ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT:
AMERICAN SAMOA ARCHIPELAGO FISHERY ECOSYSTEM PLAN
2018

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 AMERICAN SAMOA ARCHIPELAGO FISHERY ECOSYSTEM PLAN 2018 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council (WPRFMC), National Marine Fisheries Service (NMFS)-Pacific Island Fisheries Science Center, Pacific Islands Regional Office, Division of Aquatic Resources (HI) Department of Marine and Wildlife Resources (American Samoa), Division of Aquatic and Wildlife Resources (Guam), and Division of Fish and Wildlife (CNMI).

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

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

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American Samoa Department of Marine and Wildlife Resources: Domingo Ochavillo, Yvonne Mika, and Tepora Lavatai.

NMFS Pacific Islands Fisheries Science Center: Justin Hospital, Ivor Williams, Joe O'Malley, Michael Parke, Tom Oliver, Hannah Barkley, Frank Parrish, T. Todd Jones, Minling Pan, and Kirsten Leong.

NMFS Pacific Islands Regional Office: Brett Schumacher and Rebecca Walker.

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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 the National Standard regulatory requirements for Stock Assessment and Fishery Evaluation (SAFE) reports. The purpose of the reports is twofold: to monitor the performance of the fishery and ecosystem to assess the effectiveness of the FEP in meeting its management objectives, and to maintain the structure of the FEP living document. The reports are comprised of three chapters: fishery performance, ecosystem considerations, and data integration. The Council will iteratively improve the Annual SAFE Report as resources allow.

The fishery performance section of this report first presents a general description of the local fisheries, including both bottomfish and coral reef management unit species (MUS). The fishery data collection system encompasses shore-based and boat-based creel surveys, commercial receipt books, and fisher inventories. The fishery statistics for each MUS are organized into a meta-data summary table to showcase the values for the most recent fishing year in comparison to short-term (10-year) and long-term (20-year) averages. Time series for catch and effort statistics are also presented. For 2018, there was no MUS catch in American Samoa that exceeded the prescribed annual catch limits (ACLs).

The bottomfish fishery performance in American Samoa continued to show a slight decrease; relative to the short-term average, total catch of all species caught with the bottomfishing gear declined by 44%, and total landings sold decreased by 70%. Considering only bottomfish management unit species (BMUS) on a short-term basis, total estimated catch decreased by 30% while the commercial landings recorded from purchase data decreased by 34%; this indicates that the majority of the BMUS catch was non-commercial. In relation to the short-term average presented, catch-per-unit-effort (CPUE) and bycatch from the bottomfish fishery each exhibited notable decreases. The amount of effort in the bottomfish fishery (measured in gear-hours) increased by 59% in 2018 relative to average values from the last decade, falling to nearly a quarter of the 2017 values. The total number of bottomfish trips taken decreased by 11% compared to the short-term average.

Coral reef fishery performance appeared to have mixed trends. The 2018 catch from the boat-based fisheries in American Samoa was 62% lower than the short-term average in a decreasing trend over extending over the past two decades. The shore-based coral reef fisheries had an estimated catch in 2018 that was 61% lower than the short-term average catch of the preceding decade. In relation to the short-term average presented, CPUE and bycatch from the coral reef fishery each exhibited notable decreases with the exception of shore-based rod and reel fishing and spearfishing. Trolling CPUE decreased 55% in 2018, but the amount of participants increased 3% relative to the short-term average. Fishing effort values were lower this year for all coral reef fishery methods than the short-term average; only boat-based trolling had a slightly higher (+1%) fishing effort than the short-term average. Data showed that shore-based hook-and-line effort had significantly decreased in 2018 to three total gear-hours (i.e., a 93% decrease from the short-term average).

An ecosystem considerations section was 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 indicators, essential fish habitat, and marine planning information are included in the ecosystem considerations chapter.

Fishery independent ecosystem survey data were acquired through visual surveys conducted in American Samoa, the Pacific Remote Island Areas, the Commonwealth of Northern Mariana Islands, Guam, the Main Hawaiian Islands, and the Northwest Hawaiian Islands; the data illustrate mean fish biomass for reef areas in these locations. Additionally, the mean reef fish biomass and mean size of fishes (>10 centimeters) found in American Samoa are presented by sampling year and reef area. Finally, reef fish population estimates for various study sites in American Samoa are provided for hardbottom habitat (0-30 meters).

For American Samoa, life history parameters including 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 for several species of both coral reef fish and bottomfish. Several length-derived parameters for coral reef fish and bottomfish were also summarized and included: maximum fish length, mean length, sample size, sample size for L-W regression, and length-weight coefficients. Values for 23 species of reef fish and two species of bottomfish are presented for American Samoa.

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 American Samoan 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, provides a summary of relevant studies and data for American Samoa, gives summaries of relevant data and studies for each American Samoan fishery, and concludes with available socioeconomic data. There were no new data reported for neither the crustacean nor the precious coral fisheries in the territory for 2018. Considering the American Samoan bottomfish fishery, there was an estimated total of 1,016 lbs. sold for $4,270, which was roughly in-line with statsitics from the past few years. The average cost for a bottomfishing trip was roughly just above 2016-2017 levels at $131 despite decreases in costs for ice, fishing gear, and bait, mostly due to increases in fuel cost. The coral reef fishery in American Samoa had 36,177 estimated pounds sold in 2018 worth $109,688. For the coral reef fishery in the region, the average cost of a fishing trip was notably more expensive than the previous year at $73.

The protected species section of this report summarizes information and monitors protected species interactions in fisheries managed under the American Samoa FEP. These fisheries generally have limited impacts to protected species, and 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 American Samoa bottomfish and coral reef fisheries that would affect the potential for interactions with protected species, and there is no other information to indicate that impacts to protected species in these fisheries have changed in recent years. There are currently no crustacean or precious coral fisheries operating in federal waters around American Samoa.

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, provide historical context, and identify patterns and trends. The trend of atmospheric concentration of carbon dioxide (CO_2), for example, has been increasing exponentially with a time series maximum at 409 ppm in 2018. Since 1989, the oceanic pH at Station Aloha in Hawaii has shown a statistically significant linear decrease of -0.0386 pH units, or roughly a 9.4% increase in acidity ([H+]). Tropical cyclone activity and the ACE Index were both below average in the South Pacific in 2018; there were nine total storms, three of which were hurricanes and one major.

The American Samoa Archipelago FEP and National Standard 2 guidelines require that this report include a report on the review of essential fish habitat (EFH) information, and the 2018 Annual Report fulfills these requirements by including cumulative impacts on EFH. The guidelines also require a report on the condition of the habitat. In the 2017 annual report, a literature review of the life history and habitat requirements for each life stage for four species of reef-associated crustaceans that are landed in commercial fisheries Western Pacific region was presented, including information on two species of spiny lobster (*Panulirus marginatus* and *Scyllarides squammosus*), scaly slipper lobster (*Scyllarides squammosus*), and Kona crab (*Ranina ranina*). In the 2017 review, the most up to date information is summarized on species distribution, fishery performance in the Western Pacific region, and life history. For the 2018 report, an associated review on the EFH of reef-associated crustacean species was supposed to be completed, but was not included in the 2018 Annual SAFE Report at the time of publication. The annual report is also meant to address any Council directives toward its Fishery Ecosystem Plan Team, however there were no directives associated with EFH in 2018.

The marine planning section of the annual 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. No ocean activities with multi-year planning horizons were identified for American Samoa. The Pacific Islands Regional Planning Body (RPB), originally established under the National Ocean Policy and responsible for finalizing the American Samoa Ocean Plan, was disbanded in 2018 resulting from Executive Order (EO) 13840 Regarding the Ocean Policy to Advance Economic, Security, and Environmental Interests of the United States, which revoked EO 13547. However, EO 13840 established a policy focused on public access to marine data and information, and requires federal agencies to 1) coordinate activities regarding ocean-related matters and 2) facilitate the coordination and collaboration of ocean-related matters with governments and ocean stakeholders. To that end, the American Samoa Coastal and Marine Spatial Planning Data Portal was created in October 2018 by Marine Cadastre, a collaboration of the Bureau of Ocean Energy Management (BOEM) and the National Oceanic and Atmispheric Administration (NOAA).

The data integration chapter of this report is still under development. The archipelagic data integration chapter explores the potential association between fishery parameters and ecologically-associated variables that may be able to explain a portion of the variance in a fishery. A contractor completed preliminary evaluations, and results of exploratory analyses have been included for the first time in the 2017 Annual SAFE Report; however, suggested revisions at the request of the Archipelagic Plan Team delayed updates to be implemented for the American Samoa data integration section. Results presented from the 2017 analyses showed that the non-commercial coral reef fishery in American Samoa generally had no association with the environmental parameters assessed (i.e, primary productivity, sea surface temperature, and precipitation. Members of the family Scaridae (i.e. parrotfish) showed a negative relationship with sea surface temperature in the region, while species in the family Mullidae displayed a positive relationship. No statistically significant association was uncovered between the fishery and chlorophyll-*a* concentrations with the incorporation of phase lag. A non-metric multidimensional scaling analysis showed that, while presented evaluations were not able to identify any significant levels of association between expanded creel catch data and a range of environmental parameters, the first axis, responsible for explaining 91% of the variance, illustrated the strongest relationships with salinity (negative) and rainfall (positive).

Going forward with the analyses and presentation of results for the data integration chapter of the American Samoa Annual SAFE Report, 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. Many of these recommendations were applied to datasets from Hawaii in 2018, and will similarly be done for American Samoa data integration analyses in the upcoming report cycles. Implementation of these suggestions will allow for the preparation of a more finalized version of the data integration chapter in the coming report cycles.

Regarding the revisions to the 2018 Annual FEP SAFE Report, the 2019 Archipelagic Plan Team recommends the Council:

- Direct staff to work with NMFS to convene the Plan Team working group for American Samoa, Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and Hawaii to define the ecosystem component species that will be monitored as species that comprise the functional groups (e.g., ‘parrotfish’, ‘browsing surgeon’, ‘mid-size targeted surgeon’, ‘medium large snappers’, ‘non-planktivorous butterflyfishes’), and those that comprise key species in the fisheries (i.e., top 5 consistently monitored important species and the 10 annual catch landings)

- Direct staff to work with NMFS and American Samoa Department Marine Wildlife Resources (AS-DMWR), CNMI Division of Fish and Wildlife (DFW), Guam Division of Aquatic and Wildlife Resources (DAWR), Hawaii-DAR on the revisions to the fisheries modules of the Archipelagic SAFE Reports due to the changes in the Management Unit Species brought about by the Ecosystem Component designation; and
- Direct staff to work with NMFS-PIFSC-Ecosystem Science Division and Division of Aquatic Resources on applying the general linear modelling (GLM) framework to the survey data in order to validate the modeling results.

Additional work item recommendations included:

- Council staff and the Archpelagic Plan Team Chair to work with NMFS and AS-DMWR, CNMI-DFW, Guam-DAWR, Hawaii-DAR on determining which table(s) to remove from the Annual SAFE Report due to the ecosystem component amendment, etc.;
- WPacFIN to follow-up on the status of the creel survey method documentation;
- The report to incorporate more nuance in the narratives of the fishery performance sections; include the issue on pounds sold greater than pounds caught;
- The report to identify presence and absence of hi-liners in the data sets as well as define the criteria of what a hi-liner is;
- Regarding effort and participation metrics for the Annual SAFE Report, Council staff and PIFSC employees to calculate the average fishermen per trip and ensure interview has number of fishermen and average numbers of gear per trip.
- Add the abstracts for relevant data integration studies to Chapter 3; and
- "Cross-walk" tables with the information regularly needed to complete Environmental Assessments (EAs).

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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 Maximum Sustainable Yield
B_{FLAG}	reference point indicating low 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
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
DMWR	Department of Marine and Wildlife Resources
DPS	Distinct Population Segment
EC	Ecosystem Component
ECS	Ecosystem Component Species
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
GAC	Global Area Coverage
GFS	Global Forecast System
HAPC	Habitat Area of Particular Concern
IBTrACS	International Best Track Archive for Climate Stewardship
LOF	List of Fisheries
LVPA	Large Vessel Prohibited Area
MFMT	Maximum Fishing Mortality Threshold
MinSST	Minimum Stock Size Threshold
MMA	Marine Managed Area
MMPA	Marine Mammal Protection Act

Acronym	Meaning
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 and 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
NOAA	National Oceanic and Atmospheric Administration
NWHI	Northwestern Hawaiian Islands
OFL	Overfishing Limits
ONI	Ocean Niño Index
ORR	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
PIBHMC	Pacific Island Benthic Habitat Mapping Center
PIFSC	Pacific Island Fisheries Science Center
PIRCA	Pacific Islands Regional Climate Assessment
PIRO	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
SAFE	Stock Assessment and Fishery Evaluation
SBRM	Standardized Bycatch Reporting Methodologies
SD	Standard Deviation
SDC	Status Determination Criteria
SEEM	Social, Economic, Ecological, Management (Uncertainty)
SFA	Sustainable Fisheries Act
SPC	Stationary Point Count
SST	Sea Surface Temperature
TALFF	Total Allowable Level of Foreign Fishing
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
WW3	Wave Watch 3

1 FISHERY PERFORMANCE

1.1 FISHERY DESCRIPTIONS

The Samoa Archipelago is a remote chain of 13 islands of varying sizes and an atoll, located 14^0 south of the equator near the International Date Line. The islands lie between 13° and 14° latitude south and 169° and 173° longitude west, about 480 km (300 mi) from west to east, covering an area of 3,030 sq. km (1,170 sq. miles). With its tropical setting and its latitudinal range lying within the known limits of coral growth, coral reefs fringe the islands and atolls in the archipelago. The archipelago is approximately 4,200 km south of Hawaii in the central South Pacific Ocean. The archipelago is divided into two political entities: the Independent Samoa and American Samoa. The Independent Samoa has two large islands, Upolu and Savaii, and eight islets. American Samoa is comprised of five volcanic islands (Tutuila, Aunu'u, Ofu, Olosega, and Ta'u), one low-island (Swains Island), and a coral atoll (Rose Atoll). The five volcanic islands that are part of the American Samoa territory are very steep with mountainous terrain and high sea cliffs and of various sizes. Tutuila Island, the largest (137 km^2) and most populated island, is the most eroded with the most extensive shelf area and has banks and barrier reefs. Aunuu is a small island very close to Tutuila. Ofu and Olosega (together as 13 km^2) are twin volcanic islands separated by a strait which is a shallow and narrow break in the reef flat between the islands. Tau is the easternmost island (45 km^2) with a more steeply-sloping bathymetry.

The Samoa archipelago was formed by a series of volcanic eruptions from the "Samoan hotspot" (Hart et al., 2000). Based on the classic hotspot model, Savaii Island (the westernmost) in Samoa would be the oldest and Tau island (the easternmost) in American Samoa the youngest of the islands in the archipelago. Geological data indicate that Savaii is about four to five million years old, Upolu in Samoa about two to three million years old, Tutuila about 1.5 million years old, Ofu-Olosega about 300,000 years old, and Tau about 100,000 years old. Swains and Rose are built on much older volcanoes, they but are not part of the Samoan volcanic chain (Hart et al., 2004). The geological age and formation of Rose Atoll is not well known, and Swains is part of the Tokelau hot-spot chain which is anywhere from 59 to 72 million years old (Neall and Trewick, 2008; Konter et al., 2008). There are numerous banks in the archipelago, the origins of which are not well known. The South Bank near Tutuila Island, for instance, is of another geological origin.

American Samoa experiences occasional cyclones due to its geographic location in the Pacific. Cyclones occur on one- to 13-year intervals, with the six strong occurrences happening over the last 30 years (Esau, 1981; Tusi, 1987; Ofa, 1990; Val, 1991; Heta, 2004; Olaf, 2005). The territory had two tsunamis in the last 100 years due to its proximity to the geologically active Tonga Trench.

It is in this geological and physical setting that the Samoans have established their culture over the last 3,500 years. For three millennia, the Samoans have relied on the ocean for their sustenance. Fish and fishing activities constitute an integral part of the "fa'a samoa", or the Samoan culture. Fish are also used for chiefly position entitlements and other cultural activities during the "*fa*'*a lalave*" or ceremonies.

1.1.1 Bottomfish Fishery

Deep, zooxanthellate, scleractinian coral reefs that have been documented in the Pacific often occur around islands in clear tropical oceanic waters (Lang 1974; Fricke and Meischner 1985; Kahng and Maragos 2006). These mesophotic coral ecosystems are found at depths of 30-40 m up to 150 m, and have been exploited by bottomfishing fishermen mainly targeting snappers, emperors, and groupers. Bottomfishing utilizing traditional canoes by the indigenous residents of American Samoa has been a subsistence practice since the Samoans settled on the Tutuila, Manua, and Aunu'u islands. It was not until the early 1970s that the bottomfish fishery developed into a commercial scheme utilizing motorized boats. The bottomfish fishery of American Samoa was typically comprised of commercial overnight bottomfish handlining using skipjack as bait on 28 to 30 foot-long aluminum/plywood "alia" (a term used for larger boats in Samoa). Imported bottomfish from the independent state of Samoa help satisfy demand, however the imports weaken the local bottomfish fishery. A government-subsidized program, called the Dory Project, was initiated in 1972 to develop the offshore fisheries into a commercial venture, and resulted in an abrupt increase in the size of the fishing fleet and total landings. In 1982, a fisheries development project aimed at exporting high-priced deepwater snappers to Hawaii initiated another notable increase in bottomfish landings and revenue. Between 1982 and 1988, the botttomfish fishery accounted for as much as half of the total commercial landings (by weight).

American Samoa's bottomfish fishery was a relatively larger size between 1982 and 1985 when it was new and expanding. In 1988, a decline in bottomfish fisheries occurred as many skilled and full-time commercial fishermen converted to trolling. Additionally, profits and revenue in bottomfishing suffered from four separate hurricanes; Tusi in 1987, Ofa in February of 1990, Val in December of 1991, Heta in January of 2004, and the 2009 tsunami. The gradual depletion of newly-discovered banks and migration of many fishermen into other fishing vendors resulted in the decline of landings through the mid-1980s. Fuel prices have gradually risen in the past four years causing yet another strain on the bottomfish fisheries. The average price of bottomfish has also declined due to the shift in demand from local to imported bottomfish that complete closely with local prices. In 2004, 60 percent of coolers imported from the independent state of Samoa on the Lady Naomi Ferry were designated for commercial sale; data from the Commercial Invoice System show that half of these coolers were filled with bottomfish.

Beginning in 1988, the nature of American Samoa's fisheries changed dramatically with a shift in importance from bottomfishing to trolling. In the past eight years, the dominant fishing method has been longlining (by weight). Bottomfishing has been in decline for years, but it was dealt a final devastating blow by the impacts of the 2009 tsunami. A fishery failure was declared, and the U.S. Congress allocated $1 million to revive the fishery. This fund has been used to repair boats damaged by the tsunami, maintain the floating docks used by the alia boats, and build a boat ramp. In 2013, the American Samoan government also implemented a subsidy program that provided financial relief associated the rising fuel prices; the fuel price has since become notably lower.

1.1.2 Coral Reef Fishery

Traditional coral reef fishing in the lagoons and shallow reef areas has included methods such as gleaning and using bamboo poles with lines and baits or with a multi-pronged spear attached. The deepwater and pelagic fisheries have traditionally used wooden canoes, hand-woven sennit lines with shell hooks and stone sinkers, and lures made of wood and shell pieces.

Presumably, the change from traditional to present-day fishing methods started with Western contact in the 18th century. Today the fisheries in American Samoa can be broadly categorized in terms of habitat and target species as either pelagic fisheries, bottomfish fisheries in mesophotic reefs, or nearshore coral reef fisheries. For creel monitoring program purposes, fisheries are either subsistence (i.e. primarily shore-based and mostly for personal consumption) or commercial (i.e. primarily boat-based and mostly sold). Bottomfishing is a combination of mesophotic reef fishing and/or pelagic fishing (i.e. trolling). The coral reef fishery involves gleaning, spearfishing (snorkel or free dive from shore or using boat), rod-and-reel using nylon lines and metal hooks, bamboo pole, throw nets, and gillnets. SCUBA spearfishing was introduced in 1994, restricted for use by native American Samoans around 1997-1998, and finally banned in 2002 following recommendations by biologists from the Department of Marine and Wildlife Resources and local scientists.

1.2 FISHERY DATA COLLECTION SYSTEM

American Samoa has been regularly conducting fishery-dependent monitoring since 1982 for the boat-based fishery and since the 1970s for the shore-based component (though the database was established in the 1990s). The boat-based fishery is mostly trolling for tuna, skipjacks, and trevally, and bottomfishing mostly targets snappers, emperors, and groupers. The shore-based fishery is mostly gleaning for shellfish and octopus, rod-and-reel fishing for groupers and jacks, and spearfishing for surgeonfish and parrotfish. Both boat- and shore-based data collection involve two runs: first is the participation run used to determine the number of boats/fisherman out to fish and identify the type of gear being used; second is the interview run where the fishermen are interviewed for the effort and economic data while also measuring the length and weight of each fish identified to the species level.

1.2.1 Boat-Based Creel Survey

The boat-based data collection focuses mostly on the main docks in Fagatogo and Pago Pago, and on opportunistically surveying sites like Aunuu, Auasi, and Asili. Both boat- and shore-based data collection are also being conducted in Manu'a. The boat-based data collection in Ofu-Olosega and Tau are opportunistic since there is no set schedule for boats to go out and land their catches.

The survey follows a random stratified design. The stratification is by survey area, weekday/weekend, and time of day. The survey is divided into two phases: 1) participation run; and 2) catch interview phase. The participation run attempts to estimate the amount of participation by counting the number of boats "not on the dock" or the presence of trailers. The catch interview phase occurs after the participation run that documents catch composition, CPUE, length-weight information, catch disposition, and some socio-economic information. The data is transcribed weekly into the WPacFIN database. Catch expansion is done on an annual scale through a simple expansion algorithm using expanded effort and CPUE. For more details of the boat-based creel survey see Oram et al. (2011).

1.2.2 Shore-Based Creel Survey

The shore-based data collection follows the same general scheme as the boat-based creel survey, and by randomly selects eight-hour periods and locations four to five times per week to conduct necessary runs. Survey locations are: western Tutuila from Vailoa to Amanave, central Tutuila from Aua to Nuuuli, eastern Tutuila from Lauli'i to Tula, while the Manu'a routes are relatively more complicated. The following data are generated through these creel collection programs: 1) catch landings; 2) effort; 3) CPUE; 4) catch composition; 5) length (accurate to the nearest centimeter); 6) weight (lbs.). The survey follows a random stratified design. The stratification is by survey area, weekday/weekend, and time of day. The survey is divided into two phases: the participation run and the catch interview phase. The participation run attempts to estimate the amount of participation by counting the number of fishermen along the shoreline. The gear type, number of gears, and number of fishers are recorded. The catch interview phase occurs after the participation run, and documents catch composition, CPUE, length-weight information, catch disposition, and some socioeconomic information. The data is transcribed weekly into the WPacFIN database. Catch expansion is done on an annual basis through an expansion algorithm using expanded effort and CPUE values. For more details of the shore-based creel survey see Oram et al. (2011).

1.2.3 Commercial Receipt Book System

Entities that sell any seafood products are required by law to report their sales to DMWR (ASCA § 24.0305). This is done through a receipt book system collected on the fifth day of every month. Information required to be reported are: (a) the weight and number of each species of fish or shellfish received; (b) the name of the fisherman providing the fish or shellfish; (c) boat name and registration number, if applicable; (d) the name of the dealer; (e) the date of receipt; (f) the price paid per species; (g) the type of fishing gear used; (h) whether the fish or shellfish are intended for sale in fresh, frozen, or processed form; (i) which fish or shellfish were taken within/outside of territorial waters; and (j) other statistical information the department may require.

1.2.4 Boat Inventory

An annual boat inventory is being conducted to track down fishing boats and determine their ownership. This will provide information on how many boats are potentially available to engage in the fishery.

1.3 META-DATA DASHBOARD STATISTICS

The meta-data dashboard statistics describe the amount of data used or available to calculate the fishery-dependent information. Creel surveys are sampling-based systems that require random-stratified design applied to pre-scheduled surveys. The number of sampling days, participation runs, and catch interviews would determine if there are sufficient samples to run the expansion algorithm. The trends of these parameters over time may infer survey performance. Monitoring the survey performance is critical for explaining the reliability of the expanded information.

Commercial receipt book information depends on the amount of invoices submitted and the number of vendors participating in the program. Variations in these meta-data affect the commercial landing and revenue estimates.

1.3.1 Creel Survey Meta-Data Statistics

Calculations: Shore-based data

Interview Days: Count of the number of actual days that Creel Survey Data were collected. It is a count of the number of unique dates found in the interview sampling data (the actual sampling date data, including opportunistic interviews).

Participation Runs: Count of the number of unique occurrences of the combination of survey date and run number in the participation detail data.

Catch Interviews: Count of the number of unique occurrences of the combination of date and run number in the participation detail data/count of unique surveyor initials and date in PAR. This is divided into two categories, interviews conducted during a complete survey (Regular), and opportunistic interviews (Opportunistic) which are completed on days when the whole survey is not conducted.

Calculations: Boat-based data

Sample days: Count of the total number of unique dates found in the boat log sampling date data.

Catch Interviews: Count of the total number of data records found in the interview header data (number of interview headers). This is divided into two categories, interviews conducted during scheduled survey days (Regular), and opportunistic interviews (Opportunistic) which are collected on non-scheduled days.

Table 1. Summary of American Samoa creel survey meta-data from 1986-2018

Year	Shore-based				Boat-based		
	# Interview Days	# Participation Runs	# Catch Interviews		# Sample Days	# Catch Interviews	
			Regular	Opportunistic		Regular	Opportunistic
1986					186	682	1

1987					110	346	0
1988	124	0	179	0	158	470	0
1989	126	0	184	0	160	514	0
1990	145	261	393	0	160	331	21
1991	129	458	349	0	134	281	4
1992	84	274	133	0	127	244	4
1993	140	305	255	0	140	285	8
1994	167	544	382	0	209	516	5
1995	157	524	302	0	239	638	8
1996	136	230	218	0	222	654	3
1997	82	0	108	0	226	1,135	1
1998	104	0	143	0	229	1,067	1
1999	34	0	51	0	207	887	0
2000	52	0	67	0	206	729	0
2001	0	0	0	0	205	441	2
2002	20	293	42	38	194	376	0
2003	5	196	7	11	220	503	0
2004	0	409	0	0	239	506	5
2005	33	437	51	4	238	340	0
2006	53	695	89	21	238	325	7
2007	119	1,143	227	50	251	485	6
2008	86	904	127	13	225	303	11
2009	98	963	173	10	165	174	9
2010	102	892	176	5	188	168	2
2011	139	1,234	246	39	240	203	1
2012	77	648	108	9	269	285	14
2013	107	1,028	191	156	262	245	0
2014	68	925	77	27	236	254	26
2015	84	953	150	43	233	247	26
2016	98	891	144	18	224	165	47
2017	65	658	121	35	222	139	33
2018	47	694	54	60	215	176	11
10 yr avg	**89**	**889**	**144**	**40**	**225**	**206**	**17**
10 yr SD	**25**	**173**	**54**	**42**	**30**	**46**	**15**
20 yr avg	**64**	**648**	**105**	**27**	**224**	**348**	**10**
20 yr SD	**40**	**380**	**72**	**35**	**25**	**192**	**13**

1.3.2 Commercial Receipt Book Statistics

Calculations for # Vendors: Count of the number of unique buyer codes found in the commercial purchase header data from the Commercial Receipt Book.

Calculations for # Invoices: Count of the number of unique invoice numbers found in the commercial header data from the Commercial Receipt Book.

Table 2. Summary of American Samoa commercial receipt book meta-data from 1998-2018

Year	Number of Vendors	Total Invoices Collected
1998	21	1,693
1999	19	1,452
2000	18	1,110
2001	31	1,095
2002	25	940
2003	29	1,055
2004	26	811
2005	58	794
2006	51	868
2007	53	966
2008	40	704
2009	37	570
2010	28	486
2011	25	648
2012	26	699
2013	32	581
2014	38	902
2015	43	1281
2016	40	855
2017	37	732
2018	41	646
10 yr avg	**35**	**740**
10 yr SD	**6**	**217**
20 yr avg	**35**	**860**
20 yr SD	**11**	**242**

1.4 FISHERY SUMMARY DASHBOARD STATISTICS

The Fishery Summary Dashboard Statics section consolidates all fishery-dependent information comparing the most recent year with short-term (recent 10 years) and long-term (recent 20 years) average (shown bolded in [brackets]). Trend analysis of the past 10 years will dictate the trends (increasing, decreasing, or no trend). The right-most symbol indicates whether the mean of the short-term and long-term years were above, below, or within one standard deviation of the mean of the full time series.

Legend Key:

- *increasing trend in the time series*
- *decreasing trend in the time series*
- *no trend in the time series*
- *above 1 standard deviation*
- *below 1 standard deviation*
- *within 1 standard deviation*

e.g. 10,000 [**1,000**] – *point estimate of fishery statistic* [% ***difference from short/long term average***]

Table 3. Annual indicators for coral reef and bottomfish fisheries describing performance comparing current American Samoa 2018 estimates with short- (10-year) and long-term (20-year) averages

Fishery	Fishery statistics	Short-term (recent 10 years)	Long-term (recent 20 years)
Bottomfish	**Estimated Catch (lbs.)**		
All species caught in the bottom-fishing gear	Boat and shore creel data estimated (expanded) total lbs. (all BF trips)	**12,837[▼44%]**	**12,837[▼41%]**
	Estimated total lbs. (all species) Commercial Purchase Data	**1,714[▼70%]**	**1,714[▼86%]**
BMUS only	Total Creel Data Estimated (expanded) total lbs. (all BF trips)	**12,811[▼30%]**	**12,811[▼29%]**
	Estimated total lbs. (all species) Commercial Purchase Data	**1,016[▼34%]**	**1,016[▼57%]**
	CPUE (lbs./fishing hours)		
	Creel Data only	**0.0334[▼36%]**	**0.0334[▼62%]**
	Fishing Effort *(*only available for creel data*)*		
	Estimated (expanded) total gear-hours using bottomfishing method	**112,591[▼59%]**	**112,591[▼52%]**
	Fishing Participation (# of trips)		
	Estimated total # of bottomfishing trips	**339[▼11%]**	**339[▲3%]**
	Bycatch (Boat-Based)		
	# bycatch caught	**1,372[▼77%]**	**1,372[▼78%]**

	# bycatch released	**N/A**	**N/A**
	# bycatch kept	**1,372[▼77%]**	**1,372[▼78%]**
Coral Reef	**Estimated Catch (lbs.)**		
	Boat-based Creel Data (expanded estimate, all gears)	**15,669[▼62%]**	**15,669[▼61%]**
	Shore-based Creel Data (expanded estimate, all gears)	**13,190[▼61%]**	**13,190[▼45%]**
	Commercial Purchase Data	**36,178[▼29%]**	**36,178[▼26%]**
	CPUE (lbs./fishing hours)		
	BB mixed-method	**0.2697[▼75%]**	**0.2697[▼78%]**
	BB spear	**0.0201[▼85%]**	**0.0201[▼96%]**
	BB troll	**0.0933[▼55%]**	**0.0933[▼49%]**
	SB hook and line	**0.6667[▼27%]**	**N/A**
	SB rod and reel	**0.0267[▲39%]**	**N/A**
	SB spear	**0.2134[▲80%]**	**N/A**
	SB gleaning	**0.1746[▼54%]**	**N/A**
	SB gill net	**1.3333[▲47%]**	**N/A**
	Fishing Effort (# of gear hours by gear type)		
	BB mixed-method	**4,446[▼93%]**	**4,446[▼86%]**
	BB spear	**73,440[▼26%]**	**73,440[▲23%]**
	BB troll	**59,508[▲1%]**	**59,508[▼38%]**
	SB H&L	**3[▼93%]**	**N/A**
	SB rod and reel	**7,644[▼54%]**	**N/A**
	SB spear	**984[▼97%]**	**N/A**
	SB gleaning	**126[▼64%]**	**N/A**

	SB gill net	**3[▼98%]**	**N/A**
	Fishing Participants (# of fishers)		
	BB mixed-method	**887[▼72%]**	**887[▼59%]**
	BB spear	**1,709 [▼0%]**	**1,709[▲13%]**
	BB troll	**1,073[▲3%]**	**1,073[▲15%]**
	SB hook and line	**31[▼44%]**	**31[▼68%]**
	SB rod and reel	**938[▼42%]**	**938[▼53%]**
	SB spear	**107[▼71%]**	**N/A**
	SB gleaning	**397[▼6%]**	**397[▼58%]**
	SB gill net	**6[▼90%]**	**6[▼95%]**
	Boat-Based Bycatch		
	# bycatch caught	**2,260[▼79%]**	**2,260[▼79%]**
	# bycatch released	**N/A**	**N/A**
	# bycatch kept	**2,260[▼79%]**	**2,260[▼78%]**
	Shore-Based Bycatch		
	# bycatch caught	**1,046[▼64%]**	**N/A**
	# bycatch released	**7[▲5%]**	**N/A**
	# bycatch kept	**1,039[▼64%]**	**N/A**

1.5 CATCH STATISTICS

The following section summarizes the catch statistics for the bottomfish and coral reef fisheries in American Samoa. Estimates of catch are summarized from the creel survey and commercial receipt book data collection programs. Catch statistics provide estimates of annual harvest from the different fisheries. Estimates of fishery removals can provide proxies for the level of fishing mortality and a reference level relative to established quotas. This section also provides detailed levels of catch for fishing methods and the top species complexes harvested in the coral reef and bottomfish fisheries.

