, the Pathfinder program was originally initiated in the 1990s as a joint NOAA/NASA research activity for reprocessing of satellite based data sets including SST.
The AVHRR is a space-borne scanning sensor on the National Oceanic and Atmospheric Administration (NOAA) family of Polar Orbiting Environmental Satellites (POES) having an operational legacy that traces back to the Television Infrared Observation Satellite-N (TIROS-N) launched in 1978. AVHRR instruments measure the radiance of the Earth in 5 (or 6) relatively wide spectral bands. The first two are centered around the red (0.6 micrometer) and near-infrared (0.9 micrometer) regions, the third one is located around 3.5 micrometer, and the last two sample the emitted thermal radiation, around 11 and 12 micrometers, respectively. The legacy 5 band instrument is known as AVHRR/2 while the more recent version, the AVHRR/3 (first carried on the NOAA-15 platform), acquires data in a 6th channel located at 1.6 micrometer. Typically the 11 and 12 micron channels are used to derive SST sometimes in combination with the 3.5 micron channel. For the Pathfinder SST algorithm only the 11 and 12 micron channels are used. The NOAA platforms are sun synchronous generally viewing the same earth location twice a day (latitude dependent) due to the relatively large AVHRR swath of approximately 2400 km.
The highest ground resolution that can be obtained from the current AVHRR instruments is 1.1 km at nadir.

This particular dataset is produced from Global Area Coverage (GAC) data that are derived from an on-board sample averaging of the full resolution global AVHRR data. Four out of every five samples along the scan line are used to compute on average value and the data from only every third scan line are processed, yielding an effective 4 km resolution at nadir. The collection of NOAA satellite platforms used in the AVHRR Pathfinder SST time series includes NOAA-7, NOAA-9, NOAA-11, NOAA-14, NOAA-16, NOAA-17, and NOAA-18. These platforms contain "afternoon" orbits having a daytime ascending node of between 13:30 and 14:30 local time (at time of launch) with the exception of NOAA-17 that has a daytime descending node of approximately 10:00 local time. SST AVHRR Pathfinder includes separate daytime and nighttime daily, 5 day, 8 day, monthly and yearly datasets. This particular dataset represent nighttime monthly averaged observations.

GOES-POES dataset - Text from:
https://www.star.nesdis.noaa.gov/sod/mecb/blended_validation/background.php

The National Oceanic and Atmospheric Administration's Office of Satellite Data Processing and Distribution are generating operational sea surface temperature (SST) retrievals from the Geostationary Operational Environmental Satellite (GOES) 11 and 12 satellite imagers. They are situated at longitude 135^{o}W and 75^{o}W, respectively, thus allowing the acquisition of high-temporal-resolution SST retrievals.

A new cloud masking methodology based on a probabilistic (Bayesian) approach has been implemented for improved retrieval accuracy. This new GOES SST Bayesian algorithm provides SST retrievals with an estimate of the probability of cloud contamination. This indicates the confidence level of the cloud detection for the retrieval, which can be related to retrieval accuracy.

The GOES-11 and 12 imagers observe both northern and southern hemisphere every half an hour. These 5-band (0.6, 3.9, 6.7, 10.7, 12 or 13.3 micron) and 4-band (0.6, 3.9, 6.7, 10.7. or 13.3 micron) images are processed to retrieve SST retrievals at 4-km resolution. The window infrared channels determine the SST, and all channels (except the 6.7 and 13.3 µm) determine the cloud contamination. These retrievals are remapped, averaged, and composited hourly and posted to a server for user access. The retrievals are available approximately 90 minutes after the nominal epoch of the SST determinations. Three-hour and 24-hour averages are also made available. CoastWatch Regional Imagery is generated every three hours by combining the 1hourly SST images for these areas.

Timeframe: 1982-2017, Daily data available, Monthly means shown.

Region/Location: Global.

Data Source:

1. "AVHRR Pathfinder v. 5 (ERDDAP Monthly)"
2. "AVHRR GAC v. 5 (ERDDAP Monthly)"
3. "GOES-POES v. 5 (ERDDAP Monthly)"

http://oceanwatch.pifsc.noaa.gov/doc.html

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

Rationale: Sea surface temperature is one of the most directly observable measures we have for tracking increasing ocean temperature.

References:

Li, X., Pichel, W., Maturi, E., Clemente-Colón, P., and J. Sapper, J., 2001a. Deriving the operational nonlinear multi-channel sea surface temperature algorithm coefficients for NOAA-15 AVHRR/3. *Int. J. Remote Sens*., *22*(4), pp. 699-704.

Li, X, Pichel, W., Clemente-Colón, P., Krasnopolsky, V., and Sapper, J., 2001b. Validation of coastal sea and lake surface temperature measurements derived from NOAA/AVHRR Data. *Int. J. Remote Sens*., *22*(7), pp. 1285-1303.

Stowe, L.L., Davis, P.A., and McClain, E.P., 1999. Scientific basis and initial evaluation of the CLAVR-1 global clear/cloud classification algorithm for the advanced very high resolution radiometer. *J. Atmos. Oceanic Technol*., *16*, pp. 656-681.

Walton C.C., Pichel, W.G., Sapper, J.F., and May, D.A., 1998. The development and operational application of nonlinear algorithms for the measurement of sea surface temperatures with the NOAA polar-orbiting environmental satellites. *J. Geophys. Res*., *103*(C12), pp. 27999-28012.

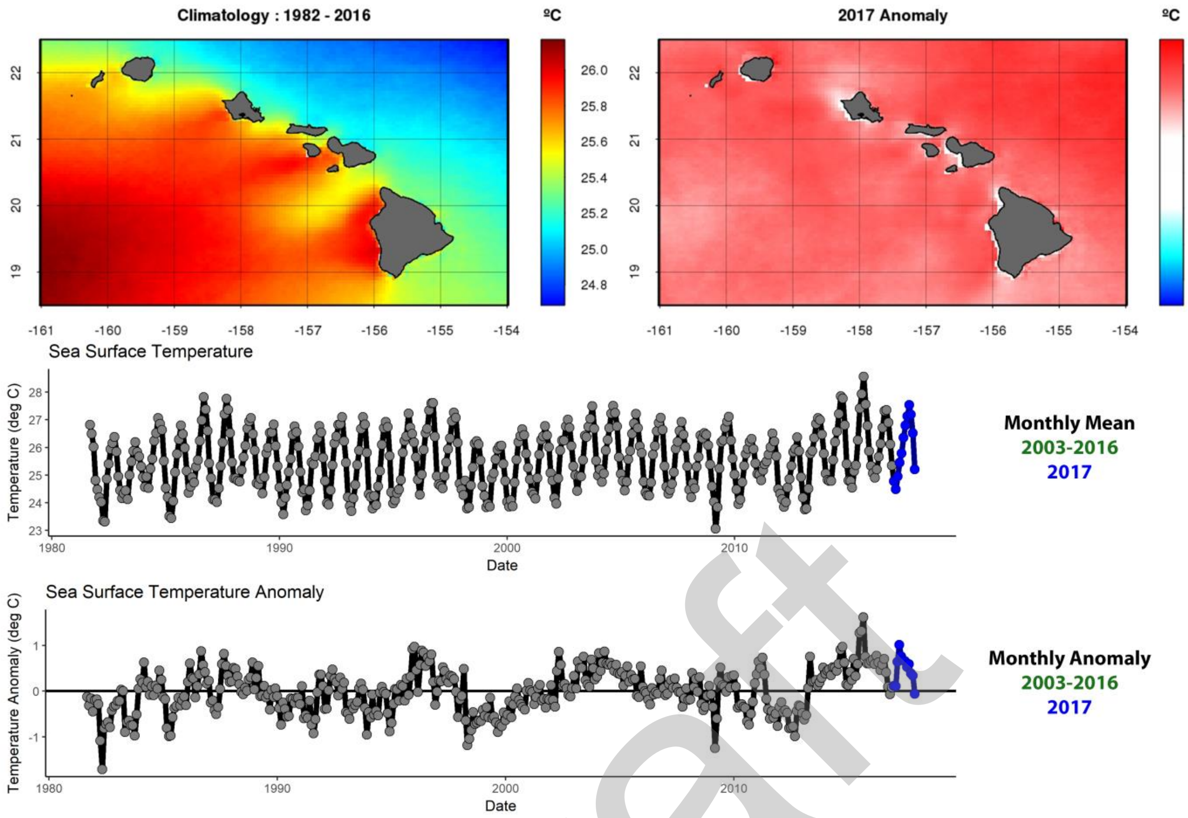


Figure 28. Sea surface temperature (SST) and SST Anomaly.

2.5.3.6 Coral Thermal Stress Exposure: Degree Heating Weeks

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 a rolling sum weekly thermal anomalies over a 12-week window. Higher DHW measures imply a greater likelihood of mass coral bleaching or mortality from thermal stress.

Short Description:

Text inserted from the NOAA Coral Reef Watch website.

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.

Technical Summary:

Text inserted from: https://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php

The NOAA Coral Reef Watch (CRW) experimental daily global 5km (0.05 degree) satellite coral bleaching heat stress monitoring product suite presented here is the third version (Version 3). The 5km suite is based on the NOAA/NESDIS operational daily global 5km geostationary-polar-orbiting (Geo-Polar) Blended Night-only SST Analysis. Current CRW 5km products include sea surface temperature (SST), SST Anomaly, Coral Bleaching HotSpot, Degree Heating Week (DHW), a 7-day maximum Bleaching Alert Area, and a 7-day SST Trend. CRW also has a 5km Regional Virtual Stations/Bleaching Heat Stress Gauges product and a free, automated 5km Bleaching Alert Email System that are based on this product suite.

A significantly improved climatology was introduced in the Version 3 products. It was derived from a combination of NOAA/NESDIS' 2002-2012 reprocessed daily global 5km Geo-Polar Blended Night-only SST Analysis and the 1985-2002 daily global 5km SST reanalysis, produced by the United Kingdom Met Office, on the Operational SST and Sea Ice Analysis (OSTIA) system. The near-real-time OSTIA SST was recently incorporated into the generation of NESDIS' operational daily 5km Blended SST that CRW's 5km coral bleaching heat stress monitoring product suite is based on. Hence, the 2002-2012 reprocessed 5km Geo-Polar Blended SST that has just become available, extended with the 1985-2002 portion of the 5km OSTIA SST reanalysis, is the best historical 1985-2012 global SST dataset for deriving a climatology that is internally consistent and compatible with CRW's near-real-time 5km satellite coral bleaching heat stress monitoring products. Although the reprocessed 5km Geo-Polar Blended SST dataset is available to the end of 2016, to be consistent with the time period (1985-2012) of the climatology used in our Version 2 5km product suite, the Version 3 climatology is based on the same time period. It was then re-centered to the center of the baseline time period of 1985-1990 plus 1993, using the method described in Heron *et al.*, (2015)and Liu *et al.*, (2014), and was based on our monitoring algorithm (also described in these articles). More recent years may be incorporated in the climatology for future versions of CRW's 5 km products, but potential impacts on the products require further evaluation first.

This Version 3 suite was released on May 4, 2017, along with a new version of CRW's 5km Regional Virtual Stations/Bleaching Heat Stress Gauges product. Version 2 of the 5km product suite (that Version 3 replaces) was released on May 5, 2014, and Version 1 was released on July 5, 2012 (based on NESDIS' operational daily global 5 km Geo-Polar Blended Day-Night SST Analysis and an earlier version of the climatology derived from the PFV5.2).

Development of this next-generation 5 km product suite was accomplished through a collaboration of NOAA Coral Reef Watch, the University of South Florida, NASA-Ames, the

UNEP World Conservation Monitoring Centre, and the Cooperative Institute for Research in Environmental Science, with funding support from the NASA Biodiversity and Ecological Forecasting program, the NOAA Coral Reef Conservation Program, and the NOAA/NESDIS Ocean Remote Sensing Program. Production of the Version 3 suite was made possible through funding from the NOAA Coral Reef Conservation Program. The 5km product suite, which was featured in the NASA Applied Sciences Program's 2013 Annual Report, will undergo continuous improvements.

Regional Virtual Stations Product Description: NOAA Coral Reef Watch (CRW) has developed a set of experimental 5 km Regional Virtual Stations (213 total).

NOAA CRW also expanded the geographic network of 5 km Virtual Stations to include all coral reefs around the world, based on available references. These included the Millennium Coral Reef project maps, the IUCN Coral Reefs of the World three-volume set, the UNEP/WCMC World Atlas of Coral Reefs, several country scale atlas publications, and a few other resources. These references were also used to develop the outline (in black) for each 5 km Regional Virtual Station. Each Virtual Station outline is based on a global 5 km reef pixel mask developed by NOAA CRW, with the addition of a 20 km buffer around each 5 km reef mask. If we have missed a coral reef that you know of, please let us know the name and coordinates of the missing reef.

Timeframe: 2013-2017, Daily data.

Region/Location: Global.

Data Source: “NOAA Coral Reef Watch”   https://coralreefwatch.noaa.gov

Measurement Platform: NOAA/NESDIS operational daily global 5km geostationary-polar-orbiting (Geo-Polar) Blended Night-only SST Analysis

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

References:

Liu, G., Heron, S.F., Eakin, C.M., Muller-Karger, F.E., Vega-Rodriguez, M., Guild, L.S., De La Cour, J.L., Geiger, E.F., Skirving, W.J., Burgess, T.F. and Strong, A.E., 2014. Reef-scale thermal stress monitoring of coral ecosystems: new 5-km global products from NOAA Coral Reef Watch. *Remote Sensing*, *6*(11), pp.11579-11606.

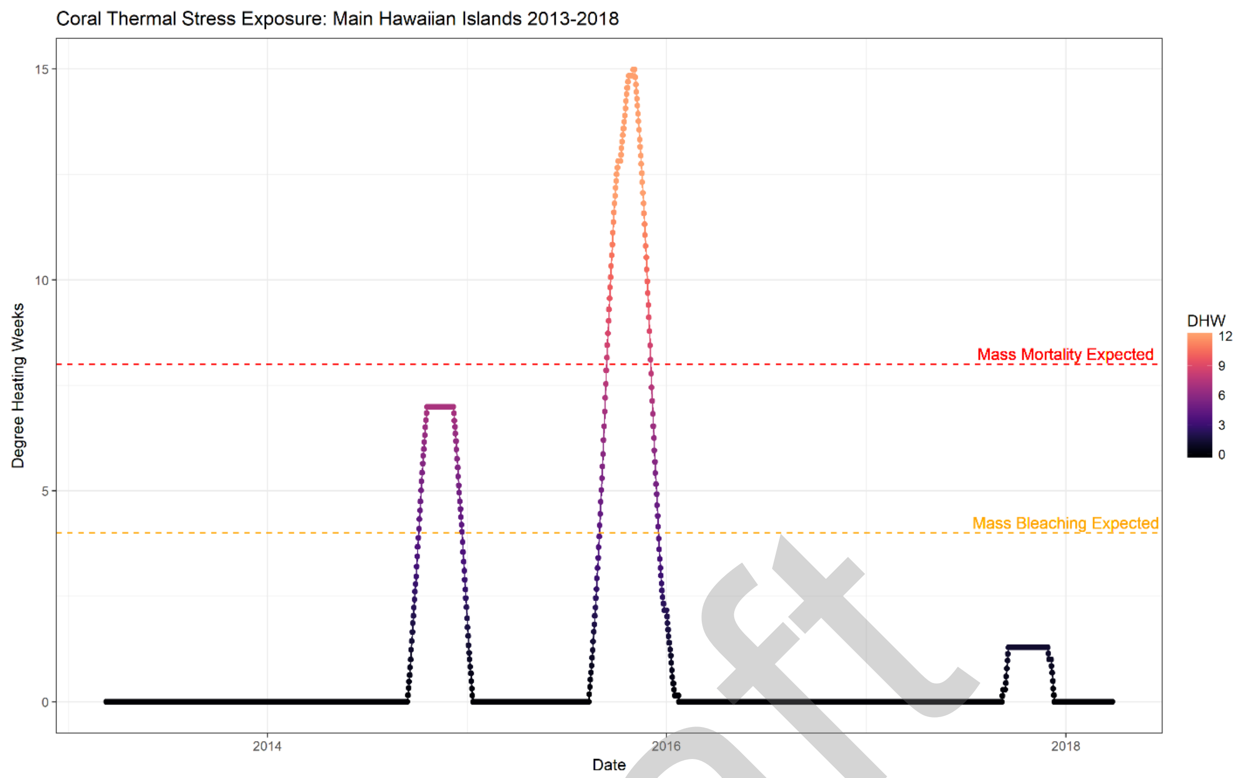


Figure 29. Coral Thermal Stress Exposure, Main Hawaiian Island Virtual Station from 2013-2017, measured in Coral Reef Watch Degree Heating Weeks.

2.5.3.7 Chlorophyll-A and Anomaly

Description: Chlorophyll-A Concentration from 2002-2017, derived from the MODIS Ocean Color sensor aboard the NASA Aqua Satellite. A monthly climatology was generated across the entire period (1982-2017) to provide both a 2017 spatial anomaly, and an anomaly time series.

Short Description:

Text inserted from the [OceanWatch Central Pacific Node:]()

The MODIS (Moderate Resolution Imaging Spectro-radiometer) sensor was deployed onboard the NASA Aqua satellite. It is a multi-disciplinary sensor providing data for the ocean, land, aerosol, and cloud research and is used for detecting chlorophyll-a concentrations in the world's oceans, among other applications. Aqua MODIS views the entire Earth's surface every 2 days, acquiring data in 36 spectral bands. The data available here is the latest reprocessing from June 2015, which NASA undertook to correct for some sensor drift issues.

Technical Summary:

Text inserted from:

https://podaac-www.jpl.nasa.gov/dataset/MODIS_Aqua_L3_CHLA_Monthly_4km_V2014.0_R

The Moderate-resolution Imaging Spectroradiometer (MODIS) is a scientific instrument (radiometer) launched by NASA in 2002 on board the Aqua satellite platform (a second series is on the Terra platform) to study global dynamics of the Earths atmosphere, land and oceans. MODIS captures data in 36 spectral bands ranging in wavelength from 0.4 um to 14.4 um and at varying spatial resolutions (2 bands at 250 m, 5 bands at 500 m and 29 bands at 1 km). The Aqua platform is in a sun synchronous, near polar orbit at 705 km altitude and the MODIS instrument images the entire Earth every 1 to 2 days. The Level 3 standard mapped image (SMI) chlorophyll-a dataset has a monthly temporal resolution and 4.6 km (at the equator) spatial resolution. The SMI dataset is an image representation of binned MODIS data (more detailed information on the SMI format can be found at http://oceancolor.gsfc.nasa.gov). The MODIS Aqua instrument provides quantitative data on global ocean bio-optical properties to examine oceanic factors that affect global change and to assess the oceans' role in the global carbon cycle, as well as other biogeochemical cycles. Subtle changes in chlorophyll-a signify various types and quantities of marine phytoplankton (microscopic marine plants), the knowledge of which has both scientific and practical applications. This is a local dataset derived from the NASA Ocean Biology Processing Group (OBPG) meant to expose these data to tools and services at the PO.DAAC.

Timeframe: 2003-2017, Daily data available, Monthly means shown.

Region/Location: Global.

Data Source: “MODIS-Aqua (ERDDAP Monthly)” http://oceanwatch.pifsc.noaa.gov/doc.html

Measurement Platform: *MODIS sensor on NASA Aqua Satellite*

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

References:

Savtchenko, A., Ouzounov, D., Ahmad, S., Acker, J., Leptoukh, G., Koziana, J. and Nickless, D., 2004. Terra and Aqua MODIS products available from NASA GES DAAC. *Advances in Space Research*, *34*(4), pp.710-714.