1.5.1 Catch by Data Stream

This section describes the estimated total catch from the shore- and boat-based creel survey programs as well as the commercial landings from the commercial receipt book system. The difference between the creel total and the commercial landings is assumed to be the non-commercial component. However, there are cases where the commercial landing may be higher than the estimated creel total of the commercial receipt book program. In this case, the commercial receipt books are able to capture the fishery better than the creel surveys.

Calculations: Estimated landings are based on all bottomfish species harvested, regardless of the gear used, for all data collection programs (e.g. shore-based creel, boat-based creel, and the commercial purchase reports).

Table 4. Summary time series of catch for all species caught using the bottomfishing gear: estimated lbs. (expanded) from the American Samoa boat and shore-based creel surveys and estimated total lbs. from the commercial purchase system from 1989-2018

Year	Creel Survey Estimates		Creel Total	Commercial landings
	Boat-based	Shore-based		
1989	28,708		28,708	
1990	10,796	2,009	12,805	
1991	12,136	345	12,481	4,383
1992	8,673	1,132	9,805	4,756
1993	11,634	403	12,037	4,849
1994	30,116	567	30,683	6,100
1995	25,340	262	25,602	24,315
1996	26,924	1,531	28,455	24,482
1997	27,174		27,174	15,757
1998	11,204		11,204	19,032
1999	13,675		13,675	12,133
2000	14,098		14,098	19,273
2001	30,962		30,962	25,101
2002	24,275		24,275	28,229
2003	13,520		13,520	21,675
2004	22,015	45	22,060	15,138
2005	13,955	334	14,289	13,563
2006	7,649	1,206	8,855	23,187
2007	23,497	4,883	28,380	15,983
2008	33,256	4,804	38,060	17,195
2009	42,633	798	43,431	12,632
2010	8,232	1,067	9,299	5,115
2011	25,017	2,104	27,121	3,405
2012	14,780	414	15,194	2,687
2013	27,888	5,019	32,907	6,363
2014	15,392	878	16,270	5,224

2015	23,213	4,560	27,773	3,942
2016	20,893	4,140	25,033	10,696
2017	16,498	1,075	17,573	5,639
2018	12,320	517	12,837	1,714
10 yr avg	**20,687**	**2,057**	**22,744**	**5,742**
10 yr SD	**9,297**	**1,714**	**9,927**	**3,276**
20 yr avg	**20,188**	**2,123**	**21,781**	**12,445**
20 yr SD	**8,674**	**1,872**	**9,513**	**7,927**

Calculations: Estimated landings are based on a pre-determined list of species (Appendix A) identified as the BMUS Complex regardless of the gear used, for all data collection (shore-based creel, boat-based creel, and the commercial purchase reports).

Table 5. Summary of the available BMUS catch time series: estimated lbs. (expanded) from the American Samoa boat- and shore-based creel surveys and estimated lbs. from the commercial purchase system from 1989-2018

Year	Creel survey Estimates		Creel Total	Commercial landings
	Boat-based	Shore-based		
1989	28,547		28,547	
1990	10,181	2,009	12,190	
1991	12,136	345	12,481	2,242
1992	8,240	1,132	9,372	1,928
1993	11,174	403	11,577	3,541
1994	29,991	560	30,551	3,024
1995	23,507	262	23,769	5,259
1996	24,280	1,040	25,320	1,143
1997	26,857		26,857	419
1998	10,717		10,717	851
1999	12,911		12,911	3,197
2000	14,043		14,043	3,693
2001	30,876		30,876	3,447
2002	23,734		23,734	1,448
2003	13,407		13,407	2,511
2004	15,478	45	15,523	3,233
2005	9,395	334	9,729	2,490
2006	5,107	1,206	6,313	3,142
2007	12,409	4,883	17,292	4,001
2008	26,596	4,804	31,400	4,996
2009	42,541	798	43,339	3,035
2010	8,208	1,067	9,275	1,084
2011	15,170	2,090	17,260	711
2012	3,234	414	3,648	1,161
2013	6,071	4,999	11,070	882

2014	15,382	878	16,260	3,140
2015	23,194	4,528	27,722	2,047
2016	20,865	3,954	24,819	1,131
2017	16,451	974	17,425	1,137
2018	12,314	497	12,811	1,016
10 yr avg	**16,343**	**2,020**	**18,363**	**1,534**
10 yr SD	**10,563**	**1,691**	**10,690**	**844**
20 yr avg	**16,369**	**2,098**	**17,943**	**2,375**
20 yr SD	**9,228**	**1,860**	**9,478**	**1,214**

Calculations: Estimated landings are based on a pre-determined list of species (Appendix A) identified as the CREMUS Complex regardless of the gear used, for each data collection (shore-based creel, boat-based creel, and the commercial purchase reports).

Table 6. Summary of the catch time series for the CREMUS complex from the American Samoa boat- and shore-based creel surveys and the commercial purchase system from 1989-2018

Year	Creel survey Estimates		Creel Total	Commercial Landings
	Boat-based	Shore-based		
1989	63,301		63,301	
1990	9,511	132,471	141,982	
1991	10,825	216,896	227,721	16,515
1992	9,397	104,056	113,453	7,589
1993	12,902	86,078	98,980	18,830
1994	57,061	50,935	107,996	38,263
1995	27,101	56,018	83,119	84,337
1996	29,319	86,339	115,658	88,835
1997	110,448		110,448	114,337
1998	89,663		89,663	107,484
1999	73,818		73,818	76,414
2000	62,843		62,843	59,693
2001	39,909		39,909	47,975
2002	36,437		36,437	52,352
2003	23,306		23,306	43,690
2004	23,277	2,847	26,124	25,919
2005	12,853	29,520	42,373	36,165
2006	12,537	29,211	41,748	44,713
2007	50,678	39,897	90,575	43,916
2008	46,837	38,189	85,026	36,765
2009	58,124	13,762	71,886	35,772
2010	67,646	53,031	120,677	21,694
2011	49,950	63,863	113,813	28,398
2012	32,606	19,939	52,545	38,581

2013	54,615	44,815	99,430	41,533
2014	37,439	18,930	56,369	66,387
2015	48,349	25,185	73,534	80,005
2016	24,839	76,266	101,105	117,871
2017	27,758	12,789	40,547	41,163
2018	15,699	13,190	28,889	36,178
10 yr avg	**41,703**	**34,177**	**75,880**	**50,758**
10 yr SD	**15,740**	**22,253**	**30,066**	**27,769**
20 yr avg	**39,976**	**24,072**	**64,048**	**48,759**
20 yr SD	**17,882**	**22,166**	**29,232**	**21,839**

1.5.2 Expanded Catch Estimates by Fishing Method

Catch information is provided for the top shore- and boat-based fishing methods (i.e., those that contribute a majority of the annual catch for the region).

Calculations: The creel survey catch time series are the sum of the estimated weight for selected gear in all strata for all species (except for trolling, which excludes PMUS as well as any other non-PMUS pelagic species).

Table 7. Total expanded catch time series estimates (lbs.) using American Samoa shore- and boat-based creel survey data by gear type from 1990-2018

Year	Shore-Based Methods						Boat-Based Methods			
	R&R	Spear	Gleaning	Gill net	H&L	Throw Net	Bottomfish	Bottom-troll Mixed	Spear	Troll*
1990	688	0	1,462	0	505	1,278	2,423	3,725	1,360	23,283
1991	1,591	0	539	0	396	721	3,887	4,154	717	18,383
1992	192	0	480	0	19	661	3,610	0	0	27,235
1993	389	0	836	0	67	516	4,728	766	70	12,163
1994	608	0	1,038	0	27	390	5,027	1,736	988	33,544
1995	490	0	1,240	124	54	252	2,791	3,994	0	48,438
1996	417	0	863	39	21	691	5,303	2,834	0	29,546
1997	201	0	470	0	0	566	6,407	2,122	9,124	19,596
1998	345	0	679	0	462	445	2,971	70	785	4,846
1999	118	0	126	0	209	171	2,266	103	746	12,376
2000	104	0	327	0	0	168	1,235	36	0	1,445
2001	0	0	0	0	0	0	5,186	0	1,479	5,095
2002	134	57	59	15	6	90	3,597	0	1,245	3,804
2003	7	23	45	0	0	13	8,687	1,574	1,250	20,341
2004	0	0	0	0	0	0	7,957	3,023	463	21,613
2005	25	80	3	55	0	39	5,408	4,016	30	11,567
2006	122	190	23	60	1	211	7,109	1,169	601	14,557
2007	360	854	350	323	33	315	18,692	1,125	7,362	12,040

2008	199	302	94	31	2	96	20,080	1,073	3,713	20,136
2009	203	564	87	53	12	193	34,875	2,226	8,913	2,862
2010	97	526	102	29	20	234	7,988	507	23,170	3,461
2011	280	2,225	160	167	19	214	10,737	5,249	18,890	13,634
2012	82	520	63	117	6	153	5,390	1,133	7,279	8,552
2013	303	4,777	184	87	151	511	6,098	1,787	16,770	7,865
2014	95	844	18	7	15	132	10,184	1,313	7,214	17,097
2015	422	628	20	18	15	246	13,339	3,769	3,814	5,551
2016	372	547	77	39	23	192	5,469	7,636	1,730	10,350
2017	621	190	66	17	0	187	6,613	2,604	1,563	7,972
2018	204	210	22	4	2	158	3,760	1,199	1,453	6,253
10 yr avg	**268**	**1,103**	**80**	**54**	**26**	**222**	**10,445**	**2,742**	**9,080**	**8,360**
10 yr SD	**162**	**1,340**	**54**	**51**	**42**	**102**	**8,602**	**2,109**	**7,464**	**4,185**
20 yr avg	**208**	**697**	**101**	**57**	**29**	**185**	**9,234**	**1,977**	**5,384**	**10,329**
20 yr SD	**154**	**1,112**	**97**	**78**	**55**	**106**	**7,561**	**1,911**	**6,618**	**5,971**

1.5.3 Top Species in Shore- and Boat-Based Fishery Catch

Catch time series can act as indicators of fishery performance. Variations in the catch can be attributed to various factors, and there is no single explanatory variable for the observed trends. The top ten species groups in the shore and boat-based catch records from the coral reef fishery make up majority of the total annual catches.

Calculations: Catch by species complex is tallied directly from the boat-based expanded species composition data combining all gear types and species for all strata.

The averages for Table 8 below were calculated from catch estimates for the entire time series across each of the CREMUS groupings. The average catch for each grouping is ranked from the highest to lowest. The dominant groups that make up more than half of the total annual catch are reported.

The averages for Table 9 below were calculated from catch estimates from the entire time series for each CREMUS grouping. The average catch is ranked from the highest to lowest. The dominant groups that make up a majority of the reported catch.

Table 8. Catch time series of ten eleven CREMUS complexes from American Samoa boat-based creel data from 1989-2018

Year	Bottomfish	BMUS	Surgeonfish	Snappers	Emperors	Parrotfish	Groupers	Jacks	Crustaceans	Squirrelfish	Atulai
1989	28,708	28,547	19,229	5,922	4,222	7,962	4,797	3,961	4,602	4,448	0
1990	10,797	10,182	824	1,149	1,669	319	512	1,017	186	148	108
1991	12,138	12,138	388	2,441	2,053	167	1,040	760	155	271	0
1992	8,672	8,239	0	683	3,905	0	298	1,269	0	35	0
1993	11,634	11,174	221	1,405	2,292	330	1,926	636	50	233	0
1994	30,118	29,993	9,277	4,459	6,169	15,557	4,626	3,440	1,526	816	0
1995	25,339	23,506	1,588	2,222	4,853	2,960	2,594	4,675	294	457	2
1996	26,923	24,280	3,560	1,847	7,458	1,409	1,824	2,915	413	679	22
1997	27,173	26,856	49,629	3,881	5,784	17,553	7,155	2,930	5,319	3,696	272
1998	11,203	10,716	35,789	1,293	1,341	22,231	4,797	2,676	4,728	1,264	0
1999	13,675	12,912	34,665	2,127	1,342	13,769	4,773	1,794	2,136	2,599	0
2000	14,099	14,044	22,286	1,291	8,977	10,905	3,489	3,578	1,769	2,546	631
2001	30,964	30,877	5,802	4,840	11,448	953	1,641	1,766	1,677	510	55
2002	24,274	23,733	4,751	3,081	14,576	1,528	2,275	2,721	753	1,381	0
2003	13,521	13,408	3,088	4,108	6,793	844	1,338	1,122	1,034	584	0
2004	22,015	15,477	2,338	3,351	1,633	732	1,691	1,848	645	525	0
2005	13,955	9,395	106	3,348	579	74	803	735	29	181	0
2006	7,649	5,106	753	1,435	449	481	600	507	253	276	36
2007	23,498	12,411	5,615	4,331	5,914	3,069	1,454	959	1,654	739	2,585
2008	33,254	26,595	3,203	8,075	7,582	2,220	3,240	1,280	1,151	1,095	1,759
2009	42,635	42,543	7,872	16,944	10,280	4,889	3,587	2,362	2,861	1,309	198
2010	8,230	8,206	25,301	3,269	2,365	14,712	1,970	410	14,358	2,243	14
2011	25,017	15,169	10,515	5,597	4,177	6,909	2,379	186	3,160	1,726	37
2012	14,780	3,234	1,588	1,384	1,201	1,762	367	472	573	368	3,481
2013	27,889	6,072	6,733	3,834	2,220	2,422	1,231	1,162	1,791	994	1,092
2014	15,390	15,379	8,539	8,430	4,943	7,803	2,778	932	140	810	157
2015	23,214	23,195	11,137	10,360	8,425	11,886	2,043	735	11	942	0
2016	20,894	20,866	1,423	10,126	1,435	2,937	1,555	1,476	269	429	72
2017	16,499	16,451	3,239	11,556	847	3,015	1,421	2,432	1,093	375	0

2018	12,320	12,314	1,877	3,204	1,144	2,459	1,388	688	148	279	0
10 yr avg	**20,687**	**16,343**	**7,822**	**7,470**	**3,704**	**5,879**	**1,872**	**1,086**	**2,440**	**948**	**505**
10 yr SD	**9,297**	**10,564**	**6,794**	**4,609**	**3,121**	**4,211**	**853**	**745**	**4,118**	**618**	**1,041**
20 yr avg	**20,189**	**16,369**	**8,042**	**5,535**	**4,817**	**4,668**	**2,001**	**1,358**	**1,775**	**996**	**506**
20 yr SD	**8,674**	**9,229**	**8,922**	**4,014**	**4,113**	**4,553**	**1,080**	**866**	**3,023**	**736**	**960**

Table 9. Catch time series of ten top CREMUS complexes from American Samoa shore-based creel data from 1990-2018

Year	Atulai	Mollusks	Surgeonfish	Parrotfish	Mullet	Grouper	Squirrel	Wrasse	Crustaceans	Snappers
1990	46,835	10,543	16,080	1,232	18,013	2,244	1,952	135	448	3,337
1991	113,228	18,045	14,729	2,221	1,543	5,334	4,772	759	849	2,360
1992	7,412	9,439	17,770	2,735	4,190	5,750	10,570	171	1,444	663
1993	7,642	39,941	10,930	1,650	964	4,347	1,426	308	1,160	1,023
1994	12,942	16,558	1,647	2,035	583	1,502	640	293	559	1,088
1995	20	22,520	4,322	2,003	1,935	1,904	1,595	167	2,298	100
1996	25,427	24,900	1,971	2,475	1,231	1,174	8,765	167	971	249
1997										
1998										
1999										
2000										
2001										
2002										
2003										
2004	33	585	473	100	435	213	160	322	40	19
2005	1,076	6,731	5,986	1,358	2,559	2,068	825	3,157	728	269
2006	733	2,657	5,386	1,619	3,431	3,383	448	1,937	589	802
2007	2,679	9,368	7,057	2,252	2,819	4,434	700	949	477	444
2008	5,640	16,496	3,851	1,158	1,189	2,534	1,148	2,278	68	108
2009	238	3,206	2,662	840	434	1,221	1,136	759	520	98
2010	2,110	4,596	12,440	20,382	2,235	1,984	4,282	228	2,262	386

2011	16,117	7,500	14,462	12,161	2,603	1,852	3,776	125	1,894	267
2012	4,001	4,544	4,868	1,147	1,241	957	547	199	483	68
2013	6,189	18,039	6,884	2,011	3,145	1,730	1,181	561	818	344
2014	462	5,984	3,602	766	576	2,412	1,689	169	138	205
2015	2,465	5,993	7,126	747	693	813	806	105	177	272
2016	2,080	28,446	10,114	17,497	908	3,096	2,689	392	3,939	430
2017	503	2,692	503	421	236	646	563	177	0	400
2018	937	4,662	2,387	466	808	526	285	71	53	57
10 yr avg	**3,510**	**8,566**	**6,505**	**5,644**	**1,288**	**1,524**	**1,695**	**279**	**1,028**	**253**
10 yr SD	**4,551**	**7,809**	**4,370**	**7,474**	**956**	**794**	**1,340**	**212**	**1,219**	**134**
20 yr avg	**3,018**	**8,100**	**5,853**	**4,195**	**1,554**	**1,858**	**1,349**	**762**	**812**	**278**
20 yr SD	**3,953**	**7,174**	**3,914**	**6,450**	**1,076**	**1,143**	**1,215**	**910**	**1,054**	**197**

1.6 CATCH-PER-UNIT-EFFORT (CPUE) STATISTICS

This section summarizes the estimates for CPUE in the shore- and boat-based fisheries. The boat-based fisheries include bottomfishing (handline gear), spearfishing (snorkel), troll, atulai nets, and cast nets that comprise a majority of the total catch. Trolling is primarily a pelagic fishing method but also catches coral reef fishes including jacks and gray jobfish. The shore-based fisheries include the hook-and-line, spearfishing, and cast nets, which also comprise a large portion of the total coral reef fish catch. CPUE is reported as pounds per gear hours for the shore-based methods, but it is measured as pounds per trip in the boat-based methods.

Calculations: CPUE is calculated from interview data by gear type using ∑catch /∑ (hours fished*number of fishers) for boat-based and ∑catch/∑ (hours fished*number of gears used) for shore-based. If the value is blank (i.e., an empty cell), then there was no interview collected for that method. Landings from interviews without fishing hours are excluded from the calculations.

Table 10. CPUE time series for dominant fishing methods in the American Samoa shore-based fishery from 1990-2018 for the top dominant groups

Year	Shore-based Gear CPUE (lbs./fishing hours)				
	R&R	Spear	Gleaning	Gill Net	H&L
1990	0.0532		0.5061		0.0370
1991	0.0561		0.1922		0.0299
1992	0.5486		0.4786		0.1152
1993	0.0745		0.2136		5.5833
1994	0.0322		0.0943		0.0229
1995	0.0904		0.0792	4.5926	0.0741
1996	0.0925		0.2517	0.1866	0.0367
1997					
1998					
1999					
2000					
2001					
2002	0.0124	2.2800	0.2341	2.5000	0.3750
2003	0.0374	1.0952	0.4945	0	0
2004					
2005	0.0470	0.1379	0.2500	3.9286	0
2006	0.0341	0.1000	0.1769	0.5714	0.5000
2007	0.0120	0.1069	0.0594	0.2553	0.6735
2008	0.0455	0.0944	0.1741	0.5741	0.1333
2009	0.0166	0.1112	0.1014	0.4907	0.2400
2010	0.0226	0.0502	0.4880	0.7250	0.6667
2011	0.0105	0.0319	0.1309	0.3591	0.2468
2012	0.0138	0.1337	0.3462	0.1275	0.3333
2013	0.0157	0.0213	0.3810	0.9560	1.1185

2014	0.0335	0.0799	0.9000	0.2333	5.0000
2015	0.0098	0.1661	0.3704	0.6000	0.6250
2016	0.0182	0.1796	0.3775	3.9000	0.2018
2017	0.0249	0.2000	0.4889	0.3269	0
2018	0.0267	0.2134	0.1746	1.3333	0.6667
10 yr avg	**0.0192**	**0.1187**	**0.3759**	**0.9052**	**0.9099**
10 yr SD	**0.0072**	**0.0671**	**0.2184**	**1.0555**	**1.3972**
20 yr avg	**0.0238**	**0.3126**	**0.3217**	**1.1254**	**0.7187**
20 yr SD	**0.012**	**0.5629**	**0.2032**	**1.2313**	**1.1808**

Table 11. CPUE time series for dominant fishing methods in the American Samoa boat-based fishery from 1986-2018 for the top dominant groups

Year	Boat-based Gear CPUE (lbs./fishing hours)			
	Bottomfishing	Bottom-Troll Mix	Spear	Troll
1986	0.0242	0.0633	0.1295	0.0237
1987	0.2486	0.0905	0.1038	0.0411
1988	0.1611	0.2023	0.078	0.061
1989	0.2189	0.1531	0.1812	0.0252
1990	0.2227	0.2841	0.6667	0.0496
1991	0.1002	0.3337	3.1867	0.062
1992	0.16	0	0	0.1005
1993	0.0754	1.5958	0.9333	0.0761
1994	0.0674	0.3674	1.0228	0.0436
1995	0.1424	0.1411	0	0.0321
1996	0.1469	0.7409	0	0.0533
1997	0.1147	0.4486	0.3283	0.0491
1998	0.2814	0.7292	5.4514	0.184
1999	0.3536	5.7222	1.7933	0.1317
2000	0.3869	3.0000	0	0.391
2001	0.1717	0	0.7043	0.2042
2002	0.062	0	0.5231	0.3254
2003	0.0687	0.8211	1.0629	0.0628
2004	0.0285	0.2928	1.3538	0.0548
2005	0.0709	0.2499	3.0000	0.0633
2006	0.0404	0.3619	0.7457	0.0811
2007	0.0355	0.2856	0.0396	0.1147
2008	0.0425	0.3794	0.0984	0.1609
2009	0.0526	0.5162	0.3038	0.2901
2010	0.0921	7.6818	0.0642	0.2161
2011	0.0888	0.486	0.1406	0.2276
2012	0.0528	0.9257	0.447	0.4691
2013	0.052	0.3961	0.1181	0.0936

2014	0.0565	0.3245	0.0594	0.1252
2015	0.0307	0.1911	0.1371	0.1243
2016	0.0396	0.0962	0.0429	0.3796
2017	0.0208	0.0507	0.0139	0.0596
2018	0.0334	0.2697	0.0201	0.0933
10 yr avg	**0.0519**	**1.0938**	**0.1347**	**0.2079**
10 yr SD	**0.0222**	**2.2088**	**0.1316**	**0.1292**
20 yr avg	**0.0890**	**1.2251**	**0.5615**	**0.1834**
20 yr SD	**0.0992**	**2.0637**	**0.7567**	**0.1226**

1.7 EFFORT STATISTICS

This section summarizes the effort trends in the coral reef and bottomfish fishery. Fishing effort trends provide insights on the level of fishing pressure through time. Effort information is provided for the top shore-based and boat-based fishing methods that contribute a majority of the annual catch.

Calculations: Effort estimates (in gear hours) are generated by summing the effort data collected from interviews by gear type. For the shore-based estimates, the database was started in 1990 even though data collection began in the 1970s.

Table 12. Effort (gear-hours) for dominant fishing methods in the coral reef and bottomfish fisheries of American Samoa from 1986-2018

Year	Estimated Effort by Gear Type								
	Shore-Based Gear Hours					Boat-Based Gear Hours			
	Rod and Reel	Spear	Gleaning	Gill Net	Hook-and-Line	Bottom-fishing	Bottom-Troll Mixed	Spear	Troll
1986						744,246	272,557	77,520	2,098,512
1987						10,368	136,072	94,644	1,033,006
1988						45,114	50,220	201,500	1,006,845
1989						20,713	80,388	74,501	1,823,029
1990	12,936	0	2,889	0	13,653	11,137	13,410	2,040	457,300
1991	28,380	0	2,805	0	13,261	40,255	14,442	225	294,930
1992	350	0	1,003	0	165	23,374	0	0	273,612
1993	5,220	0	3,913	0	12	66,215	480	15	146,376
1994	18,860	0	11,005	0	1,178	76,900	4,900	1,656	785,880
1995	5,421	0	15,660	27	729	19,950	28,768	0	1,954,350
1996	4,510	0	3,429	209	572	34,656	4,284	0	589,380
1997	0	0	0	0	0	59,631	4,730	26,634	499,260
1998	0	0	0	0	0	10,764	96	144	30,753
1999	0	0	0	0	0	6,408	12	416	107,177
2000	0	0	0	0	0	3,192	12	0	3,619
2001						31,540	0	2,100	31,616
2002	10,816	25	252	6	16	57,988	0	2,380	11,248
2003	187	21	91	0	0	105,222	1,349	756	238,392
2004						519,726	9,800	266	369,104
2005	532	580	12	14	1	54,540	13,596	10	170,016
2006	3,575	1,900	130	105	2	155,709	3,230	650	171,270
2007	29,882	7,986	5,893	1,265	49	524,706	3,939	164,016	98,154

2008	4,371	3,200	540	54	15	460,290	3,838	37,000	120,776
2009	12,231	5,074	858	108	50	654,515	4,312	24,840	8,494
2010	4,284	10,472	209	40	30	84,240	66	316,820	10,362
2011	26,543	69,776	1,222	465	77	123,804	11,016	124,146	51,471
2012	5,922	3,888	182	918	18	98,600	1,173	15,222	15,222
2013	19,352	224,349	483	91	135	203,548	4,032	138,726	71,052
2014	2,838	10,564	20	30	3	184,052	5,593	119,583	152,492
2015	42,880	3,780	54	30	24	470,106	439,999	27,820	46,508
2016	20,400	3,045	204	10	114	378,658	86,825	40,560	25,986
2017	24,969	950	135	52	2	416,150	59,361	109,568	149,490
2018	7,644	984	126	3	3	112,591	4,446	73,440	59,508
10 yr avg	**16,706**	**33,288**	**349**	**175**	**46**	**272,626**	**61,682**	**99,073**	**59,059**
10 yr SD	**11,983**	**66,639**	**374**	**279**	**45**	**185,157**	**129,160**	**84,761**	**50,210**
20 yr avg	**12,024**	**19,255**	**578**	**177**	**30**	**232,279**	**32,630**	**59,916**	**95,598**
20 yr SD	**12,172**	**52,118**	**1,327**	**344**	**40**	**200,874**	**95,890**	**79,524**	**90,957**

1.8 PARTICIPANTS

This section summarizes the estimated number of participants in each fishery. The information presented here can be used in impact analysis of potential amendments in the fishery ecosystem plans (FEPs) associated with the bottomfish and coral reef fisheries. The trend in the number of participants over time can also be used as an indicator of fishing pressure.

Calculations: For boat-based data, the estimated number of participants is calculated by multiplying the average number of fishers per trip by the number of trips per day, and then by the number of dates in the calendar year by gear type. The total is a combination of weekend and weekday stratum estimates.

For shore-based data, the estimated number of participants is calculated by using an average number of fishers per day multiplied by the numbers of dates in the calendar year across gear types. The total is a combination of weekend, weekday, day, and night stratum estimates.

Table 13. Estimated number of fishers in the American Samoa bottomfish fishery with gear counts and number of trips in the boat-based and the shore-based coral reef fishery from 1986-2018

Year	Bottomfish		Coral Reef Boat-Based			Coral Reef Shore-Based				
	# Gears	# Trips	Bottom-Troll Mixed	Spear	Troll	R&R	Spear	Gleaning	Gill Net	H&L
1986	935	288	871	1,909	1,003					
1987	922	70	935	1,710	1,026					
1988	919	125	1,163	1,629	1,189					
1989	962	115	1,456	1,903	1,253					
1990	828	73	1,098	1,556	1,044	10,147	0	7,219	0	16,962
1991	947	117	1,114	1,643	1,125	14,498	0	8,406	0	8,234
1992	816	121	0	0	996	3,558	0	11,685	0	850
1993	913	151	973	365	1,053	7,338	0	15,308	0	1,005
1994	913	246	1,136	2,190	979	9,710	0	9,243	0	4,710
1995	905	131	905	0	1,322	6,194	0	10,917	125	1,655
1996	812	185	876	0	991	12,493	0	7,202	212	9,684
1997	970	199	958	1,389	1,248					
1998	954	54	936	1,872	1,224					
1999	751	107	626	1,252	994					
2000	879	160	942	0	868					
2001	804	252	0	1,043	1,054					
2002	943	378	0	1,560	790	4,102	2,492	3,233	256	192
2003	803	272	595	805	624	4,158	1,821	3,909	211	402
2004	1,786	402	885	1,475	753	3,199	1,372	1,233	139	158
2005	604	220	712	1,565	690	1,444	636	1,255	189	86
2006	843	160	991	1,118	777	1,540	297	708	281	119
2007	1,006	331	951	1,366	886	1,847	566	562	223	67
2008	1,015	468	1,208	1,345	876	1,376	549	789	89	80
2009	1,131	622	1,092	1,595	691	976	529	758	66	54
2010	1,012	251	945	1,712	671	712	500	339	51	51
2011	982	265	895	1,863	807	1,927	642	363	65	98

2012	644	264	1,467	748	741	1,418	437	402	207	41
2013	1,451	413	1,233	1,795	823	1,550	490	588	34	87
2014	782	401	1,222	1,819	995	700	279	231	73	12
2015	986	469	20,200	1,630	965	2,627	300	226	62	57
2016	2,993	400	1,195	1,622	965	4,363	255	696	10	74
2017	2,870	406	2,859	2,670	2,689	998	126	213	7	40
2018	1,123	339	887	1,709	1,073	938	107	397	6	31
10 yr avg	**1,397**	**383**	**3,200**	**1,716**	**1,042**	**1,621**	**367**	**421**	**58**	**55**
10 yr SD	**794**	**107**	**5,693**	**438**	**564**	**1,078**	**170**	**186**	**55**	**25**
20 yr avg	**1,170**	**329**	**2,161**	**1,510**	**937**	**1,993**	**670**	**935**	**116**	**97**
20 yr SD	**642**	**122**	**4,401**	**419**	**422**	**1,200**	**619**	**1,015**	**90**	**88**

1.9 BYCATCH ESTIMATES

This section focuses on MSA § 303(a)(11), which requires that all fishery management plans (FMPs) establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery. Additionally, it is required to include conservation and management measures that, to the extent practicable, minimize bycatch and bycatch mortality. The MSA § 303(a)(11) standardized reporting methodology is commonly referred to as a ''Standardized Bycatch Reporting Methodology'' (SBRM) and was added to the MSA by the Sustainable Fisheries Act of 1996 (SFA). The Council implemented omnibus amendments to FMPs in 2003 to address MSA bycatch provisions and established SBRMs at that time.

Calculations: The number caught is the sum of the total number of individuals found in the raw data including bycatch. The number kept is the total number of individuals in the raw data that are not marked as bycatch. The number released is bycatch caught minus the number of bycatch kept. Percent bycatch is the sum of all bycatch divided by the total catch.

Table 14. Time series of bycatch in the American Samoa non-bottomfish boat-based fisheries from 1986-2018

Year	Bycatch from Boat-Based Non-Bottomfishing Gear Type			
	# Caught	Kept	Released	% Bycatch
1986	0	0	0	0
1987	0	0	0	0
1988	43	43	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	5,277	5,277	0	0
1993	2,637	2,637	0	0
1994	7,562	7,562	0	0
1995	10,279	10,279	0	0
1996	7,088	7,088	0	0
1997	24,977	24,977	0	0
1998	17,491	17,491	0	0
1999	16,705	16,705	0	0
2000	12,642	12,641	1	0
2001	8,651	8,649	2	0
2002	6,531	6,522	9	0
2003	8,936	8,931	5	0
2004	8,611	8,604	7	0
2005	5,036	5,036	0	0
2006	6,306	6,306	0	0
2007	17,555	17,555	0	0
2008	9,799	9,799	0	0

2009	9,630	9,630	0	0
2010	22,283	22,283	0	0
2011	18,659	18,659	0	0
2012	15,512	15,512	0	0
2013	13,919	13,919	0	0
2014	11,560	11,560	0	0
2015	7,280	7,280	0	0
2016	5,257	5,257	0	0
2017	3,118	3,118	0	0
2018	2,260	2,260	0	0
10 yr avg	**10,948**	**10,948**	**0**	**0**
10 yr SD	**6,343**	**6,343**	**0**	**0**
20 yr avg	**10,513**	**10,511**	**1**	**0**
20 yr SD	**5,340**	**5,341**	**3**	**0**

Table 15. Time series of bycatch in the American Samoa bottomfish fishery from 1986-2018

Year	Bycatch from Boat-Based Bottomfishing Gear Type			
	# Caught	Kept	Released	% Bycatch
1986	0	0	0	0
1987	0	0	0	0
1988	91	91	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	2,440	2,440	0	0
1993	2,394	2,394	0	0
1994	7,657	7,657	0	0
1995	3,405	3,405	0	0
1996	5,999	5,999	0	0
1997	5,193	5,193	0	0
1998	1,844	1,844	0	0
1999	5,630	5,630	0	0
2000	6,438	6,438	0	0
2001	6,202	6,202	0	0
2002	6,959	6,959	0	0
2003	7,797	7,796	1	0
2004	6,734	6,734	0	0
2005	3,684	3,684	0	0
2006	5,833	5,833	0	0
2007	6,936	6,936	0	0

2008	8,588	8,588	0	0
2009	19,521	19,521	0	0
2010	5,021	5,021	0	0
2011	7,359	7,359	0	0
2012	5,137	5,137	0	0
2013	4,525	4,525	0	0
2014	4,462	4,462	0	0
2015	7,268	7,268	0	0
2016	2,122	2,122	0	0
2017	2,351	2,351	0	0
2018	1,372	1,372	0	0
10 yr avg	**5,914**	**5,914**	**0**	**0**
10 yr SD	**4,922**	**4,922**	**0**	**0**
20 yr avg	**6,197**	**6,197**	**0**	**0**
20 yr SD	**3,602**	**3,602**	**0**	**0**

Table 16. Time series of bycatch in American Samoa shore-based fisheries for all gears from 2005-2018

Year	**Bycatch from Shore-Based Fishing (all gears combined)**			
	# Caught	**Kept**	**Released**	**% Bycatch**
2005	658	655	3	0
2006	1,619	1,613	6	0
2007	5,442	5,441	1	0
2008	2,145	2,145	0	0
2009	2,199	2,199	0	0
2010	1,994	1,993	1	0
2011	3,981	3,980	1	0
2012	1,572	1,572	0	0
2013	9,220	9,214	6	0
2014	1,829	1,829	0	0
2015	2,469	2,469	0	0
2016	3,302	3,302	0	0
2017	1,386	1,386	0	0
2018	1,046	1,039	7	0
10 yr avg	**2,900**	**2,898**	**2**	**0**
10 yr SD	**2,267**	**2,266**	**3**	**0**
20 yr avg	**2,776**	**2,774**	**2**	**0**
20 yr SD	**2,153**	**2,152**	**3**	**0**

1.10 NUMBER OF FEDERAL PERMIT HOLDERS

In American Samoa, 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.

1.10.1 Special Coral Reef Ecosystem Permit

Regulations require the special coral reef ecosystem fishing permit for anyone fishing for coral reef ecosystem management unit species 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 American Samoa coral reef 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 MUS caught in a low-use MPA.

1.10.2 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).

1.10.3 Western Pacific Crustacean 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 three nautical miles of the shoreline of the Northern Mariana Islands.

There is no record of special coral reef or precious coral fishery permits issued for the EEZ around American Samoa since 2007. NMFS has issued few crustacean fishery permits as shown in Table 17. Table 17 provides the number of permits issued to American Samoa FEP fisheries between 2009 and 2018.

Table 17. Number of federal permit holders in crustacean fisheries from 2009-2018

Crustacean Fishery	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Lobster	4*	0	0	0	0	1	0	0	0	0
Shrimp	0	1*	1*	0	0	1	0	0	0	0

*Same permit applies to American Samoa, Guam, and CNMI.

1.11 STATUS DETERMINATION CRITERIA

1.11.1 Bottomfish 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 MSY control rule is used as the maximum fishing mortality threshold (MFMT). The MFMT and minimum stock size threshold (MSST) are specified based on the recommendations of Restrepo et al. (1998) and both are dependent on the natural mortality rate (M). The value of M used to determine the reference point values is not specified in this document. The latest estimate published annually in the stock assessment and fishery evaluation (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 reaching the threshold. MFMT, MSST, and B_{FLAG} are specified as indicated in Table 18.

Table 18. Overfishing threshold specifications for BMUS

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 fishing mortality (F) and biomass (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 is 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 ($SSBP_t$) to a given reference level ($SSBP_{REF}$) is used to determine if individual stocks are experiencing recruitment overfishing. SSBP is CPUE scaled by percent mature fish in the catch. When the ratio $SSBP_t/SSBP_{REF}$, or the "SSBP ratio" (SSBPR) for any species drops below a certain limit ($SSBPR_{MIN}$), that species is considered to be recruitment overfished and management measures will be implemented to reduce fishing mortality on that species. The rule applies only when the SSBP ratio drops below the $SSBPR_{MIN}$, but it will continue to apply until the ratio achieves the "SSBP ratio recovery target" ($SSBPR_{TARGET}$), which is set at a level no less than $SSBPR_{MIN}$. These two reference points and their associated recruitment overfishing control rule, which prescribe a target fishing mortality rate ($F_{RO-REBUILD}$) as a function of the SSBP ratio, are specified as indicated in Table 19. Again, E_{MSY} is used as a proxy for F_{MSY}.

Table 19. Recruitment overfishing control rule specifications for BMUS

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

1.11.2 Coral Reef Fishery

Available biological and fishery data are poor for all coral reef ecosystem management unit species in American Samoa. 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 independently, without proxy.

1.11.2.1 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 20.

Table 20. Status determination criteria for the coral reef MUS 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 ($CPUE_{REF}$).

1.11.3 Current Stock Status

1.11.3.1 Bottomfish

Biological and other fishery data are poor for all bottomfish species in the America Samoa Archipelago. Generally, data are only available on commercial landings by species and catch-per-unit-effort (CPUE) for the multi-species complexes as a whole. At this time it is not possible to partition these effort measures among the various bottomfish MUS. The most recent stock assessment update (Yau et al., 2015) for the American Samoa bottomfish management unit species complex (comprised of 17 species of shallow and deep species of snapper, grouper, jacks, and emperors) was based on estimate of total catch, an abundance index derived from the nominal CPUE generated from the creel surveys, and a fishery-independent point estimate of MSY from the Our Living Oceans Report (Humphreys and Moffitt 1999; NMFS 2009). 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 American Samoa BMUS is not subject to overfishing and is not overfished (

Table 21).

Table 21. Stock assessment parameters for the BMUS complex (from Yau et al., 2015)

Parameter	Value	Notes	Status
MSY	76.74 ± 14.06	Expressed in 1000 lbs. (± std. error)	
H_{2013}	0.039	Expressed in percentage	
H_{MSY}	0.238 ± 0.062	Expressed in percentage (± std. error)	
H/H_{MSY}	0.17		No overfishing occurring
B_{2013}	661.3	Expressed in thousand pounds	
B_{MSY}	333.7 ± 65.3	Expressed in 1000 lbs. (± std. error)	
B/B_{MSY}	1.98		Not overfished

1.11.3.2 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 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 22. The SSC utilized the MSYs for the coral reef MUS complexes as the OFLs.

Table 22. Most recent MSY estimates for Western Pacific CREMUS

Coral Reef MUS Complex	MSY (lbs.)
Selar crumenophthalmus – atulai / bigeye scad	45,300
Acanthuridae – surgeonfish	148,600
Carangidae – jacks	24,300
Crustaceans – crabs	7,800
Holocentridae – squirrelfish	16,800

Coral Reef MUS Complex	MSY (lbs.)
Kyphosidae – chubs/rudderfish	2,600
Labridae – wrasses	19,000
Lethrinidae – emperors	23,700
Lutjanidae – snappers	65,400
Mollusks – turbo snail; octopus; giant clams	12,700
Mugilidae – mullets	8,200
Mullidae – goatfish	29,600
Scaridae – parrotfish	294,600
Serranidae – groupers	30,500
Siganidae – rabbitfish	200
All Other CREMUS Combined (Other CRE-finfish, other invertebrates, misc. bottomfish, misc. reef fish, and misc. shallow bottomfish)	28,500
Cheilinus undulatus – humphead (Napoleon) wrasse	N.A.
Bolbometopon muricatum – bumphead parrotfish	N.A.
Carcharhinidae – reef sharks	2,300

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

1.12.1 Brief Description of the ACL Process

The Council developed a Tiered system of control rules to guide the specification of ACLs and Accountability Measures (AMs; WPRFMC 2011). The process starts with the use of the best scientific information available (BSIA) in the form of, but not limited to, stock assessments, published paper, reports, or available data. These data are classified to 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 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 is comprised of stocks with MSY estimates but no active fisheries, the control rule is 91 percent of MSY. For Tier 5, which has catch-only information, the control rule is a 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 (percent reduction from ABC based on expert opinion) or the use of an Annual Catch Target (ACT). Specifications are done on an annual basis but the Council normally specifies a multi-year specification.

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

1.12.2 Current OFL, ABC, ACL, and Recent Catch

The most recent multiyear specification of OFL, ABC, and ACL for the coral reef fishery was completed in the 160th Council meeting on June 25 to 27, 2014. The specification covers fishing year 2015, 2016, 2017, and 2018 for the coral reef MUS complexes. A P* and SEEM analysis was performed for this multiyear specification (NMFS 2015). For the bottomfish, it was a roll over from the previous specification since an assessment update was not available for fishing year 2018; a new territorial bottomfish assessment is scheduled to be completed in the first half of 2019.

Table 23. American Samoa 2018 ACL table with three-year recent average catch (lbs.)

Fishery	MUS	OFL	ABC	ACL	Catch
Bottomfish	Bottomfish multi-species complex	N.A.	106,000	106,000	16,544
Crustacean	Deepwater shrimp	N.A.	80,000	80,000	N.A.F.
	Spiny lobster	7,300	5,100	4,845	743
	Slipper lobster	N.A.	30	30	N.A.F.
	Kona crab	N.A.	3,200	3,200	N.A.F.
Precious Coral	Black coral	8,250	790	790	N.A.F.
	Precious coral in AS expl. area	N.A.	2,205	2,205	N.A.F.

The catch shown in Table 23 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. ACLs were not specified by NMFS for the 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 management unit species (50 CFR Part 665). "N.A.F." indicates no active fisheries to date. "N.D." indicates data unavailable at the time of publication or the species was not detected in the surveys.

1.13 BEST SCIENTIFIC INFORMATION AVAILABLE

1.13.1 Bottomfish fishery

1.13.1.1 Stock Assessment Benchmark

The benchmark stock assessment for the Territory Bottomfish Management Unit Species complex was developed and finalized by Moffitt et al. (2007). This benchmark utilized a Bayesian statistical framework to estimate parameters of a Schaefer model fit to a time series of annual CPUE statistics. The surplus production model included process error in biomass production dynamics and observation error in the CPUE data. This was an improvement to the previous approach of using index-based proxies for B_{MSY} and F_{MSY}. Best available information for the bottomfish stock assessment is as follows:

Input data: The CPUE and catch data used were from the Guam off-shore creel survey. The catch and CPUE were expanded on an annual level. CPUE was expressed in line-hours. The data was screened for trips that landed more than 50 percent BMUS species using the handline gear.

Model: State-space model with explicit process and observation error terms (Meyer and Millar, 1999).

Fishery independent source for biomass: point estimate of MSY from the Our Living Oceans Report (Humphreys and Moffitt 1999; NMFS 2009).

1.13.1.2 Stock Assessment Updates

Updates to the 2007 benchmark done in 2012 (Brodziak et al., 2012) and 2015 (Yau et al., 2015). These included a two-year stock projection table used for selecting the level of risk the fishery will be managed under ACLs. Yau et al. (2015) is considered the best scientific information available for the Territory bottomfish MUS complex after undergoing a WPSAR Tier 3 panel review (Franklin 2016). This was the basis for the P* analysis and SEEM analysis that determined the risk levels to specify ABCs and ACLs.

1.13.1.3 Other Information Available

Approximately every five years PIFSC administers a socioeconomic survey to small boat fishermen in American Samoa. 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.

1.13.2 Coral reef fishery

1.13.2.1 Stock Assessment Benchmark

No stock assessment has been generated for the coral reef fisheries. The SDCs using index-based proxies were tested for its applicability in the different MUS in the coral reef fisheries (Hawhee 2007). This analysis was done on a gear level. It paints a dire situation for the shore-based fishery with 43% of the gear/species combination falling below B_{flag} and 33% below MSST with most catch and CPUE trends showing a decline over time. The off-shore fisheries were shown to be less dire with 50% of the gear/species combination falling below B_{flag} and 38% below MSST but the catch and CPUE trends were increasing over time. The inconsistency in the CPUE and catch trends with the SDC results makes this type of assessment to be unreliable.

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). This model was based on the original Martell and Froese (2013) 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 inshore and off-shore creel surveys. Commercial receipt book information was also used in combination of the creel data. A downward adjustment was done to address for potential overlap due to double reporting.

Model: Biomass Augmented Catch MSY approach based on the original catch-MSY model (Martell and Froese 2013; Sabater and Kleiber 2014).

Fishery independent source for biomass: biomass density from the Rapid Assessment and Monitoring Program of NMFS-CRED 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.

1.13.2.2 Stock Assessment Updates

No updates available for the coral reef MUS complex. However, NMFS-PIFSC is finalizing a length-based model for estimating sustainable yield levels and various biological reference points (Nadon et al., 2015). This can be used on a species level. The Council is also working with a contractor to enhance the BAC-MSY model to incorporate catch, biomass, CPUE, effort, length-based information in an integrated framework (Martell 2015).

1.13.2.3 Other Information Available

Approximately every five years PIFSC administers a socioeconomic survey to small boat fishermen in American Samoa. 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.

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. The criteria developed from this workshop had been applied to American Samoa. Scoring was conducted with representatives from American Samoa. This was the basis for the SEEM analysis that determined the risk levels to specify ACLs.

1.14 HARVEST CAPACITY AND EXTENT

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

- 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). in 2018.

Table 24 summarizes the harvest extent and harvest capacity information for American Samoa in 2018.

Table 24. The 2018 proportion of harvest extent and harvest capacity for insular fisheries in American Samoa

Fishery	MUS	ACL	Catch	Harvest extent (%)	Harvest capacity (%)
Bottomfish	Bottomfish multi-species complex	106,000	16,544	15.6	84.4
Crustacean	Deepwater shrimp	80,000	N.A.F.	0.0	100.0
	Spiny lobster	4,845	743	15.3	84.7
	Slipper lobster	30	N.A.F.	0.0	100.0
	Kona crab	3,200	N.A.F.	0.0	100.0

1.15 ADMINISTRATIVE AND REGULATORY ACTIONS

NMFS implemented two management actions related to the American Samoa FEP after the April 2018 Joint FEP Plan Team meeting. NMFS published the following harvest specifications, as described below:

June 14, 2018. Final rule. 5-Year Extension of Moratorium on Harvest of Gold Corals. This final rule extends the region-wide moratorium on the harvest of gold corals in the U.S. Pacific Islands through June 30, 2023. NOAA Fisheries intends this final rule to prevent overfishing and to stimulate research on gold corals.

August 22, 2018. NOAA Fisheries announces approval of a marine conservation plan (MCP) for American Samoa, effective from July 25, 2018, through July 24, 2021. MCPs identify priority conservation and management projects using funds from the Western Pacific Sustainable Fisheries Fund.

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

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2 ECOSYSTEM CONSIDERATIONS

2.1 CORAL REEF FISH ECOSYSTEM PARAMETERS

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 between 2010 and 2018.

Rationale: Reef fish biomass has been widely used as an indicator of relative ecosystem status, and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime.

Data Category: Fishery-independent

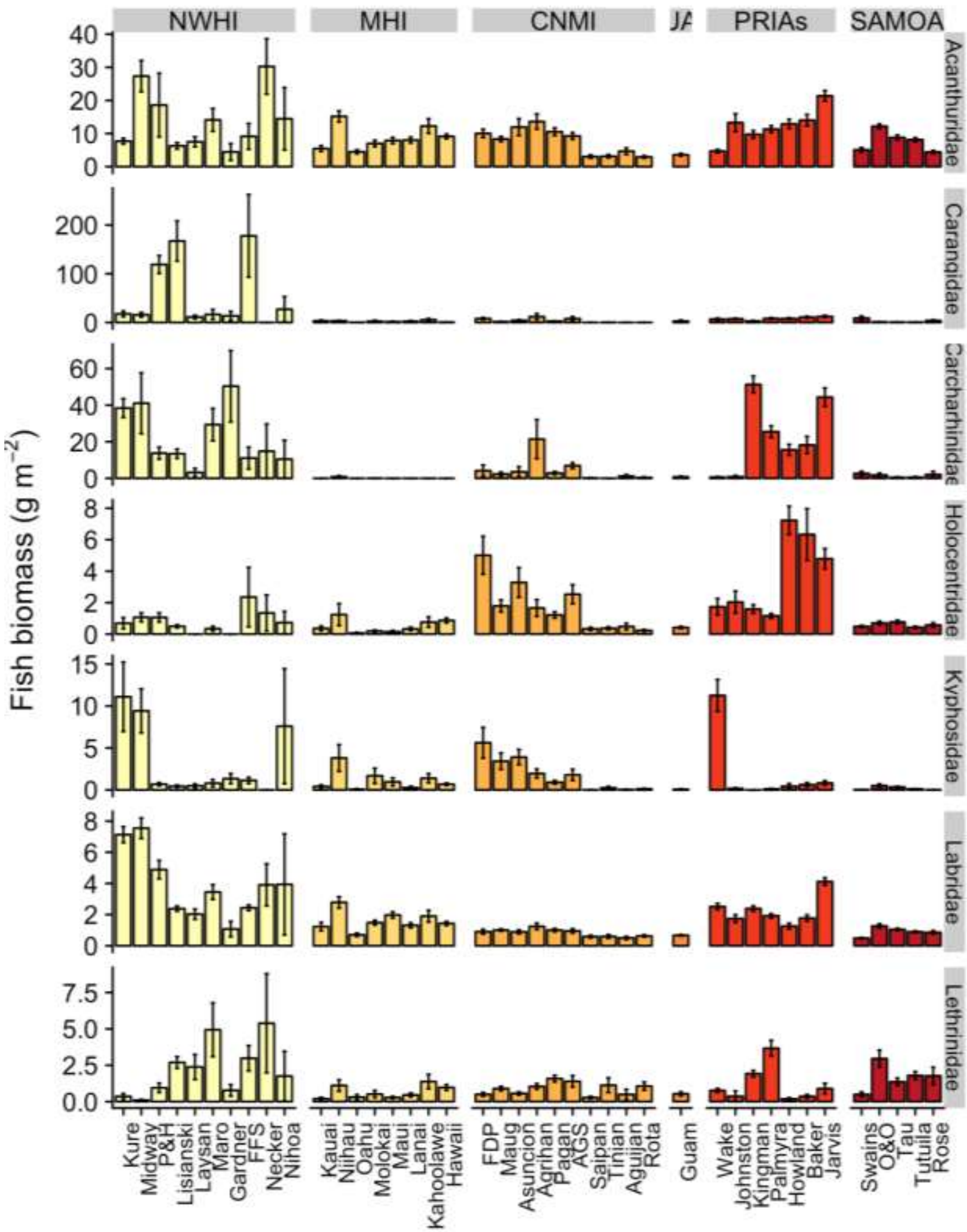
Timeframe: Triennial

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

Spatial Scale: Regional

Data Source: Data used to generate biomass estimates come from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and their partners as part of the Pacific Reef Assessment and Monitoring Program (RAMP; http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods are described in detail at http://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_15-07.pdf. In brief, they involve teams of divers conducting stationary point count cylinder (SPC) surveys within a target domain of < 30 meter hard-bottom habitat at each island, stratified by depth zone and, for larger islands, by section of coastline. For consistency among islands, only data from forereef habitats are used. At each SPC, divers record the number, size, and species of all fishes within or passing through paired 15 meter-diameter cylinders over the course of a standard count procedure.

Fish sizes and abundance are converted to biomass using standard length-to-weight conversion parameters, taken largely from FishBase (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.



NWHI
MHI
CNMI
JA
PRIAs
SAMOA
Acanthuridae
Carangidae
Carcharhinidae
Holocentridae
Kyphosidae
Labridae
Lethrinidae
Fish biomass (g m^{-2})
Kure
Midway
P&H
Lisianski
Laysan
Maro
Gardner
FFS
Necker
Nihoa
Kauai
Niihau
Oahu
Molokai
Maui
Lanai
Kahoolawe
Hawaii
FDP
Maug
Asuncion
Agrihan
Pagan
AGS
Saipan
Tinian
Aguijan
Rota
Guam
Wake
Johnston
Kingman
Palmyra
Howland
Baker
Jarvis
Swains
O&O
Tau
Tutuila
Rose

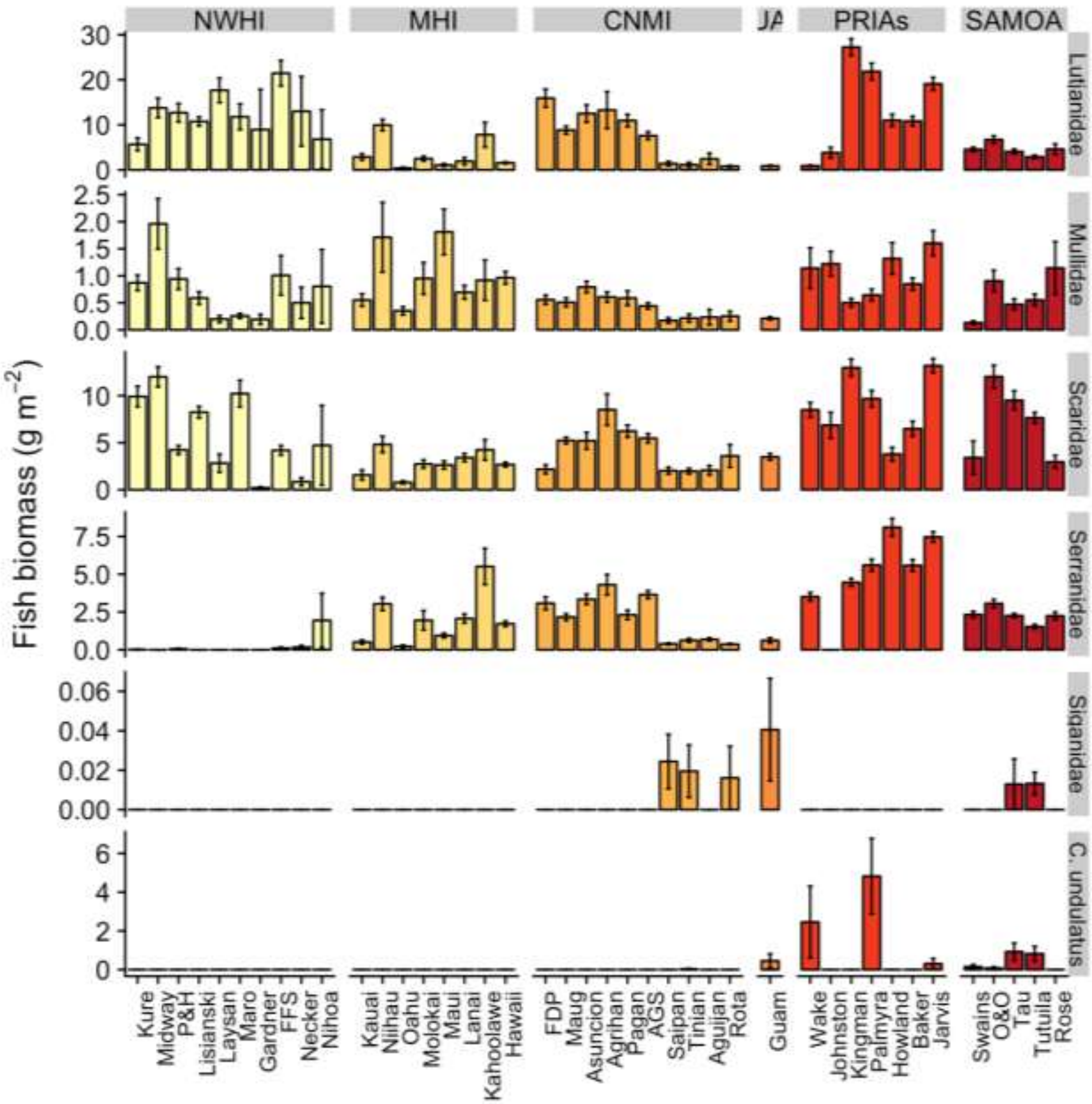


Figure 1. Mean fish biomass (g/m^2 ± standard error) of CREMUS grouped by U.S. Pacific reef area from the years 2010-2018 by latitude; figure continued from previous page

2.1.2 Archipelagic Reef Fish Biomass

Description: 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2018.

Rationale: Reef fish biomass has been widely used as an indicator of relative ecosystem status, and has repeatedly been shown to be sensitive to changes in fishing pressure, habitat quality, and oceanographic regime.

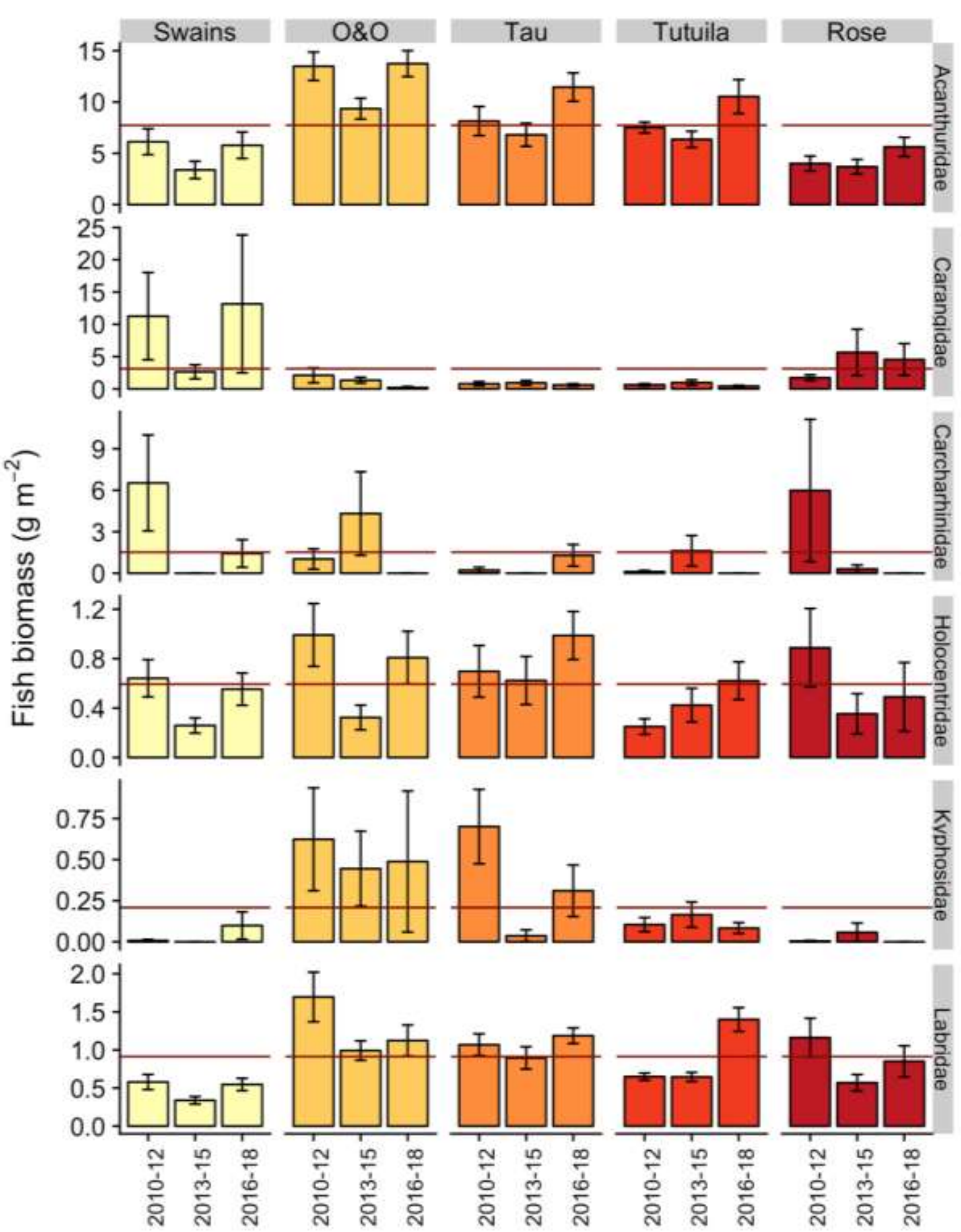
Data Category: Fishery-independent

Timeframe: Triennial

Jurisdiction: American Samoa

Spatial Scale: Island

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. Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2.1.1).


Swains
O&O
Tau
Tutuila
Rose
Acanthuridae
Carangidae
Carcharhinidae
Holocentridae
Kyphosidae
Labridae
Fish biomass (g m⁻²)
2010-12
2013-15
2016-18

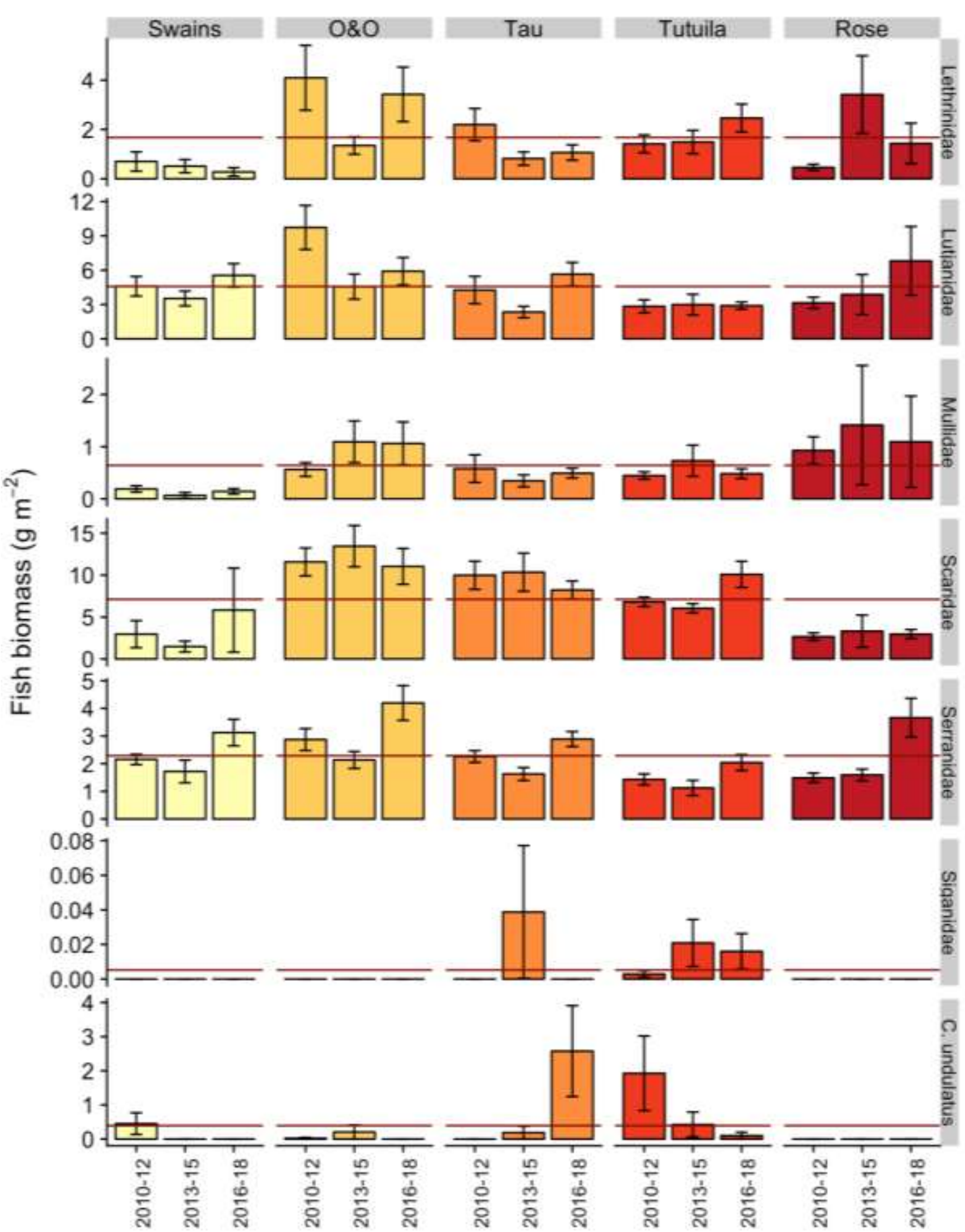


Figure 2. Mean fish biomass (g/m^2 ± standard error) of American Samoa CREMUS from 2010-2018 with American Samoa archipelago mean estimates plotted for reference (red line); figure continued from previous page

2.1.3 Archipelagic Mean 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 between 2010 and 2018.

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.