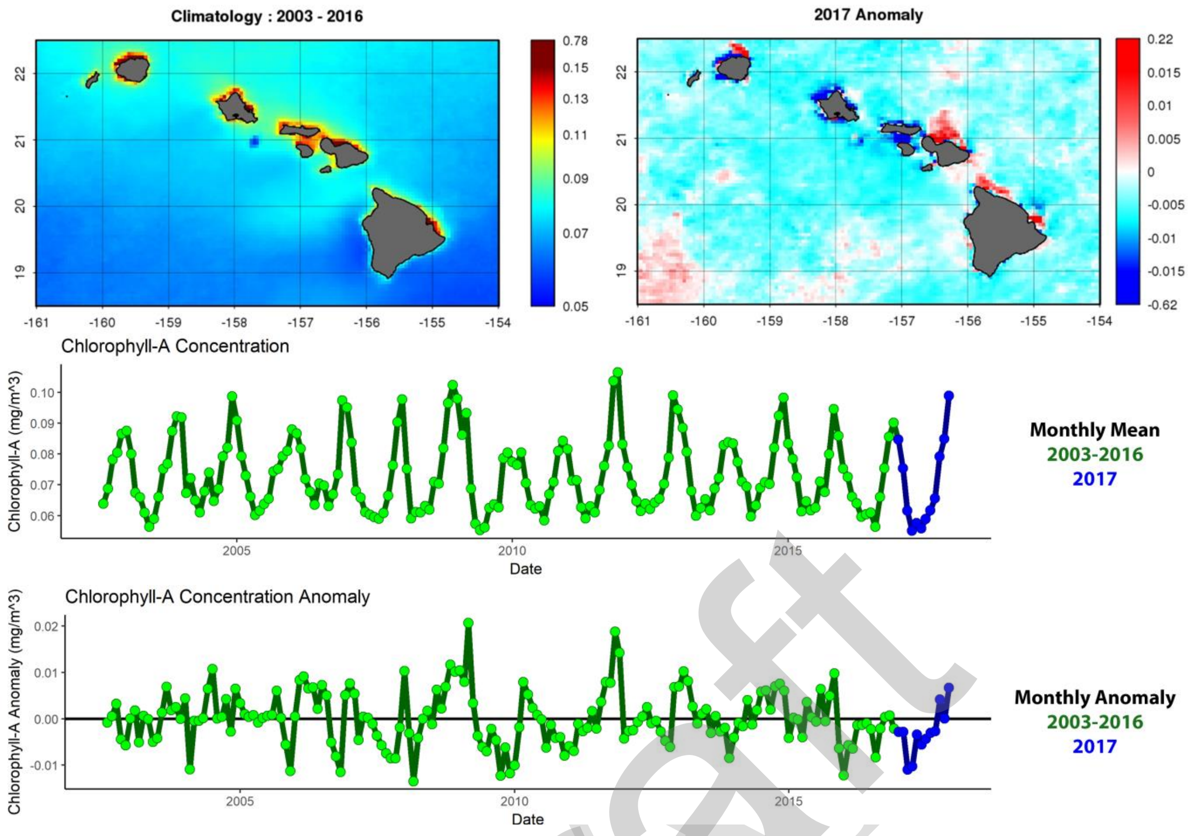


Figure 30. Chlorophyll-A (Chl-A) and Chl-A Anomaly.

2.5.3.8 Heavy Weather (Tropical Cyclones & Storm-Force Winds)

Description: This indicator uses historical data from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) International Best Track Archive for Climate Stewardship (IBTrACS; Knapp *et al.*, 2010) to track the number of tropical cyclones in the western, central, and south Pacific basins. This indicator also monitors the Accumulated Cyclone Energy (ACE) Index, one way of monitoring the strength and duration of tropical cyclones based only on wind speed measurements.

The annual frequency of storms passing through the Pacific basin is tracked and a stacked time series plot shows the representative breakdown of the Saffir-Simpson hurricane categories. Three solid color groups in the graph represent a) the annual number of named storms, b) the annual number of typhoons, and c) the annual number of major typhoons (Cat 3 and above).

Every cyclone has an ACE Index value, which is a computed value 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 knot; 39 mph). Therefore, a storm's ACE Index value accounts for both strength and duration. This plot shows the historical ACE values for each typhoon season and has a solid line representing the 1981-2010 average ACE value.

In addition, we also plot the percentage occurrence of "storm-force" winds, wind occurrences greater than, or equal to, 34 knots since 1980 in the three sub-regions. The value of 34 knots represents “Gale, fresh gale” on the Beaufort scale, which corresponds to 5-8 m wave heights and boating becomes very challenging. Characterizing the percent occurrence of these gale-force winds gives an indication of storminess5 frequency within each sub-region. Indeed, slight increases in the frequency of gale-force winds are noted in both the South and Western Pacific basins, while a downward trend is evident in the Central Pacific. (Marra *et al.*, 2017)

Timeframe: Yearly

Region/Location: Hawaii and U.S. Affiliated Pacific Islands

Data Source/Responsible Party: NCEI’s International Best Track Archive for Climate Stewardship (IBTrACS).

Measurement Platform: Satellite

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 Hawaii longline fishery, for example, had serious problems between August and November 2015 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. The associated storm surge, the large volume of ocean water pushed toward shore by the cyclone’s strong winds, can cause severe flooding and destruction.

Neither the Pacific ENSO Applications Climate Center nor the Bulletin of the AMS has yet published their annual tropical cyclone report covering the central or south pacific in 2017.

While reports on activity during 2017 are not yet available for the south and central pacific, the NOAA National Centers for Environmental Information, State of the Climate: Hurricanes and Tropical Storms for Annual 2017, published online January 2018, notes that “The 2017 East Pacific hurricane season had 18 named storms, including nine hurricanes, four of which became major.” The 1981-2010 average number of named storms in the East Pacific was 16.5, with 8.9 hurricanes, and 4.3 major hurricanes. Five Eastern Pacific tropical cyclones made landfall in 2017. Tropical Storm Selma made landfall in El Salvador and tropical storms Beatrix, Calvin, Lidia and Hurricane Max made landfall in Mexico. Tropical Storm Selma was the first named tropical cyclone on record to make landfall in El Salvador. Tropical Storm Adrian formed on May 9th, marking the earliest occurrence of a named storm in the East Pacific basin. The previous earliest occurrence was Tropical Storm Alma forming on May 12, 1990. For the first year since 2012 no tropical cyclones passed near the Hawaiian Islands. The ACE index for the East Pacific basin during 2016 was 98 ($x10^4$ knots^2), which is below the 1981-2010 average of 132 ($x10^4$ knots^2), and the lowest since 2013.” Inserted from: https://www.ncdc.noaa.gov/sotc/tropical-cyclones/201713

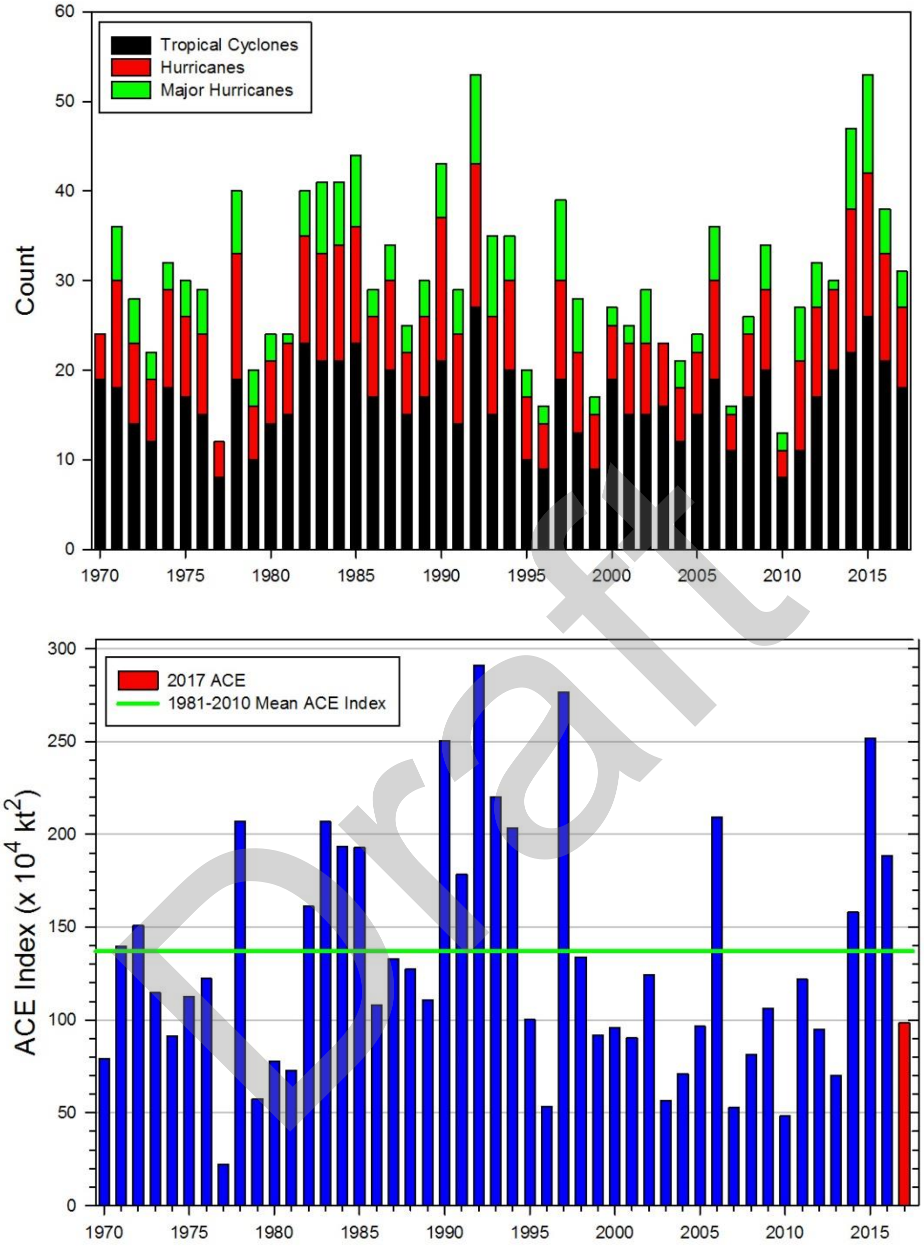


Figure 31. Annual Patterns of Tropical Cyclones in the Eastern Pacific, 1970-2017, with 1981-2010 mean superimposed. Source: NOAA's National Centers for Environmental Information.

Eastern pacific climate / 2017 data

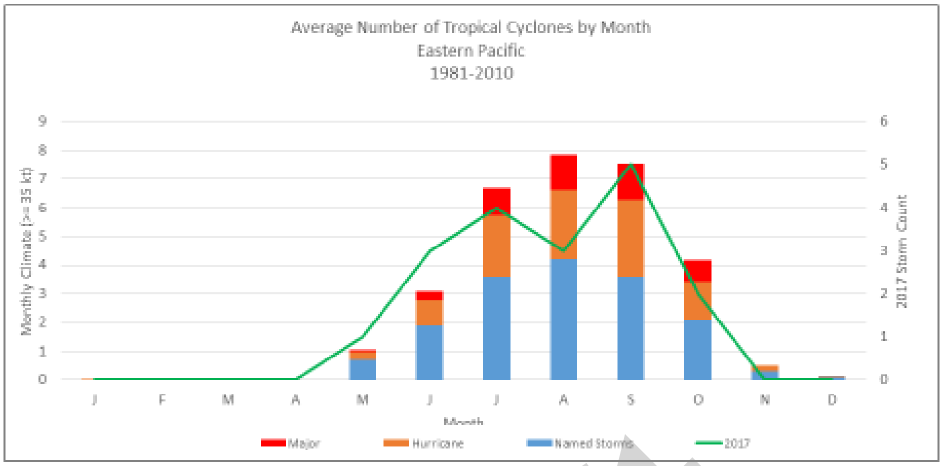


Figure 32. Seasonal Climatology of Tropical Cyclones in the Eastern Pacific, 1981-2010, with 2017 storms superimposed in green. Source: NOAA's National Centers for Environmental Information.

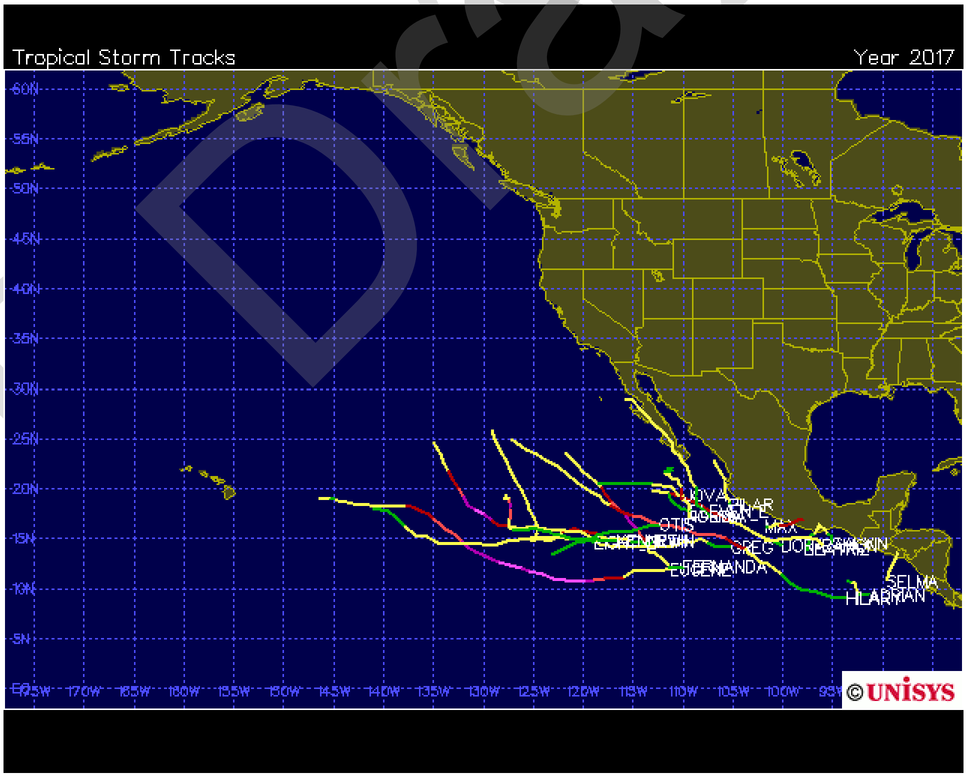


Figure 33. Eastern Pacific Cyclone Tracks in 2017.

References:

NOAA National Centers for Environmental Information, State of the Climate: Hurricanes and Tropical Storms for Annual 2017, published online January 2018, retrieved on March 30, 2018 from http://www.ncdc.noaa.gov/sotc/tropical-cyclones/201713.

Kanamitsu, M., W. Ebisuzaki, J. Woollen, S-K Yang, J.J. Hnilo, M. Fiorino, and G. L. Potter, 2002. NCEPDOE AMIP-II Reanalysis (R-2). *Bull. Am. Met. Soc.*, *83*, pp. 1631-1643. https://doi.org/10.1175/BAMS-83- 11-1631.

Knapp, K. R., M. C. Kruk, D. H. Levinson, H. J. Diamond, and C. J. Neumann, 2010: The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying tropical cyclone best track data. *Bulletin of the American Meteorological Society*, *91*, 363-376. doi:10.1175/2009BAMS2755.1.

State of Environmental Conditions in Hawaii and the U.S. Affiliated Pacific Islands under a Changing Climate, 2017. Coordinating Authors: J.J. Marra and M.C. Kruk. Contributing Authors: M.Abecassis; H. Diamond; A. Genz; S.F. Heron; M. Lander; G. Liu; J. T. Potemra; W.V. Sweet; P. Thompson; M.W. Widlansky; and P. Woodworth-Jefcoats. NOAA NCEI.

2.5.3.9 Rainfall (CMAP Precipitation)

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 raingauges are merged with precipitation estimates from several satellite-based algorithms (infrared and microwave). The analyses are are on a 2.5 x 2.5 degree latitude/longitude grid and extend back to 1979. These data are comparable (but should not be confused with) similarly combined analyses by the Project, which are 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 of 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 polar 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). Here the data output from step 1 is used to define the "shape" of the precipitation field and the rain gauge data are used to constrain the amplitude.

Monthly and pentad CMAP estimates back to the 1979 are available from CPC ftp server.

[Text taken from: http://www.cpc.ncep.noaa.gov/products/global_precip/html/wpage.cmap.html]

The monthly data set consists of two files containing monthly averaged precipitation rate values. Values are obtained from 5 kinds of satellite estimates (GPI,OPI,SSM/I scattering, SSM/I emission and MSU) and gauge data. The enhanced file also includes blended NCEP/NCAR Reanalysis Precipitation values.

[Text taken from: https://www.esrl.noaa.gov/psd/data/gridded/data.cmap.html#detail]

Timeframe: Monthly

Region/Location: Global

Data Source *CMAP Precipitation data provided by the NOAA/OAR/ESRL PSD, Boulder, Colorado, USA, from their Web site at https://www.esrl.noaa.gov/psd/*

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

References:

Xie, P. and Arkin, P.A., 1997. Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bull. Amer. Meteor. Soc.*, *78*, pp. 2539 - 2558.

Huffman, G.J., Adler, R.F., Arkin, P., Chang, A., Ferraro, R., Gruber, A., Janowiak, J., McNab, A., Rudolf, B. and Schneider, U., 1997. The global precipitation climatology project (GPCP) combined precipitation dataset. *Bull. Amer. Meteor. Soc.*, *78*(1), pp.5-20.

Reynolds, R.W., 1988. A real-time global sea surface temperature analysis. *J. Climate*, *1*, pp. 75-86.

Spencer, R.W., 1993. Global oceanic precipitation from the MSU during 1979-91 and comparisons to other climatologies. *J. Climate*, *6*, pp. 1301-1326.

Xie P. and Arkin, P.A., 1997. Global precipitation: a 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bull. Amer. Meteor. Soc.*, *78*, pp. 2539-2558.

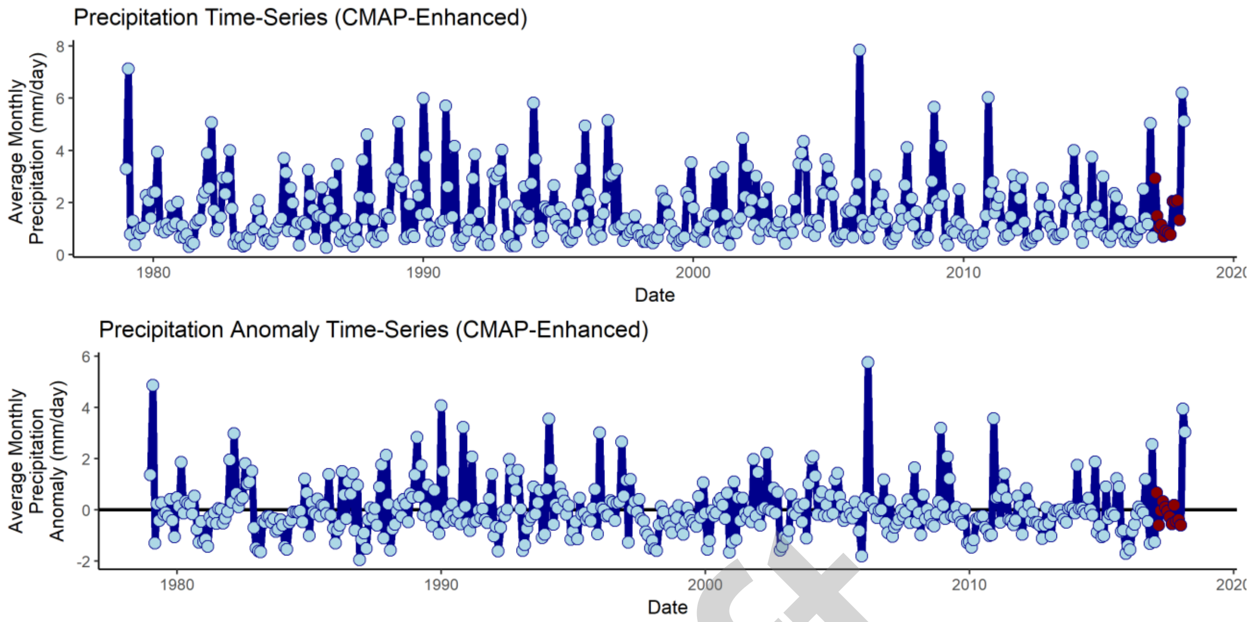


Figure 34. CMAP precipitation across the Main Hawaiian Islands Grid. 2017 values in red.

2.5.3.10 Sea Level (Sea Surface Height and Anomaly)

Description: Monthly mean sea level time series, including extremes

Timeframe: Monthly

Region/Location: Observations from selected sites within the Hawaiian Islands

Data Source/Responsible Party: Basin-wide context from satellite altimetry:
http://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/el-nino-bulletin.html

Quarterly time series of mean sea level anomalies from satellite altimetry:
http://sealevel.jpl.nasa.gov/science/elninopdo/latestdata/archive/index.cfm?y=2015

Sea Surface Height and Anomaly from NOAA Ocean Service, Tides and Currents, Sea Level Trends: https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=1770000

Measurement Platform: Satellite and *in situ* tide gauges

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.

2.5.3.10.1 Basin-Wide Perspective

This image of the mean sea level anomaly for February 2016 compared to 1993-2013 climatology from satellite altimetry provides a glimpse into how the 2015-2016 El Niño continues to affect sea level across the Pacific Basin. The image captures the fact that sea level continues to be lower in the Western Pacific and higher in the Central and Eastern Pacific (a standard pattern during El Niño events. This basin-wide perspective provides a context for the location-specific sea level/sea surface height images that follow.)