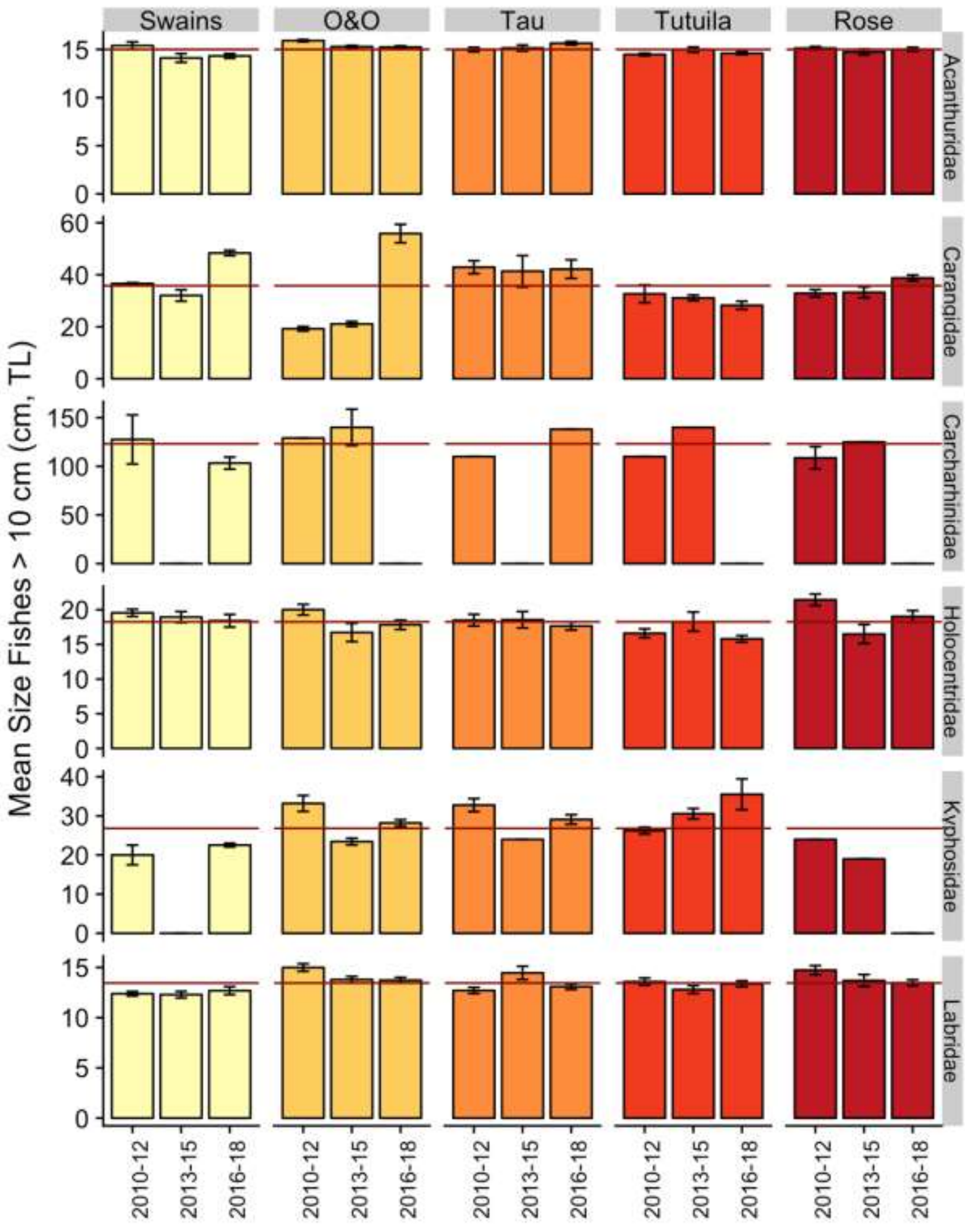
Category: Fishery-independent

Timeframe: Triennial

Jurisdiction: American Samoa

Spatial Scale: Island

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. 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.


Swains
O&O
Tau
Tutuila
Rose
Acanthuridae
Carangidae
Carcharhinidae
Holocentridae
Kyphosidae
Labridae
Mean Size Fishes > 10 cm (cm, TL)
2010-12
2013-15
2016-18

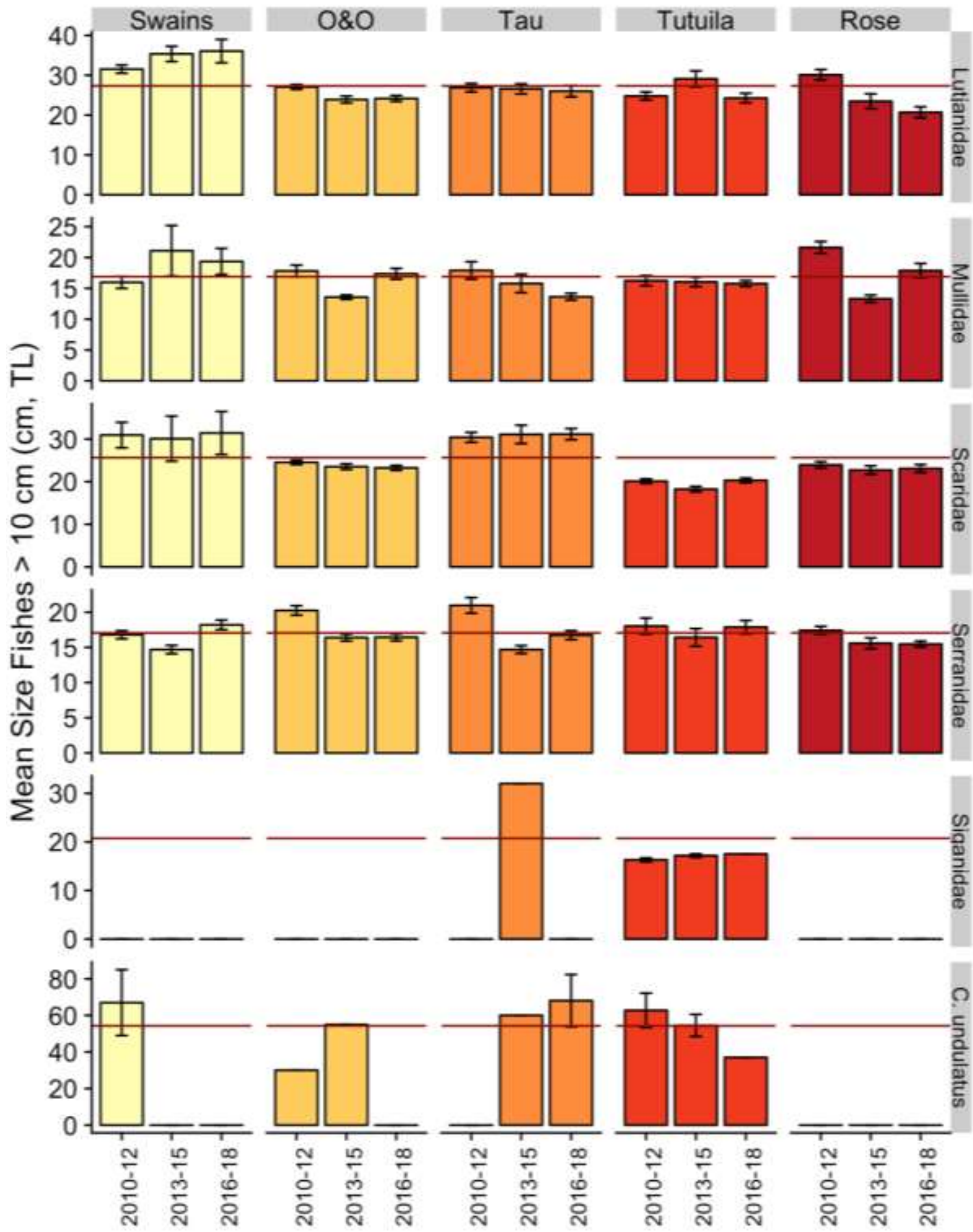


Figure 3. Mean fish size (cm, TL ± standard error) of American Samoa CREMUS from the years 2010-2018, with American Samoa archipelago mean estimates plotted for reference (red line); figure continued from previous page

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 hard bottom forereef habitat in < 30 meters of water).

Rationale: Reef fish population estimate data have utility in understanding the size of populations from which fishery harvests are extracted.

Category: Fishery-independent

Timeframe: Triennial

Jurisdiction: American Samoa

Spatial Scale: Island

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 hard bottom 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 those surveyed by the program, while some taxa likely require the majority of their populations to reside in deeper water than is surveyed. 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.

Table 25. Reef fish population estimates for American Samoa CREMUS over hard bottom habitat of 0 – 30 meters depth

0	Total area of reef (Ha)	*N*	Estimated population biomass (metric tons) in survey domain of < 30 m hard bottom					
			Acanthuridae	Carangidae	Carcharhinids	Holocentridae	Kyphosidae	Labridae
Swains	281	124	14.3	25.3	7.4	1.4	0.1	1.4
Ofu and Olosega	793	148	96.7	9.7	14.1	5.6	4.1	10.1
Tau	904	169	79.5	7.1	4.6	7.0	3.2	9.5
Tutuila	4,379	529	356.1	29.9	25.3	18.9	5.2	39.3
Rose	396	196	17.6	15.7	8.3	2.3	0.1	3.4
South Bank	25	2	0.3	0.9	-	0.0	-	0.0

TOTAL	6,688	1168	560.0	86.9	60.0	34.9	12.6	63.0
Island	**Total area of reef (Ha)**	***N***	**Lethrinidae**	**Lutjanidae**	**Mullidae**	**Scaridae**	**Serranidae**	**Siganidae**
Swains	281	124	1.4	12.8	0.4	9.6	6.5	-
Ofu and Olosega	793	148	23.4	53.5	7.2	95.4	24.3	-
Tau	904	169	12.3	36.9	4.3	86.0	20.4	0.1
Tutuila	4,379	529	78.3	127.5	24.2	334.9	67.0	0.6
Rose	396	196	7.0	18.3	4.5	11.8	8.9	-
South Bank	25	2	0.1	-	-	-	-	-
TOTAL	**6,688**	**1168**	**121.5**	**246.6**	**40.2**	**532.7**	**125.9**	**0.7**

Notes: (1) *N* is the number of sites surveyed
(2) No *Bolbometopon muricatum* were recorded during American Samoa surveys.
(3) *Cheilinus undulatus* were observed at Swains (1.0 t), Ofu and Olosega (0.7 t), Tau (0.5t), and Tutuila (64.2 t).

2.1.5 References

Smith, S.G., Ault, J.S., Bohnsack, J.A., Harper, D.E., Luo, J., and D.B. McClellan., 2011. Multispecies urvey design for assessing reef-fish stocks, spatially explicit management performance, and ecosystem condition. *Fisheries Research*, *109*(1), pp. 29-41.

2.2 LIFE HISTORY INFORMATION AND LENGTH-DERIVED VARIABLES

The Annual SAFE Report will serve as the repository of available life history information for the Western Pacific region. Life history data particularly age, growth, reproduction and mortality information inform the stock assessment on fish productivity and population dynamics. Some assessments particularly for data poor stocks like coral reefs utilize information from other areas that introduces errors and uncertainties in the population estimates. An archipelago specific life history parameter ensures accuracy in the input parameters used in the assessment.

The NMFS Bio-Sampling Program allows for significant collection of life history samples like otoliths and gonads from priority species in the bottomfish and coral reef fisheries. A significant number of samples are also collected during research cruises. These life history samples, once processed and data extracted, will contribute to the body of scientific information for the two data-poor fisheries in the region. The life history information available from the region will be monitored by the Fishery Ecosystem Plan Team and will be tracked through this section of the report.

This section will be divided into two fisheries: 1) coral reef; and 2) bottomfish. Within each fishery, the available life history information will be described under the age, growth, and reproductive maturity section. The section labelled fish length derived parameters summarizes available information derived from sampling the fish catch or the market. Monitoring length information provides insight on the state of the fish stock where the change in length can be used as an indicator of population level mortality. Length-weight conversion coefficients provide area-specific values to convert length from fishery-dependent and fishery-independent data collection to weight or biomass.

2.2.1 Coral 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 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, 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 for the data based on statistical analyses. The mid-point of the fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region), such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes, standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three- or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and 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 and 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 (i.e., one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Data Category: Biological

Timeframe: N/A

Jurisdiction: American Samoa

Spatial Scale: Archipelagic

Data Source: Sources of data are directly derived from research cruises sampling and market samples collected by the American Samoa contracted bio-sampling team which samples the catch of fishermen and 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 26 for specific details on data sources by species.

Parameter Definitions:

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

L_{∞} (asymptotic length) – One of three coefficients of the 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. Units are centimeters.

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

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

***M* (natural mortality)** – 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. Units are years.

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

L_{50} (length at which 50% of a fish 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 and growth. Units are centimeters.

$L\Delta_{50}$ (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 and growth. Units are centimeters.

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. Currently, the assessment of coral reef fish resources in American Samoa 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 26. Available age, growth, and reproductive maturity information for coral reef species targeted for otolith and gonad sampling in American Samoa

Species	Age, growth, reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Lethrinus xanthochilus	19[d]	39.6 (f), 40.5 (m)[d]	0.67 (f), 0.63 (m)[d]	-0.12 (f), -0.12 (m)[d]	0.22 [d]	2.1 (f)[d]		30.0 (f)[d]		Taylor et al. (2018)
Lutjanus gibbus	27[d]	28.9 (f), 38.8 (m)[d]	0.66 (f), 0.32 (m)[d]	-0.29 (f), -0.29 (m)[d]	0.15 [d]	3.2 (f)[d]		24.9 (f)[d]		Taylor et al. (2018)
Lutjanus rufolineatus	12 [d]	21.8 (f) 23.3 (m)[d]	0.86 (f) 0.80 (m)[d]	-0.20 (f), -0.20 (m)[d]	0.35 [d]	16.4 (f)[d]				Taylor et al. (2018)
Myripristis amaena							NA		NA	
Myripristis berndti							NA	166[b]	NA	
Myripristis murdjan							NA		NA	
Naso unicornis							NA		NA	
Sargocentron caudimaculatum							NA		NA	
Sargocentron spiniferum							NA		NA	
Sargocentron tiere							NA	150[b]	NA	
Scarus rubrovioaceus	14[d]	40.6 (f), 47.8	0.63 (f), 0.50	-0.06 (f), - 0.06		2.6 (f) [d]		31.9 (f)[d]	42.3[d]	Taylor and Pardee (2017)

		(m)[d]	(m)[d]	(m)[d]						

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

Parameter estimates are for females unless otherwise noted (F=females, M=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in years; L_∞, L_{50}, and $L\Delta_{50}$ are in mm fork length (FL); k is in units of year^{-1}; X means the parameter estimate is too preliminary and Y means the published age and growth parameter estimates are based on DGI numerical integration technique and likely to be inaccurate. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are shown in "Reference" column.

2.2.1.2 Fish Length Derived Parameters

Description: The NMFS Commercial Fishery Bio-Sampling Program started in 2009. This program has two components: first is the Field/Market Sampling Program and the second is the Life History Program, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program are:

- Broad scale look at commercial landings (by fisher/trip, gear, and area fished);
- Length and weight frequencies of whole commercial landings per fisher-trip (with an effort to also sample landings not sold commercially);
- Accurate species identification; and
- Develop accurate local length-weight curves.

In American Samoa, the Bio-Sampling is focused on the commercial coral reef spear fishery with occasional sampling of the bottomfish fishery occurring locally and less frequently at the northern islands. Sampling is conducted in partnership with the fish vendors. The Market Sampling information includes (but not limited to): 1) fish length; 2) fish weight; 3) species identification; and 4) basic effort information.

Data Category: Biological

Timeframe: N/A

Jurisdiction: American Samoa

Spatial Scale: Archipelagic

Data Source: NMFS Bio-Sampling Program

Parameter Definitions:

L_{max}* – *maximum fish length is the longest fish per species recorded in the Bio-Sampling Program from the commercial spear fishery. This value is derived from measuring the fork length of individual samples for species occurring in the spear fishery. Units are centimeters.

***L_{bar}* – mean length** is the average value of all lengths recorded from the commercial spear fishery. This can be influenced by gear selectivity since the commercial spear fishery has a typical-size target based on customer demand. This can also be influenced by size regulations. Units are centimeters.

***n* – sample size** is the total number of samples accumulated for each species recorded in the commercial spear fishery.

***N_{L-W}* – sample size for L-W regression** is the number of samples used to generate the *a* and *b* coefficients.

***a* and *b* – length-weight coefficients** are the coefficients derived from the regression line fitted to all length and weight measured per species in the commercial spear fishery. These values are used to convert length information to weight. Values are influenced by the life history characteristics of the species, geographic location, population status, and nature of the fisheries from which the species are harvested.

Rationale: Length-derived information is being used as an indicator of population status particularly for data-poor stocks like coral reef fish. Average length (L_{bar}) was used as a principal stock assessment indicator variable for exploited reef fish population (Nadon et al., 2015). Average length was also shown to be correlated with population size (Kerr and Dickle, 2001). Maximum length (L_{max}), typically coupled with maximum age, is typically used as a proxy for fish longevity which has implications on the productivity and susceptibility of a species to fishing pressure. The length-weight coefficients (*a* and *b* values) are used to convert length to weight for fishery-dependent and fishery-independent data collection where length are typically recorded but weight is the factor being used for management. This section of the report presents the best available information for the length-derived variables for the CNMI coral reef and bottomfish fisheries.

Table 27. Available length-derived information for coral reef species in American Samoa

Species	Length-derived parameters						Reference
	L_{max}	L_{bar}	*n*	*L-W*	*a*	*b*	
Acanthurus lineatus	24.5	18.8	1,955	0.87	0.068	2.68	
Ctenochaetus striatus	25.2	18.0	424	0.87	0.043	2.83	
Naso lituratus	47.4	22.2	8,752	0.93	0.022	3.02	
Sargocentron tiere	25.0	18.0	3,002	0.85	0.069	2.62	
Chlorurus japanensis	46.2	26.4	6,852	0.97	0.018	3.07	
Naso unicornis	55.0	32.3	5,042	0.99	0.033	2.85	
Scarus rubroviolaceus	54	34.9	4,556	0.99	0.012	3.17	
Panulirus penicillatus	15.8	9.1	3,365	0.94	2.614	2.41	
Scaru oviceps	44.5	23.6	3,987	0.97	0.013	3.17	
Myripristis berndti	27.2	17.8	4,228	0.89	0.100	2.53	
Acanthurus nigricans	36.0	16.9	3,003	0.79	0.171	2.42	
Lutjanus gibbus	56.8	30.9	2,291	0.96	0.04	2.8	
Lethrinus xanthochilus	54.5	36.8	2,186	0.97	0.028	2.85	
Epinephelus melanostigma	54.9	26.5	2,653	0.95	0.012	3.10	

Species	Length-derived parameters						Reference
	L_{max}	L_{bar}	*n*	*L-W*	*a*	*b*	
Myripristis amaena	22.5	16.9	2,849	0.82	0.149	2.39	
Acanthurus guttatus	24.5	16.8	1,872	0.87	0.084	2.69	
Panulirus sp.	15.3	8.6	3,331	0.91	5.755	2.06	
Myripristis murdjan	27.5	17.0	1,707	0.84	0.72	1.83	
Scarus frenatus	44.5	26.9	1,777	0.98	0.014	3.14	
Selar crumenopthalmus	32.7	19.3	298	0.96	0.007	3.30	
Parupeneus bifasciatus	34.5	22.6	1,413	0.96	0.015	3.12	
Variola albimarginatus	43.6	27.0	965	0.89	0.122	2.42	
Scarus globiceps	33.9	23.5	1,258	0.95	0.02	3.03	

2.2.2 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 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. This technique provides age estimates independent of age estimates based on visual counts of annuli or DGIs. 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. The ^{14}C derived ages typically provide more accurate estimates of older ages (≥30 years) and hence more realistic values of T_{max} compared to annuli or DGI-based counts of otolith sections.

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 three- or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have undergone 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 and 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: Biological

Timeframe: N/A

Jurisdiction: American Samoa

Spatial Scale: Island

Data Source: Sources of data are directly derived from field samples collected at sea on NOAA research vessels and from the American Samoa contracted bio-sampling team which samples the catch of fishermen and 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 28 for specific details on data sources by species.

Parameter definitions: Identical to Section 2.2.1.1.

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 American Samoa 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 28. Available age, growth, and reproductive maturity information for bottomfish species targeted for otoliths and gonads sampling in American Samoa

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	X[a]	X[a]	X[a]	X[a]	X[a]		NA		NA	LHP (in prep)
Aprion virescens							NA		NA	
Etelis carbunculus							NA		NA	
Etelis coruscans							NA		NA	
Hyporthodus octofasciatus	72[d]	164.8 [d]	0.07 [d]	-0.39 [d]	01 .0 [d]					DiBattista et al. (2018)
Lethrinus amboinensis										
Lethrinus xanthochilus										
Lutjanus gibbus							NA		NA	
Pristipomoides auricilla							NA		NA	
Pristipomoides filamentosus							NA		NA	
Pristipomoides flavipinnis	X[c]	X[c]	X[c]	X[c]	X[c]		NA		NA	O'Malley et al. (in review)
Pristipomoides sieboldii							NA		NA	
Pristipomoides zonatus							NA		NA	

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

2.2.2.2 Fish Length Derived Parameters

Description: The NMFS Commercial Fishery BioSampling Program started in 2009. This program has two components: first is the Field/Market Sampling Program and the second is the Life History Program, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program are:

- Broad scale look at commercial landings (by fisher/trip, gear, and area fished);
- Length and weight frequencies of whole commercial landings per fisher-trip (with an effort to also sample landings not sold commercially);
- Accurate species identification; and
- Develop accurate local length-weight curves.

In American Samoa, the BioSampling is focused on the commercial coral reef spear fishery with occasional sampling of the bottomfish fishery occurring locally and less frequently at the northern islands. Sampling is conducted in partnership with the fish vendors. The Market

Sampling information includes (but not limited to): 1) fish length; 2) fish weight; 3) species identification; and 4) basic effort information.

Category: Biological

Timeframe: N/A

Jurisdiction: American Samoa

Spatial Scale: Archipelagic

Data Source: NMFS BioSampling Program

Parameter Definition: Identical to Section 2.2.1.2.

Rationale: Length-derived information is being used as an indicator of population status particularly for data-poor stocks like coral reef fish. Average length (L_{bar}) was used as a principal stock assessment indicator variable for exploited reef fish population (Nadon et al., 2015). Average length was also shown to be correlated with population size (Kerr and Dickle 2001). Maximum length (L_{max}), typically coupled with maximum age, is typically used as a proxy for fish longevity which has implications on the productivity and susceptibility of a species to fishing pressure. The length-weight coefficients (*a* and *b* values) are used to convert length to weight for fishery dependent and fishery independent data collection where length are typically recorded but weight is the factor being used for management. This section of the report presents the best available information for the length-derived variables for the CNMI coral reef and bottomfish fisheries.

Table 29. Available length-derived information for two bottomfish in American Samoa

Species	Length derived parameters						Reference
	L_{max}	L_{bar}	*n*	*L-W*	*a*	*b*	
Lutjanus kasmira	35.0	22.3	459	0.92	0.017	3.02	
Lethrinus rubrioperculatus	57	27.3	2,348	0.97	0.029	2.86	

2.2.2.3 References

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Kerr, S.R. and L.M. Dickie, 2001. *The biomass spectrum: a predator-prey theory of aquatic production*. New York: Columbia University Press.

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Taylor B.M., Oyafuso Z.S., Pardee C.B., Ochavillo D., and S.J. Newman. 2018. Comparative demography of commercially-harvested snappers and an emperor from American Samoa. *PeerJ*, *6*, e5069. http://dx.doi.org/10.7717/peerj.5069.

Taylor, B.M. and C.B. Pardee, 2017. Growth and maturation of the redlip parrotfish *Scarus rubroviolaceus*. *Journal of Fish Biology*. https://doi.org/10.1111/jfb.13309.

2.3 SOCIOECONOMICS

This section outlines the pertinent economic, social, and community information available for assessing the successes and impacts of management measures and the achievements of the Fishery Ecosystem Plan (FEP) for the Pacific Remote Island Area (PRIA; Western Pacific Regional Fishery Management Council, 2016). It meets the objective of "Support Fishing Communities" adopted at the 165th Council meeting; specifically, it identifies the various social and economic groups within the regions' 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 the PRIA.

In 1996, the Magnuson-Stevens Fishery Conservation and Management Act's National Standard 8 (NS8) specified that conservation and management measures nee to account for the importance of fishery resources in fishing communities, to support sustained participation in the fisheries, and to minimize adverse economic impacts, provided that these considerations do not compromise conservation. Unlike other regions of the U.S., the settlement of the Western Pacific region was intimately tied to the ocean, which is reflected in local culture, customs, and traditions (Figure 4).

Figure 4. 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 have a similar reliance on marine resources. Thus, fishing and seafood are integral to local community ways of life. This is reflected in the amount of seafood eaten in the region relative to the rest of the United States, as well as in the language, customs, ceremonies, and community events. The amount of available seafood can also affect seasonality in prices of fish. Because fishing is such an integral part of the culture, it is difficult to discern commercial from non-commercial fishing where most trips involving multiple motivations and multiple uses of the fish caught. While the economic perspective is an important consideration, fishermen report other motivations, such as customary exchange, as being equally important. Due to changing economies and westernization, waning 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 173rd meeting held in Wailea, HI, the Council recommended PIFSC conduct an economic cost-benefit analysis on the use of large circle hooks in the American Samoa longline fishery. PIFSC staff prepared and delivered an internal report in October 2018 (Raynor, 2018). During the 174th Council meeting, PIFSC staff reviewed the feasibility assessment with Council staff and Council members. It was determined that no immediate next steps would be taken.

2.3.2 Introduction

Fishing has played a crucial role in American Samoan culture and society since the Samoan archipelago was settled. An overview of American Samoa history, culture, geography, and relationship with the U.S. is described in Section 1.3 of the Fishery Ecosystem Plan for American Samoa (Western Pacific Regional Fishery Management Council, 2016a). Over the past decade, a number of studies have synthesized details about the role of fishing and marine resources in American Samoa, as well as information about the people who engage in the fisheries or use fishery resources (e.g. Armstrong, et al., 2011; Grace-McCaskey, 2015; Kleiber and Leong, 2018; Levine and Allen, 2009; Richmond and Levine, 2012). These studies describe the importance of marine resources in cultural, economics, and subsistence aspects of American Samoan village life. Fishing was held in high esteem in traditional Samoan culture, with fishing skill bringing high social status and fishing activities figuring prominently in mythology. The basic components of Samoan social structure are the family and village, with the family acting as the central unit. The village leadership decides, according to season, what sort of community fishing should take place. The tautai, or master fishermen, of the village were key decision makers who were awarded higher status than others who might otherwise outrank him when it came to matters of fishing. Village-level systems of governance and resource tenure are still largely intact, and American Samoan cultural systems and representation are formally incorporated into the territorial government. Reciprocity is emphasized over individual accumulation. Gifts of food, especially fish and other marine resources, mark every occasion and are a pivotal part of American Samoan social structure to this day.

Recent studies have found that American Samoa is homogeneous both ethnically and culturally (Levine et al., 2016; Richmond and Levine, 2012). Polynesians account for the vast majority of the territory's people (93%), and the primary language spoken at home is Samoan (91%) though

English is often spoken in school and business settings. Contemporary American Samoan culture is characterized by a combination of traditional Samoan values and systems of social organization with a strong influence from Christianity. Maintaining "*fa'a samoa*", or "the Samoan way", was considered a priority under the territorial constitution. Given the cultural homogeneity, nearly everyone in American Samoa accepts and complies with Samoan traditions of land and resource tenure.

However, over the last half century or so, fishing has become less prominent as a central and organized community force. During this time, modern fishing gears and technologies were introduced, tuna canneries became a major economic force in Pago Pago, the population more than tripled, and the gradual but continuous introduction of Western cultural norms and practices altered American Samoans' relationship with the sea. While many traditions and village-based systems of governance have been maintained, the islands have experienced a shift from a subsistence-oriented economy, where sharing of fish catch was extremely important, to a cash-based economy, where fishing is often viewed as a more commercial venture.

A recent study by Levine et al. (2016) found that American Samoans still consume seafood frequently, with 78% of respondents stating that they eat fish or seafood once a week or more. Most American Samoans purchase seafood from stores or restaurants, with 65% of survey respondents listing these sellers as their first or second choice for obtaining seafood. Other common means for obtaining fish include markets and roadside vendors (45%) and fish caught by household members (37%). These results corroborate Levine and Allen's (2009) observation that American Samoans largely rely on, and in many cases prefer, store-bought food to locally caught fish, with the majority of fish consumed in American Samoa imported from neighboring Samoa.

The introduction of outboard engines and other technology in the 1950s and 1960s allowed American Samoan boats to go farther and faster, but also made it necessary for boat owners and operators to sell a portion of their catch to pay for fuel and engine maintenance. The disruption of other traditional values, as well as the introduction of a cash economy based primarily on government jobs and cannery employment, also decreased reliance on traditional, subsistence fishing; this allowed commercial fishing to develop on the islands (Levine and Allen, 2009).

Unlike other areas of the Western Pacific region, American Samoa also experienced the development of domestic industrial-scale fisheries, including tuna processing, transshipment, and home port industries. These domestic industrial fisheries came about due to the harbor at Pago Pago, 390,000 km^2 of EEZ, and certain special provisions of U.S. law, which allowed the development of American Samoa's decades-old fish processing industry. For example, the territory is exempt from the Nicholson Act, which prohibits foreign ships from landing their catch in U.S. ports, and American Samoan products with less than 50% market value from foreign sources enter the U.S. duty-free.

The two most important economic sectors are the American Samoa Government (ASG), which receives income and capital subsidies from the federal government, and tuna canning. According to the Statistical Yearbook, main imports include fish brought in for processing (American Samoa Government, 2018). Exports are primarily canned tuna and by-products, including fish meal and pet food. In 2017, domestic exports (including re-exports) from American Samoa were valued at $309,221,000, of which $307,732,000 (over 99%) came from canned tuna sale (American Samoa Government, 2018). Private business and commerce comprise a third sector. Unlike some of their neighbors in the South Pacific, American Samoa has never been known for having a robust tourist industry.

In 2017, the ASG employed 5,849 people accounting for 36% of the total workforce in the territory (American Samoa Government, 2018), and the private sector employed 8,247 people (Figure 5). The canneries employed 2,312 people, accounting 14% of the workforce. Ancillary businesses involved in re-provisioning the fishing fleet also generated a notable number of jobs and income for local residents.

The canneries in American Samoa have been operating since 1954, represent the largest private-sector source of employment in the region, and, until recently, were the principle industry in the territory. Although as many as 90% of cannery workers are not American Samoa citizens, the canneries play a large role in the American Samoa economy (e.g. delivering goods or services to tuna processors, and improving buying patterns of cannery workers). Trends in world trade, specifically reductions in tariffs, have been reducing the competitive advantage of American Samoa's duty-free access to the U.S. canned tuna market, and the viability of the canneries has been in question for nearly the past decade. In 2009, the Chicken of the Sea cannery closed, resulting in a loss of approximately 2,000 jobs. It was bought by Tri Marine International, which invested $70 million in rebuilding and expansion, and reopened in 2015. In October 2016, Sunkist Co. suspended operations due to lack of fish, in part due to Effort Limit Area for Purse Seine (ELAPS) closures (Pacific Islands Report, 2016). That same month, Tri Marine International announced that it would suspend production indefinitely in December 2016 (Honolulu Star Advertiser, 2016), and there are currently no plans to reopen (Pacific Islands Report, 2017). Tuna cannery closures in American Samoa are likely to have significant impacts on the American Samoa economy and communities, although the specific effects are still unknown.

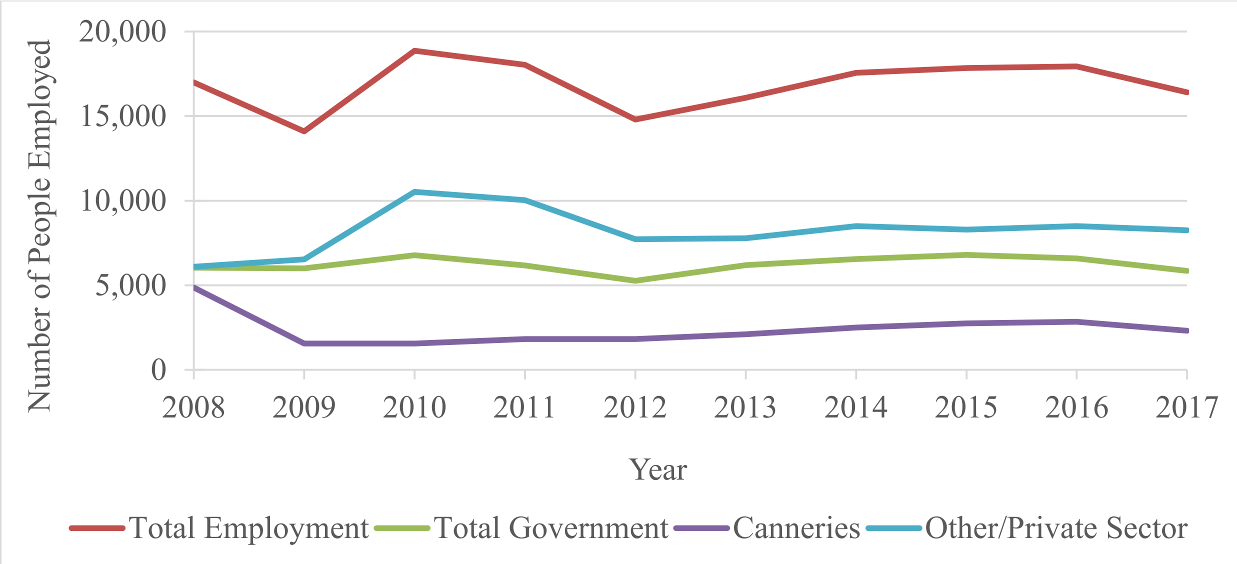

Figure 5. American Samoa Employment Estimates from 2008-2017; sourced from the American Samoa Statistical Yearbook 2017, American Samoa Government (2018)

Table 30. Supporting data for Figure 5.