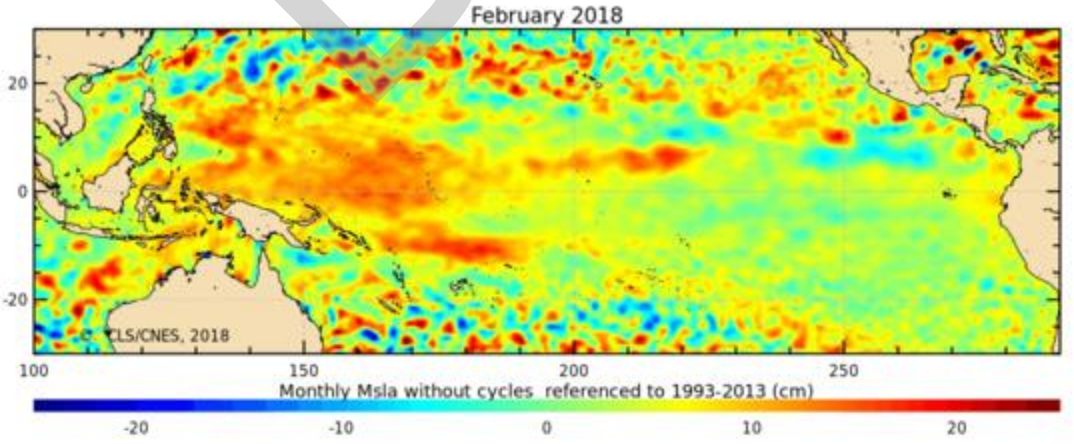


Figure 35a. Sea surface height and anomaly

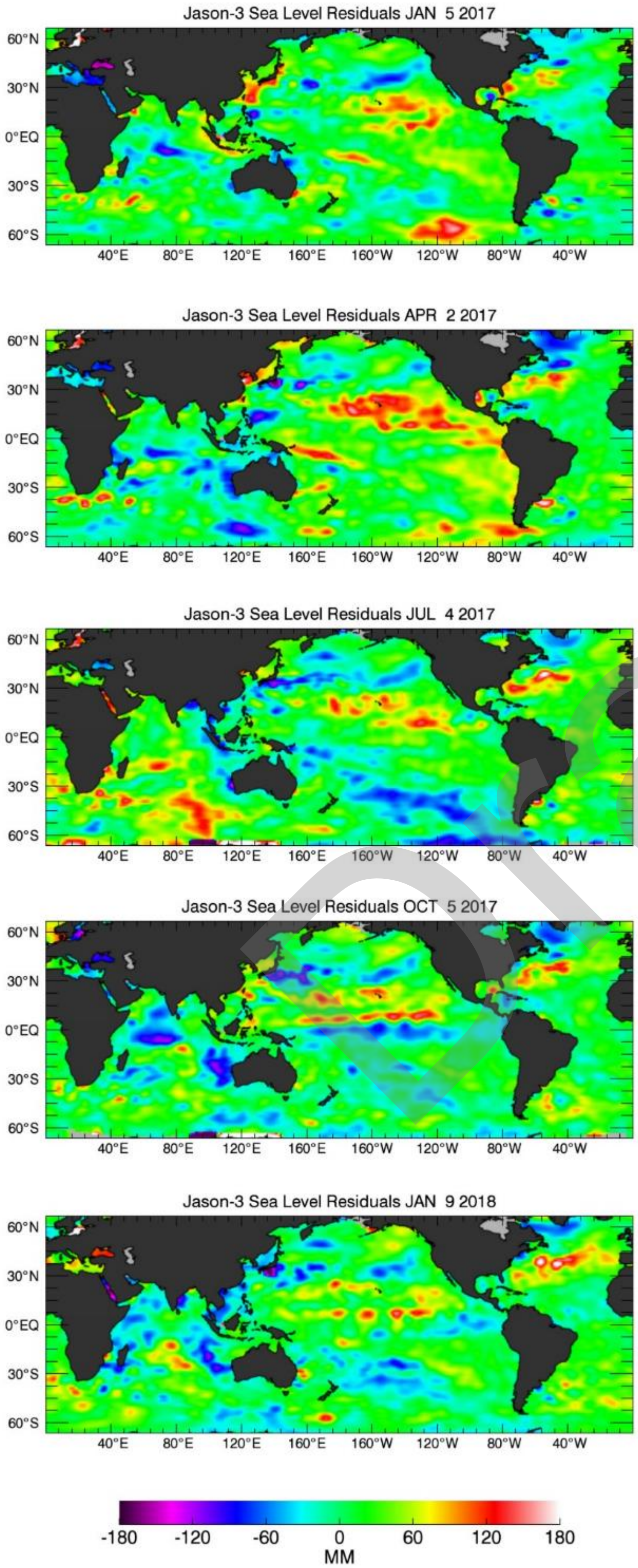
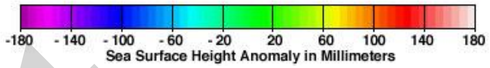


Figure 35b. Quarterly time series of mean sea level anomalies during 2017 show no pattern of El Niño throughout the year according to satellite altimetry measurements of sea level height (unlike 2015).

http://sealevel.jpl.nasa.gov/science/elninopdo/latestdata/archive/index.cfm?y=2017).



2.5.3.10.2 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/COOPS).

The following figures and descriptive paragraphs were inserted from https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=1612340.

Figure 36 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 (0.3 meters = 1 foot). 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.

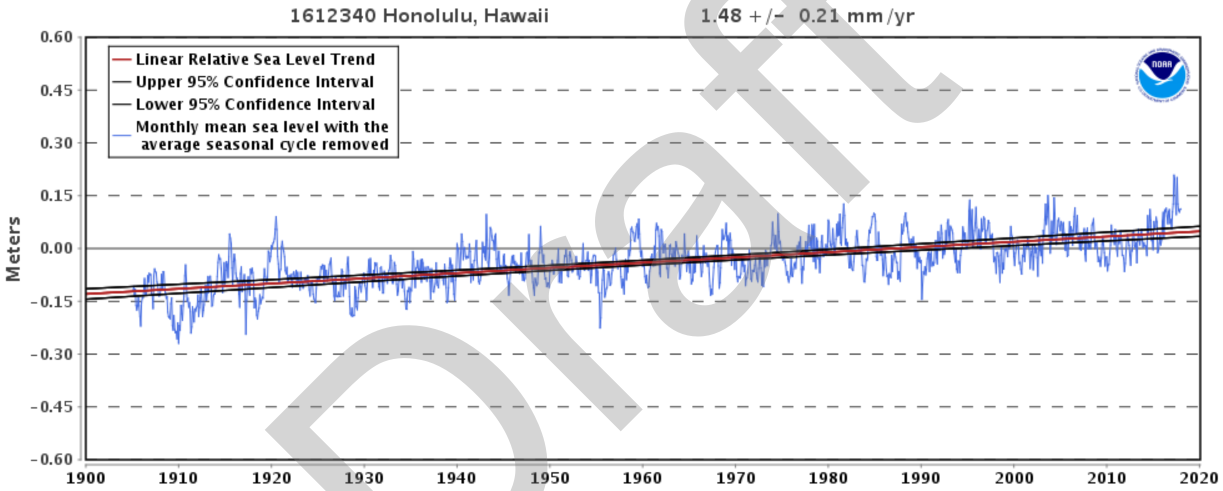


Figure 36. Monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents.

The monthly extreme water levels include a Mean Sea Level (MSL) trend of 1.48 millimeters/year with a 95% confidence interval of +/- 0.21 millimeters/year based on monthly MSL data from 1905 to 2017 which is equivalent to a change of 0.49 feet in 100 years.

2.6 ESSENTIAL FISH HABITAT

2.6.1 Introduction

The Magnuson-Stevens Fishery Conservation and Management Act 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 Magnuson-Stevens Act defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Habitat Areas of Particular Concern (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.

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

The EFH Final Rule strongly recommends regional fisheries management councils and NMFS to conduct a review and revision of the EFH components of fisheries management plans every 5 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 report is designed to meet the FEP requirements and EFH Final Rule guidelines regarding EFH reviews.

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

2.6.1.1 EFH Information

The EFH components of fisheries management plans include the description and identification of EFH, lists of prey species and locations for each managed species, and optionally, habitat areas of particular concern (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 SAFE report.

The Council has described EFH for five management unit species (MUS) under its management authority: pelagic (PMUS), bottomfish (BMUS), crustaceans (CMUS), coral reef ecosystem (CREMUS), and precious corals (PCMUS). The Hawaii FEP describes EFH for the BMUS, CMUS, CREMUS, 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 Section 0.
- Updated research and information needs, which can be found in Section 2.6.5. These can be used to directly update the FEP.
- An analysis that distinguishes EFH from all potential habitats used by the species, which is the basis for an options paper for the Council. This part is developed if enough information exists to refine EFH.

2.6.1.2 Habitat Objectives of FEP

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

a. 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;
b. 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.

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

2.6.1.3 Response to Previous Council Recommendations

At its 170th meeting, the Council directed staff to develop options for refining precious corals essential fish habitat for the Council's consideration, based on the review in the 2016 SAFE report. The options paper is under development.

At its 170th meeting, the Council directed staff to scope the non-fishing impacts review, from the 2016 SAFE reports, through its advisory bodies. The Hawaii Regional Ecosystem Advisory Committee provided comments on the non-fishing impacts review at a meeting held December 1, 2017, in Honolulu.

2.6.2 Habitat Use by MUS and Trends in Habitat Condition

The Hawaiian Archipelago is an island chain in the central North Pacific Ocean. It runs for approximately 1,500 miles in a northwest direction, from Hawaii Island in the southeast to Kure

Atoll in the northwest and is among the most isolated island areas in the world. The chain can be divided according to the large and mountainous Main Hawaiian Islands (MHI) (Hawaii, Maui, Lanai, Molokai, Kahoolawe, Oahu, Kauai, and Niihau) and the small, low-lying Northwest Hawaiian Islands (NWHI), which include Necker, French Frigate Shoals, Laysan, and Midway atoll. The largest of the MHI is Hawaii Island at just over 4,000 square miles – the largest in Polynesia, while Kahoolawe is the smallest, at 44.6 square miles.

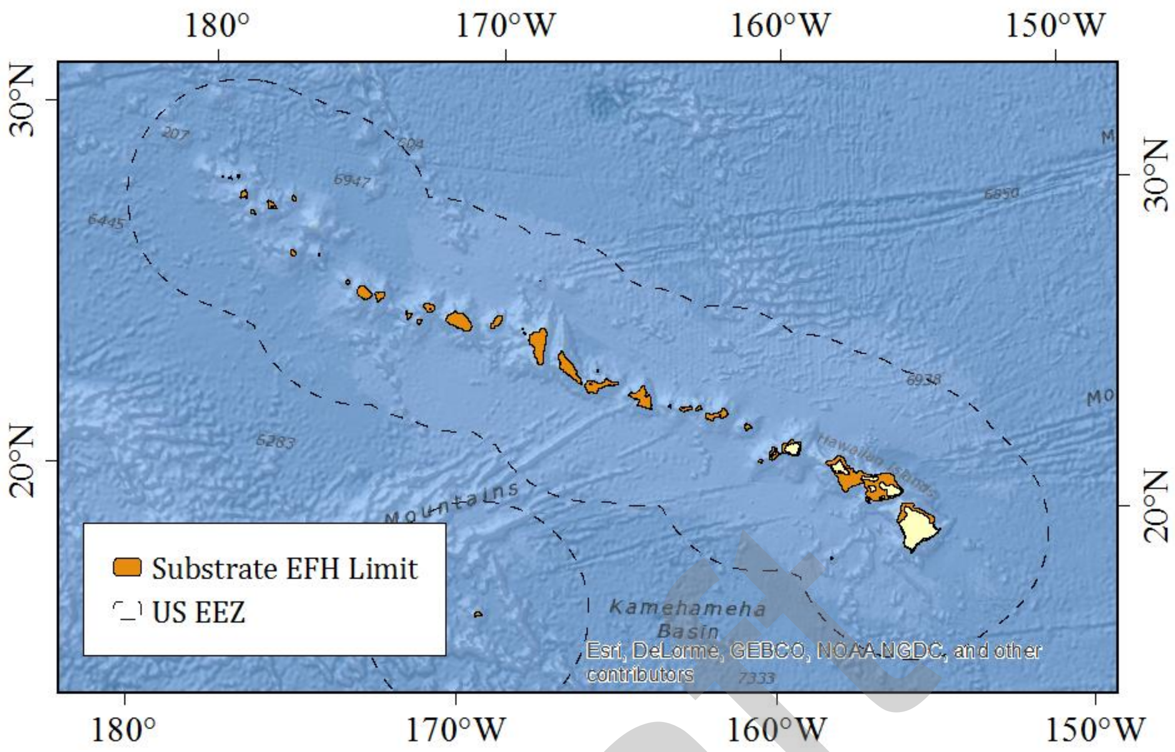
The archipelago developed as the Pacific plate moved slowly over a hotspot in the Earth's mantle. Thus, the islands on the northwest end of the archipelago are older; it is estimated that Kure Atoll is approximately 28 million years old while Hawaii Island is approximately 400,000 years old. The highest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

The MHI are all in tropical latitudes. The archipelago becomes subtropical at about French Frigate Shoals (23° 46’ N). The climate of the Hawaiian Islands is generally tropical, but there is great climactic variation, due primarily to elevation and leeward vs. 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, though the MHI, because they are much younger, have more fringing reef habitat than the NWHI, which has more shallow reef habitat overall.

Essential fish habitat in the Hawaiian Archipelago for the four 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 exclusive economic zone (EEZ). While 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 Program (CREP) biennially since 2002, surveys are focused on the nearshore environments surrounding the islands, atolls, and reefs (PIBHMC).

The mission of the PIFSC Coral Reef Ecosystem Program (CREP) is to “provide high-quality, scientific information about the status of coral reef ecosystems of the U.S. Pacific islands to the public, resource managers, and policymakers on local, regional, national, and international levels” (PIFSC, 2011). CREP’s Reef Assessment and Monitoring Program (RAMP) conducts comprehensive ecosystem monitoring surveys at about 50 island, atoll, and shallow bank sites in the Western Pacific Region on a one to three year schedule (PIFSC, 2008). CREP coral reef monitoring reports provide the most comprehensive description of nearshore habitat quality in the region. The benthic habitat mapping program provides information on the quantity of habitat.



Esri, DeLorme, GEBCO, NOAA NGDC, and other contributors

Figure 37. Substrate EFH limit of 700 m isobath around the islands and surrounding banks of the Hawaiian Archipelago (from GMRT).

2.6.2.1 Habitat Mapping

Interpreted IKONOS benthic habitat maps in the 0 – 30 m depth range have been completed for all islands in the MHI and NWHI (CRCP, 2011). While there are gaps in multibeam coverage in the MHI (CRCP, 2011), 60 m resolution bathymetry and backscatter are available from the Falkor for much of the NWHI (MHI Multibeam Bathymetry and Backscatter Synthesis).

Table 68. Summary of habitat mapping in the MHI.

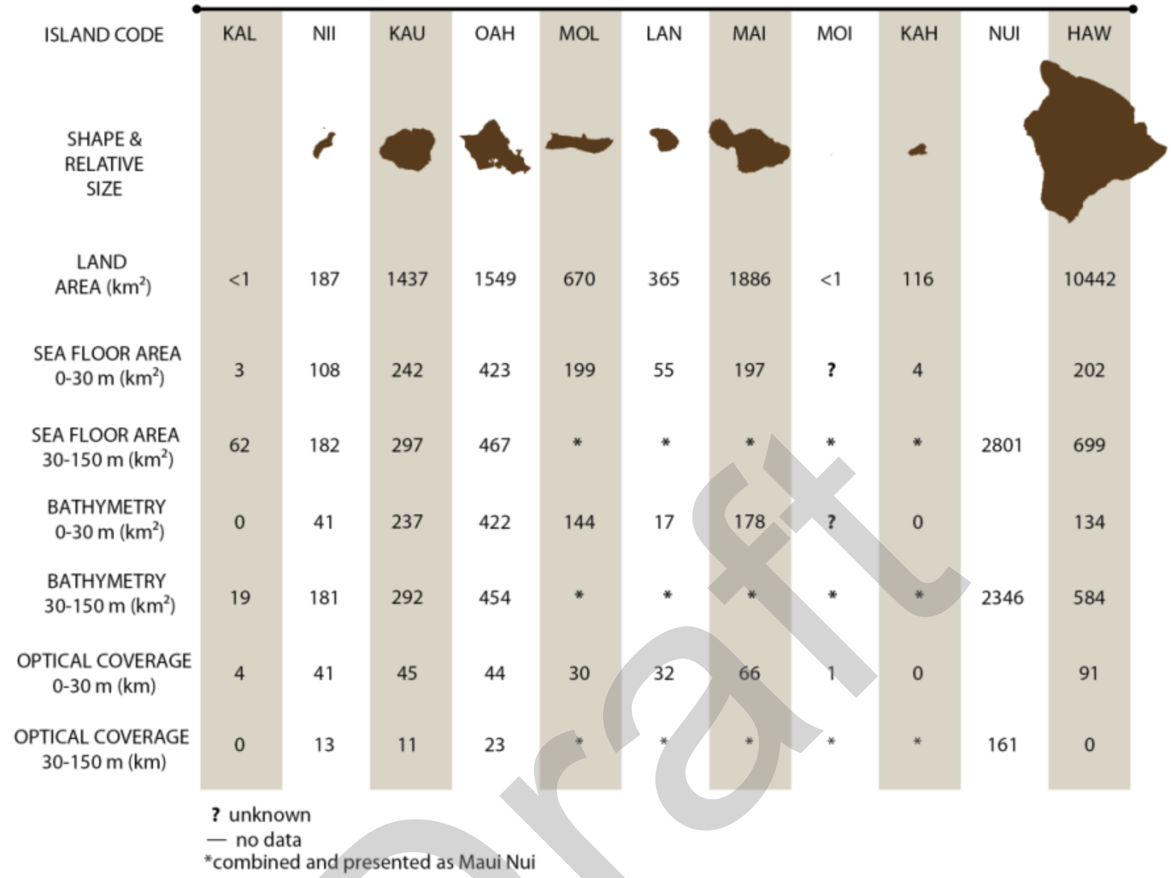
Depth Range	Timeline/Mapping Product	Progress	Source
0-30 m	IKONOS Benthic Habitat Maps	All islands complete	CRCP 2011
	2000-2010 Bathymetry	84%	DesRochers 2016
	2011-2015 Multibeam Bathymetry	4%	DesRochers 2016
	2011-2015 Satellite WorldView 2 Bathymetry	5%	DesRochers 2016
0-150 m	Multibeam Bathymetry	Gaps exist around Maui, Lanai, and Kahoolawe. Access restricted at	CRCP 2011

		Kahoolawe.	
30-150 m	2000-2010 Bathymetry	86%	DesRochers 2016
	2011-2015 Multibeam Bathymetry	2%	DesRochers 2016
Over all multibeam depths	Derived Products	Few exist	CRCP 2011

Table 69. Summary of habitat mapping in the NWHI.

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

The land and seafloor area surrounding the islands of the MHI as well as primary data coverage are reproduced from CRCP (2011) in Figure 38.

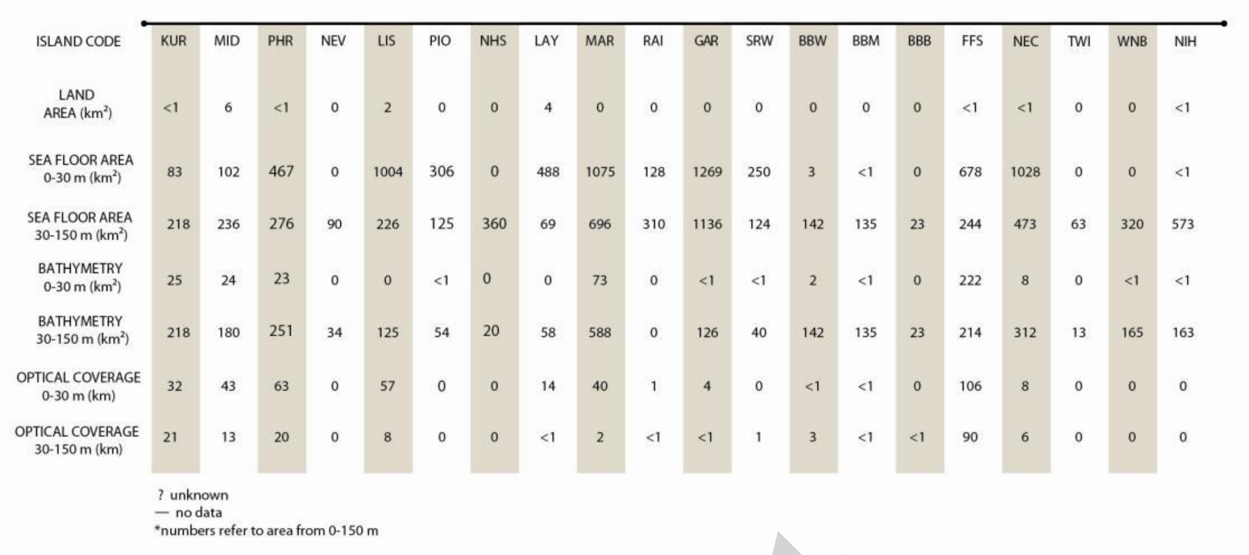


ISLAND CODE	KAL	NII	KAU	OAH	MOL	LAN	MAI	MOI	KAH	NUI	HAW
SHAPE & RELATIVE SIZE											
LAND AREA (km^2)	<1	187	1437	1549	670	365	1886	<1	116		10442
SEA FLOOR AREA 0-30 m (km^2)	3	108	242	423	199	55	197	?	4		202
SEA FLOOR AREA 30-150 m (km^2)	62	182	297	467	*	*	*	*	*	2801	699
BATHYMETRY 0-30 m (km^2)	0	41	237	422	144	17	178	?	0		134
BATHYMETRY 30-150 m (km^2)	19	181	292	454	*	*	*	*	*	2346	584
OPTICAL COVERAGE 0-30 m (km)	4	41	45	44	30	32	66	1	0		91
OPTICAL COVERAGE 30-150 m (km)	0	13	11	23	*	*	*	*	*	161	0

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

Figure 38. MHI Land and Seafloor Area and Primary Data Coverage (from CRCP, 2011).