Labor force status	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total Employment	16,990	14,108	18,862	18,028	14,806	16,089	17,565	17,853	17,930	16,408
Total Government	6,035	6,004	6,782	6,177	5,258	6,198	6,556	6,804	6,585	5,849
Canneries	4,861	1,562	1,553	1,815	1,827	2,108	2,500	2,759	2,843	2,312
Other/Private Sector	6,094	6,542	10,527	10,036	7,721	7,783	8,509	8,290	8,502	8,247

Even before Tri Marine International's closure, American Samoa's economy was identified as being in a highly transitional state that should be monitored closely (Grace McCaskey, 2015). It will be important to monitor any changes and developments related to the tuna industry, given the historically close connection between the tuna canneries, employment levels, population trends, and the economic welfare of the territory. It is also possible that increased federal aid in recent years has obfuscated the full extent of the economic recession.

Members of the American Samoa fishing community have also expressed concerns about the impact of National Marine Sanctuary of American Samoa (NMSAS) expansion as well as the management of fishing activities in the Rose Atoll Marine National Monument. In both of these cases, the local communities have been concerned about the impacts of regulation on fishing practices and broader social and cultural issues.

While pelagic fisheries play a larger role in the broader economy, insular fisheries are fundamentally important from a socio-cultural and dietary standpoint (Levine and Allen, 2009). Village leaders still have a significant degree of control over the nearshore waters, enforcing their own village rules and regulations despite the waning strength of many of these village-based management systems. The American Samoa Department of Marine and Wildlife Resources (DMWR) is the primary agency for fisheries management. The DMWR also monitors the status of nearshore fish and marine habitats through the collection of fishery independent data, however it has limited patrolling and enforcement capacity. In 2000, the DMWR initiated the Community-based Fisheries Management Program (CFMP) to assist villages in managing and conserving their inshore fishery resources through a voluntary scheme of co-management with the government. In general, villages manage their marine areas through establishment of village marine protected areas (MPAs) sometimes called VMPAs to distinguish this program from federal or territorial MPAs. Because VMPAs are managed by local communities that have a direct interest in their success, compliance with fishing bans is generally high, and most villages with MPAs actively enforce their own rules.

Richmond and Levine (2012) described the role of community-based marine resource management in American Samoa. Organized trips for specialized fishing are marked by considerable ceremony and tradition. While more frequent in the past, organized fishing efforts continue to take place in a few villages in American Samoa. Village-wide fish drives are timed with the tides and the spawning of certain species, and after these efforts, the fish are traditionally distributed to all village families who participated in the fishing.

In 2017, understanding the relationship of pelagic fisheries to cultural fishing practices typically associated with insular fisheries has taken on greater importance. During the peak of longline landings in 2002, the National Marine Fisheries Service (NMFS) created a Large Vessel Prohibited Area (LVPA) to prevent gear conflicts and catch competition between large and small vessels, and to preserve opportunities for fishing by American Samoa's small boat ("alia") fleet (NOAA, 2017). Since the creation of the LVPA in 2002, both large and small vessels have experienced declining catch rates, fish prices, and increasing fuel and operating costs. In 2016, NMFS published an exemption to the LVPA rule to allow large U.S. vessels holding a Federal American Samoa longline limited entry permit to fish in portions of the LVPA (NOAA, 2016). NMFS and the Western Pacific Regional Fisheries Management Council (WPRFMC) were then sued by the American Samoa government, who claimed that the 1900 and 1904 Deeds of Cession were not considered in the rulemaking process. The U.S. District Court ruled in favor of American Samoa in March 2017, requiring NMFS to preserve American Samoan cultural fishing practices as part of the obligations of the Deeds of Cession. A study examining dimensions of cultural fishing for the small and large longline fleets found that these fisheries play an important role in maintaining cultural practices, primarily through sharing of catch (Kleiber and Leong, 2018).

2.3.3 People Who Fish

Few studies have been conducted that include demographics or other information about people who fish in American Samoa. Information at the fishery level will be reported in the fishery specific sections below. Qualitative research has resulted in some general observations about trends in fishing by American Samoans.

One household survey by Levine et al. (2016) found that over half of residents participate in fishing or gathering of marine resources. Approximately 15% reported fishing once a week or more and over 30% of households stated that they engaged in fishing or gathering at least once a month. Commercial fishing is very uncommon in American Samoa, with only 3% of those who fish stated that they frequently did so to sell their catch and 62% never selling their catch. More commonly, people fish to feed themselves and their family or to give to extended friends, family, pastors, and village leaders.

While fishing and marine resources are universally considered to be important aspects of *fa'a samoa*, limited income has made American Samoans less inclined to engage in strenuous fishing activities when food imports are relatively more available (Levine and Allen, 2009). Only a small number of American Samoans engage in boat-based or commercial fishing. Although unemployment in the territory has increased, the percentage of individuals participating in subsistence activities (including fishing for food or home use) decreased between 2000 and 2013 (Grace McCaskey, 2015). However, a large number of island residents have been employed by the canneries in Pago Pago, which facilitated the availability of low-cost fish for many residents and ensured that the livelihood of American Samoans are still tightly tied to fishing activities.

As described in the FEP, American Samoans have been discouraged from working on foreign longline vessels delivering tuna to the canneries for a number of reasons, including harsh working conditions, low wages, and long fishing trips. While American Samoans prefer employment on the U.S. purse seine vessels, the capital-intensive nature of purse seine operations limits the number of job opportunities for locals in that sector.

Local fishermen have indicated an interest in participating in the more lucrative overseas markets for fresh fish. However, they are limited by inadequate shore-side ice and cold storage facilities, as well as infrequent and expensive air transportation.

As noted by Levine and Allen (2009), the trend of decreasing reliance on local fish as a food source is reflective of a society that has been undergoing a shift from a subsistence-oriented economy to a cash economy. Changes such as a decrease in leisure time, a shift in dietary preferences towards store-bought foods, a preference to buy fish at the market rather than expend effort in fishing, and an increased availability of inexpensive imported reef fish from Western Samoa and Tonga are also likely contributing to decreasing rates of subsistence fishing in the region (Richmond and Levine, 2012).

2.3.4 Bottomfish

Levine and Allen (2009) described the bottomfish fishery as part of their review of American Samoa as a fishing community. Prior to the arrival of Europeans in Samoa, the indigenous people had developed specialized techniques for catching bottomfish from outrigger canoes (paopao). Some of the bottomfish, such as trevally (malauli), held a particular social significance and were reserved for the matai chiefs.

In the early 1970s, the American Samoa Office of Economic Opportunity (OEO) funded the Dory Project, which provided easy credit and loans to fishermen to develop offshore fisheries. Records indicate that 70% of these dories were engaged in bottomfishing activities, conducted primarily at night on the shallow reef area around Tutuila. The result was an abrupt increase in the fishing fleet and total landings, but the limited nearshore bottomfish habitat meant that catch rates there declined rapidly and fishermen began to venture farther offshore to previously unexploited seamounts and banks to maintain profitable catch rates.

In the 1980s, dories were replaced by alia catamarans, larger, more powerful boats that could stay multiple days at sea. Alias primarily engaged in trolling and bottomfishing, and spearfishing, netting, and vertical longlining were used on occasion. Bottomfishing peaked between 1982 and 1988, with landings comprised as much as half of the total catch of the commercial fishery in American Samoa. In December 1980, a fish market opened in Fagatogo, which allowed fishermen to market their catch at a centralized, relatively sanitary location. Although the price for bottomfish rose between the 1970s and 1980s, it was still difficult for fishermen to make a profit from bottomfish sales due to competition with sales of inexpensive incidental catch from longline and purse seine vessels landing at the canneries.

Since 1988, there has been with a steady decrease in the importance of bottomfish fishing, as people converted to trolling and longlining for pelagic species, increasing fuel prices forced others out of the fishery, and imported fish from Western Samoa and Tonga became more available. Markrich and Hawkins (2016) noted that recently there have been fewer than 20 boats active in the bottomfish fishery. The demand for bottomfish varies depending on the need for fish at government and cultural events, though alia fishermen do return to bottomfish fishing during periods when longline catches or prices are low.

2.3.4.1 Commercial Participation, Landings, Revenues, and Prices

This section will describe trends in commercial pounds sold, revenues and prices, for the American Samoa bottomfish fishery. Figure 6 presents the trends of commercial pounds sold and revenues of bottomfish fishery (for BMUS only) during 2009-2019 and Figure 7 presents the trend of fish price of bottomfish sold during 2009-2018. Supporting data for Figure 6 and Figure 7are shown in Table 31. Table 31 also includes fish price and the % of pounds sold to the total pounds caught of the bottomfish fishery. In addition, the table also includes both nominal and adjusted values.

From, we may observe the trend for commercial landings (pounds sold) of the bottomfish fishery during the period of 2009-2018. The total pounds sold of bottomfish reported in 2018 were 1,016, only 8% of the estimated total Figure 6 landings. Revenue follows the similar pattern of the pounds sold. Bottomfish price was steady in most of the time period, but it went up substantially in 2017. The bottomfish price in 2018 was lower than 2017, but was higher than the other years.

Please notice that the data for pounds caught and pounds sold are collected by two different data collection methods. The data of pounds sold were collected through "Commercial Sales Receipt Books" Program (https://www.pifsc.noaa.gov/wpacfin/as/Pages/as_crform3.htm), while the data of pounds caught were collected through "Boat-based Creel Survey" and "Shore-based Creel Survey" (https://www.pifsc.noaa.gov/wpacfin/as/Pages/as_coll_5.php). Both data series are generated from an expansion algorithm built on a non-census data collection program respectively, and the survey coverage rates of two data collection methods may change independently in individual years. Therefore, the two time series may not move coherently to each other. For example, the low percentage of pounds sold compared to pounds caught could be due to the low coverage of dealer participations in the Commercial Receipt Books Program, or vice versa.

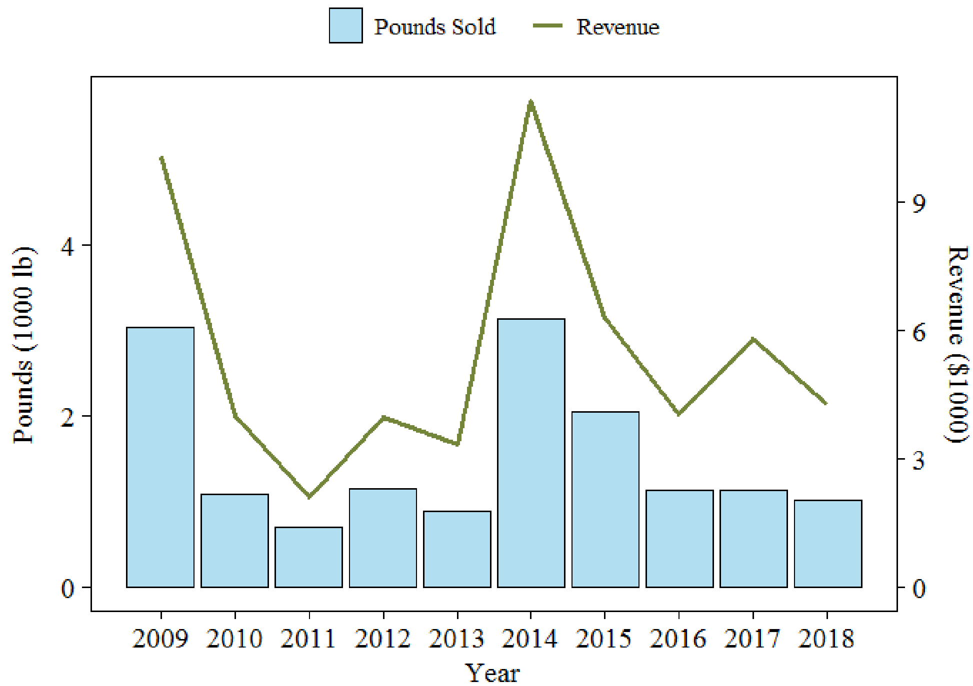

Figure 6. The pounds sold and revenues, for the American Samoa bottomfish fishery, 2009-2018 (adjusted to 2018 dollars).

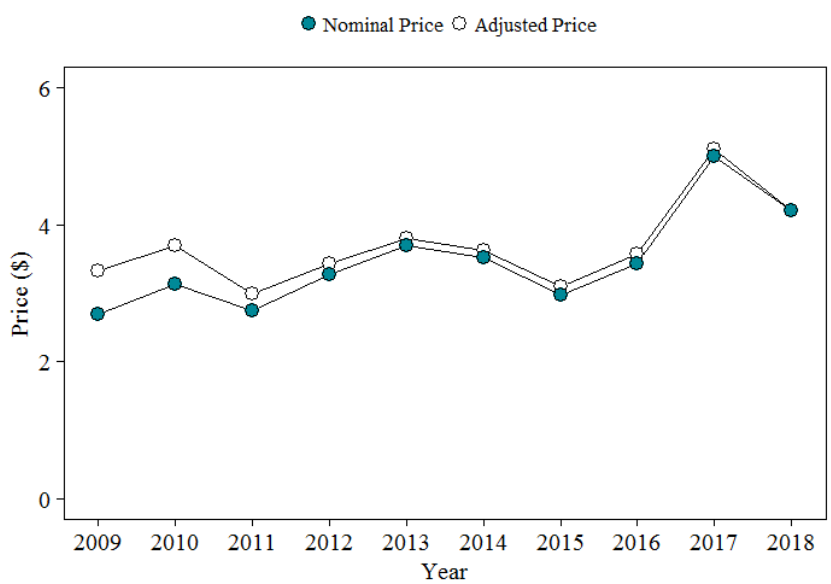

Figure 7. The prices of BMUS for the American Samoa bottomfish fishery, 2009-2018

Table 31. The Commercial landings and revenue from bottomfish fishery for American Samoa, 2009-2018

Year	Estimated pounds caught (lb)	Estimated pounds sold (lb)	Estimated revenue ($)	Estimated revenue ($ adjusted)	% of pounds sold	Fish price ($)	Fish price ($ adjusted)	CPI adjustor
2009	43,339	3,035	8,208	10,096	7%	2.70	3.33	1.23
2010	9,275	1,084	3,398	4,010	12%	3.13	3.70	1.18
2011	17,260	711	1,949	2,124	4%	2.74	2.99	1.09
2012	3,648	1,161	3,796	3,986	32%	3.27	3.43	1.05
2013	11,070	882	3,257	3,355	8%	3.69	3.80	1.03
2014	16,260	3,140	11,051	11,383	19%	3.52	3.63	1.03
2015	27,722	2,047	6,074	6,317	7%	2.97	3.09	1.04
2016	24,819	1,131	3,896	4,052	5%	3.44	3.58	1.04
2017	17,425	1,137	5,688	5,802	7%	5.00	5.10	1.02
2018	12,811	1,016	4,270	4,270	8%	4.20	4.20	1

2.3.4.2 Costs of Fishing

Since 2009, PIFSC economists have maintained a continuous economic data collection program in American Samoa through collaboration with the PIFSC Western Pacific Fisheries Information Network (WPacFIN). The economic data collection gathers fishing expenditure data for boat-based reef fish, bottomfish, and pelagic fishing trips on an ongoing basis. Data for fishing trip expenses include; gallons of fuel used, price per gallon of fuel, cost of ice used, cost of bait & chum used, cost of fishing gear lost, and the engine type of the boat. These economic data are collected from same subset of fishing trips as the boat-based creel survey carried out by the local fisheries management agencies and WPacFIN.

Figure 8 shows the average trip costs for American Samoa bottomfish trips during 2009–2018. In 2018, the average trip costs of bottomfish trips were $131, higher than 2017, mostly due to the increase of fuel price in 2018. Supporting data for Figure 8 are presented in Table 32.

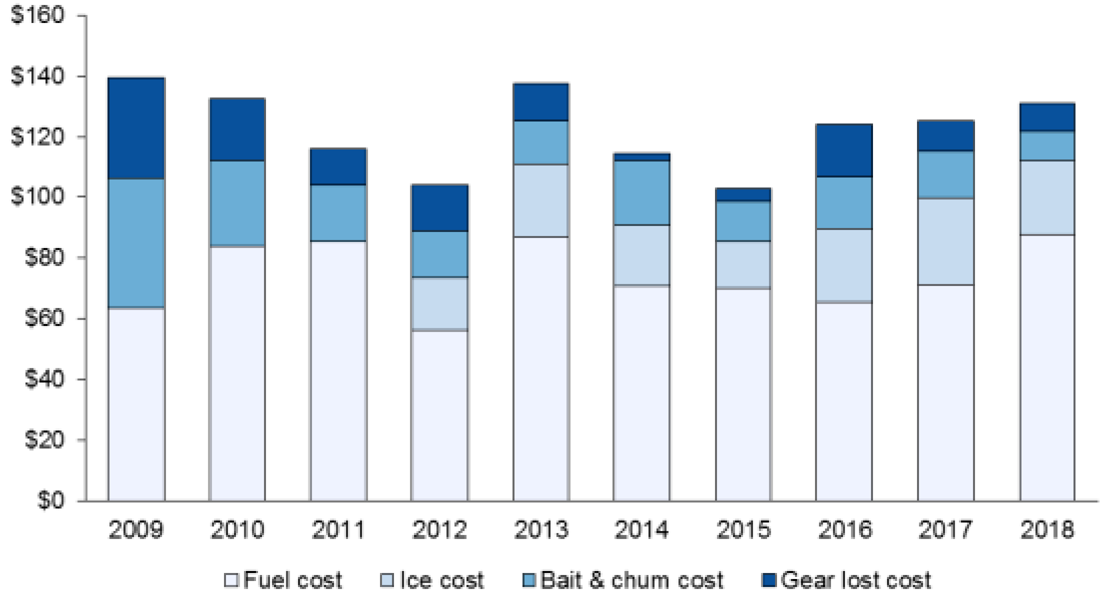

Figure 8. Average costs adjusted for American Samoa coral reef fishing trips from 2009–2018 adjusted to 2018 dollars

Table 32. Average and itemized costs for American Samoa bottomfish trips from 2009–2018 adjusted to 2018 dollars

Year	Total trip costs ($)	Total trip costs ($) (adjusted)	Fuel cost ($)	Fuel cost ($) (adjusted)	Ice cost ($)	Ice cost ($) (adjusted)	Gear losted cost ($)	Gear losted cost ($) (adjusted)	Bait & chum cost ($)	Bait & chum cost ($) (adjusted)	CPI adjustor
2009	113	139	52	64	-	-	27	33	34	42	1.234
2010	112	132	71	84	-	-	17	20	24	28	1.178
2011	106	116	79	86	-	-	11	12	17	18	1.090
2012	99	104	54	56	16	17	14	15	15	15	1.055
2013	133	137	84	87	23	24	12	12	14	14	1.034
2014	111	114	69	71	19	20	2	2	21	21	1.027
2015	99	103	68	70	15	15	4	4	12	13	1.036
2016	119	124	63	65	23	24	17	17	16	17	1.037
2017	123	125	70	71	28	28	10	10	15	15	1.016
2018	131	131	88	88	24	24	9	9	10	10	1.000

Data source: PIFSC Continuous Cost Data Collection Program (Chan and Pan 2019).

2.3.5 Reef Fish

American Samoa's nearshore fishing is focused on the narrow fringing coral reef that partially surrounds the islands (Levine and Allen, 2009; Richmond and Levine, 2012). A diverse array of fish and shellfish is harvested by local residents on an almost daily basis. Most fishing is accomplished by individuals on foot in areas adjacent to their village. While the gender division in fishing is not as strict as it was in the past, women, and children still predominantly engage in gathering shellfish and small fish in the intertidal zone, while men fish farther off shore. Traditionally, women were not permitted by Samoan custom to fish outside the reef. Common fishing techniques included intertidal gleaning, diving, rod and reel, netting and trapping (including communal fish drives), and boat-based fishing.

There are a number of traditional fisheries associated with seasonal runs of certain species. Atule, or bigeye scad (*Selar crumenophthalmus*), is a coastal migratory species that spawns in mass near shore. Atule are caught through a village-wide effort in some areas where they spawn, with villagers driving the fish to a central location to be harvested. I'asina (juvenile goatfish) are caught in hand-woven funnel traps called enu. Thousands of i'asina may appear along sandy shorelines during the months of October–April. The palolo worm *(Palola viridis)*, a coral-dwelling polychaete worm, is another unique species that is caught in large numbers in the Samoa Islands during spawning events. Palolo generally emerge once a year, one week after the full moon in October or November, to release their reproductive segments (epitokes) into nearshore waters. These epitokes are a local delicacy, and Samoans will gather in the thousands at midnight on the predicted spawning event to collect them in hand nets and screens.

Despite increasing levels of participation in the commercial fishing industry in American Samoa, most nearshore fishermen do not sell their catch. Traditionally, fish in American Samoa are not sold, but shared with others or distributed amongst the community. Many American Samoans still believe that some species, such as the palolo, should not be sold at the risk of ruining catch in future years. Sharing fish amongst the wider village community is still an important cultural practice. For example, atule are divided equally amongst village members after a group harvesting event, and palolo are still distributed to family members with a portion reserved for village pastors. However, since the advent of refrigeration, people are more likely to catch more fish during mass spawning events and share fewer, as they can be stored for longer periods for personal use.

The American Samoa Department of Marine and Wildlife Resources (DMWR) have conducted inshore creel surveys along the southern shore of Tutuila Island since 1990. They documented a significant decrease in the level of shoreline fishing effort over the past three decades despite the increase in the human population over the same time period.

Studies that have examined how residents value coral reef resources found that most people perceive coral reefs as an important food source that also provides passive benefits associated with culture, biodiversity, and community (Levine and Allen, 2009; Levine *et al*,. 2016). Less importance was placed on the ecosystem, recreational benefits, shoreline protection, or other direct-use benefits. Because there is relatively little tourism, the economic value of American Samoa's coral reefs has been estimated to be relatively lower than other islands in the Western Pacific region; an analysis in 2004 estimated their value at $5 million per year (Grace-McCaskey, 2014).

2.3.5.1 Commercial Participation, Landings, Revenues, and Prices

This section will describe trends in commercial pounds sold, revenues and prices, for the American Samoa coral reef fish (CREMUS only). Figure 9 presents the trends of commercial pounds sold and revenues of coral reef fishery during 2009-2018 and Figure 10 presents the trend of fish price of coral reef fish during 2009-2018. Supporting data for Figure 9 and Figure 10 are shown in Table 33. Table 33 also includes fish price and the percent of pounds sold to the total pounds caught of the coral reef fish fishery. In addition, the table also includes both nominal and adjusted values.

In Figure 9, we may observe the fluctuation in commercial landings (pounds sold) of the reef fish across years during the period 2009-2018. The total pounds of reef fish sold in 2018 were over 36,000 lbs, while in the peak year (appeared in 2016), pounds sold was 117,000 lbs. On an average of the recent 10 years (2009-2018), 78% of the reef fish landed was sold to the markets. Accordingly to the local creel survey staff, the percentage of sale for reef fish species (CREMUS) were higher (compared to bottomfish) because reef fish was more popular in the local markets. However, in recent years, the pounds sold of reef fish were even greater than that pounds landed. The cause to the phenomena needs to further investigate.

Please notice that the data for pounds caught and pounds sold are collected by two different data collection methods. The data of pounds sold were collected through "Commercial Sales Receipt Books" Program (https://www.pifsc.noaa.gov/wpacfin/as/Pages/as_crform3.htm), while the data of pounds caught were collected through "Boat-based Creel Survey" and "Shore-based Creel Survey" (https://www.pifsc.noaa.gov/wpacfin/as/Pages/as_coll_5.php). Both data series are generated from an expansion algorithm built on a non-census data collection program respectively, and the survey coverage rates of two data collection methods may change independently in individual years. Therefore, the two time series may not move coherently to each other. For example, the low percentage of pounds sold compared to pounds caught could be due to the low coverage of dealer participations in the Commercial Receipt Books Program, or vice versa.

Most of the reef fish were caught by spear fishing gear (using boat or in shore). Figure 10 shows the average trip costs for American Samoa boat-base spear fishing trips during 2009–2018. In 2018, the average trip costs of boat base spear trips were $73, 17 dollar higher (adjusted to 2018 dollars) compared to 2017. Supporting data for Figure 10 are presented in Table 33.

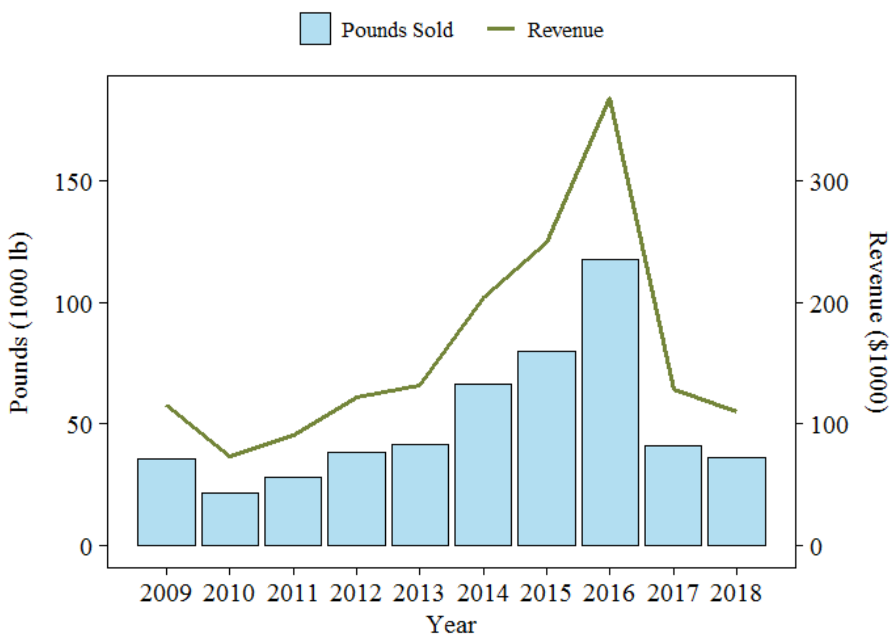

Figure 9. The pounds sold and revenue of CREMUS for the American Samoa Coral Reef fishery, 2009-2018 (adjusted to 2018 dollars)

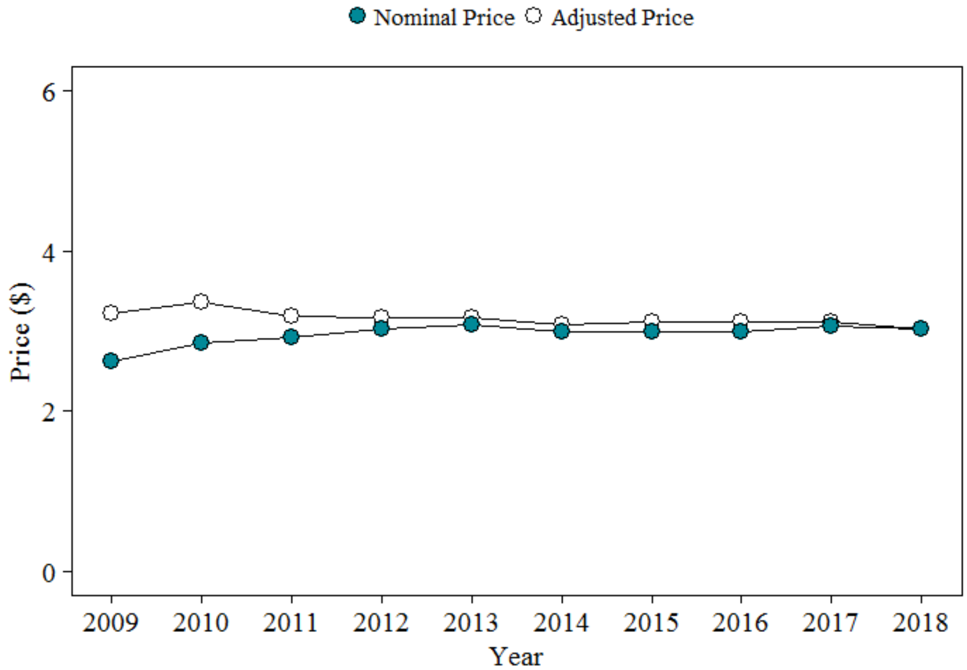

Figure 10. The prices of CREMUS for the American Samoa coral reef fishery, 2009-2018

Table 33. The Commercial landings and revenue from coral reef for American Samoa, 2009-2018

Year	Estimated pounds caught (lb)	Estimated pounds sold (lb)	Estimated revenue ($)	Estimated revenue ($ adjusted)	% of pounds sold	Fish price ($)	Fish price ($ adjusted)	CPI adjustor
2009	71,888	35,773	93,827	115,407	50%	2.62	3.23	1.23
2010	120,676	21,693	61,908	73,051	18%	2.85	3.37	1.18
2011	113,814	28,398	83,061	90,536	25%	2.92	3.19	1.09
2012	52,547	38,581	116,437	122,259	73%	3.02	3.17	1.05
2013	99,426	41,534	127,886	131,723	42%	3.08	3.17	1.03
2014	56,369	66,388	198,541	204,497	118%	2.99	3.08	1.03
2015	73,532	80,004	239,582	249,165	109%	2.99	3.11	1.04
2016	101,097	117,872	353,800	367,952	117%	3.00	3.12	1.04
2017	40,553	41,163	125,953	128,472	102%	3.06	3.12	1.02
2018	28,891	36,177	109,688	109,688	125%	3.03	3.03	1

Data source: PIFSC Continuous Cost Data Collection Program (Chan and Pan 2019).

2.3.5.2 Costs of Fishing

Since 2009, PIFSC economists have maintained a continuous economic data collection program in American Samoa through collaboration with the PIFSC Western Pacific Fisheries Information Network (WPacFIN). The economic data collection gathers fishing expenditure data for boat-based reef fish, bottomfish, and pelagic fishing trips on an ongoing basis. Data for fishing trip expenses include; gallons of fuel used, price per gallon of fuel, cost of ice used, cost of bait and chum used, cost of fishing gear lost, and the engine type of the boat. These economic data are collected from same subset of fishing trips as the boat-based creel survey carried out by the local fisheries management agencies and WPacFIN.

Figure 11 shows the trend of average trip costs for American Samoa coral reef fish fishing trips during 2009–2018. In 2018, the average trip costs of coral reef fish trips were $73, higher than 2017. Supporting data for Figure 11 are presented in Table 34.

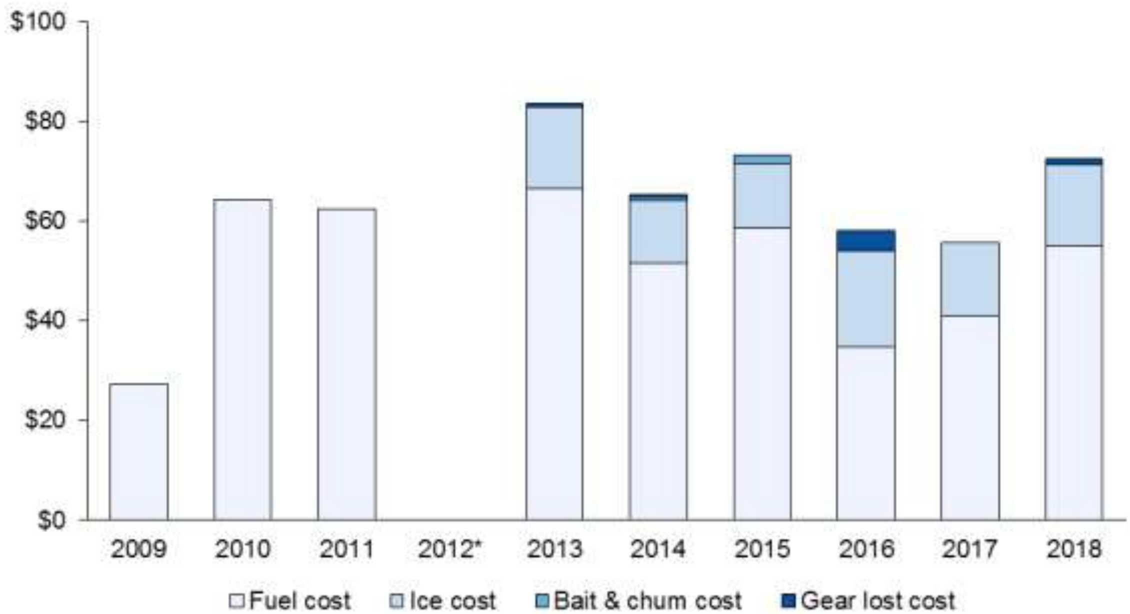

Figure 11. Average costs for American Samoa spearfishing trips from 2009–2018 (adjusted to 2018 dollars)

*Data for 2012 are not presented due to less than three observations.