The land and seafloor area surrounding the islands of the MHI as well as primary data coverage are reproduced from CRCP (2011) in Figure 39.



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

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

Figure 39. NWHI Land and Seafloor Area and Primary Data Coverage (from CRCP, 2011).

2.6.2.2 Benthic Habitat

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

2.6.2.2.1 RAMP Indicators

Benthic percent cover of coral, macroalgae, and crustose coralline algae from CREP are found in the following tables. CREP uses the benthic towed-diver survey method to monitor changes in benthic composition. In this method, “a pair of scuba divers (one collecting fish data, the other collecting benthic data) is towed about 1 m above the reef roughly 60 m behind a small boat at a constant speed of about 1.5 kt. Each diver maneuvers a towboard platform, which is connected to the boat by a bridle and towline and outfitted with a communications telegraph and various survey equipment, including a downward-facing digital SLR camera (Canon EOS 50D, Canon Inc., Tokyo). The benthic towed diver records general habitat complexity and type (e.g., spur and groove, pavement), percent cover by functional-group (hard corals, stressed corals, soft corals, macroalgae, crustose coralline algae, sand, and rubble), and for macroinvertebrates (crown-of-thorns seastars, sea cucumbers, free and boring urchins, and giant clams).

Towed-diver surveys are typically 50 minutes long and cover about 2-3 km of habitat. Each survey is divided into five-minute segments, with data recorded separately per segment to allow for later location of observations within the ~ 200-300 m length of each segment. Throughout each survey, latitude and longitude of the survey track are recorded on the small boat using a

GPS; and after the survey, diver tracks are generated with the GPS data and a layback algorithm that accounts for position of the diver relative to the boat. (PIFSC Website, 2016).

Table 70. Mean percent cover of live coral from RAMP sites collected from towed-diver surveys in the MHI.

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

Table 71. Mean percent cover of macroalgae from RAMP sites collected from towed-diver surveys in the MHI.

Year	**2005**	**2006**	**2008**	**2010**	**2016**
Hawaii		5.46	1.01	1.05	0.29
Kauai	35.67	27.92	16.45	16.25	9.61
Kaula		5.94			
Lanai	7.38	13.18	17.13	11.14	2.69
Maui	17.84	16.24	12.04	2.13	12.12
Molokai	23.31	24.22	12.71	4.75	9.47
Niihau	41.3	14.57	2.58	2.22	0.03
Oahu	37.03	27.41	12.58	13.03	

Table 72. Mean percent cover of crustose coralline algae from RAMP sites collected from towed-diver surveys in the MHI.

Year	**2005**	**2006**	**2008**	**2010**	**2016**
Hawaii		14.82	16.09	6.94	5.97
Kauai	3.67	2.94	4.14	1.71	2.7
Kaula		7.4			
Lanai	2.42	1.31	3.72	2.82	0.03
Maui	4.37	4.83	6.82	4.31	1.22
Molokai	3.71	3.79	5.24	4.19	0.65
Niihau	10.87	6.68	8.05	1.88	0.28
Oahu	13.95	2.74	4.28	2.42	

Table 73. Mean percent cover of live coral from RAMP sites collected from towed-diver surveys in the NWHI.

Year	2000	2001	2002	2003	2004	2006	2008	2010	2016
French Frigate	27.23	5	14.22	13.47	11.29	18.25	15.23	13.28	17.53
Gardner	3			2.5	1.65				
Kure	7.3		9.61	12.34	12.63	17.2	17.6	14.57	13.08
Laysan	9.96		9.76	4	7.33	6.96	8.43		
Lisianski	28.17		24.29	15.2	26.81	27.22	25.69	27.56	26.96
Maro	27.38	18.31	13.77	16.54	25.59	22.67	19.78		
Midway			5.58	3.06	1.24	3.91	2.66		
Necker	6.5			14.52		14.92			
Nihoa	3.89								
Pearl & Hermes	15.82		10.71	6.47	9.45	11.64	10.79	8.25	7.91
Raita		2.5							

Table 74. Mean percent cover of macroalgae from RAMP sites collected from towed-diver surveys in the NWHI.

Year	2000	2001	2002	2003	2004	2006	2008	2010	2016
French Frigate	0	10.5	30.13	29.05	23.15	17.33	17.81	18.42	9.6
Gardner	0			73.63	26.94				
Kure	0		38.84	42.79	29.84	23.14	26.22	12.99	11.00
Laysan	0		26.9	47.03	30.63	28.66	25.7		
Lisianski	0		20.04	24.61	17.14	21.46	20.83	13.85	10.92
Maro	0	17.01	20.39	17.69	30.01	20.79	18.19		
Midway			42.28	44.9	24.86	11.02	19.93		
Necker	0			23.39		33.51			
Nihoa	0								
Pearl & Hermes	0		36.94	41.51	114.87	33.56	33.79	36.96	39.84
Raita		68.83							

Table 75. Mean percent cover of crustose coralline algae from RAMP sites collected from towed-diver surveys in the NWHI.

Year	2000	2001	2002	2003	2004	2006	2008	2010	2016
French Frigate	0	0	8.55	8.56	2.52	9.46	8.55	1.87	4.21
Gardner	0			9.13	1.5				
Kure	0		3.38	7.65	5.87	7.31	6.91	4.11	7.18
Laysan	0		3.95	11.17	5.11	10.21	7.93		

Year	**2000**	**2001**	**2002**	**2003**	**2004**	**2006**	**2008**	**2010**	**2016**
Lisianski	0		14.21	7.97	12.11	17.19	17.42	11.78	13.29
Maro	0	13.95	15.17	12.89	4.36	16.54	15.29		
Midway			7.58	3.69	7.17	5.8	5.62		
Necker	0			7.86		1.48			
Nihoa	0								
Pearl & Hermes	0		14.13	14.38	11.84	10.07	12.43	7.61	14.44
Raita		0.42							

2.6.2.3 Oceanography and Water Quality

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

2.6.3 Report on Review of EFH Information

One EFH review was drafted this year; the review of the biological components of crustaceans EFH can be found in Appendix C.

2.6.4 EFH Levels

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

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

The Council adopted a fifth level, denoted Level 0, for situations in which there is no information available about the geographic extent of a particular managed species' life stage. The existing level of data for individual MUS in each fishery are presented in tables per fishery. In subsequent SAFE reports, each fishery section will include the description of EFH method, method used to assess the value of the habitat to the species, description of data sources used if there was analysis; and description of method for analysis.

2.6.4.1 Precious Corals

Essential Fish Habitat for precious corals was originally designated in Amendment 4 to the Precious Corals Fishery Management Plan (64 FR 19067, April 19, 1999), using the level of data found in the table.

Table 76. Level of EFH available for Hawaii precious corals management unit species complex.

Species	Pelagic phase (larval stage)	Benthic phase	Source(s)
Pink Coral (*Corallium)*			
Pleurocorallium secundum (prev. *Corallium secundum)*	0	1	Figueroa & Baco, 2014 HURL Database
C. regale	0	1	HURL Database
Hemicorallium laauense (prev. C. laauense)	0	1	HURL Database
Gold Coral			
Kulamanamana haumeaae (prev.	0	1	Sinniger, *et al.* (2013) HURL Database
Callogorgia gilberti	0	1	HURL Database
Narella spp.	0	1	HURL Database
Bamboo Coral			
Lepidisis olapa	0	1	HURL Database
Acanella spp.	0	1	HURL Database
Black Coral			
Antipathes griggi (prev. *Antipathes dichotoma)*	0	2	Opresko, 2009 HURL Database
A. grandis	0	1	HURL Database
Myriopathes ulex (prev. *A. ulex)*	0	1	Opresko, 2009 HURL Database

2.6.4.2 Bottomfish and Seamount Groundfish

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

Table 77. Level of EFH information available for Hawaii bottomfish and seamount groundfish management unit species complex.

Life History Stage	**Eggs**	**Larvae**	**Juvenile**	**Adult**
Bottomfish: (scientific/english common)				
Aphareus rutilans (red snapper/silvermouth)	0	0	0	2
Aprion virescens (gray snapper/jobfish)	0	0	1	2
Caranx ignoblis (giant trevally/jack)	0	0	1	2
C. lugubris (black trevally/jack)	0	0	0	2
Epinephelus faciatus (blacktip grouper)	0	0	0	1
E quernus (sea bass)	0	0	1	2
Etelis carbunculus (red snapper)	0	0	1	2
E. coruscans (red snapper)	0	0	1	2
Lethrinus amboinensis (ambon emperor)	0	0	0	1
L. rubrioperculatus (redgill emperor)	0	0	0	1
Lutjanus kasmira (blueline snapper)	0	0	1	1
Pristipomoides auricilla (yellowtail snapper)	0	0	0	2
P. filamentosus (pink snapper)	0	0	1	2

Life History Stage	**Eggs**	**Larvae**	**Juvenile**	**Adult**
P. flavipinnis (yelloweye snapper)	0	0	0	2
P. seiboldi (pink snapper)	0	0	1	2
P. zonatus (snapper)	0	0	0	2
Pseudocaranx dentex (thicklip trevally)	0	0	1	2
Seriola dumerili (amberjack)	0	0	0	2
Variola louti (lunartail grouper)	0	0	0	2
Seamount Groundfish:				
Beryx splendens (alfonsin)	0	1	2	2
Hyperoglyphe japonica (ratfish/butterfish)	0	0	0	1
Pseudopentaceros richardsoni (armorhead)	0	1	1	3

2.6.4.3 Crustaceans

Essential Fish Habitat for crustaceans MUS 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 78. Level of EFH information available for Hawaii crustacean management unit species complex.

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

2.6.4.4 Coral Reef

Essential Fish Habitat for coral reef ecosystem species was originally designated in the Coral Reef Ecosystem FMP (69 FR 8336, February 24, 2004). An EFH review of CREMUS will not be undertaken until the Council completes its process of re-designating certain CREMUS into the ecosystem component classification. Ecosystem component species do not require EFH designations, as they are not a managed species.

2.6.5 Research and Information Needs

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

2.6.5.1 All FMP Fisheries

- Distribution of early life history stages (eggs and larvae) of management unit species by habitat.
- Juvenile habitat (including physical, chemical, and biological features that determine suitable juvenile habitat).
- Food habits (feeding depth, major prey species etc).
- Habitat-related densities for all MUS life history stages.
- Growth, reproduction, and survival rates for MUS within habitats.

2.6.5.2 Bottomfish Fishery

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

2.6.5.3 Crustaceans Fishery

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

2.6.5.4 Precious Coral Fishery

- Statistically sound estimates of distribution, abundance, and condition of precious corals throughout the MHI. Targeted surveys of areas that meet the depth and hardness criteria could provide very accurate estimates.
- Environmental conditions necessary for precious coral settlement, growth, and reproduction. The same surveys used for abundance and distribution could collect these data as well.
- Quantitative measures of growth and productivity.
- Taxonomic investigations to ascertain if the *H. laauense* that is commonly observed between 200 and 600 meters depth is the same species as those *H. laauense* observed below 1000 meters in depth.
- Continuous backscatter or LIDAR data in depths shallower than 60 m.

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2.7 MARINE PLANNING

2.7.1 Introduction

Marine planning is a science-based 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. The Council's efforts to formalize incorporation of marine planning in its actions began in response to Executive Order 13547, Stewardship of the Ocean, Our Coasts, and the Great Lakes. Executive Order 13158, Marine Protected Areas (MPAs), proposes that agencies strengthen the management, protection, and conservation of existing MPAs, develop a national system of MPAs representing diverse ecosystems, and avoid causing harm to MPAs through federal activities. MPAs, or marine managed areas (MMAs) are one tool used in fisheries management and marine planning.

At its 165th meeting in March 2016, in Honolulu, Hawai`i, the Council approved the following objective for the FEPs: Consider the Implications of Spatial Management Arrangements in Council Decision-making. The following sub-objectives apply:

a. Identify and prioritize research that examines the positive and negative consequences of areas that restrict or prohibit fishing to fisheries, fishery ecosystems, and fishermen, such as the Bottomfish Fishing Restricted Areas, military installations, NWHI restrictions, and Marine Life Conservation Districts.

b. Establish effective spatially-based fishing zones.

c. Consider modifying or removing spatial-based fishing restrictions that are no longer necessary or effective in meeting their management objectives.

d. As needed, periodically evaluate the management effectiveness of existing spatial-based fishing zones in Federal waters.

In order to monitor implementation of this objective, this annual report includes the Council's spatially-based fishing restrictions or marine managed areas (MMAs), the goals associated with those, and the most recent evaluation. Council research needs are identified and prioritized through the 5 Year Research Priorities and other processes, and are not tracked in this report.

In order 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 or 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 FEP's EFH cumulative impacts section. These are redundant efforts; therefore, this report can provide material or suggest resources to meet both mandates.

2.7.2 Response to Previous Council Recommendations

There are no standing Council recommendations indicating review deadlines for Hawaii marine managed areas.

2.7.3 Marine Managed Areas established under FEPs

Council-established marine managed areas (MMAs) were compiled in Table 79 from 50 CFR § 665, Western Pacific Fisheries, the Federal Register, and Council amendment documents. Geodesic areas were calculated in square kilometers in ArcGIS 10.2. Regulated fishing areas, including the Papahānaumokuākea Marine National Monument, are shown in Figure 40.

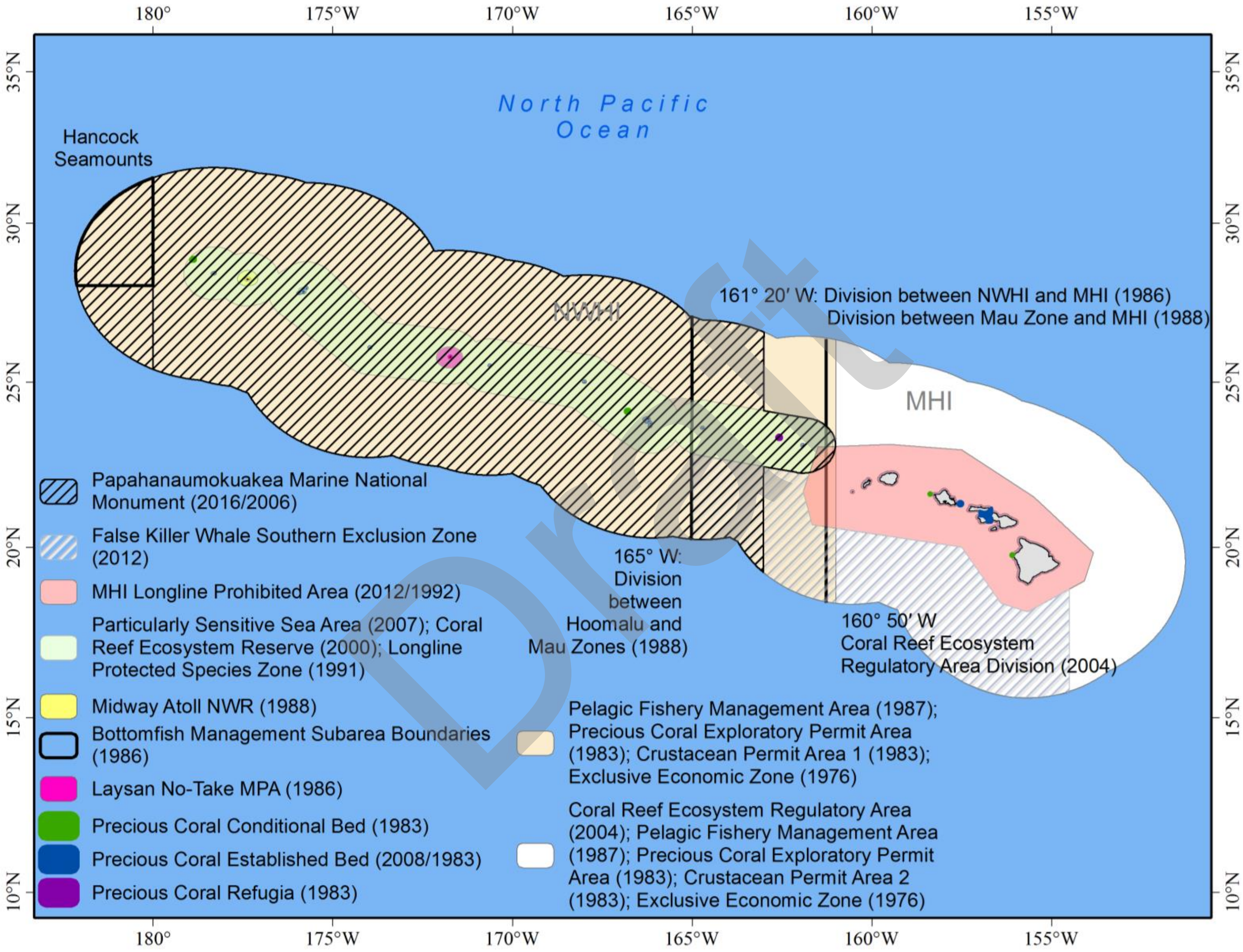

Figure 40. Regulated fishing areas of the Main Hawaiian Islands.

Table 79. MMAs established under FEP from 50 CFR § 665.

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

2.7.4 Fishing Activities and Facilities

2.7.4.1 Aquaculture facilities

Hawaiʻi has one permitted offshore aquaculture facility. The information in Table 80 was transferred from the Joint NMFS and U.S. Army Corps of Engineers EFH Assessment for the Proposed Issuance of a Permit to Authorize the Use of a Net Pen and Feed Barge Moored in Federal Waters West of the Island of Hawaii to Fish for a Coral Reef Ecosystem Management Unit Species, *Seriola rivoliana* (RIN 0648-XD961), unless otherwise noted.

Table 80. Aquaculture facilities.

Name	Size	Location	Species	Stage
Kampachi Farms	Shape: Cylindrical Height: 33 ft Diameter: 39 ft Volume: 36,600 ft^3	5.5 nautical miles (nm) west of Keauhou Bay and 7 nm south-southwest of Kailua Bay, off the west coast of Hawaiʻi Island 19 deg 33 min N 156 deg 04 min W. mooring scope is 10,400 foot radius.	*Seriola rivoliana*	Permit authorizes culture and harvest of 30,000 kampachi. In March 2017 the Kampachi Farms permit was transferred to Forever Oceans Corporation. Because of the delay in beginning culture activities the permit was extended through March 31, 2019. No gear is in the water at this time (pers. comm. David Nichols, March 8, 2018).

2.7.5 Non-Fishing Activities and Facilities

The following section includes activities or facilities associated with known uses and predicted future uses. The Plan Team will add to 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 in this report. Activities which are no longer reasonably foreseeable or have been replaced with another planning activity are removed from the report, though may occur in previous reports.

2.7.5.1 Alternative energy facilities

Hawaiʻi has three proposed wind energy facilities in Federal waters and several existing alternative energy facilities. The information in

Table 81 is from various sources.

Table 81. Alternative Energy Facilities and Development

Name	Type	Location	Impact to Fisheries	Stage of Development	Source
AWH O‘ahu Northwest Project	408 MW Wind	12 miles W of Ka‘ena Pt, O‘ahu	Hazard to navigation; benthic impacts from cables	BOEM Area Identification and EA	BOEM Hawai`i
AWH O‘ahu South Project	408 MW Wind	17 miles S of Waikiki, O‘ahu	Hazard to navigation; benthic impacts from cables; close to Penguin Bank	BOEM Area Identification and EA	BOEM Hawai`i
Progression South Coast of Oahu Project	400 MW Wind	SSE of Barber’s Pt and SW of Waikiki, O‘ahu	Hazard to navigation; in popular trolling area; benthic impacts from cables	BOEM Area Identification and EA	Progression Energy BOEM Lease Application, BOEM Hawai`i
Statoil Wind US, LLC	-	-	-	BOEM Area Identification and EA	BOEM Hawaii
Natural Energy Laboratory of Hawai`i	120 kW OTEC Test Site/ 1 MW Test Site	West Hawai`i	Intake	120 kW operational; DEA for 1 MW Test Site using existing infrastructure submitted July 2012 HEPA Exemption List memo Dec. 27, 2016	http://nelha.Hawai`i.gov/energy-portfolio/ Final Environmental Assessment, NELHA, July 2012
Honolulu Sea Water Air Conditioning	SWAC	4 miles S of Kaka‘ako, O‘ahu	Benthic impacts; intake	USACE Record of Decision (ROD) signed	http://honoluluswac.com/pressroom.html
Marine Corps Base Hawai`i Wave Energy Test Site	Shallow- and Deep-Water Wave Energy	1, 2 and 2.5 km N of Mokapu, O‘ahu	Hazard to navigation	Shallow and Deep-water wave energy units are operational	Final Environmental Assessment, NAVFACPAC, January 2014 http://www.eenews.net/stories/1060046254

2.7.5.2 Military training and testing activities and impacts

The Department of Defense major planning activities in the region are summarized below. Maps of the Hawaii-Southern California Range Complex from the Hawaii Range Complex FEIS are included in the maps section.

Action	Description	Phase	Impacts
Hawaii-Southern California Training and Testing	Increase naval testing and training activities	DEIS published October 13, 2017. Comment period closed Dec. 12, 2017. Staff attended	EFH consultation has not been initiated. Likely access and habitat

		a public hearing.	impacts similar to previous analysis.
Long Range Strike Weapon Systems Evaluation Program (WSEP)	Conduct operational evaluations of Long Range Strike weapons and other munitions as part of Long Range Strike WSEP operations at the Pacific Missile Range Facility at Kauai, Hawaii	Comment period closed Feb. 6, 2017 on NMFS authorization to take marine mammals incidental to conducting munitions testing for their Long Range Strike Weapons Systems Evaluation Program (LRS WSEP) over the course of five years, from September 1, 2017 through August 31, 2022 (82 FR 1702).	Access – closures during training

2.7.6 Pacific Islands Regional Planning Body Report

The Council is a member of the Pacific Islands RPB and as such, the interests of the Council will be incorporated into the CMS plan. It is through the Council member that the Council may submit recommendations to the Pacific Islands RPB.

The Pacific Islands RPB met in Honolulu from February 14-15, 2018. The RPB's American Samoa Ocean Planning Team has completed its draft Regional Ocean Plan, on which the RPB provided comments and endorsement. CNMI and Guam Ocean Planning Teams have held their kick-off meetings. The RPB, by consensus, adopted the following goals for 2018: finalize the American Samoa Ocean Plan; continue planning in Guam and CNMI including conducting coastal and marine spatial planning training; transfer data portal prototype to permanent site and identify data gaps; and increase funding.

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3 DATA INTEGRATION

3.1 INTRODUCTION

3.1.1 Potential Indicators for Insular Fisheries

The purpose of this section ("Chapter 3") of the Stock Assessment and Fishery Evaluation (SAFE) annual 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 (WPR). "Fishery ecosystem relationships" are those associations between various fishery-dependent data measures (e.g. catch, effort, or catch-per-unit-effort), and other environmental attributes (e.g. precipitation, sea surface temperature, primary productivity) 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 what factors may be useful going forward.

To support the development of Chapter 3 of the annual SAFE report, staff from the Council, National Marine Fisheries Service (NMFS), Pacific Islands Fisheries Science Center (PIFSC), Pacific Islands Regional Offices (PIRO), and Triton Aquatics (consultants), held a SAFE Report Data Integration Workshop (hereafter, "the Workshop") convened on November 30, 2016 to identify potential fishery ecosystem relationships relevant to local policy in the WPR and determine appropriate methods to analyze them. Participants are listed in Table 82.

Table 82. Participants of the Data Integration Workshop held in late 2016.

Name	**Affiliation**	**Name**	**Affiliation**
Keith Bigelow	PIFSC	Kevin Kelley	Consultant/PIRO
Chris Boggs	PIFSC	Eric Kingma	Council
Rusty Brainard	PIFSC	Don Kobayashi	PIFSC
Paul Dalzell	Council	Tom Oliver	PIFSC
Joshua DeMello	Council	Michael Parke	PIFSC
Stefanie Dukes	PIFSC	Frank Parrish	PIFSC
Sarah Ellgen	PIRO	Marlowe Sabater	Council
Jamison Gove	PIFSC	Sylvia Spalding	Council
Justin Hospital	PIFSC	Rebecca Walker	Council
Asuka Ishizaki	Council	Mariska Weijerman	PIFSC

Ariel Jacobs	PIRO	Ivor Williams	PIFSC

Following background presentations and discussions regarding ecosystem-based fishery management (EBFM) and previous attempts at data integration, participants were segregated into two smaller working groups to brainstorm island and pelagic fishery and environmental/ecological relationships that may be of use in this section. Several guided questions were provided for every combination of variables:

- What can we reasonably expect to learn from or monitor with the results?
- How does it inform Council decision-making, consistent with the purposes of the FEP?
- Is it part of an ongoing research initiative?

The archipelagic fisheries group developed nearly 30 potential fishery ecosystem relationships (Table 83) to examine across bottomfish, coral reef, and crustacean fisheries based on data reliability, suitability of methodology, repeatability on an annual basis, and how well analyses could potentially inform management decisions.

Table 83. List of prioritized potential fishery ecosystem relationships in insular areas of Western Pacific island regions developed by the archipelagic fisheries group at the Data Integration Workshop.

Relationships	**FEP**	**Score**	**Rank**
Bottomfish catch/effort/CPUE/species composition and benthos/substrate (i.e. depth, structure)	All	22	3
Bottomfish catch/effort/ CPUE /species composition and Pacific Decadal Oscillation	All	20	3
Coral reef fish/fishery/biomass and temperature-derived variable	All	20	3
Akule/opelu and precipitation (MHI and Guam)	HI	20	3
Bottomfish catchability and wind speed	All	19	3
Coral reef fish/fishery/biomass and chlorophyll-*a* (with phase lag)	All	19	3
Bottomfish Catch /CPUE and lunar cycle/moon phase	All	19	3
Bottomfish catch/effort/ CPUE /species composition and sea-level height (eddy feature)	All	18	2
Coral reef fish/fishery/biomass and Pacific Decadal Oscillation	All	18	2
Green/red spiny lobster catch/CPUE and vertical relief	HI	18	2
Green/red spiny lobster catch/CPUE and Pacific Decadal Oscillation	HI	18	2
Bottomfish catchability and fishing conditions (i.e. surface, subsurface current, speed, and direction)	All	17	2

Coral reef fish/fishery/biomass and moon phase	All	17	2
Coral reef fish/fishery/biomass and Oceanic Niño Index	All	17	2
Coral reef fish/fishery/biomass and sea-level height	All	17	2
Coral reef fish/fishery/biomass and pH	All	17	2
Bottomfish catch/effort/ CPUE /species composition and temperature-derived variable (e.g. temperature at depth)	All	16	2
Bottomfish catch/effort/ CPUE /species composition and chlorophyll-*a* (with phase lag)	All	16	2
Bottomfish catch/effort/ CPUE /species composition and precipitation	All	16	2
Coral reef fish/fishery/biomass and structural complexity /benthic habitat	All	16	2
Bottomfish catch/effort/ CPUE /species composition and dissolved oxygen	All	15	2
Coral reef fish/fishery/biomass and precipitation	All	14	2
Bottomfish catch/effort/ CPUE /species composition and pH	All	13	2
Bottomfish catch/effort/ CPUE /species composition and predator abundance	All	12	2
Coral reef fish/fishery/biomass and salinity	All	12	2
Coral reef fish/fishery/biomass and dissolved oxygen	All	12	2
Bottomfish catch/effort/ CPUE /species composition and salinity	All	10	1

To begin, this chapter will include brief descriptions of past work on fishery ecosystem relationship assessment in coral reefs of the U.S. Western Pacific, followed by initial evaluations of relationships previously recommended for analysis by participants of the Workshop using current data streams in Hawaii. The evaluations completed were exploratory in nature, and were used as the first step of analyses to know which comparisons may hold more utility going forward. Those relationships deemed potentially relevant were emphasized and recommended for further analysis. In subsequent years, this chapter will be updated with analyses through the SAFE report process to include more of the described climate change indicators from Section 2.5.3, and as the strength of certain fishery ecosystem relationships relevant to advancing ecosystem-based fishery management are determined.

3.1.2 2018 Recommendations for Section Development

At the most recent FEP Plan Team Meeting held on April 30th – May 1st, 2018, participants were presented preliminary data integration results shown here, and 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 be implemented in the coming year to ensure that more refined analyses comprise the data integration section. FEP 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 (e.g. purse seine harvest of *Selar crumenophthalmus* in the MHI).
- 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.
- Spatial specificity and precision should be increased for analyses of environmental variables in relation to areas commonly fished.

At its 172nd Council meeting, the WPRFMC provided no formal recommendations. However, it was suggested by individual Council members that, in addition to implementing additional data streams when time series of sufficient length become available (e.g. bio-sampling data), that the results should be standardized in such that they can be presented as estimated potential percent change in the fishery in response to measured environmental variability.

At its 128th meeting, the Science and Statistical Committee (SSC) was also presented the preliminary data integration results shown here. Going forward, the SSC suggested the use of multivariate assessment in the form of Structural Equation Models to determine difference in parameters between years, but there existed disagreement as to whether these analyses should be used only as precedence for more thorough univariate assessments. Additionally, it was suggested that examining the potential fishery ecosystem relationships from an energetics perspective may emphasize changes in the fishery associated with ecological change. However, it was noted that such relationships between fishery and environmental parameters, if they exist, may already be (or should already be) represented in prevailing stock assessments.

Incorporating such recommendations into the 2018 version of 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 Past Work

Richards *et al.* (2012) performed a study on a range environmental factors that could potentially affect the distribution of large-bodied coral reef fish in Mariana Archipelago. Large-bodied reef fish were determined to typically be at the greatest risk of overfishing, and their distribution in the region was shown to be negatively associated with human population density. Additionally, depth, sea surface temperature (SST), and distance to deep water were identified as important environmental factors to large-bodied coral reef fish, whereas topographic complexity, benthic habitat structure, and benthic cover had little association with reef fish distribution in the Mariana Archipelago.

Kitiona *et al.* (2016) completed a study of the impacts climate and/or ecosystem change on coral reefs fish stocks of American Samoa using climate and oceanic indicators (see Section 2.5.3). 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 was also noted that larger natural disturbances in recent decades, such as cyclones and tsunamis, negatively impacted reef fish assemblages and lowed reef fishery CPUE in American Samoa (Ochavillo *et al*., 2012).

On a larger spatial scale, an analysis of various drivers on coral reef fish populations across 37 U.S.-affiliated islands in the Central and Western Pacific was performed by Williams *et al.* (2015), and evaluated relationships between fish biomass in these reefs with human and environmental factors. Again, reef fish assemblages were negatively associated with increasing human population density (even at relatively low levels) across the WRP, but were positively associated with elevated levels of ocean productivity across islands. The authors warned, however, that the ability of reefs surrounding uninhabited islands to maintain fish populations varies, and that high biomass observed in remote areas (e.g. the NWHI) may not necessarily be reflective of baselines or recovery response levels for all reef systems.

A common method of EBFM used in coral reef ecosystems is the implementation of biological reference points, statistical indicators of potential overfishing used to help determine how a fishery is performing relative to these points at a given time (McClanahan *et al*., 2007). Hawhee (2007) adapted this idea, generating biological reference points in the form of CPUE-based proxies to be used as indicators for reef fish stocks in the WPR. However, the devised method was determined to be inappropriate for application in management of reef stocks in the U.S. Western Pacific due to the lack of a historical CPUE to use as a baseline for the reference points and their limit thresholds (Remington and Field, 2016).

3.2 PRECIPITATION

Participants of the Workshop determined that the potential fishery ecosystem relationships between precipitation levels and akule and opelu (bigeye scad and mackerel scad, *Selar crumenophthalmu*s and *Decapterus macarellus*, respectively) were among the highest priority of those involving coral reef fisheries in the MHI. It has been suggested that the recruitment of small tropical pelagic fish is related to annual rainfall and subsequent runoff enrichment (Longhurst and Pauly, 1987). The direct freshwater and nutrient input to reefs associated with increased precipitation can alter the physiochemical composition of the water, and it has been shown that reef assemblages are positively associated with this sort of increased ocean productivity (Williams *et al.*, 2015). Weng and Sibert (2000) explicitly suggested a link between precipitation levels and the carrying capacity for akule in the MHI with a phase lag of two years. Data for precipitation in the MHI was gathered from local databases maintained by the National Weather Service (NWS-HI). Based on direction from SSC members, future analyses involving precipitation and fishery parameters will look to include time series from the Hawaii State Rainfall Atlas or station data from the NWS.

3.2.1 Trends in Precipitation

Figure 41and Figure 42show that total annual precipitation in both the Honolulu and Hilo areas have had non-significant, interannually-variable trends over the last seven decades (e.g. for Honolulu, R^2=0.14; CV=46.0; Figure 41). Honolulu precipitation was the focus for many of the comparisons, though Hilo rainfall data was more closely considered when subsequently incorporating phase lag, etc.

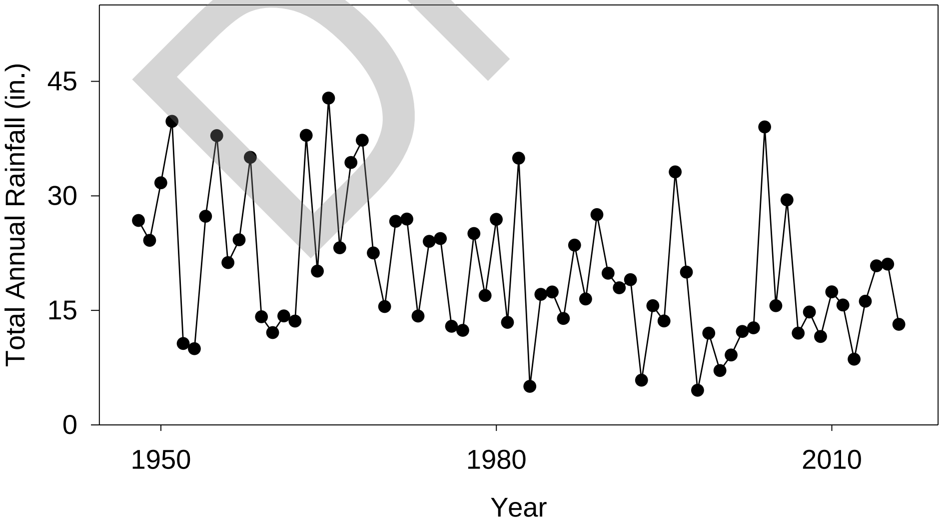

Figure 41. Annual rainfall (in.) for the Honolulu area of Oahu, HI from 1948-2016.

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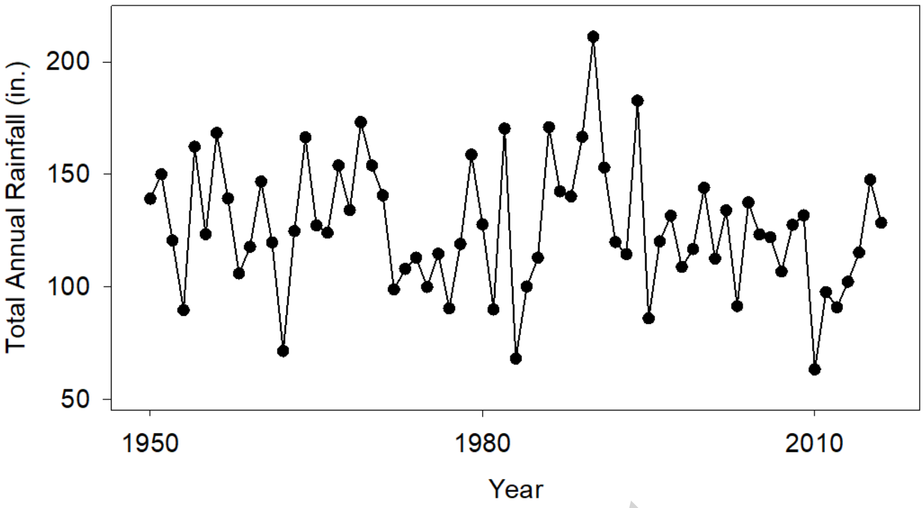


Figure 42. Annual rainfall (in.) for the Hilo area of the Big Island, HI from 1950-2016.

3.2.2 Relationship with Hawaiian scads

3.2.2.1 Akule

Total annual akule landings in the MHI commercial coral reef fishery have been showing a slight increase over the last several decades with a maximum catch of over 1.2 million lbs. in the early 2000s, though the trend is not statistically significant considering the entirety of the available time series (R^2=0.08; CV=50.5; Figure 43). The number of annual fishing trips for akule, conversely, has been observably declining since 1948 with a more observable (non-significant) trend apart from some increased effort in the late 20th century (R^2=0.15; Figure 43). The slight increase in Hawaiian akule landings combined with decreasing effort over the course of the time series has led to an increase in akule CPUE in the MHI over time, though this trend was also not statistically significant (R^2=0.17; Figure 43).

In comparing the time series of commercial CPUE for akule to total annual rainfall in the MHI, there are some segments of the time series that visually appeared to covary, especially in the mid-1980s and late-2000s (Figure 44). Analyzing further, the correlation between akule CPUE in the MHI and these two rainfall parameters showed almost no association considering all available data (R^2=0.01 and R^2=0.00, respectively; Figure 45). It has been suggested that evaluating the entirety of the time series may obfuscate any potential relationship between akule and interannual precipitation because of major shifts in fishery dynamics over the decades (Miyasaka, A., personal communication).