Table 34. Average trip costs and itemized costs for American Samoa coral reef fish trips from 2009–2018 adjusted to 2018 dollars

Year	Total trip costs ($)	Total trip costs ($) (adjusted)	Fuel cost ($)	Fuel cost ($) (adjusted)	Ice cost ($)	Ice cost ($) (adjusted)	Gear losted cost ($)	Gear losted cost ($) (adjusted)	Bait & chum cost ($)	Bait & chum cost ($) (adjusted)	CPI adjustor
2009	22	27	22	27	-	-	0	0	0	0	1.234
2010	55	64	55	64	-	-	0	0	0	0	1.178
2011	57	62	57	62	-	-	0	0	0	0	1.090
2012*	0	0	-	-	-	-	-	-	-	-	1.055
2013	81	83	64	66	16	16	1	1	0	0	1.034
2014	63	65	50	52	12	13	0	1	0	1	1.027
2015	71	73	56	58	13	13	0	0	1	1	1.036
2016	56	58	33	35	18	19	4	4	0	0	1.037
2017	55	56	40	41	14	15	0	0	0	0	1.016
2018	73	73	55	55	17	17	1	1	0	0	1

Data source: PIFSC Continuous Cost Data Collection Program (Chan and Pan 2019).

2.3.6 Crustaceans

In American Samoa, spiny lobsters constitute the bulk of the crustacean fishery (description available in Markrich and Hawkins, 2016). Lobsters are often present at important meals in American Samoa such as weddings, funerals, and holidays. In the past, lobsters were typically harvested and consumed on the family and village level. They are now primarily caught by commercial fishermen in territorial waters and purchased by the public at market. Crustaceans harvested in American Samoa are processed at sea on the vessel and marketed as fresh product or as frozen lobster tails.

2.3.6.1 Commercial Participation, Landings, Revenues, and Prices

This section will describe trends in commercial participation, landings, revenues, and prices as data allow for the American Samoa crustacean fishery. Supporting figures and tables will be added in future reports.

2.3.7 Precious Corals

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

2.3.7.1 Commercial Participation, Landings, Revenues, and Prices

This section will describe trends in commercial participation, landings, revenues, and prices as data allow for the American Samoa precious coral fishery. Supporting figures and tables will be added in future reports.

2.3.8 Ongoing Research and Information Collection

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

The table below represents the most recent data available for CFEAI metrics for select regional commercial fisheries for 2018. Entries for American Samoa fisheries are bolded in red. These values represent the most recent year of data for key economic data monitoring parameters (fishing revenues, operating costs, and fixed costs). The assessment column indicates the most recent publication year for specific economic assessments (returns above operating cost, profit), where available.

Table 35. Pacific Islands Region 2018 Commercial Fishing Economic Assessment Index

	2018 Projected CFEAI				
	2018 Reporting Year (e.g. 1/2018-12/2018)				
	Data			Assessment	
Pacific Islands Fisheries	Anticipated Fishing Revenue Most Recent Year	Anticipated Operating Cost Most Recent Year	Anticipated Fixed Cost Most Recent Year	Anticipated Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year	Anticipated Profit Assessment Most Recent Year
HI Longline	2018	2018	2013	2018	2016
ASam Longline	**2018**	**2018**	**2017**	**2018**	**2016**
HI Offshore Handline	2018	2014	2014	2018	2018
HI Small Boat (pelagic)	2018	2014	2014	2017	2017
HI Small Boat (bottomfish)	2018	2014	2014	2017	2017
HI Small Boat (reef)	2018	2014	2014	2017	2017
Guam Small boat	2018	2018	2018	2018	
CNMI Small boat	2018	2018	2018	2018	
ASam Small boat	**2018**	**2018**	**2018**	**2018**	

PIFSC also generates projections for upcoming fiscal years, and the table below provides the projected CFEAI report for 2019 (*all projected activities and analyses are subject to funding*). Based on early projections PIFSC intends to maintain ongoing economic data collections in American Samoa for both the longline fishery (Pan, 2018) and small boat fisheries (Chan and Pan, 2019) during 2019. PIFSC conducted a cost-earnings survey for the American Samoa longline fishery in 2017 and results, including a profit assessment, are set for publication in 2019.

Table 36. Pacific Islands Region 2019 Commercial Fishing Economic Assessment Index

	2019 Projected CFEAI				
	2019 Reporting Year (e.g. 1/2019-12/2019)				
	Data			Assessment	
Pacific Islands Fisheries	Anticipated Fishing Revenue Most Recent Year	Anticipated Operating Cost Most Recent Year	Anticipated Fixed Cost Most Recent Year	Anticipated Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year	Anticipated Profit Assessment Most Recent Year
HI Longline	2019	2019	2019	2019	2016
ASam Longline	**2019**	**2019**	**2017**	**2019**	**2019**
HI Offshore Handline	2019	2014	2014	2018	2018
HI Small Boat (pelagic)	2019	2014	2014	2017	2017
HI Small Boat (bottomfish)	2019	2014	2014	2017	2017
HI Small Boat (reef)	2019	2014	2014	2017	2017
Guam Small boat	2019	2019	2018	2019	2019
CNMI Small boat	2019	2019	2018	2019	2019
ASam Small boat	**2019**	**2019**	**2018**	**2019**	

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2.4 PROTECTED SPECIES

This section of the report summarizes information on protected species interactions in fisheries managed under the American Samoa 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), Marine Mammal Protection Act (MMPA), and/or Migratory Bird Treaty Act (MBTA). A list of protected species found in or near American Samoa 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 American Samoa FEP Fisheries

This report monitors the status of protected species interactions in the American Samoa 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 territorial waters.

2.4.1.1 FEP Conservation Measures

Bottomfish, precious coral, coral reef and crustacean fisheries managed under this FEP have not had reported interactions with protected species, and no specific regulations are in place to mitigate protected species interactions. 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.

2.4.1.2 ESA Consultations

ESA consultations were conducted by NMFS and the U.S. Fish and Wildlife Service (USFWS; for species under their jurisdiction including seabirds) to ensure ongoing fisheries operations managed under the American Samoa FEP are not jeopardizing the continued existence of any listed species or adversely modifying critical habitat. The results of these consultations conducted under section 7 of the ESA are briefly described below and summarized in Table 37.

NMFS concluded in an informal consultation dated April 9, 2015 that all fisheries managed under the American Samoa FEP are not likely to adversely affect the Indo-West Pacific DPS of scalloped hammerhead shark or ESA-listed reef-building corals.

In January 2018, oceanic whitetip sharks and giant manta rays were listed under the ESA (83 FR 4153 and 83 FR 2916, respectively). If NMFS determines that American Samoa fisheries are likely to adversely affect these species, NMFS will consult on the fisheries' effects on these two species. There is no record of giant manta ray incidental catches in American Samoa non-longline fisheries, and NMFS is reviewing catch data on oceanic whitetip shark incidental catch in these fisheries.

Table 37. Summary of ESA consultations for American Samoa FEP Fisheries

Fishery	Consultation date	Consultation type[a]	Outcome[b]	Species

Fishery	Consultation date	Consultation type[a]	Outcome[b]	Species
Bottomfish	3/8/2002	BiOp	NLAA	Blue whale, fin whale, green sea turtle, hawksbill sea turtle, humpback whale, leatherback sea turtle, loggerhead sea turtle, olive ridley sea turtle, sei whale, sperm whale
Coral reef ecosystem	3/7/2002	LOC	NLAA	Blue whale, fin whale, green sea turtle, hawksbill sea turtle, humpback whale, leatherback sea turtle, loggerhead sea turtle, olive ridley sea turtle, sei whale, sperm whale
	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.
Crustaceans	9/28/2007	LOC	NLAA	Blue whale, fin whale, green sea turtle, hawksbill sea turtle, humpback whale, leatherback sea turtle, loggerhead sea turtle, olive ridley sea turtle, sei whale, sperm whale
Precious corals	10/4/1978	BiOp	Does not constitute threat	Leatherback sea turtle, sperm whale
	12/20/2000	LOC	NLAA	Green sea turtle, hawksbill sea turtle, humpback whale
All fisheries	4/9/2015	LOC	NLAA	Reef-building corals, scalloped hammerhead shark (Indo-West Pacific DPS)

[a] BiOp = Biological Opinion; LOC = Letter of Concurrence

[b] LAA = likely to adversely affect; NLAA = not likely to adversely affect.

Bottomfish Fishery

In a biological opinion issued on March 3, 2002, NMFS concluded that the ongoing operation of the Western Pacific Region’s bottomfish and seamount groundfish fisheries is not likely to jeopardize the continued existence of five sea turtle species (loggerhead, leatherback, olive ridley, green and hawksbill turtles) and five marine mammal species (humpback, blue, fin, sei and sperm whales).

Crustacean Fishery

In an informal consultation completed on September 28, 2007, NMFS concluded that American Samoa crustacean fisheries are not likely to adversely affect five sea turtle species (loggerhead, leatherback, olive ridley, green and hawksbill turtles) and five marine mammal species (humpback, blue, fin, sei and sperm whales).

Coral Reef Ecosystem Fishery
In an informal consultation completed on March 7, 2002, NMFS concluded that the American Samoa coral reef ecosystem fisheries are not likely to adversely affect five sea turtle species (loggerhead, leatherback, olive ridley, green and hawksbill turtles) and five marine mammal species (humpback, blue, fin, sei and sperm whales).

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).

Precious Coral Fishery
In a biological opinion issued on October 4, 1978, NMFS concluded that the ongoing operation of the Western Pacific Region's precious coral fisheries was not likely to jeopardize the continued existence of any threatened or endangered species under NMFS's jurisdiction or destroy or adversely modify critical habitat. In an informal consultation completed on December 20, 2000, NMFS concluded that American Samoa precious coral fisheries are not likely to adversely affect humpback whales, green turtles or hawksbill turtles.

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 2019 LOF (84 FR 22051, May 16, 2019), the American Samoa bottomfish fishery is classified as a Category III fishery (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 American Samoa FEP Fisheries

Bottomfish and Coral Reef Fisheries
There are no observer data available for the American Samoa bottomfish or coral reef fisheries. However based on the information in the 2002 BiOp for fisheries operating under the American Samoa FEP, bottomfish fisheries are not expected to interact with any ESA-listed species in federal waters around American Samoa. Based on current ESA consultations, coral reef fisheries are not expected to interact with any ESA-listed species in federal waters around American Samoa. NMFS has also concluded that the American Samoa bottomfish and coral reef commercial fisheries will not affect marine mammals in any manner not considered or authorized under the Marine Mammal Protection Act.

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 and Precious Coral Fisheries
There are currently no crustacean or precious coral fisheries operating in federal waters around American Samoa. However, based on current ESA consultations, crustacean fisheries are not expected to interact with any ESA-listed species in federal waters around American Samoa. NMFS has also concluded that the American Samoa crustacean and precious coral commercial

fisheries will not affect marine mammals in any manner not considered or authorized under the Marine Mammal Protection Act.

2.4.3 Identification of Emerging Issues

One species that occur in American Samoa is currently a candidate for listing under the ESA, and several more ESA-listed species are being evaluated for critical habitat designation (Table 38). If this species is listed or critical habitat are designated, they will be included in this SAFE report and impacts from FEP-managed fisheries will be evaluated under applicable mandates.

Table 38. 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, 1/30/2018)	Not determinable because of insufficient data (83 FR 4153, 1/30/2018)	TBA
Pacific bluefin tuna	*Thunnus orientalis*	Positive (81 FR 70074, 10/11/2016)	Not warranted (82 FR 37060, 8/8/2017)	N/A	N/A	N/A
Chambered nautilus	*Nautilus pompilius*	Positive (81 FR 58895, 8/26/2016)	Positive, threatened (82 FR 48948, 10/23/2017)	Listed as threatened (83 FR 48876, 9/28/2018)	N/A	N/A
Giant manta ray	*Manta birostris*	Positive (81 FR 8874, 2/23/2016)	Positive, threatened (82 FR 3694, 1/12/2017)	Listed as Threatened (83 FR 2916, 1/22/2018)	Not determinable because of insufficient data (83 FR 2916, 1/22/2018)	TBA
Corals	N/A	Positive for 82 species (75 FR 6616, 2/10/2010)	Positive for 66 species (77 FR 73219, 12/7/2012)	20 species listed as threatened (79 FR 53851, 9/10/2014)	In development, proposal expected TBA	In development, expected TBA, interim recovery outline in place
Cauliflower coral	*Pocillopora meandrina*	Positive (83 FR 47592, 9/20/2018)	TBA (status review ongoing)	TBA	N/A	N/A

Species		Listing Process			Post-Listing Activity	
Common Name	**Scientific Name**	**90-Day Finding**	**12-Month Finding / Proposed Rule**	**Final Rule**	**Critical Habitat**	**Recovery Plan**
Giant clams	*Hippopus hippopus, H. porcellanus, Tridacna costata, T. derasa, T. gigas, T. Squamosa,* and *T. tevoroa*	Positive (82 FR 28946, 06/26/2017)	TBA (status review ongoing)	TBA	N/A	N/A
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
Leatherback sea turtle	*Dermochelys coriacea*	Positive 90-day finding on a petition to identify the Northwest Atlantic leatherback turtle as a DPS (82 FR 57565, 12/06/2017)	TBA (status review ongoing)	TBA	N/A	N/A

[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.

2.5 CLIMATE AND OCEANIC INDICATORS

2.5.1 Introduction

Over the past few years, the Council has incorporated climate change into the overall management of the fisheries over which it has jurisdiction. This 2018 Annual SAFE Report includes a now standard chapter on indicators of climate and oceanic conditions in the Western Pacific region. These indicators reflect global climate variability and change as well as trends in local oceanographic conditions.

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

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

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

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

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

This annual report focuses previous years' efforts by refining existing indicators and improving communication of their relevance and status. Future reports will include additional indicators as the information becomes available and their relevance to the development, evaluation, and revision of the FEPs becomes clearer. Working with national and jurisdictional partners, the Council will make all datasets used in the preparation of this and future reports available and easily accessible.

2.5.2 Response to Previous Plan Team and Council Recommendations

At its 170th meeting from June 20-22, 2017, the Council directed staff to support the development of community training and outreach materials and activities on climate change. In addition, the Council directed staff to coordinate a "train-the-trainers" workshop that includes NOAA scientists who presented at the 6th Marine Planning and Climate Change Committee (MPCCC) meeting and the MPCCC committee members in preparation for community workshops on climate and fisheries. The Council and NOAA partnered to deliver the workshops in the fall of 2017 to the MPCCC members in Hawaii (with the Hawaii Regional Ecosystem Advisory Committee), as well as American Samoa, Guam, and the CNMI (with their respective Advisory Panel groups). Feedback from workshop participants has been incorporated into this year's climate and oceanic indicator section. To prepare for community outreach, Guam-based MPCCC members conducted a climate change survey and shared the results with the MPCCC at its 7th meeting on April 10th and 11th, 2018. The Council also directed staff to explore funding avenues to support the development of additional oceanic and climate indicators, such as wind and extratropical storms. These indicators were added to this module by corresponding Plan Team members in 2018. There were no Council recommendations relevant to the climate and ocanic indicators section of the Annual SAFE Report in 2018.

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

2.5.3 Conceptual Model

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

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

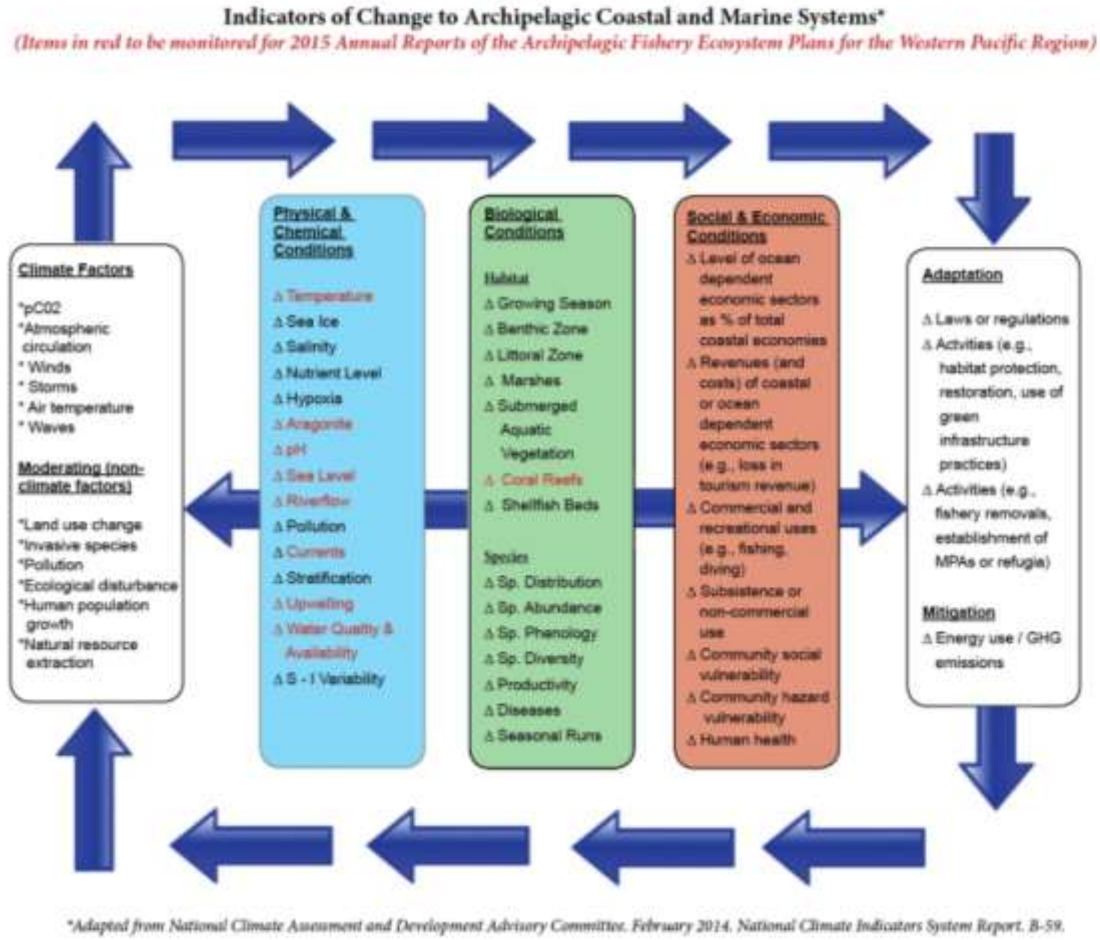


Figure 12. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability

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

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

2.5.4 Selected Indicators

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

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

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

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

Figure 13 and Figure 14 provide a description of these indicators and illustrate how they are connected to each other in terms of natural climate variability and anthropogenic climate change.

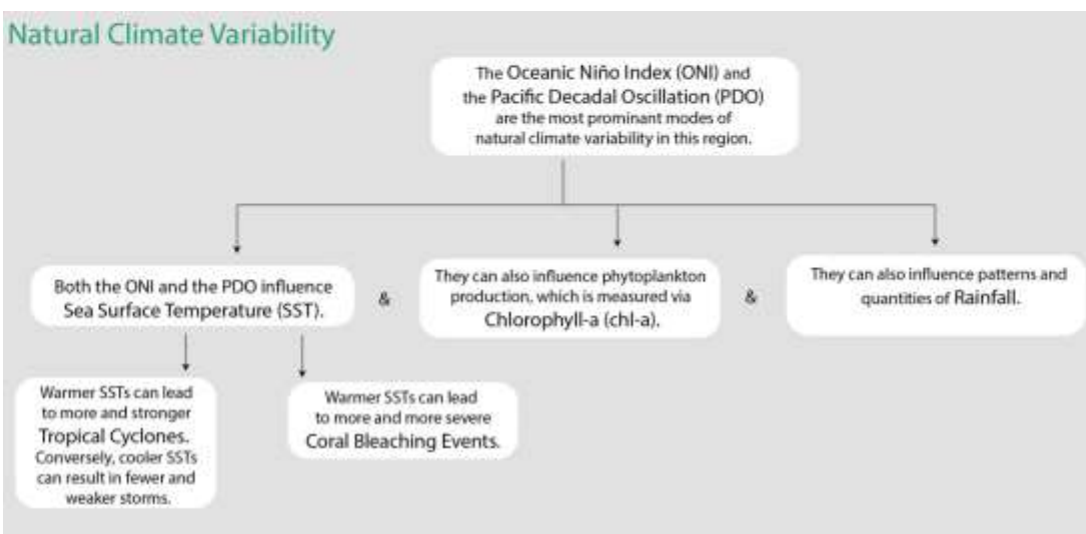


Figure 13. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability

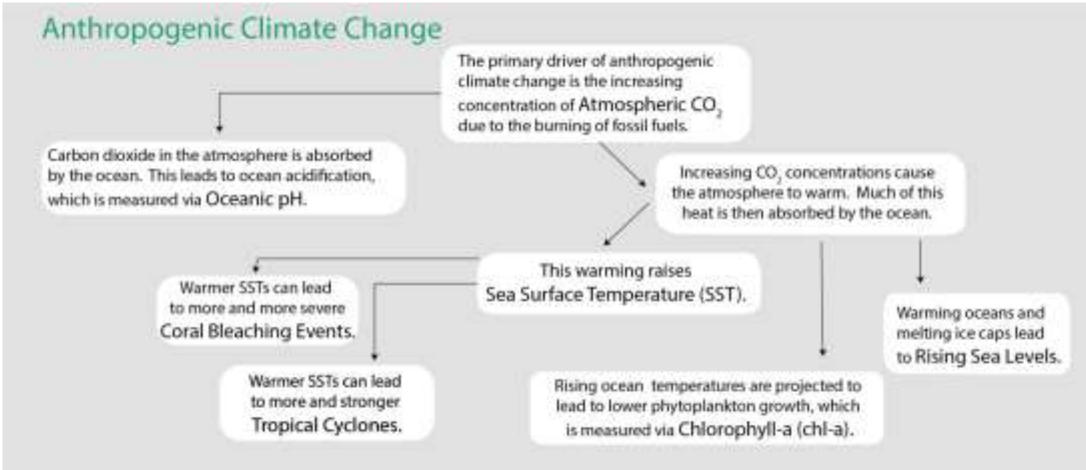


Figure 14 Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of anthropogenic climate change

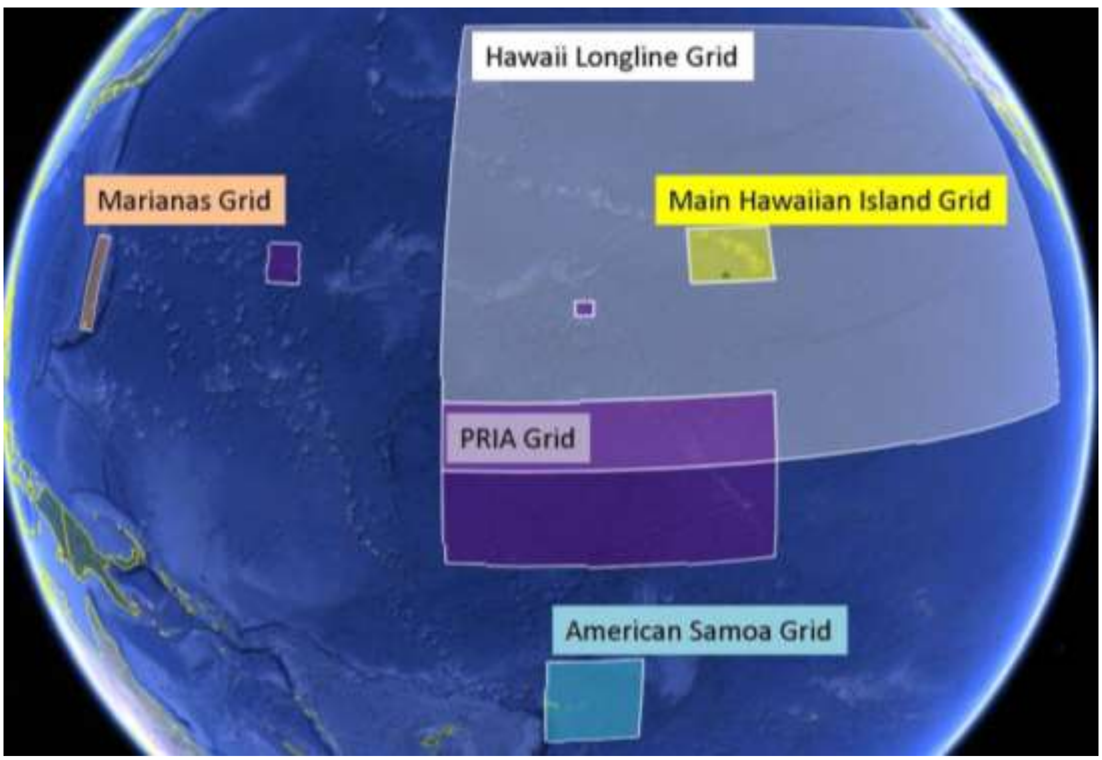


Figure 15. Regional spatial grids representing the scale of the climate change indicators being monitored

2.5.4.1 Atmospheric Concentration of Carbon Dioxide at Mauna Loa

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

Status: Atmospheric CO_2 is increasing exponentially. This means that atmospheric CO_2 is increasing at a faster rate each year. In 2018, the annual mean concentration of CO_2 was 409 ppm. In 1959, the first year of the time series, it was 316 ppm. The annual mean passed 350 ppm in 1988 and 400 ppm in 2015 (NOAA 2019b).

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

Timeframe: Annual, monthly.

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

Measurement Platform: *In-situ* station.

Sourced from: Keeling et al. (1976), Thoning et al. (1989), and NOAA (2019a).

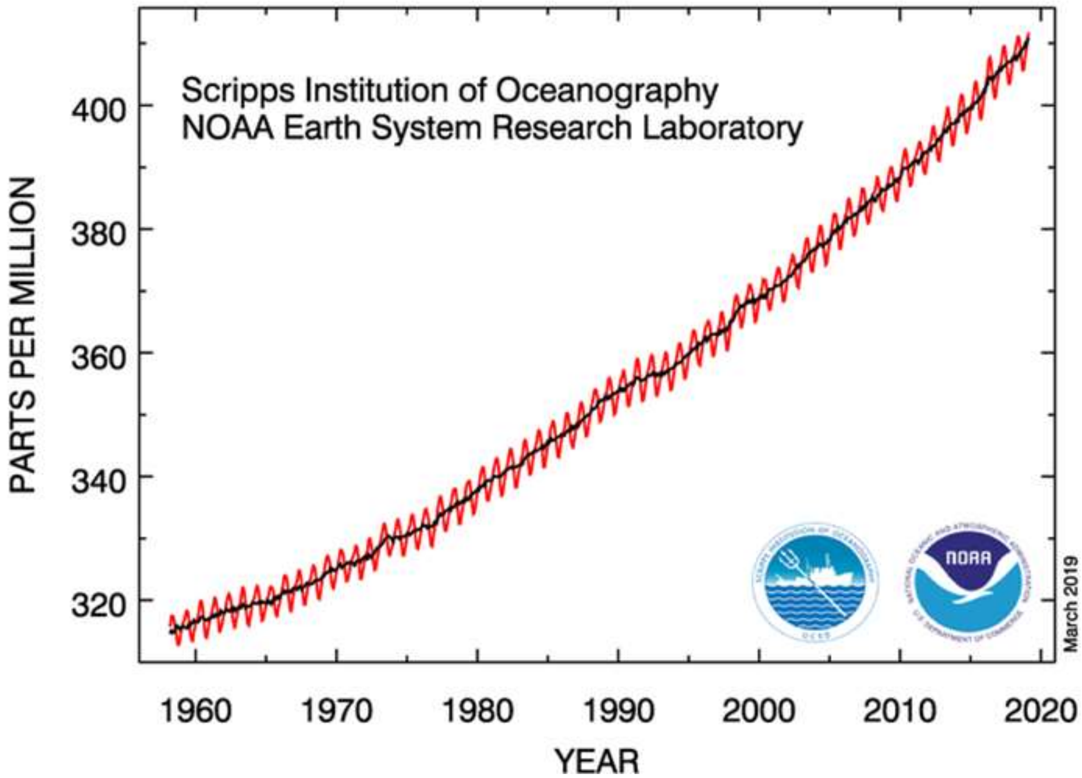


Figure 16. Monthly mean (red) and seasonally-corrected (black) atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii

2.5.4.2 Oceanic pH

Rationale: Oceanic pH is a measure of how greenhouse gas emissions have already impacted the ocean (NOAA PMEL 2019). This indicator demonstrates that oceanic pH has decreased significantly over the past several decades (i.e., the ocean has become more acidic). Increasing ocean acidification limits the ability of marine organisms to build shells and other calcareous structures. Recent research has shown that pelagic organisms such as pteropods and other prey for commercially-valuable fish species are already being negatively impacted by increasing acidification (Feely et al., 2016). The full impact of ocean acidification on the pelagic food web is an area of active research (Fabry et al., 2008).

Status: The ocean is roughly 9.4% more acidic than it was nearly 30 years ago at the start of this time series. Over this time, pH has declined by 0.0389 at a constant rate. In 2017, the most recent year for which data are available, the average pH was 8.07. Additionally, small variations seen over the course of the year are now outside the range seen in the first year of the time series. The highest pH value reported for the most recent year (8.0831) is lower than the lowest pH value reported in the first year of the time series (8.0845).

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

Timeframe: Monthly.

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

Measurement Platform: *In-situ* station.

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

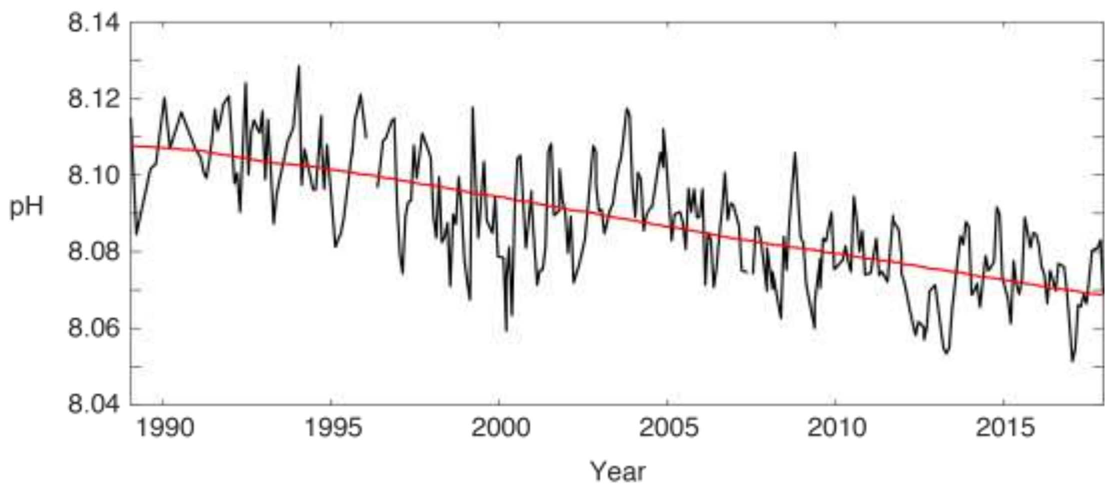


Figure 17. Oceanic pH (black) and its trend (red) at Station ALOHA from 1989 – 2017

2.5.4.3 Oceanic Niño Index

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

Status: In 2018, the ONI transitioned from a weak La Niña to neutral conditions.

Description: The three-month running mean of satellite remotely-sensed sea surface temperature (SST) anomalies in the Niño 3.4 region (5°S – 5°N, 120° – 170°W). The 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 ENSO is measured using the Southern Oscillation Index.

Timeframe: Every three months.

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

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

Sourced from NOAA CPC (2019).