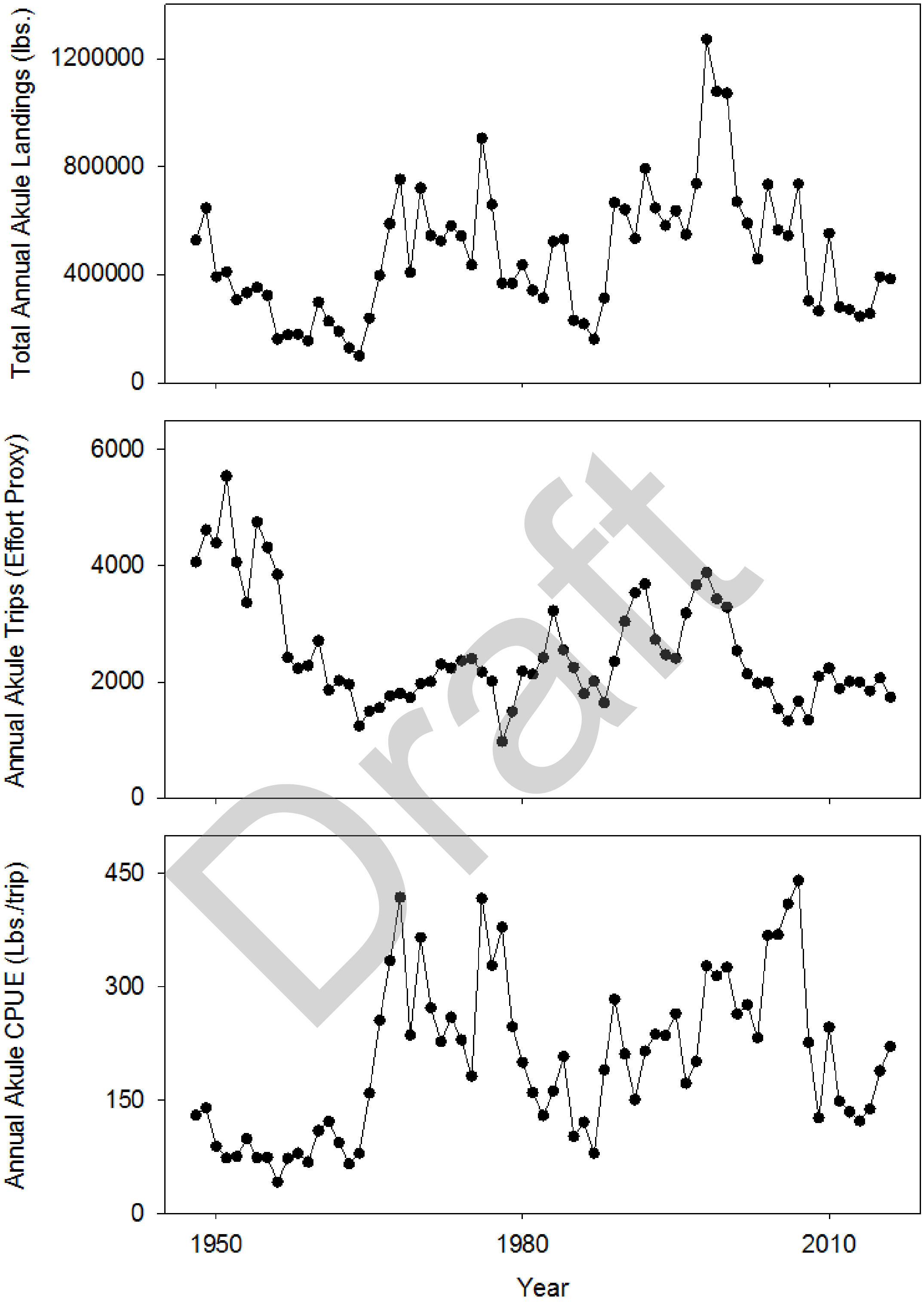


Figure 43. **Time series of landings (lbs.; top), effort (number of fishing trips; middle), and CPUE (lbs./trip; bottom) for akule harvested in the MHI commercial coral reef fishery from 1948-2016.**

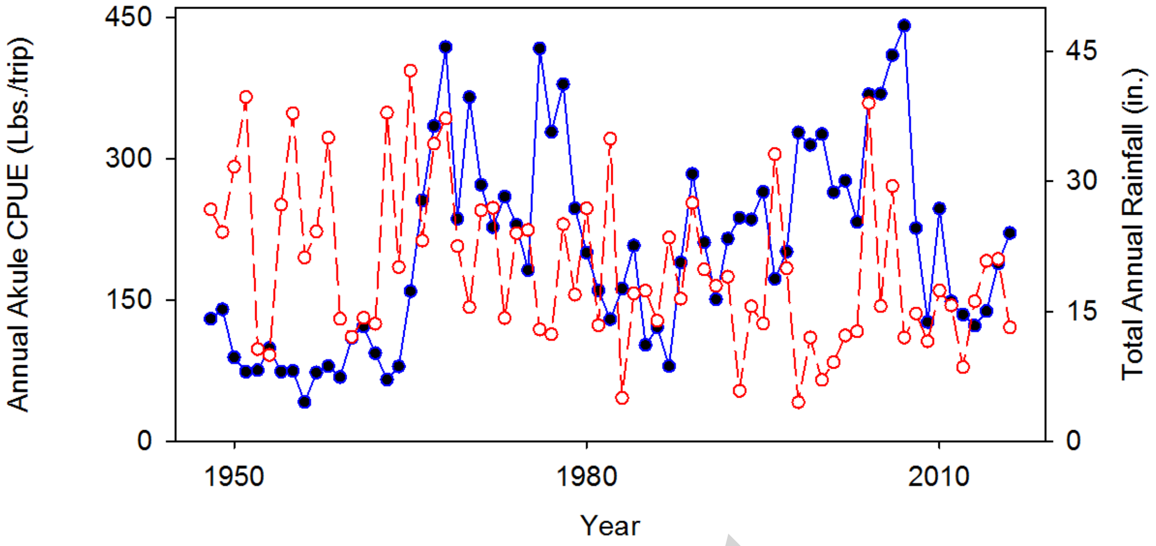


Figure 44. Comparison of time series of annual CPUE (lbs./trip) for akule in the MHI commercial coral reef fishery and total annual rainfall (in.) in the Honolulu area from 1948-2016.

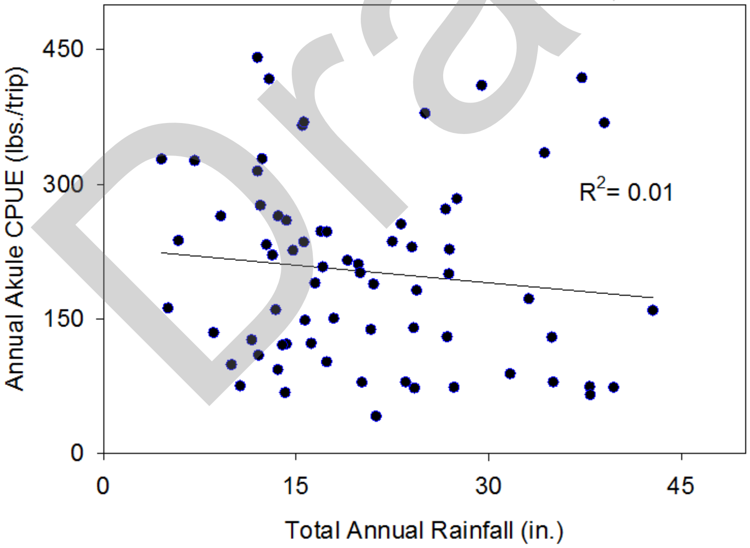


Figure 45. Linear regression between MHI commercial coral reef akule CPUE and annual rainfall (in.) from 1948-2016.

3.2.2.2 Opelu

Opelu catch, effort, and CPUE over the past seven decades in the commercial coral reef fishery of the MHI showed no notable trends despite having slightly less variability than observed for akule (all $R^2 < 0.01$; CV = 48.0; Figure 46). The opelu data showed similar levels of effort in the fishery over time as the akule records, however akule were often landed in larger amounts and thus had a relatively higher CPUE (Figure 43 and Figure 46).

Comparing time series of rainfall in the MHI to CPUE data for opelu harvested commercially over the same period was much more problematic due to outliers, though the rest of the time series has a similar scope of variability as the CPUE time series (CV = 46.0; Figure 47).These outliers apparent in the opelu fishery data were initially thought to contribute to the lack of association due to anomalously high catch (e.g. 1952) and low effort (e.g. 1978); the removal of these outliers, however, did not improve the identification of any relationship. Similar to the akule evaluations, opelu CPUE data showed no general relationship with total annual rainfall ($R^2 = 0.00$; Figure 48).

Several other comparisons were performed to determine if any relationship existed between rainfall rates and akule/opelu CPUE across different gear types or more recent portions of the available CPUE time series in the MHI (Figure 43). Considering fishery data by gear, neither akule nor opelu CPUE data from several prominent gear types showed any significant association with total annual rainfall records ($R^2 > 0.075$; Table 84). Additionally, there was no notable difference in the correlation coefficients between akule and opelu CPUE and rainfall records from the MHI across all gear types considering only standardized data after 1966 (R^2 = 0.02 and 0.00, respectively).

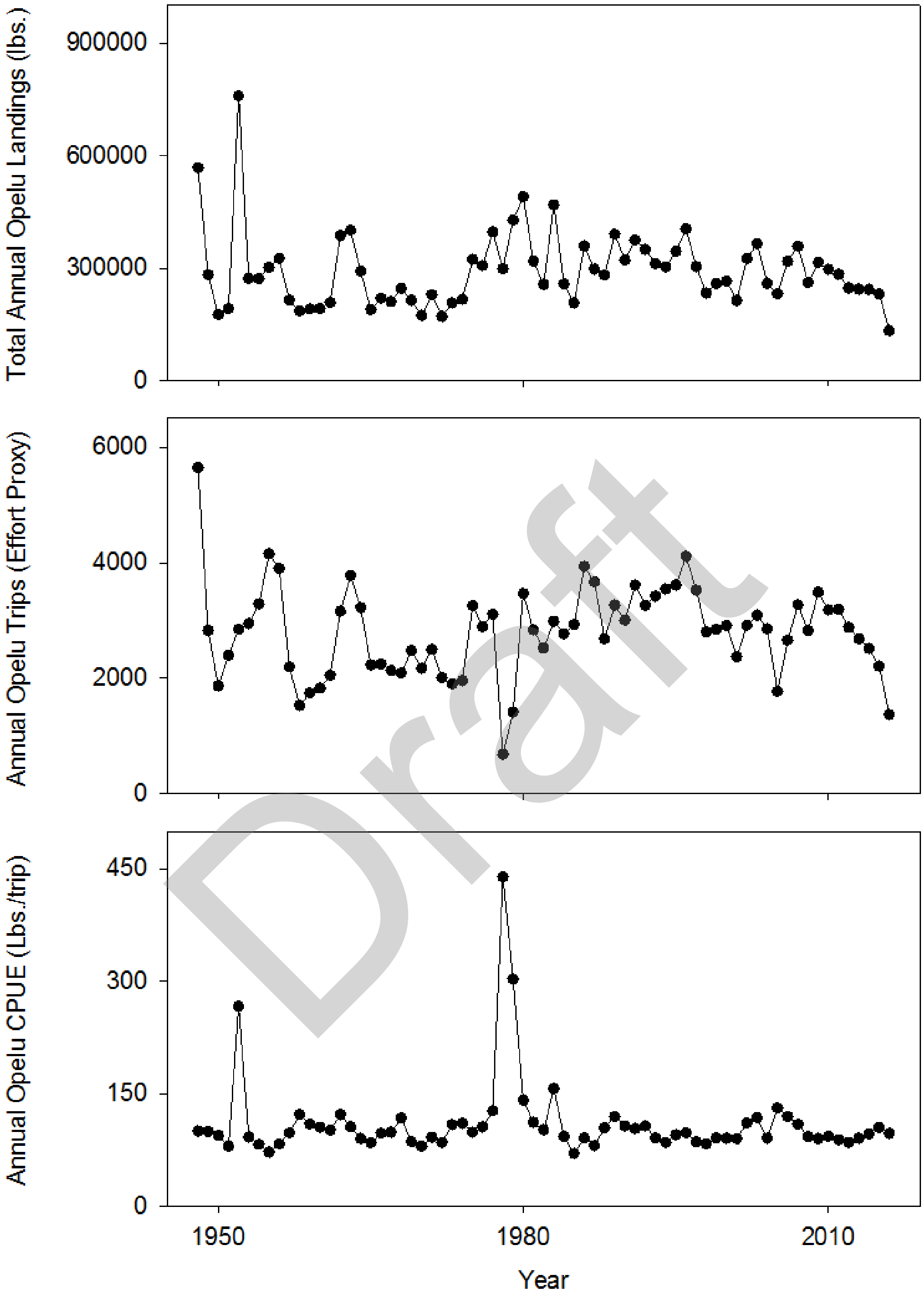


Figure 46. Time series of landings (lbs.; top), effort (number of fishing trips; middle), and CPUE (lbs./trip; bottom) for opelu harvested in the MHI commercial coral reef fishery from 1948-2016.

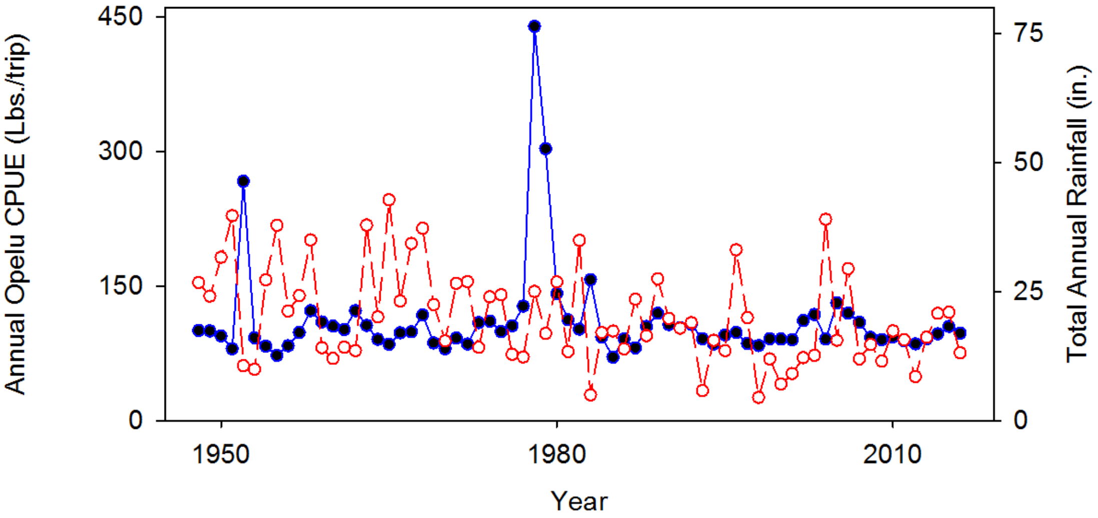


Figure 47. Comparison of time series of annual CPUE (lbs./trip) for opelu in the MHI commercial coral reef fishery and total annual rainfall (in.) in Honolulu from 1948-2016.

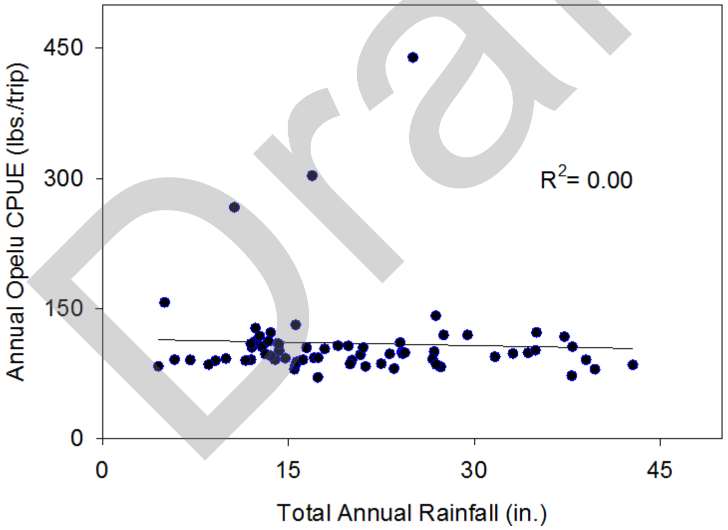


Figure 48. Linear regression between CPUE in the MHI coral reef commercial opelu fishery and the total annual rainfall (in.) from 1948-2016.

Table 84. Coefficients of determination (R^2) for comparisons of time series of rainfall and akule/opelu CPUE by gear in the MHI commercial reef fishery from 1948-2016.

	Akule				**Opelu**		
	Inshore Handline	**Gill Net**	**Akule Net**	**Bottom Handline**	**Inshore Handline**	**Lift Net**	**Bottom Handline**
Total Annual Rainfall (in.)	0.02	0.07	0.02	0.02	0.00	0.01	0.06

3.2.3 Incorporating Phase Lag(s)

Correlations were performed on time series of catch, effort, and CPUE from akule and opelu caught in the MHI commercial coral reef fishery with records of rainfall from the Honolulu and Hilo areas of the state with a phase lag of one to three years. Correlations with the addition of one year of phase lag did not produce any statistically significant *r*-values for any of the comparisons performed involving CPUE for either species (Table 85 and Table 86). The one fishery parameter that showed a significant relationship with Honolulu rainfall was akule effort from 1966-2016 such that increased rain in each year was associated with decreased effort one year later (*r* = -0.30). In addition to being well below the $|r| = 0.5$ level suggested by Weng *et al.* (2000) to indicate a causal link, albeit with a slightly longer time series, it would not necessarily follow that effort in a fishery would be directly impacted by environmental factors a year after the data was recorded.

Correlations with two years of phase lag produced relatively more statistically significant correlation coefficients with representation in each of the three different time series lengths under assessment, though all significant *r*-values that were identified showed a negative relationship between rainfall and akule catch or effort (e.g. *r*= -0.27 through -0.46; Table 85). There were significant correlations for each time series between akule catch and rainfall, however these results indicated a negative relationship such that increased rainfall coincided with decreased catch two years later and vice versa (Table 85). In addition to being below Weng *et al.*'s causality threshold, correlations involving CPUE with the same amount of phase lag were weak.

Lastly for potential fishery ecosystems relationships with rainfall represented by comparisons of fishery parameters for akule and opelu with Honolulu precipitation records, correlations with three years of phase lag generated a small amount of statistically significant *r*-values, but only for catch and effort for akule (Table 85). For both the 1948 and 1966 time series, there was a negative statistically significant correlation coefficient calculated for akule catch (*r* = -0.27 and -0.34, respectively). The strongest of all observed relationships in this portion of these analysis was between akule CPUE and rainfall with no incorporated lag, but only when comparing the time series starting from 1980 (*r* = 0.47; Table 85).

Table 85. Correlation Coefficients (*r*) generated from MHI commercial fishery harvest parameters for akule/opelu with rainfall records for Honolulu over three periods.

Location of Rainfall	**Honolulu area, Oahu**											
Year Range	**1948-2016**				**1966-2016**				**1980-2016**			
Phase Lag (t = years)	**No lag**	**t+1**	**t+2**	**t+3**	**No lag**	**t+1**	**t+2**	**t+3**	**No lag**	**t+1**	**t+2**	**t+3**
AKULE												
Catch	-0.11	-0.23	**-0.27**	**-0.27**	0.00	-0.23	**-0.32**	**-0.34**	-0.01	-0.21	**-0.32**	-0.29
Effort	0.08	0.07	-0.09	-0.09	-0.11	**-0.30**	**-0.46**	**-0.42**	0.04	-0.18	**-0.37**	**-0.36**
CPUE	-0.05	-0.12	-0.14	-0.15	0.16	0.05	-0.04	-0.11	0.08	-0.02	-0.07	-0.05
OPELU												
Catch	0.05	-0.16	-0.06	0.11	-0.06	-0.17	-0.03	-0.08	0.19	0.11	0.22	0.06
Effort	-0.16	-0.05	-0.04	0.11	-0.24	-0.22	-0.20	-0.10	-0.14	0.06	-0.09	-0.06
CPUE	0.09	-0.05	-0.02	0.04	0.03	0.06	0.08	0.04	**0.47**	0.03	0.16	0.14

Correlations performed on fishery parameters from akule and opelu caught in the MHI commercial reef fishery with records of rainfall from Hilo showed no statistically significant values for opelu across time series and ranges of phase lag implemented (Table 86). Additionally, there was only one statistically significant *r*-value calculated for akule; species CPUE from 1980-2016 and a phase lag of +3 years produced a correlation coefficient of *r* = -0.43 when compared with the Hilo rainfall time series.

Table 86. Correlation Coefficients (*r*) generated from MHI commercial fishery harvest parameters for akule/opelu with rainfall records for Honolulu over three periods.

Location of Rainfall	**Hilo area, Big Island**											
Year Range	**1948-2016**				**1966-2016**				**1980-2016**			
Phase Lag (t = years)	**No lag**	**t+1**	**t+2**	**t+3**	**No lag**	**t+1**	**t+2**	**t+3**	**No lag**	**t+1**	**t+2**	**t+3**
AKULE												
Catch	-0.04	-0.03	0.02	-0.19	-0.02	-0.02	0.03	-0.24	0.00	0.02	0.05	-0.29
Effort	0.09	0.00	0.03	0.03	-0.03	-0.14	-0.01	-0.02	0.06	-0.05	0.08	0.07
CPUE	-0.06	0.02	-0.01	-0.21	0.00	0.10	0.03	-0.27	-0.05	0.03	-0.04	**-0.43**
OPELU												
Catch	-0.09	-0.09	0.20	0.05	-0.06	-0.06	0.06	0.03	-0.02	-0.04	0.08	0.00
Effort	0.01	0.02	0.13	0.11	-0.02	-0.12	0.07	0.08	0.09	-0.02	0.13	0.06
CPUE	-0.04	0.02	0.03	-0.07	0.01	0.13	-0.05	-0.06	-0.10	-0.01	-0.06	-0.07

In summary, no fishery ecosystem relationship could be established between akule or opelu catch, effort, or CPUE and precipitation levels in the MHI from 1948 till present with no incorporation of phase lag, and no standardized index/threshold characteristic of the association between the parameters could be identified representative of an immediate population response. Exploring these same potential associations with the influence of phase lag, a strong relationship between CPUE and rainfall could not be identified within three years of lag. Though correlation coefficients were statistically significant in some instances, it was not clear if the values were reflecting the variability in the fishery parameters explained by environmental variation.

Conversely, the lack of a strong relationship discovered in these analyses does not prohibit the potential influence that precipitation levels may have in the populations of akule and opelu in the MHI, and it is more likely a combination of environmental drivers that are responsible for observed patterns in fishery parameters over the last several decades. While correlations between the two variables were also evaluated on a monthly basis, the results have yet to be finalized/

3.3 SEA SURFACE TEMPERATURE

3.3.1 Trends in Sea Surface Temperature

Sea surface temperature (SST) is a commonly used diagnostic tool in monitoring climate change and its affects both regionally and globally, as it is representative of changes in ocean temperatures over time that can affect coastal fisheries (see Section 2.5.3.3). The potential influence of temperature-derived variables in fishery ecosystem relationships for U.S. Western Pacific coral reef stocks was deemed to be among the highest priority by the participants of the Workshop. Data for SST was gathered from the NOAA's AVHRR Pathfinder v5.0 through the OceanWatch program in the Central Pacific (NOAA/NESDIS/OceanWatch).

Time series of annual SST around the MHI from 1985-2016 are shown in Figure I. Temperature time series displayed relatively low variability over time (CV = 1.51). There seemed to be a slight increase in temperature over time, with some of the highest average annual temperatures recorded in the past three years. The average SST over the course of evaluated data was 25.8°C. The highest recorded SST over the course of the time series was 26.6°C in the year 2004, whereas the lowest occurred just six years prior in 1998 (25.1°C; Figure 49).

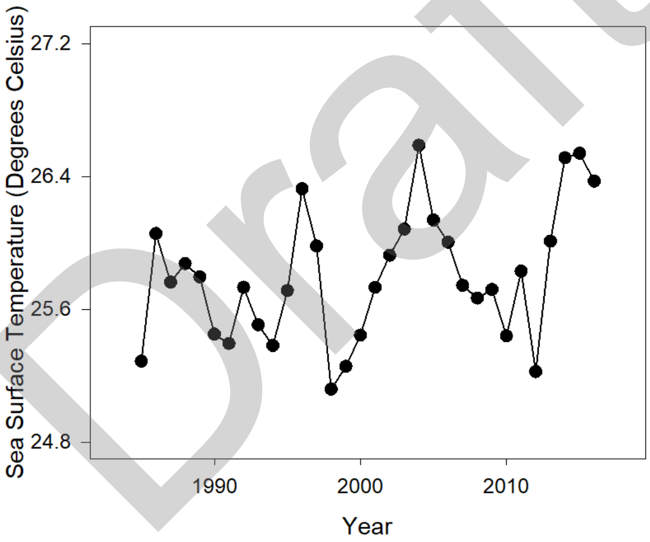


Figure 49. Time series of average annual SST (°C) in the MHI from 1985-2016 (CV = 1.51).

3.3.2 Relationship with Entire Commercial Reef Fishery

Plots depicting comparisons of time series of SST and catch, effort, and CPUE for the commercial coral reef fishery in the MHI from 1985-2016 are shown in Figure 50. Though landings from the past decade have generally been recorded in similar amounts to those from the mid-1980s, 2016 had the lowest recorded amount of commercial coral reef fish landings (< 85,000 lbs.) and catch has since been decreasing from the observed maximum of over 2.2 million lbs. landed in 1998 (Figure 50). Effort was relatively stable around ~25,000 annual fishing trips for the fishery from 1985-2000, but subsequently decreased to a low of just over 15,000 trips in 2006; after another increase back to original levels in the early-2010s, effort reached a minimum of just over 14,000 trips in 2016 (Figure 50). CPUE has displayed a slight increase over the course of the time series and the minimum recorded value was 36.7 lbs./trips in first year of the evaluated time series,1985 (Figure 50).

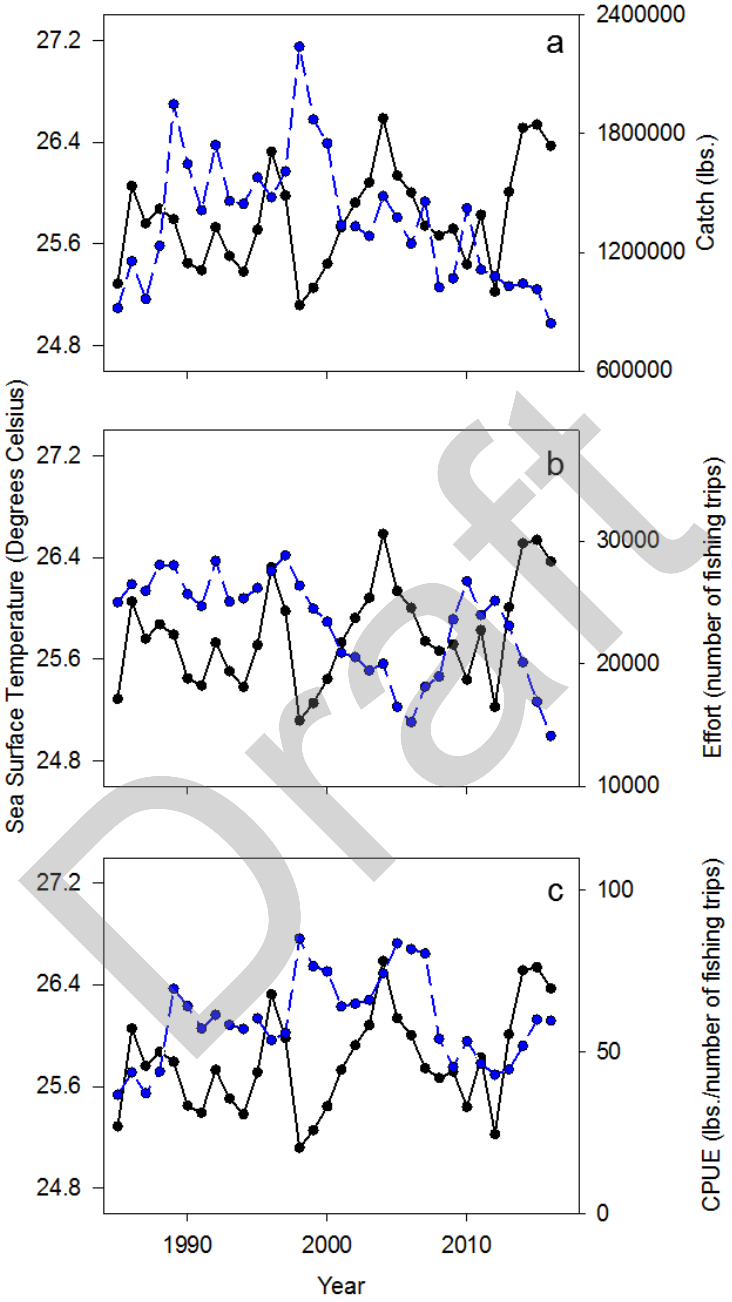


Figure 50. Time series of total annual catch (lbs.; blue; **[a]), effort (number of annual fishing trips; [b]), and CPUE (lbs./number of trips;** black; **[c]) for the MHI commercial coral reef fishery plotted with average annual** SST (°C) **from 1985-2016.**

In performing comparisons between fishery parameters and environmental variables such as SST, data were grouped based on taxa categories used in data collection while ensuring the longest, most contiguous time series possible. Table 87 displays the different dominant taxa groups considered as well as the scientific, common, and Hawaiian names of the species of which they are comprised.

Table 87. List of taxa recorded in MHI commercial catch data considered for these analyses.

Taxa code	Scientific Name	Family	Common Name	Hawaiian Name
PUALU	*Acanthurus blochii, xanthopterus*	Acanthuridae	ringtail surgeonfish	pualu
PALANI	*Acanthurus dussumieri*	Acanthuridae	eyestripe surgeonfish	palani
KALA	*Naso annulatus, brevirostris, unicornis*	Acanthuridae	whitemargin, shore-nosed, bluespine unicornfish	kala
ULUA	*Caranx ignobilis*	Carangidae	giant, bluefin trevally	ulua
AKULE	*Selar crumenophthalmus*	Carangidae	bigeye scad	akule
OPELU	*Decapterus macarellus*	Carangidae	mackerel scad	opelu
AHOLE	*Kuhila sanvicensis*	Kuhliidae	Hawaiian flagtail	aholehole
TOAU	*Lutjanus fulvus*	Lutjanidae	blacktail snapper	to'au
TAAPE	*Lutjanus kasmira*	Lutjanidae	bluestripe snapper	ta'ape
WEKE	*Mullidae spp. (Mulloidichthys flavolineatus, vanicolensis,* etc)	Mullidae	yellowstripe, red goatfish	weke'a, weke 'ula
MOANO	*Parupeneus* spp. (*misc*)	Mullidae	goatfish	-
KUMU	*Parupeneus porphyreus*	Mullidae	white-saddle goatfish	kumu
UHU	*Scarus* spp. (*Chlorurus perspecillatu, sprilurus; Scarus dubius, psittacus, rubroviolaceus, etc.*)	Scaridae	misc. parrotfish	uhu - ponuhunuhu, uhu uliuli, lauia, uh 'ele 'ele
MU	*Monotaxias grandoculis*	Lethrinidae	bigeye bream	mu

Multiple linear regressions and correlation analyses were performed on time series of commercial coral reef fishery CPUE and annual mean SST from the MHI (Table 88). Analyses measuring the association between SST and total CPUE for the entirety of the commercial coral reef fishery in the MHI showed no general relationship between 1985 and 2016 (R^2=0.03, p=0.36; Table 88; Figure 51).

Table 88. Correlation coefficients (*r*) between commercial coral reef fishery CPUE and SST (in °C) in the MHI for 14 top taxa harvested from 1985-2016. Significant correlations are indicated in bold (α=0.05).

Taxa Code	Total CPUE	PUALU	PALANI	KALA	ULUA	AKULE	OPELU	AHOLE	TOAU	TAAPE	WEKE	MOANO	KUMU	UHU	MU
n = 28															
p	0.36	0.33	0.08	0.18	0.09	0.26	0.12	0.76	0.58	0.76	**0.01**	0.80	0.16	0.76	0.48
r	0.18	0.19	0.34	0.26	-0.33	0.22	0.30	0.06	-0.11	0.06	**0.46**	-0.05	-0.27	0.06	0.14
R^2	0.03	0.03	0.12	0.07	0.11	0.05	0.09	0.00	0.01	0.00	**0.21**	0.00	0.07	0.00	0.02

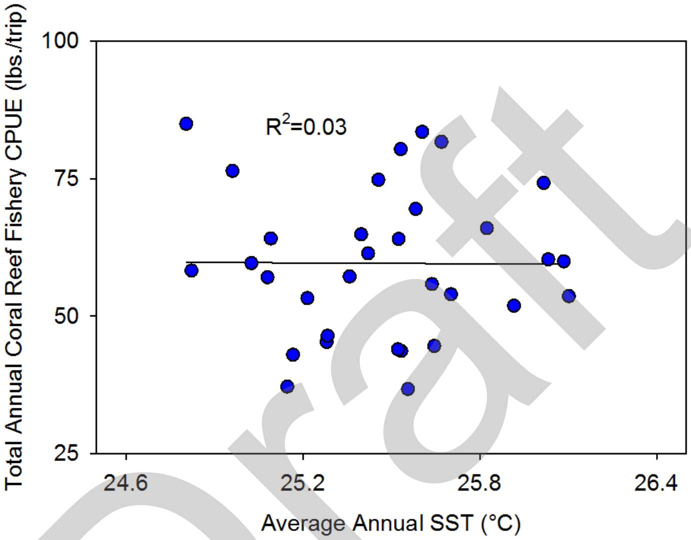


Figure 51. Linear regression showing the correlation between total annual CPUE for the commercial coral reef fishery and average annual sea surface temperature (°C) in the MHI from 1985-2016.

3.3.3 Relationship with Taxa Groups

In performing comparison analyses on time series of CPUE for prevalent taxa in the MHI commercial coral reef fishery, it was found that only weke's CPUE data showed a statistically significant correlation with SST (Table 88). The relationship between the weke taxa group and average annual SST was shown to be statistically significant in a positive manner such that for every degree Celsius of temperature increase, CPUE would approximately increase by 17 lbs./trip when harvesting weke ($R^2 = 0.21$, $p = 0.01$; Table 84 ; Figure 52). The next two strongest associations uncovered, palani and ulua, did not hold the same significance as the weke association did, but both came relatively close to the statistical significance threshold of $p = 0.05$. The palani taxa group had a positive association with SST ($R^2 = 0.12$, $p = 0.08$), whereas ulua displayed a negative relationship ($R^2 = 0.11$, $p = 0.09$; Table 88; Figure 52).

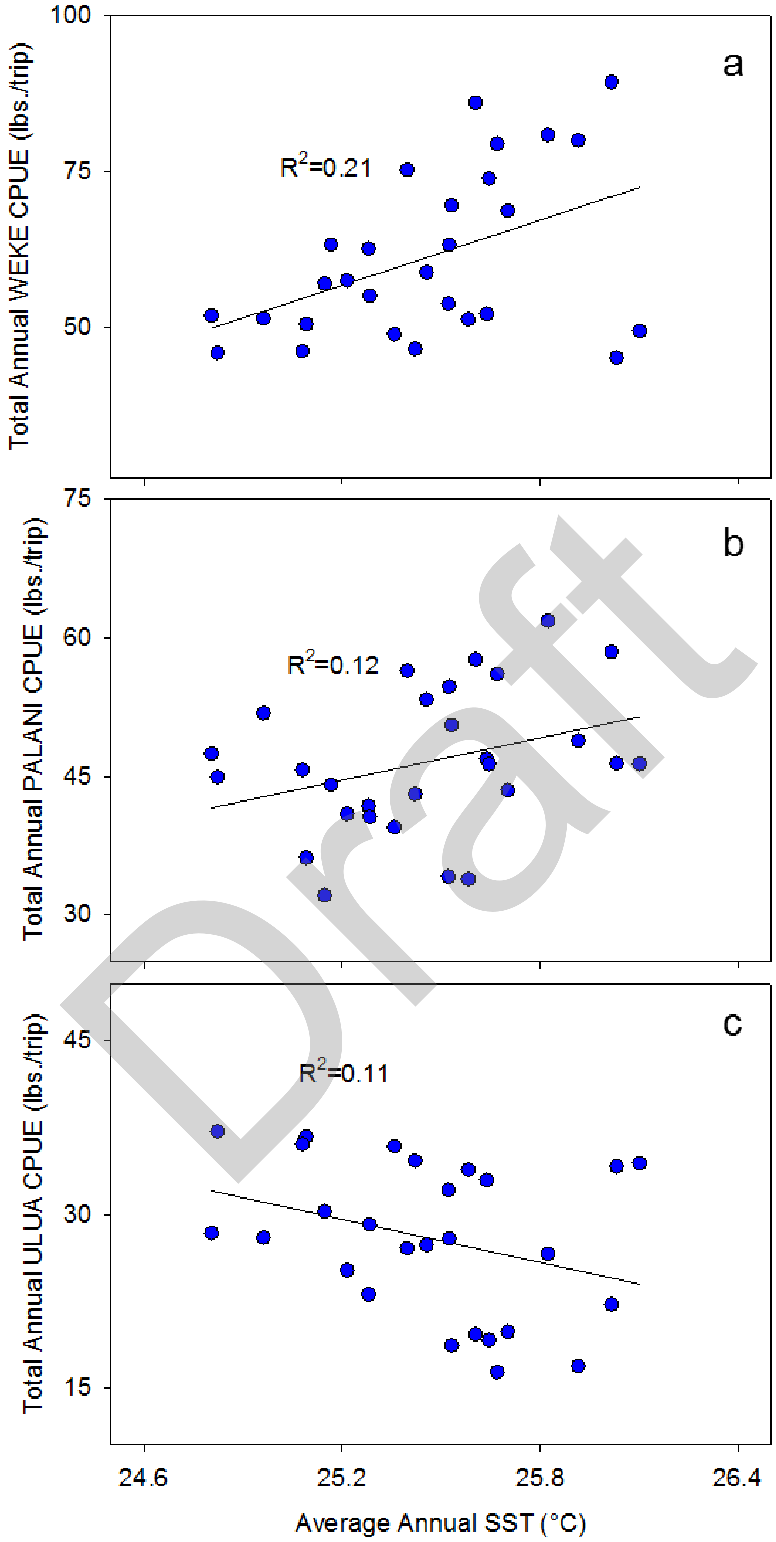


Figure 52. Linear regressions showing the three top correlations between total annual CPUE (lbs./number of trips) for the MHI commercial coral reef fishery and average annual sea surface temperature (°C) for (a) weke, (b) palani, and (c) ulua from 1985-2016.

3.4 PRIMARY PRODUCTIVITY

3.4.1 Trends in Primary Productivity

Concentrations of the pigment chlorophyll-*a* are frequently used as an index of phytoplankton biomass to represent primary production, are a commonly utilized tool in identifying eutrophication, and are noted to be among the highest priority fishery ecosystem relationships in the WPR by participants of the Workshop as well (Islam and Tanaka, 2004). In Pacific regions where interannual precipitation and associated coastal runoff are relatively high, the physiochemistry of nearshore reefs can especially be impacted by nutrient input accompanying precipitation and result in increased primary production (Ansell *et al*., 1996).

Long-term changes in regional primary productivity have the potential to change reef fish population abundance due to the susceptibility of these assemblages in shallow areas of coastal reefs to variations in water chemistry, especially when combined with the variability of other environmental parameters like sea surface temperature (Kitiona *et al.*, 2016). For example, it has been suggested that warming ocean temperatures coupled with decreasing environmental productivity, likely due to a reduction in upwelling that isolated nutrients at depth, led to waning reef fish assemblages in the Southern California Bight (Roemmich and McGowan, 1995). With recent progress in satellite and fluorometric measurements of oceanic surface waters, time series of global and regional primary production generated using chlorophyll-*a* concentration estimates have become increasingly available, and are commonly used for evaluating the impact of environmental productivity on reef fish population abundance and the marine food web in general (Behrenfed *et al*., 2006; Messié and Radenac, 2006). Data for the study at hand were gathered from the Hawaii Ocean Time series CO_2 system data products from readings at Station ALOHA for the MHI only (see Dore *et al*., 2009).

Uncertainty levels were relatively high in evaluations including chlorophyll-*a* concentrations due to the nature of incorporating phase lag and not smoothing the catch data as is typically done for creel survey information. The largest issue in performing comparison analyses between catch levels from reef fisheries in American Samoa and fluorometric chlorophyll-*a* concentrations was the relatively short time series (i.e. small sample size) muddying any signals that might have been teased out. Robust, homogenous time series highlighting inter-decadal patterns in these regions were difficult to obtain due to time series merging several sources of chlorophyll concentration information to elongate the range of continuous data. For example, the ESA’s Ocean Colour Climate Change Initiate dataset only permitted the use of less than two decades of data when evaluating the territories with the incorporation of phase lag. The length of the applied lag has a large impact in the patterns observed, so the relatively short extent of the available time series may obfuscate some of the identified relationships.

Figure N shows the fluorometric chlorophyll-*a* concentration time series for the MHI integrated from 0-200 meters depth in the water column from 1989-2015. While concentrations of chlorophyll-*a* seem to have been slightly increasing over the last several decades, the time series was relatively variable and the positive slope of the linear regression line was not statistically significant (CV = 10.2; $R^2 = 0.16$; Figure 53). The most recent years of recorded data had relatively high pigment concentrations, though the highest recorded level of chlorophyll-*a* (~30 mg/m^2) was observed in the first year of available data for the time series (1989; Figure 53). The average chlorophyll-*a* level integrated over the top 200 meters of the water column at Station

ALOHA was 23.8 mg/m^2, with the lowest recorded concentrations of fluorometric chlorophyll-*a* over the course of the time series being recorded in the year 1996 (18.6 mg/m^2; Figure 53).

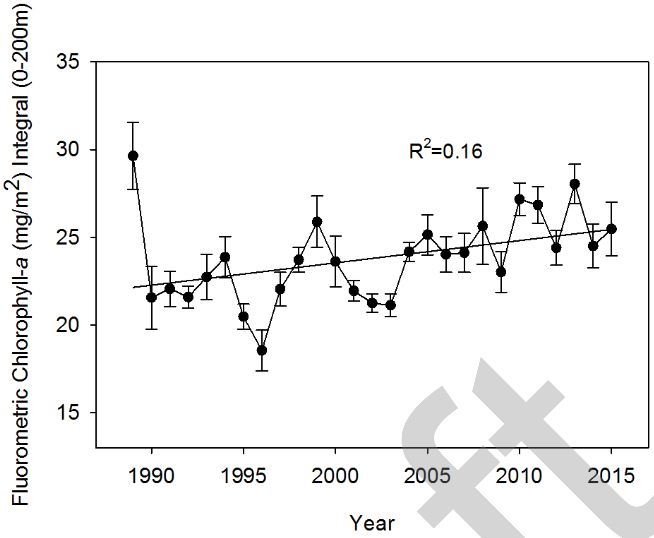


Figure 53. Time series of fluorometric chlorophyll-*a* concentrations (mg/m^2) integrated from 0-200m depth in the water column and associated intra-annual standard error at Station ALOHA (HOT 1-288) from 1989-2015 (CV=10.2).

3.4.2 Relationship with Entire Commercial Reef Fishery

Plots depicting comparisons of time series of the same chlorophyll concentration statistics and annual CPUE for the MHI commercial coral reef fishery from 1989-2013 are shown in Figure 54. The time series are two years shorter than the range of available data due to the implementation of two years of phase lag. The data displayed a pattern in which the years from 2000-2010 had relatively high CPUE levels (up to nearly 85 lbs./trip), but records available from years immediately before and after were notably lower (50-60 lbs./trip; Figure 54). The lowest CPUE was approximately 43 lbs./trip and was recorded in 2012 (Figure 54).