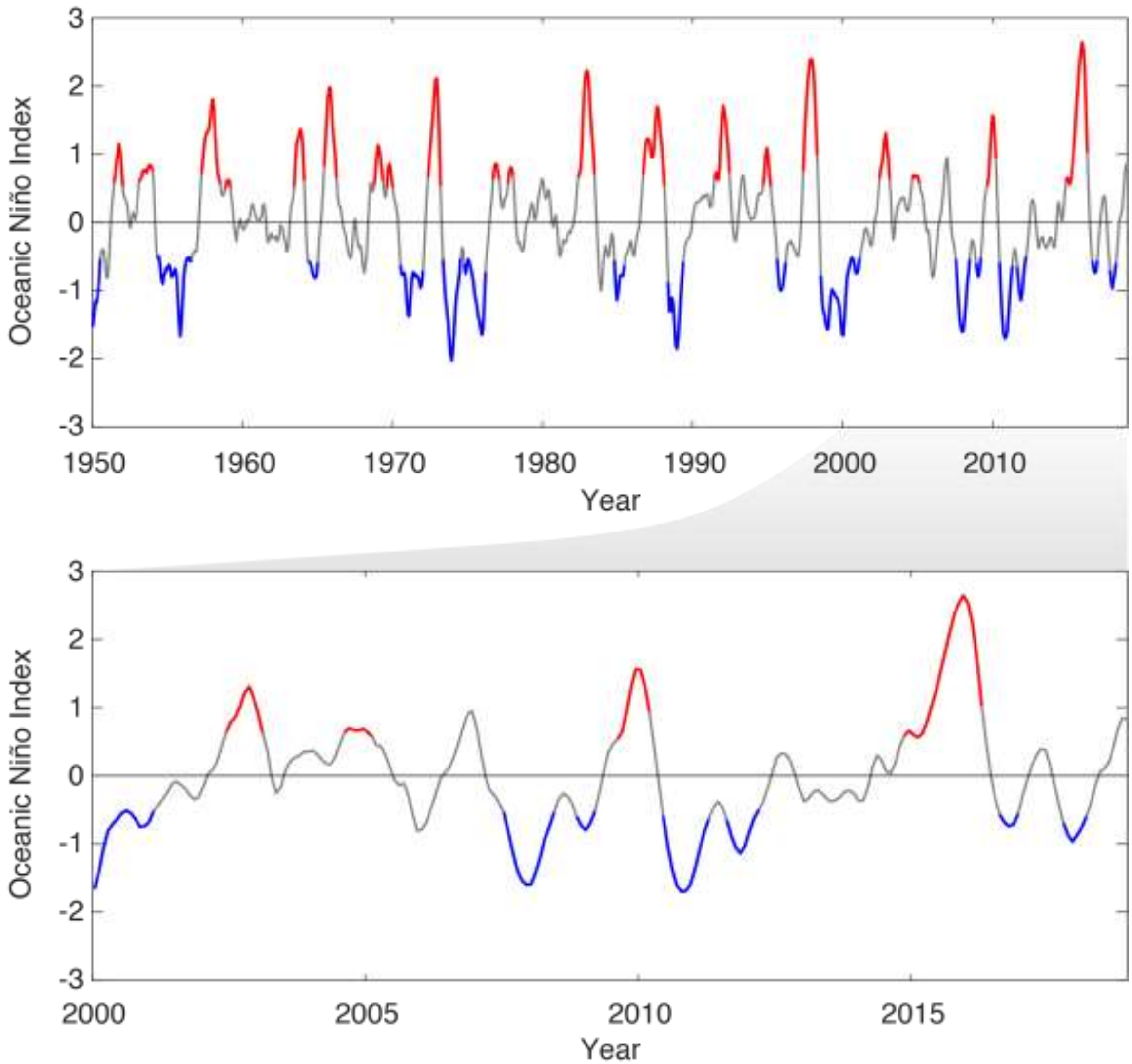


Figure 18. Oceanic Niño Index from 1950-2018 (top) and 2000–2018 (bottom) with El Niño periods in red and La Niña periods in blue

2.5.4.4 Pacific Decadal Oscillation

Rationale: The Pacific Decadal Oscillation (PDO) was initially named by fisheries scientist Steven Hare in 1996 while researching connections between Alaska salmon production cycles and Pacific climate. Like ENSO, the PDO reflects changes between periods of persistently warm or persistently cool ocean temperatures, but over a period of 20 to 30 years (versus six to 18 months for ENSO events). The climatic 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, for much of 2018. In March and June, the index dipped just below zero but returned to a positing value the following months. PDO index values were not yet available for the last three months of 2018 at the time of publication.

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

Timeframe: Annual, monthly.

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

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

Sourced from: NOAA ESRL (2019b) and Mantua (2018).

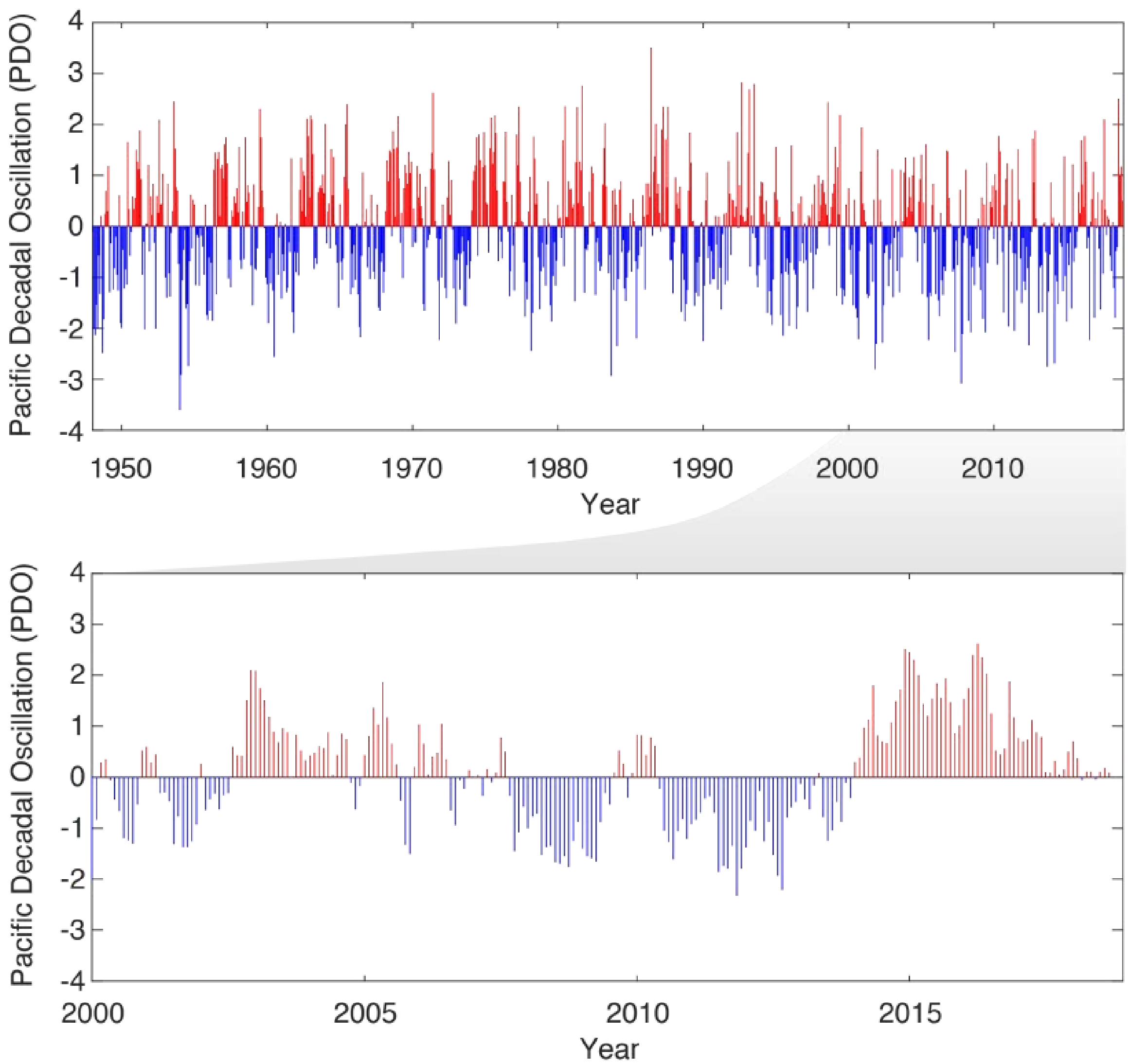


Figure 19. Pacific Decadal Oscillation from 1950–2018 (top) and 2000–2018 (bottom) with positive warm periods in red and negative cool periods in blue

2.5.4.5 Tropical Cyclones

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

Status:

Eastern North Pacific. Overall, the 2018 eastern Pacific hurricane season featured well above average activity. There were 22 named storms, of which 12 became hurricanes and 9 became major hurricanes - category 3 or higher on the Saffir-Simpson Hurricane Wind Scale. This compares to the long-term averages of 15 named storms, 8 hurricanes, and 4 major hurricanes. There were also 3 tropical depressions that did not reach tropical storm strength. In terms of Accumulated Cyclone Energy (ACE), which measures the strength and duration of tropical storms and hurricanes, activity in the basin in 2018 was the 3rd highest on record, behind 1990 and 1992. Summary inserted from https://www.nhc.noaa.gov/text/MIATWSEP.shtml.

Central North Pacific. Tropical cyclone activity in 2018 was high. The ACE index was the second highest since 1980, second only to 2015, and well above the 1981 – 2010 average of just under 20 (x 10^4 $knots^2$). Of note was Hurricane Lane, which reached Category 5 strength and passed within 110 miles of Honolulu. Lane was only the second Category 5 hurricane to pass within 250 miles of Hawaii, with the last being Hurricane John in 1994. Some of the impacts associated with Hurricane Lane include widespread reports of more than 40 inches of rain the islands of Hawaii and Kauai. There was one preliminary report of more than 52 inches of rain. At least one fatality was blamed on Hurricane Lane. Summary inserted from https://www.ncdc.noaa.gov/sotc/tropical-cyclones/201808.

Western North Pacific. Tropical cyclone activity was roughly average. The ACE Index was slightly above average in the Western North Pacific. Of note was Super Typhoon Yutu which made landfall on the islands of Tinian and Saipan as a Category 5 equivalent typhoon with estimated winds of 180 mph and a central minimum pressure of 905 mb. This marked the second strongest tropical cyclone to impact any U.S. territory on record. The storm devastated most of Tinian and Saipan with nearly every structure on the two islands being damaged or destroyed, including the Saipan International Airport. There were two fatalities reported in the Northern Marianas. Summary inserted from https://www.ncdc.noaa.gov/sotc/tropical-cyclones/201810.

South Pacific. Tropical cyclone activity and the ACE Index were below average in 2018.

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

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

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

Timeframe: Annual.

Region/Location:

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

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

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

South Pacific: south of the equator.

Measurement Platform: Satellite.

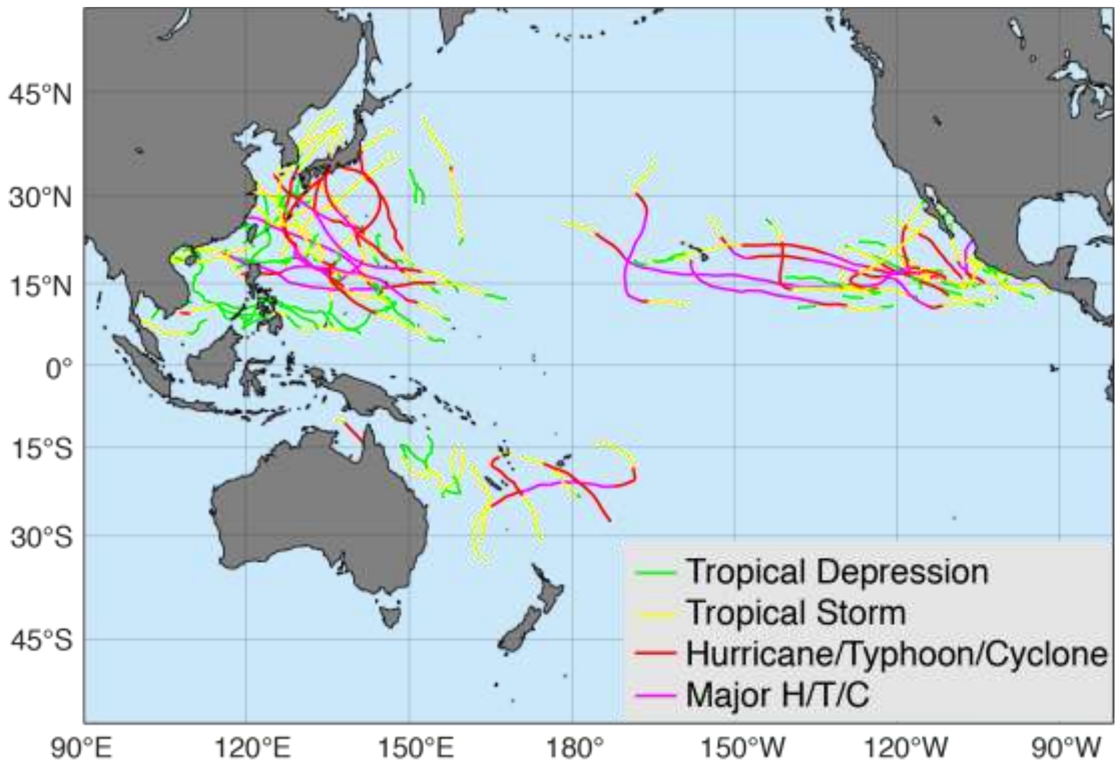


Figure 20. 2018 Pacific basin tropical cyclone tracks

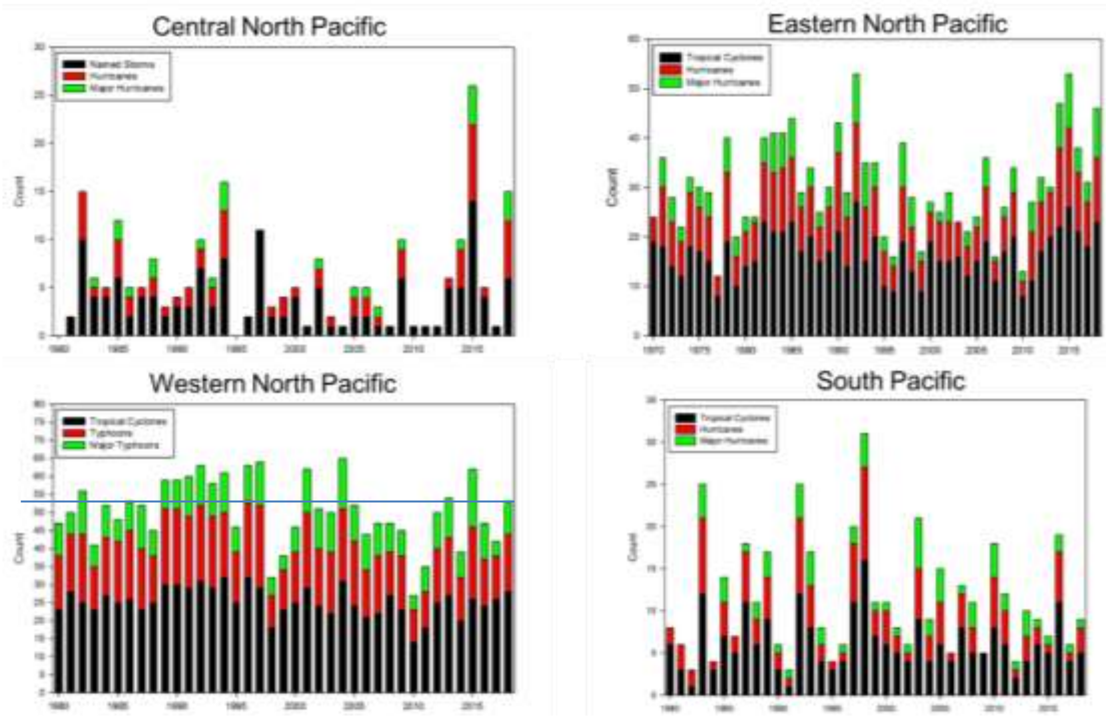


Figure 21. 2018 tropical storm totals by region

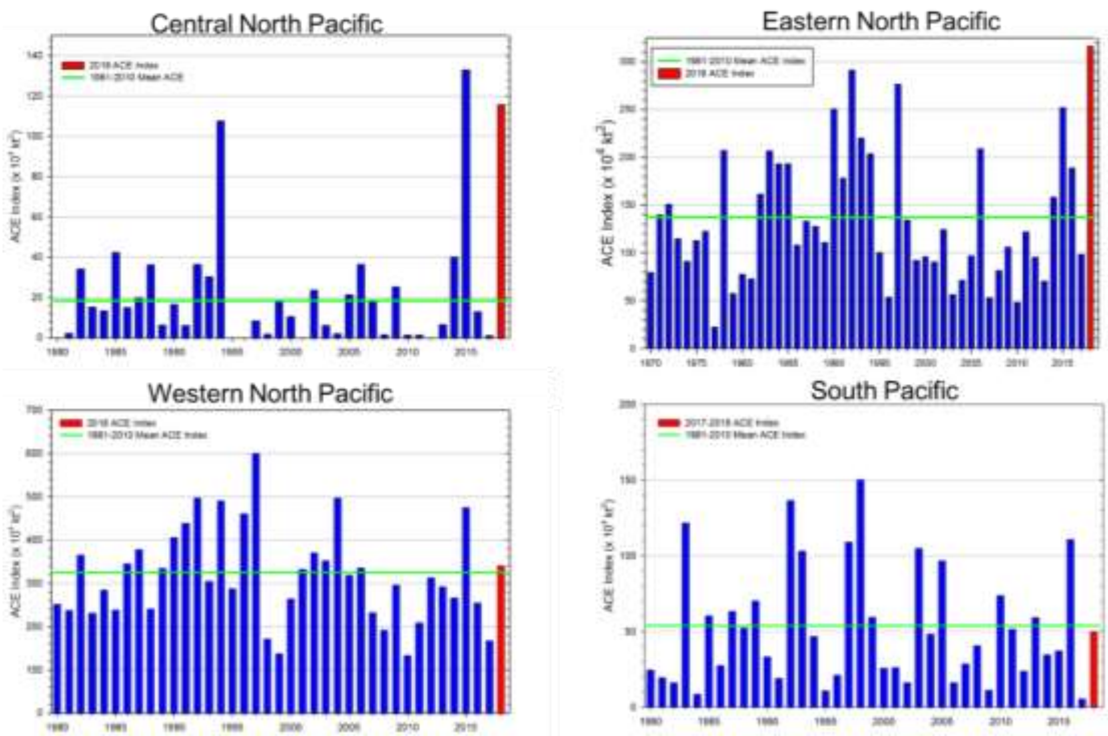


Figure 22. 2018 Accumulated Cyclone Energy (ACE) Index by region

2.5.4.6 Sea Surface Temperature and Anomaly

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

Status*:* Annual mean SST was 28.51ºC in 2018. Over the period of record, annual SST has increased at a rate of 0.013ºC yr^{-1}. Monthly SST values in 2018 ranged from 27.63 – 29.01 ºC, within the climatological range of 25.91 – 30.21 ºC. The annual anomaly was 0.184ºC hotter than average, with wide spatial variability.

Note that from the top to bottom in Figure 23, panels show climatological SST (1982-2017), 2018 SST anomaly, time series of monthly mean SST, and time series of monthly SST anomaly. The white box in the upper panels indicates the area over which SST is averaged for the time series plots.

Description: Satellite remotely-sensed monthly sea surface temperature (SST) is averaged across the American Samoa Grid (10° – 17.5°S, 165° – 172°W). A time series of monthly mean SST averaged over the American Samoa Grid Region is presented. Additionally, spatial climatologies and anomalies are shown. Data from NOAA Pathfinder v5.3 (NOAA 2019c).

Timeframe: Monthly.

Region/Location: American Samoa Grid (10° – 17.5°S, 165° – 172°W).

Measurement Platform: Satellite.

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

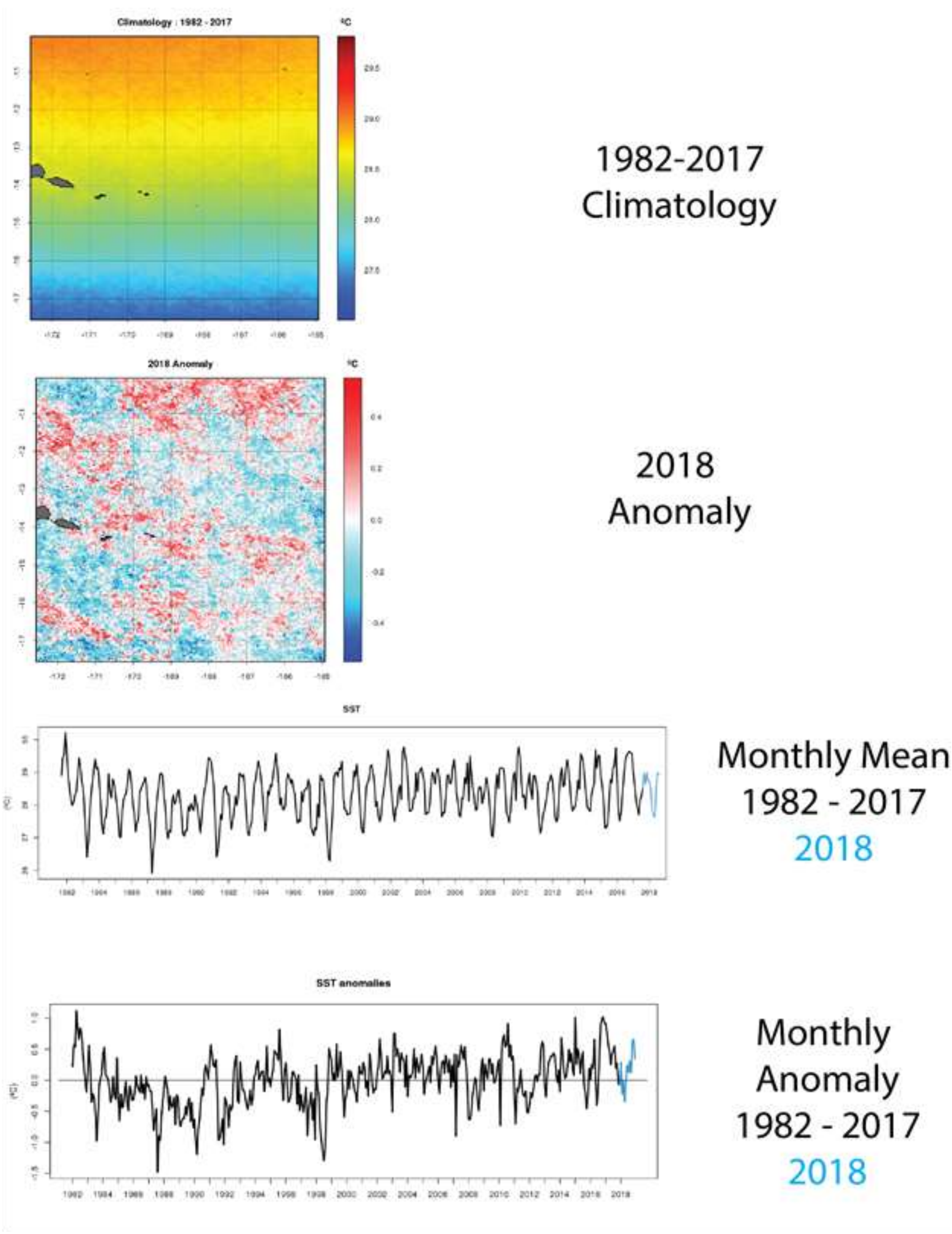


Figure 23. Sea surface temperature climatology and anomalies from 1982-2018

2.5.4.7 Coral Thermal Stress Exposure: Degree Heating Weeks

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

Status: After a series of stress events in 2014, 2015, and 2017, the Samoas are currently experiencing a coral heat stress event that began late in 2018, and is reaching it maximum at time of writing (April 2019).

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

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

The NOAA Coral Reef Watch (CRW) daily 5-km satellite coral bleaching Degree Heating Week (DHW) product presented here shows accumulated heat stress, which can lead to coral bleaching and death. The scale goes from 0 to 20 °C-weeks. The DHW product accumulates the instantaneous bleaching heat stress (measured by Coral Bleaching HotSpots) during the most-recent 12-week period. It is directly related to the timing and intensity of coral bleaching. Significant coral bleaching usually occurs when DHW values reach 4 °C-weeks. By the time DHW values reach 8 °C-weeks, widespread bleaching is likely and significant mortality can be expected (NOAA Coral Reef Watch 2019).

Timeframe: 2013-2018, Daily data.

Region/Location: Global.

Sourced from: NOAA Coral Reef Watch (2018).

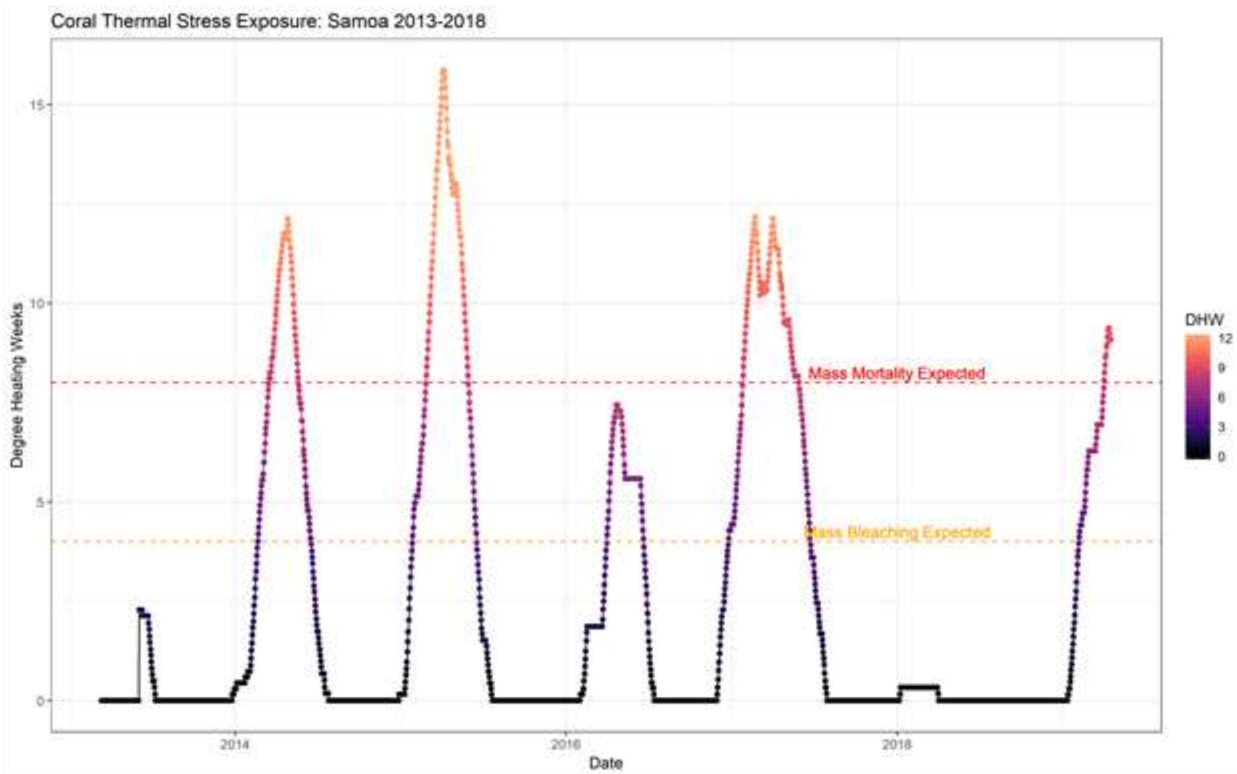


Figure 24. Coral Thermal Stress Exposure measured at Samoa Virtual Station 2013-2018 (Coral Reef Watch Degree Heating Weeks)

2.5.4.8 Chlorophyll-A and Anomaly

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

Status: Annual mean chlorophyll-A was 0.056 mg/m3 in 2018. Over the period of record, annual Chl-A has shown no significant temporal trend. Monthly chlorophyll-A values in 2018 ranged from 0.038-0.079 mg/m3, within the climatological range of 0.032 – 0.082 mg/m3. The annual anomaly was 0.005 mg/m3 higher than average, with some intensification in the southwestern section of the region.

Description: Chlorophyll-A Concentration from 1998-2018, derived from the MODIS Ocean Color sensor aboard the NASA Aqua Satellite. A monthly climatology was generated across the entire period (1982-2018) to provide both a 2018 spatial anomaly, and an anomaly time series.

The following text was inserted from the OceanWatch Central Pacific Node (NOAA 2019a). 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 two 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.

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

Region/Location: Global.

Measurement Platform: *MODIS sensor on NASA Aqua Satellite*

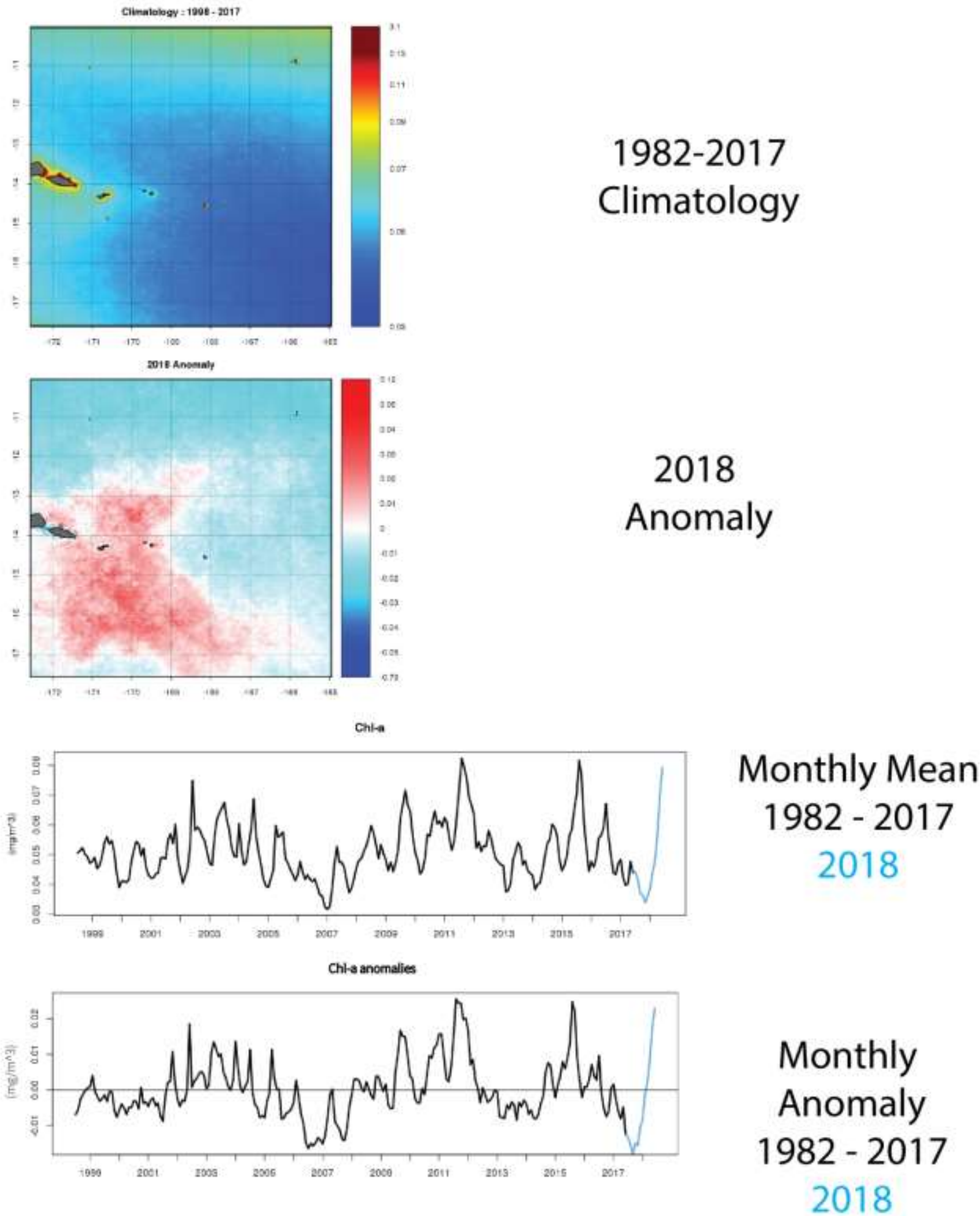


Figure 25. Chlorophyll-A (Chl-A) and Chl-A Anomaly from 1982-2018

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

It is important to note that the input data sources to make these analyses are not constant throughout the period of record. For example, SSM/I (passive microwave - scattering and emission) data became available in July 1987; prior to that the only microwave-derived estimates available are from the MSU algorithm (Spencer1993) which is emission-based thus precipitation estimates are avaialble only over oceanic areas. Furthermore, high temporal resolution IR data from geostationary satellites (every 3-hr) became available during 1986; prior to that, estimates from the OPI technique (Xie and Arkin 1997) are used based on OLR from orbiting satellites.

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

Timeframe: Monthly.

Region/Location: Global.

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

Sourced from: NOAA (2019d).