After conducting linear regressions and correlation analyses on time series of the MHI commercial coral reef fishery CPUE lagged by two years with fluorometric chlorophyll-*a* concentrations (mg/m^2) integrated from 0-200m depth in the water column, it was found that the association between these chlorophyll concentrations and total CPUE for all taxa was significantly negative between 1989 and 2013 (r = -0.44, p = 0.02; Table 89; Figure 55). The slope of the regression line was relatively gentle, however, and for every increase of 1 mg/m^2 in chlorophyll-*a* concentration integrated over the top 200 meters of the water column, CPUE would approximately decrease nearly10 lbs./trip two years later when considering the entirety of the MHI reef fishery (R^2 = 0.19, p = 0.02; Table 89; Figure 55).

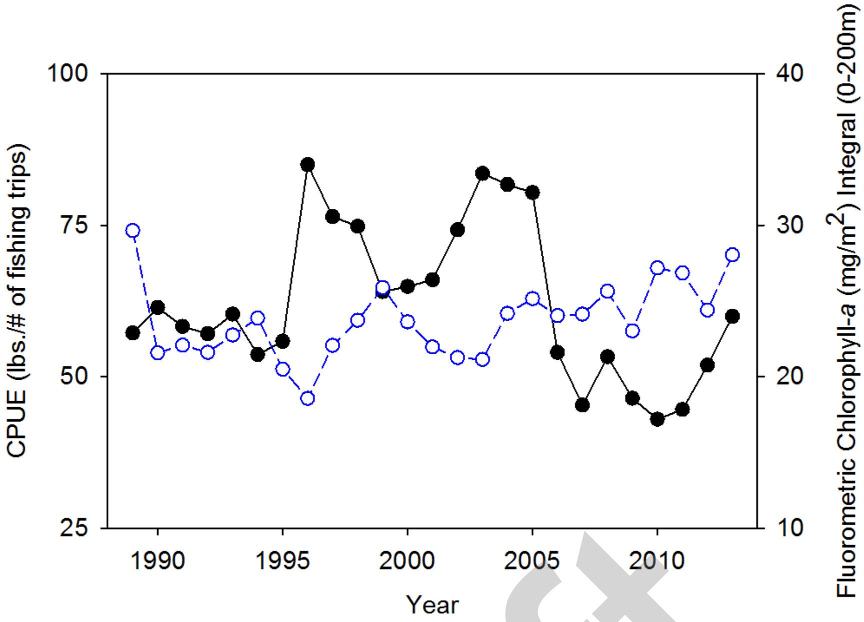
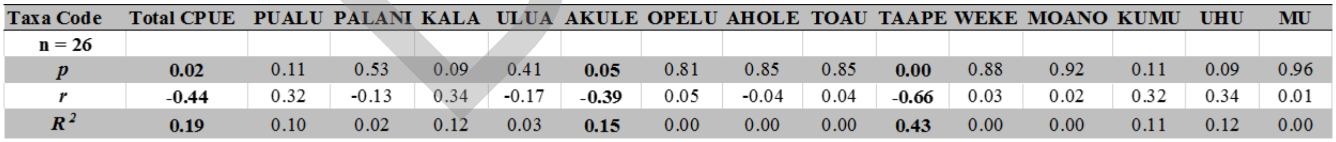


Figure 54. Comparison of CPUE (lbs./number of annual fishing trips; black**) with two years of time lag (t+2 years) and fluorometric chlorophyll-*a* concentrations (mg/m^2**; blue**) integrated from 0-200m depth in the water column from Station ALOHA (HOT 1-288) for the years 1989-2013 (*r* = -0.44).**

Table 89. Correlation coefficients (*r*) from comparisons of time series of MHI commercial coral reef fishery CPUE and fluorometric chlorophyll-*a* concentrations (mg/m^2) integrated from 0-200m depth in the water column from Station ALOHA for 14 top taxa harvested from 1989-2013. Significant correlations are indicated in bold (α=0.05).



Taxa Code	Total CPUE	PUALU	PALANI	KALA	ULUA	AKULE	OPELU	AHOLE	TOAU	TAAPE	WEKE	MOANO	KUMU	UHU	MU
n = 26															
p	**0.02**	0.11	0.53	0.09	0.41	**0.05**	0.81	0.85	0.85	**0.00**	0.88	0.92	0.11	0.09	0.96
r	**-0.44**	0.32	-0.13	0.34	-0.17	**-0.39**	0.05	-0.04	0.04	**-0.66**	0.03	0.02	0.32	0.34	0.01
R^2	**0.19**	0.10	0.02	0.12	0.03	**0.15**	0.00	0.00	0.00	**0.43**	0.00	0.00	0.11	0.12	0.00

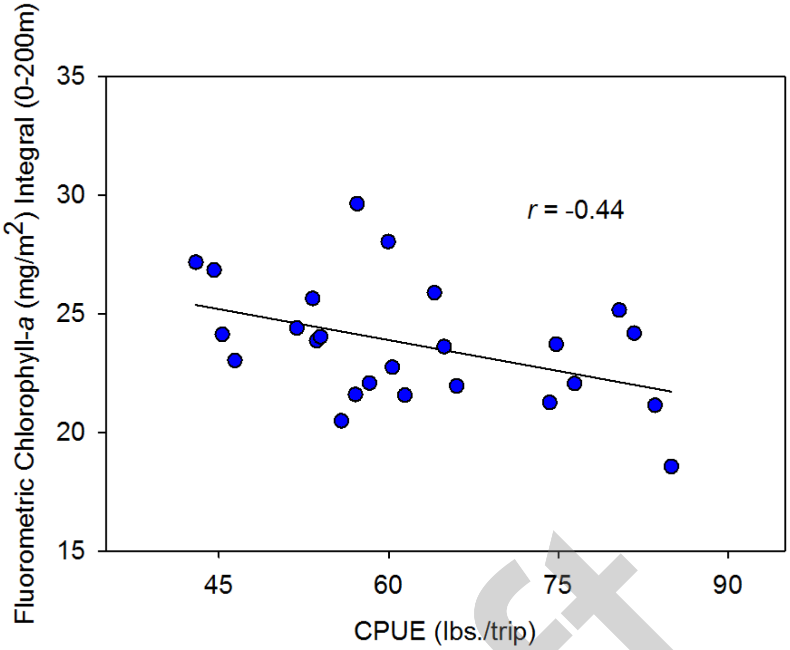


Figure 55. Linear regression showing between total annual CPUE (lbs./number of annual fishing trips) for the MHI commercial coral reef fishery with phase lag (t+2 years) and fluorometric chlorophyll-*a* concentrations (mg/m^2) integrated from 0-200m depth in the water column from Station ALOHA (HOT 1-288) from 1989-2013.

3.4.3 Relationship with Taxa Groups

Multiple linear regression and correlation analyses were performed in the same way for time series of CPUE for dominant taxa in the Hawaiian commercial reef fishery, and only two of the 14 evaluated taxa showed statistically significant associations with local chlorophyll concentrations: taape and akule (Table 89). The relationship between the CPUE of species in the taape group and chlorophyll concentration was shown to be significantly negative such that for every increase of 1 mg/m^2 in chlorophyll-*a* concentration, CPUE would decrease by approximately 1.6 lbs./trip lagged by two years (R^2=0.43, p = 0.00; Table 89; Figure 56). The relationship between CPUE of akule and chlorophyll was also shown to be significantly negative, though not to as great of an extent. Generally, with an increase of 1 mg/m^2 in chlorophyll-*a* concentration integrated over the top 200 meters of the water column in the MHI, commercial CPUE would decrease by approximately 13 lbs./trip after two years for akule (R^2=0.27, p = 0.00; Table 89; Figure 56). The next strongest associations, though not significant, belong to comparisons involving pualu, kala, kumu, and uhu (R^2=0.10-0.12, p=0.09-0.11; Figure 56); all four of these potential fishery ecosystem relationships, however, were positive (Table 89).

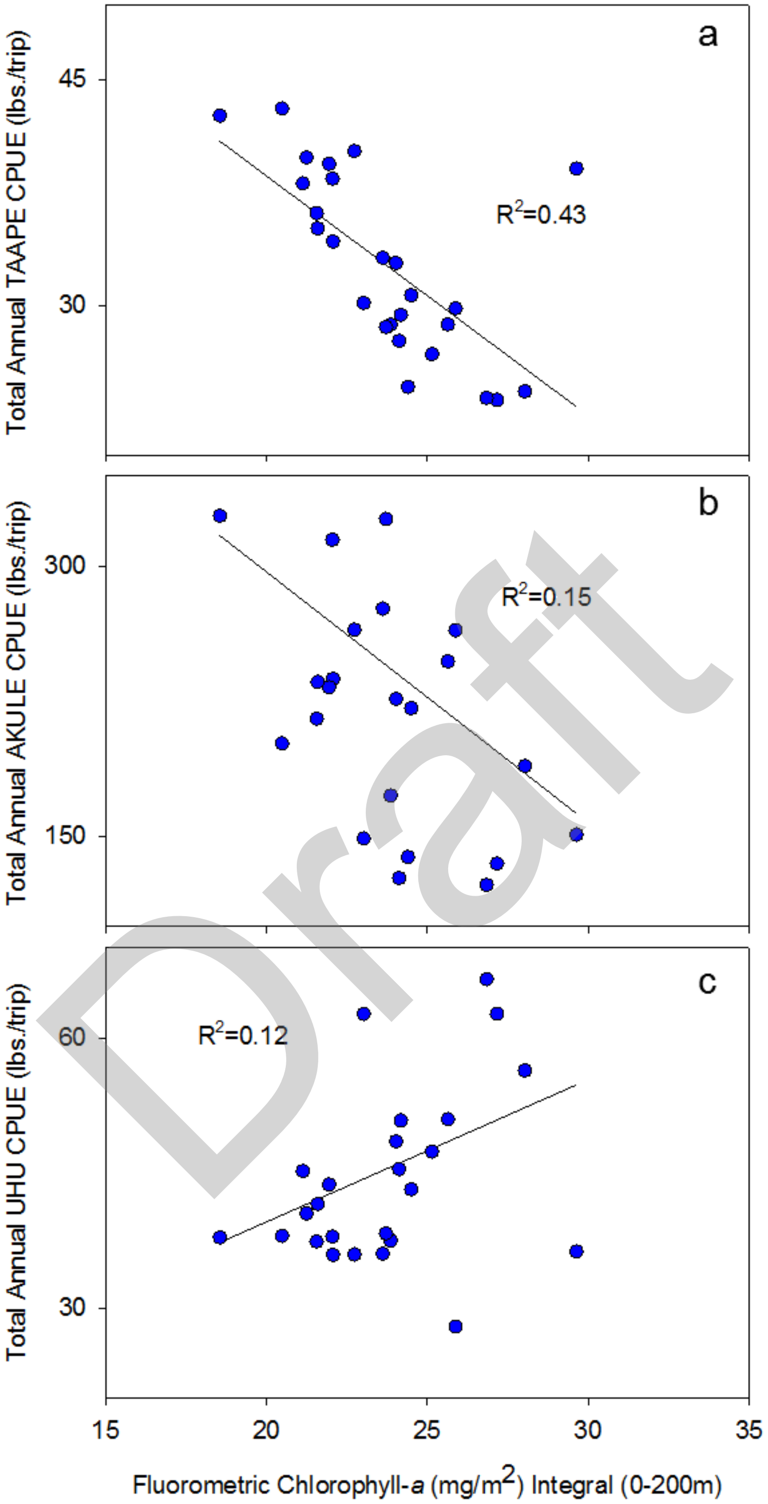


Figure 56. Linear regressions showing the three top correlations between total annual CPUE (lbs./number of annual fishing trips) for the MHI commercial coral reef fishery with phase lag (t+2 years) and fluorometric chlorophyll-*a* concentrations (mg/m^2) integrated from 0-200m depth in the water column from Station ALOHA (HOT 1-288) for (a) taape, (b) akule, and (c) uhu from 1989-2013.

3.5 MULTIVARIATE ASESSMENTS OF OTHER ECOSYSTEM VARIABLES

3.5.1 Non-metric Multidimensional Scaling

There were several other prioritized fishery ecosystem relationships for coral reefs in the American Samoa involving environmental parameters that were not to be addressed in this initial evaluation including: the Oceanic Niño Index (ONI), the Pacific Decadal Oscillation (PDO), sea level height, pH, dissolved oxygen, and salinity. Further descriptions of these climate and oceanic indicators are available in Section 2.5.3. Sea surface height data were aggregated from the Ocean Service, Tides, and Currents, and Sea Level database operated (NOAA/NOS/CO-OPS). Basin-wide data ONI were taken from NOAA's Nation Centers for Environmental Information- Equatorial Pacific Sea Surface Temperature Database (Climate Prediction Center Internet Team 2015). Similarly, PDO data were obtained from NOAA's Earth System Research Laboratory Physical Sciences Division originally derived from OI.v1 and OI.v2 SST parameters (NOAA PDO). Salinity data for American Samoa were gathered from Simple Ocean Data Assimilation (SODA) version 3.3.1 (Carton and Giese, 2008). Rainfall estimates were obtained through the local National Weather Service in American Samoa (NWS-AS).

Non-metric multidimensional scaling (NMS), a form of multivariate analysis that orders sample units along synthetic axes to reveal patterns of composition and relative abundance, is most commonly utilized when looking to identify patterns in heterogeneous species response data (Peck, 2016). For this study, NMS was used to help identify associations between coral reef fishery parameters and ecological/environmental factors using the program PC-ORD 7. To ensure the same length of time series for all catch and environmental variables considered thus allowing for the general inclusion of more parameters, data was analyzed from 1989 to 2015. The generated axes represented the best fit of patterns of redundancy in the catch data used as input, and the resulting ordination scores were a rank-order depiction of associations in the original dataset.

NMS produces robust results even in the presence of outliers by avoiding parametric and distributional assumptions (Peck, 2016). The only assumption to be met in NMS is that the relationship between the original rank ordered distances between sample units and the reduced distances in the final solution should be monotonic; that is, the slope of the association between the two is flat or positive, as determined by the stress statistic. In the most general terms, interpretable and reliable ordination axes have stress less than 10 up to 25 for datasets with large sample size, but large stress scores (i.e. greater than 30) may suggest that the final ordination results have little association with the original data matrix. Additionally, NMS ordination scores vary depending on the number of dimensions/axes designated to be solved (Peck, 2016). Dimensionality (i.e. number of axes for the final solution) for each test was identified though PC-ORD result recommendations based on final stress being lower than that for 95% of randomized runs (i.e. $p \leq 0.05$). Tau is a statistic that represents the rank correlations of the ordination scores to the original data matrices, and was used to identify explanatory variables with associations to the ordination axes. For the MHI test, data from 13 species/taxa groups from 1989 - 2015 (27 years) were included along with 10 variables of environmental data collected during the same time period (see Table 87).

The resulting ordination scores from NMS analyses performed on commercial catch data and a range of environmental parameters from 1989-2015 in the MHI selected a two-dimensional solution with 100% orthogonal axes, accounting for 98.3% of variance observed in the commercial coral reef fishery data (Figure 57). The results of the analysis had low final stress (5.26) relative to the average stress from randomizations (7.47), supporting the suggestion that the two-dimensional solution has viable results.

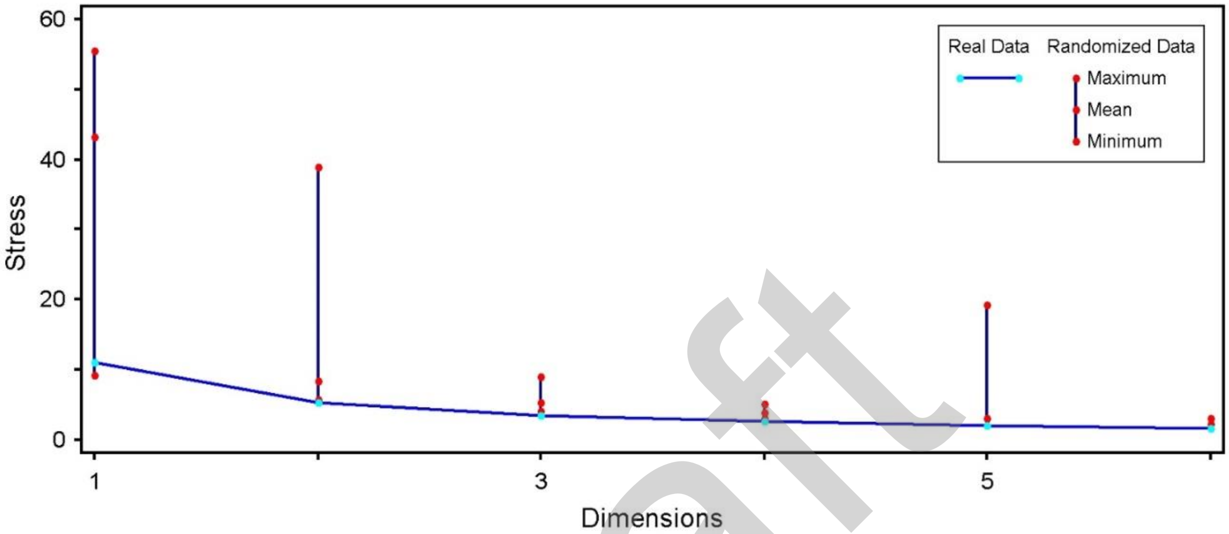


Figure 57. NMS scree plot showing a stress test to determine dimensionality for the final solution. A two-axis solution was recommended.

The final ordination scores for the taxa were crudely clustered in ordination space, with individual outliers and others with variable distance between them (Figure 58). Replicate NMS runs had similar stress levels for the final generated result. The distribution of final ordination scores for evaluated MHI taxa showed several environmental parameters that have significant associations with the selected axes. SST (tau = 0.38) and DO (tau = 0.35) were both positively associated with the first axis ($r^2 = 0.94$), whereas pH displayed a significantly negative relationship with the axis (tau = -0.46). Axis 2 ($r^2 = 0.04$), was shown to be most closely associated positively with pH (tau = 0.37) and negatively with salinity (tau = -0.37; Figure 58). Analyses including time series of pH levels and/or associated factors in Hawaii may be useful going forward.

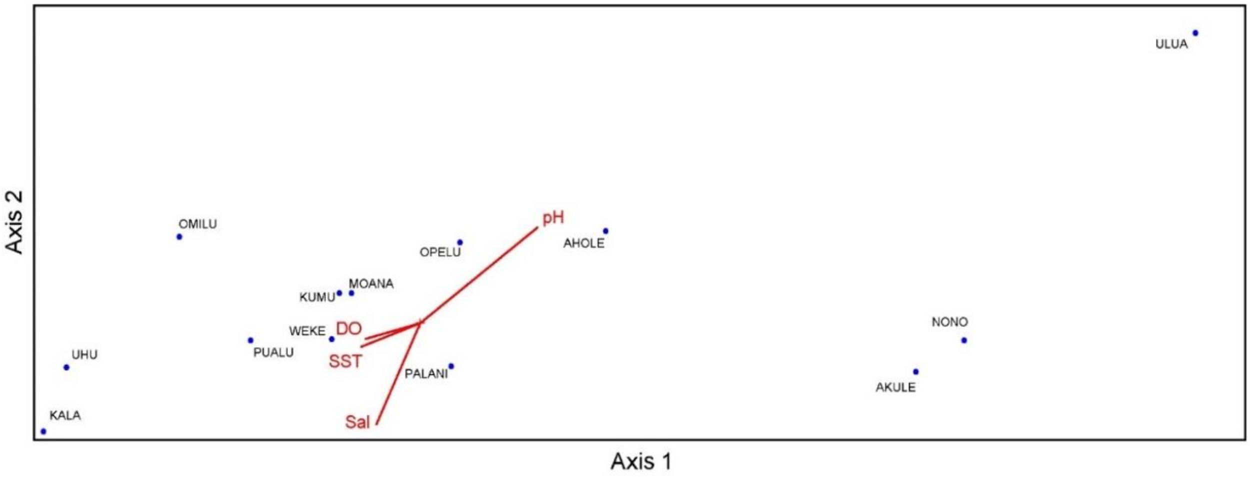


Figure 58. Two-dimensional scatterplot overlaid with a joint bi-plot depicting ordination scores resulting from an NMS analysis on commercial catch data and prominent environmental parameters in the MHI from 1989-2015.

Ultimately, stress values for all analyses were relatively low, suggesting that the generated ordination scores were robust and useful for interpretation relative to the ordination axes. Nearly all included environmental parameters had a statistically significant relationship with at least one ordination axis in at least one of the final solutions, suggesting that these parameters likely intertwine in complicated processes to produce observed impacts on coral reef fisheries in the U.S. Western Pacific. Though a fishery ecosystem relationship may have not been explicitly identified in NMS runs of this preliminary evaluation, it does not preclude the possibility that an association may still exist.

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