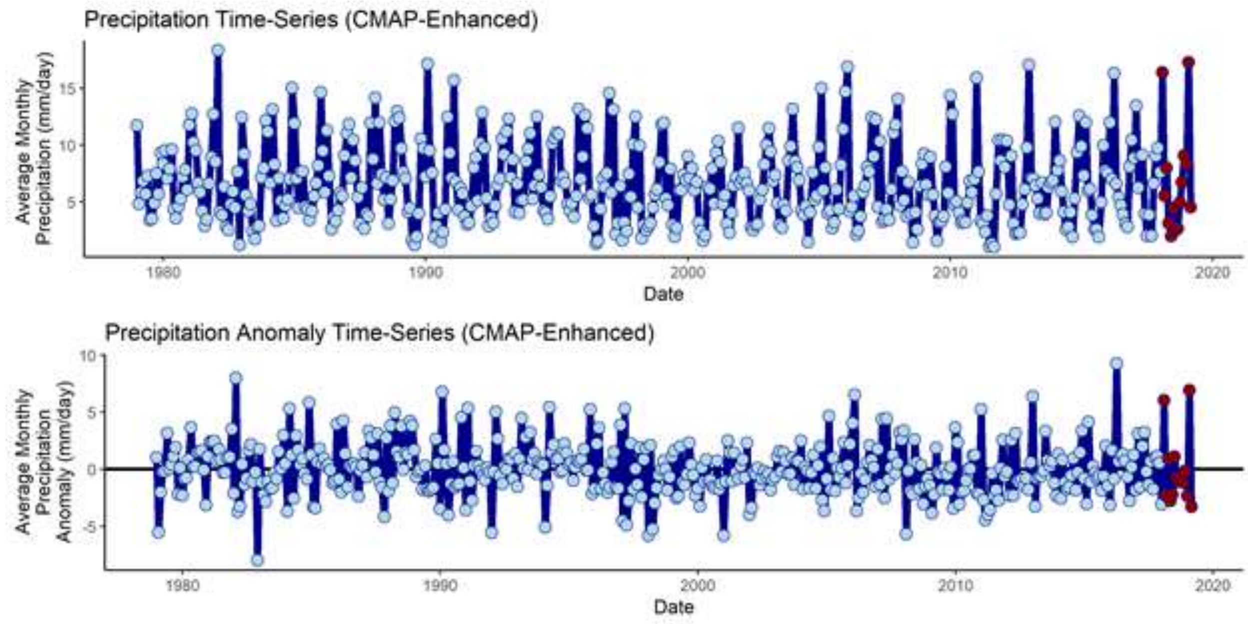


Figure 26. CMAP precipitation across the American Samoa Longline Grid with 2018 values in red

2.5.3.9 Sea Level (Sea Surface Height and Anomaly)

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

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

Timeframe: Monthly.

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

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

Sourced from: Aviso (2019) and NOAA (2018).

2.5.3.9.1 Basin-Wide Perspective

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

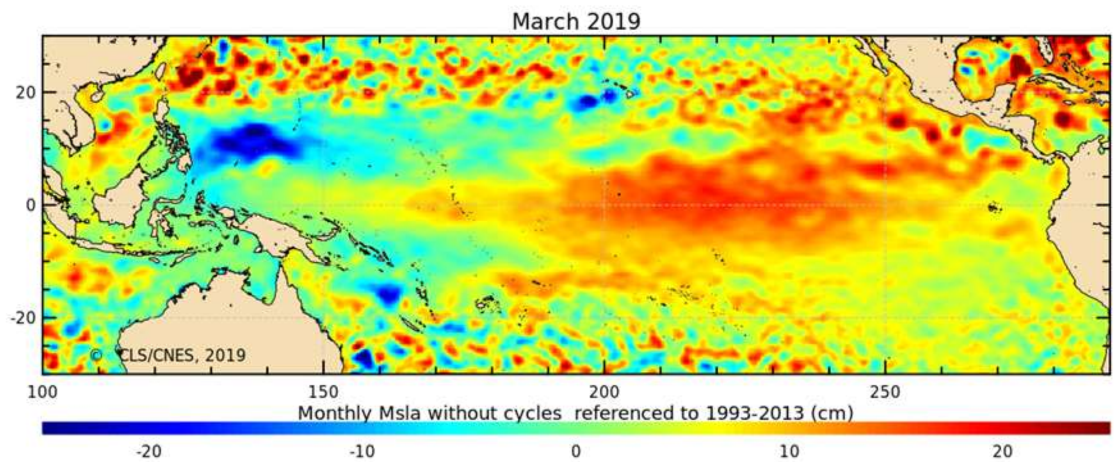


Figure 27a. Sea surface height and anomaly

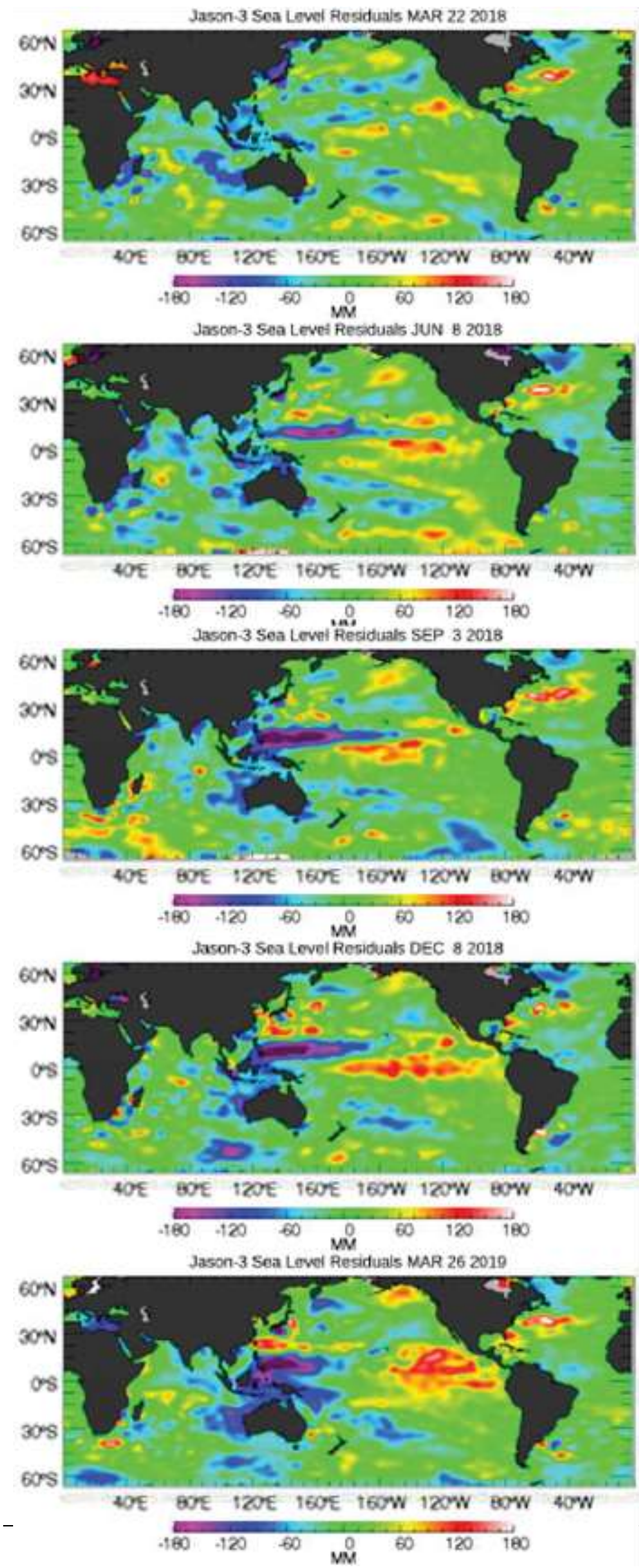
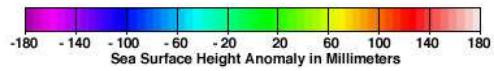


Figure 27b. Quarterly time series of mean sea level anomalies during 2018 show no pattern of El Niño throughout the year according to satellite altimetry measurements of sea level height (unlike 2015).



2.5.3.9.2 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 NOAA (2018). Figure 28 shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS. The calculated trends for all stations are available as a table in millimeters/year and in feet/century. If present, solid vertical lines indicate times of any major earthquakes in the vicinity of the station and dashed vertical lines bracket any periods of questionable data or datum shift.

The monthly extreme water levels include a Mean Sea Level (MSL) trend of 2.21 millimeters/year with a 95% confidence interval of +/- 0.81 millimeters/year based on monthly MSL data from 1948 to 2009 which is equivalent to a change of 0.73 feet in 100 years.

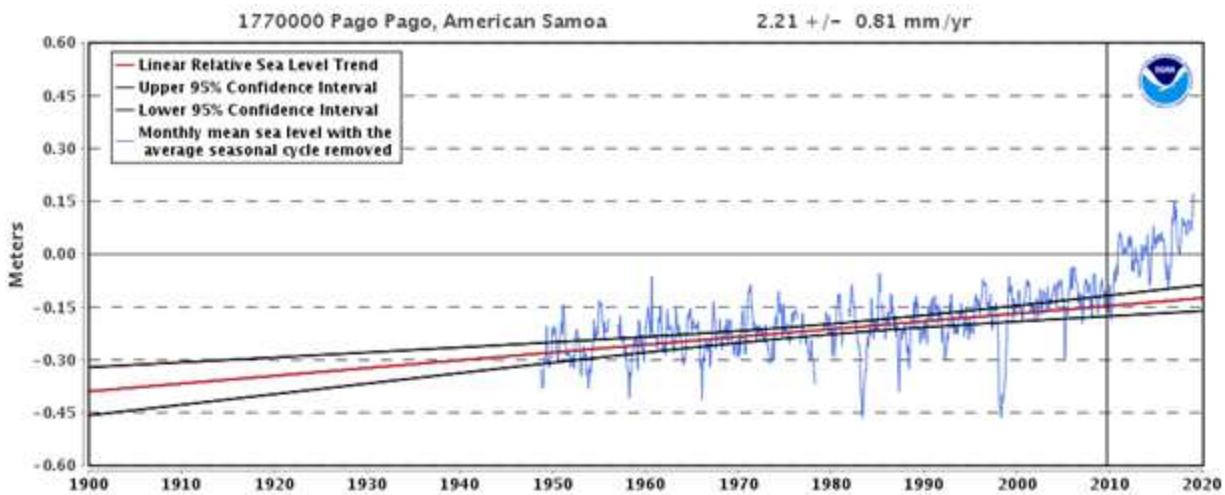


Figure 28. Monthly mean sea level without regular seasonal variability due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents

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2.6 ESSENTIAL FISH HABITAT

2.6.1 Introduction

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

NMFS and regional fishery management councils must describe and identify EFH in 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. Regional fishery manangement 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 that the regional fishery management councilsand NMFS conduct a review and revision of the EFH components of the associated FMPs every five years (600.815(a)(10)). The Council's FEPs state that new EFH information should be reviewed, as necessary, during preparation of the annual reports by the Plan Teams. Additionally, the EFH Final Rule states "Councils should report on their review of EFH information as part of the Annual 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 Council's FMPs include identification and description of EFH, lists of prey species and locations for each managed species, and optionally, HAPC. Impact-oriented components of FMPs include federal fishing activities that may adversely affect EFH; non-federal fishing activities that may adversely affect EFH; non-fishing activities that may adversely affect EFH; conservation and enhancement recommendations; and a cumulative impacts analysis on EFH. The last two components include the research and information needs section, which feeds into the Council's Five Year Research Priorities as well as the EFH update procedure, which is described in the FEP but implemented in the annual 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 American Samoa 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 2.6.4;
- Updated research and information needs, which can be found in Section 2.6.5. These can be used to directly update the FEP; and
- An analysis that distinguishes EFH from all potential habitats used by the species, which is the basis for an options paper for the Council. This part is developed if enough information exists to refine EFH.

2.6.1.2 Habitat Objectives of FEP

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

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

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

At its 174th meeting in October 2018, the Council directed staff to prepare an amendment to the Hawaii FEP to revise the Precious Corals EFH and selected the following preliminarily preferred options for the staff to further analyze:

- Action 1: Option 4 - Revise existing beds and designate new beds as EFH
- Action 2: Option 2 - Update Geographic Extent and Habitat Characteristics
- Action 3: Option 1 - Update the FEPs

The FEP amendment will be presented to the Council at its 178th meeting in June 2019.

2.6.2 Habitat Use by MUS and Trends in Habitat Condition

American Samoa is made up of five high volcanic islands (Tutuila, Aunu'u, Ofu, Olosega, and Ta'u) with fringing reefs, two coral atolls (Rose Atoll or Muliava and Swains Island), and several seamounts and banks. The high islands have surrounding banks where sand can accumulate, in contrast with the Rose and Swains, where slopes plunge steeply to abyssal depths (PIFSC 2011). Tutuila is the largest island in the territory, and has banks (320 sq. km) surrounding the island that extend between one and nine km offshore (PIBHMC) and extends more than three km from shore in most places (PIFSC 2011). The islands of Ofu, Olosega, and Ta'u make up the Manu'a Islands group, which have more limited shallow submerged banks (Figure 29). The nearshore habitat consists of narrow reef flat lagoons and fringing coral reefs (PIFSC 2011). While the five high, volcanic islands are part of the hot-spot chain that also includes the surrounding seamounts of Muli, Vailulu'u, South Bank and independent Samoa, Swains Island is part of the Tokelau hot-spot chain (Neall and Trewick 2008). Rose Atoll's geological origin is not well studied.

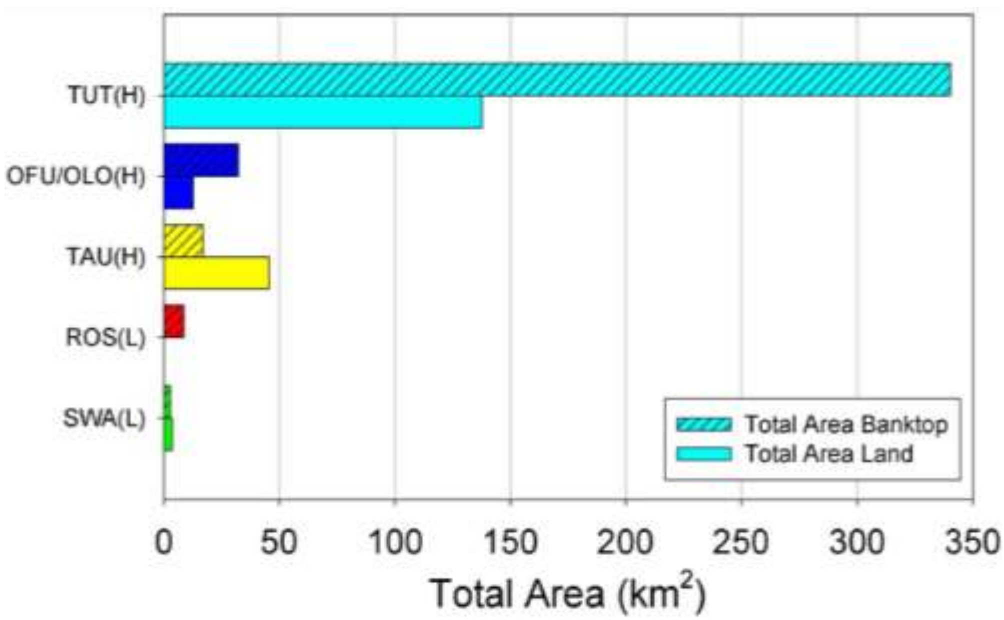

Figure 29. Banktop and terrestrial land area on high (H) or low (L) islands of Tutuila and Aunu'u (TUT), Ofu and Olosega (OFU/OLU), Ta'u (TAU), Rose (ROS), and Swains (SWA)

Essential fish habitat in the Territory of American Samoa for the four MUS comprises all substrate from the shoreline to the 700 m isobath (Figure 30). The entire water column is described as EFH from the shoreline to the 700 m isobath, and the water column to a depth of 400 m is described as EFH from the 700 m isobath to the limit or boundary of the EEZ. While the coral reef ecosystems surrounding the islands in American Samoa have been the subject of a comprehensive monitoring program through the PIFSC Coral Reef Ecosystem Program (CREP), the offshore banks and pelagic environment in which MSA-managed fisheries operate have been less studied. However, American Samoa's Territorial Monitoring Program has been monitoring bleaching in two backreef lagoon pools on Tutuila from December 2003 to present.

The mission of the PIFSC 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). CRED 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.

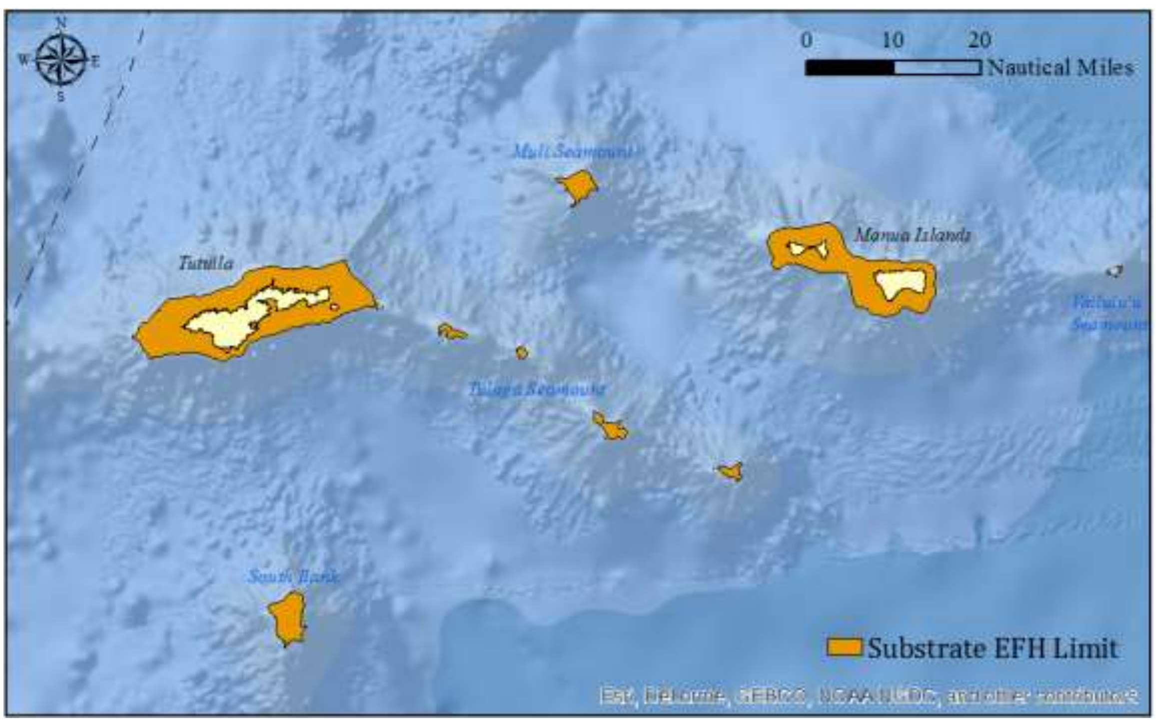

Figure 30. Substrate EFH limit of 700 m isobath around American Samoa (from Ryan et al., 2009)

2.6.2.1 Habitat Mapping

Interpreted IKONOS benthic habitat maps in the 0-30 m depth range have been completed for all islands in American Samoa (CRCP, 2011). Between the PIBHMC and academically collected data, there is nearly 100% multibeam coverage of the territory between 20 and 3000 m depths (PIBHMC).

Table 39. Summary of habitat mapping in American Samoa

Depth Range	Timeframe/Mapping Product	Progress	Source
0-30 m	2000-2010 Bathymetry	39%	DesRochers (2016)
	IKONOS Benthic Habitat Maps	All	NCCOS Data Collections: Territory Benthic Habitat Maps
	2011-2015 Satellite WorldView 2 Bathymetry	1%	DesRochers (2016)
	2011-2015 Multibeam Bathymetry	-	DesRochers (2016)
30-150 m	2000-2010 Bathymetry	97%	DesRochers (2016)
	2011 – 2015 Multibeam Bathymetry	-	DesRochers (2016)
20-3000 m	Multibeam Bathymetry	Nearly 100% coverage	Pacific Islands Benthic Habitat Mapping Center

The land and seafloor area surrounding the islands of American Samoa as well as primary data coverage are reproduced from Miller et al. (2011) in Figure 31.

ISLAND CODE	SWA	TUT	OFU	TAU	ROS	OFF
SHAPE & RELATIVE SIZE						
LAND AREA (km^2)	3	137	13	45	<1	
SEA FLOOR AREA 0-30 m (km^2)	3	51	12	10	8	43*
SEA FLOOR AREA 30-150 m (km^2)	<1	308	23	10	1	
BATHYMETRY 0-30 m (km^2)	<1	22	4	3	3	41*
BATHYMETRY 30-150 m (km^2)	<1	299	23	10	1	
OPTICAL COVERAGE 0-30 m (km)	26	91	42	38	46	0*
OPTICAL COVERAGE 30-150 m (km)	0	77	21	6	0	

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

Figure 31. American Samoa Land and Seafloor Area and Primary Data Coverage (from Miller et al., 2011)

2.6.2.1.1 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 crustaceans 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 300 m isobath to the 700 m isobath (73 FR 70603, November 21, 2008).

Table 40 shows the depths of geologic features, the occurrence of MUS EFH at that feature, and the availability of long-term monitoring data at diving depths.

Table 40. Occurrence of EFH by feature

Feature	Summit Minimum Depth	Coral Reef/Crustaceans (w/o Deepwater Shrimp)	Bottomfish	Deepwater Shrimp	Long Term Monitoring
Tutuila	Emergent	✓	✓	✓	✓
Manu’a Group	Emergent	✓	✓	✓	✓
Swains Island	Emergent	✓	✓	✓	✓
Rose Atoll	Emergent	✓	✓	✓	✓
Muli Seamount	50 m	✓	✓	✓	
Tulaga Seamount		✓	✓	✓	
South Bank		✓	✓	✓	2010 only
Vailulu’u Seamount	580 m			✓	

2.6.2.1.2 RAMP Indicators

Benthic percent cover of coral, macroalgae, and crustose coralline algae from CRED are found in the following tables. CRED 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 one meter above the reef roughly 60 m behind a small boat at a constant speed of about 1.5 kt. Each diver maneuvers a 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 sea stars, sea cucumbers, free and boring urchins, and giant clams). Towed-diver surveys are typically 50 min long and cover about two to three 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 meter 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 2016).

Table 41. Mean percent cover of live coral from RAMP sites collected from towed-diver surveys in American Samoa

Year	2002	2004	2006	2008	2010	2012	2015
Ofu and Olosega	18.1	14.21	17.76	21.21	18.88	31.43	38.4
Rose	26.23	24.2	17.99	17.83	14.45	23.83	27.8
South Bank	-	-	-	-	2.09	-	-
Swains	59.92	32.36	43.91	37.5	31.82	53.13	39.54
Tau	28.39	23.35	19.04	20.22	18.21	29.93	35.22
Tutuila	26.17	18.93	13.52	19.75	18.2	27.55	26.56

Table 42. Mean percent cover of macroalgae from RAMP sites collected from towed-diver surveys in American Samoa

Year	2002	2004	2006	2008	2010	2012	2015
Ofu and Olosega	14.74	24.76	5.35	7.74	4.61	8.64	6.42
Rose	16.1	26.46	5.99	16.86	12.67	18.52	25.13
South Bank	-	-	-	-	26.25	-	-
Swains	14.6	26.69	36.07	30.44	23.8	27.45	26.69
Tau	12.43	30.14	9.15	7.5	4.12	5.8	5.59
Tutuila	12.71	32.38	10.24	10.49	7.25	9.17	11.54

Table 43. Mean percent cover of crustose coralline algae from RAMP sites collected from towed-diver surveys in American Samoa

Year	2002	2004	2006	2008	2010	2012	2015
Ofu and Olosega	38.13	41.58	42.97	37.93	19.86	24.34	30.05
Rose	35.4	43.13	47.45	42.74	59.12	55.44	50.53
South Bank	-	-	-	-	1.76	-	-
Swains	15.29	30.48	19.4	17.08	22.76	24.61	17.08
Tau	31.83	21.46	27.7	29.38	19.72	20.88	25.25
Tutuila	17.46	28.23	17.09	25.25	17.58	16.94	18.2

2.6.2.2 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, 150 m; and bottomfish, 400 m. Please see the Ecosystem and Climate Change section (Section 2.3) 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 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.

Levels of EFH Information are presented in this section first with databases that include observations of multiple species, separated by depth, and then by current or former MUS grouping.

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

2.6.4.1 Precious Corals

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. EFH was not designated in American Samoa. There has been very little survey effort to identify precious corals in the management area of the American Samoa FEP.

Table 44. Level of EFH information available for Western Pacific PCMUS from Hawaii

Species	Pelagic phase	Benthic phase	Source(s)
Pink Coral (*Corallium)*			
Pleurocorallium secundum (prev. *Corallium secundum)*	0	1	Figueroa and Baco (2014) HURL Database
C. regale	0	1	HURL Database
Hemicorallium laauense (prev. C. laauense)	0	1	HURL Database
Gold Coral			
Kulamanamana haumeaae	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 45. Level of EFH information available for Western Pacific BMUS and seamount groundfish MUS

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

Life History Stage	Eggs	Larvae	Juvenile	Adult
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
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 46. Level of EFH information available for CMUS

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 that are needed to more effectively address the EFH provisions:

2.6.5.1 All FMP Fisheries

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

2.6.5.2 Bottomfish Fishery

- Inventory of marine habitats in the EEZ of the Western Pacific region
- Data to obtain a better SPR estimate for American Samoa's bottomfish complex
- Baseline (virgin stock) parameters (CPUE, percent immature) for the Guam/CNMI 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 Corals Fishery

- Distribution, abundance, and status of precious corals in American Samoa

2.6.6 References

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2.7 MARINE PLANNING

2.7.1 Introduction

Marine planning is a science-based management tool being utilized regionally, nationally and globally to identify and address issues of multiple human uses, ecosystem health and cumulative impacts in the coastal and ocean environment. The Council's efforts to formalize incorporation of marine planning in its actions began in response to Executive Order (EO) 13547, Stewardship of the Ocean, Our Coasts, and the Great Lakes. EO 13158, Marine Protected Areas (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, Hawaii, 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; and
d. As needed, periodically evaluate the management effectiveness of existing spatial-based fishing zones in Federal waters.

To monitor implementation of this objective, this annual report includes the Council's spatially-based fishing restrictions or MMAs, the goals associated with those, and the most recent evaluation. Council research needs are identified and prioritized through the Five Year Research Priorities and other processes, and are not tracked in this report.

To meet the EFH and National Environmental Policy Act (NEPA) mandates, this annual report tracks activities that occur in the ocean that are of interest to the Council, and incidents or facilities that may contribute to cumulative impact. 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

At its 147th meeting in March 2010, the Council recommended a no-take area from 0-12 nautical miles around Rose Atoll Marine National Monument (MNM) with the Council to review the no-take regulations after three years. The most recent review took place in 2013, with the subsequent review slated for 2016. PIRO received no requests for non-commercial permits to fish within the Rose Atoll MNM. Further, inquiries in American Samoa showed that there was no indication that the 12 nm closure around Rose Atoll MNM has been limiting fishing. Thus there is no interest to fish within the monument boundaries. The Pelagics Plan Team deferred decision on Rose Atoll in May 2017 until after the Administration reviews to make any decision on the monument provisions. At its 172nd meeting in March 2018, the Council requested that NOAA and USFWS provide a report to the Council at its following meeting to review resultant benefits to fish populations, protected species, and coral reef, deep-slope, and pelagic ecosystems from the establishment of the Rose MNM. USFWS presented thise report to the Council at its 173rd meeting in June 2018, from which no recommendations were generated.

At its 162nd meeting in March 2015, the Council recommended a regulatory amendment for the temporary exemption to the Large Vessel Protected Area (LVPA) by American Samoa longline limited entry permitted vessels greater than 50 ft. in length. The Council will review the LVPA exemption on an annual basis with regards, but not limited to; catch rates of fishery participants; small vessel participation; and fisheries development initiatives. The LVPA regulations have been vacated through legal action, and subsequent Council action is further described below.

At its 173rd meeting in June 2018, regarding the LVPA applicable to the American Samoa limited entry vessels, the Council:

- Recognized the LVPA rule has led to disagreement within the American Samoa fishing community and was the subject of litigation. The Council noted that last year's court decision requires the consideration and protection of American Samoa cultural fishing. To this end, the Council requested PIFSC conduct research on American Samoa cultural fishing practices to facilitate understanding and potential impacts of opening some restricted fishing areas within the US EEZ for American Samoa vessels that primarily target albacore. PIFSC presented the results of this research at the Council's 172nd meeting in March 2018, which indicate that all fishing in American Samoa has cultural importance, whether commercial longline, commercial alia vessels, troll or other fishing sectors, because catch from all locally-based fishing sectors flows into the American Samoa community for cultural purposes.

- Did not receive a response from the American Samoa government to its request for an option that would address its concern over the proposed action. The Council received one response from the American Samoa government in October 2017 that Council member Henry Sesepasara is the point of contact on cultural fishing, but did not receive responses to the Council's requests to consult with the American Samoa government on cultural fishing on July 6 and November 17, 2017.
- Recommended a regulatory amendment to provide a four-year exemption for vessels permitted under the American Samoa longline limited entry program to fish within the LVPA seaward of:
    - 12 nm around Tutuila;
    - 12 nm around Manua;
    - 12 nm around Swains; and
    - 2 nm around the offshore banks.
- Recommended annual monitoring of the American Samoa longline and troll catch rates, small vessel participation, and local fisheries development.

Also at its 173rd meeting, the Council directed staff to investigate whether harbor vulnerability studies have been conducted in the Western Pacific region, and if they are lacking, write to the appropriate federal and or/local agencies requesting that the studies be conducted. Efforts on this recommendation are ongoing.

2.7.3 Marine Managed Areas established under FEPs

Council-established marine managed areas (MMAs) were compiled in

Table 47 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. All regulated fishing areas and large MMAs, including Rose Atoll Marine National Monument, are shown in Figure 32.

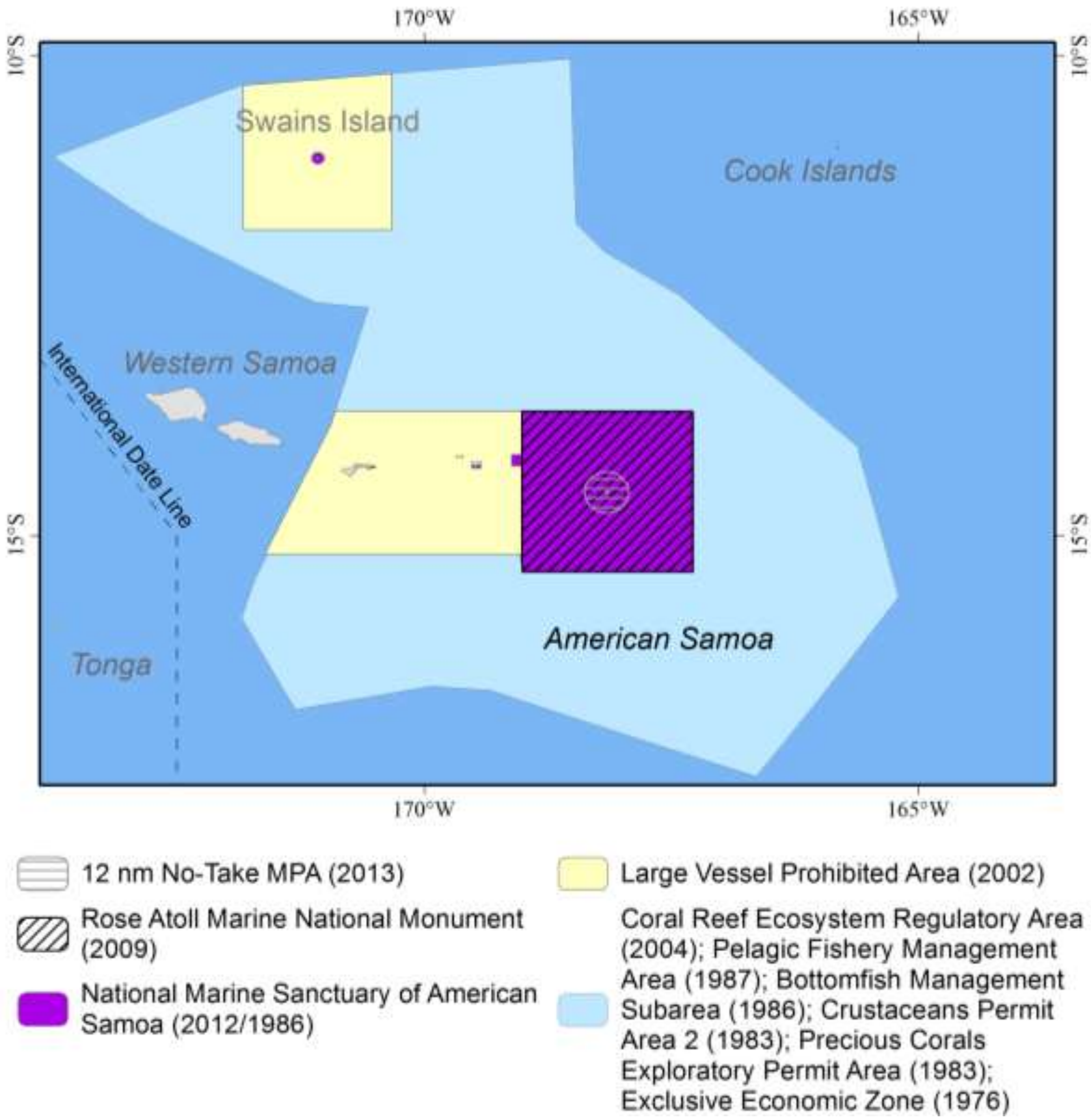

Figure 32. Regulated fishing areas of American Samoa

Table 47. MMAs established under FEPs from 50 CFR § 665

Name	FEP	Island	50 CFR / FR / Amendment Reference	Marine (km^2) Area	Fishing Restriction	Goals	Most Recent Evaluation	Review Deadline
Large Vessel Prohibited Area	Pelagic (American Samoa)	Tutuila, Manu'a, and Rose Atoll	665.806 (b)(1) 81 FR 5619	74,857.32	Vessels ≥ 50 ft. prohibited	Prevent gear conflict with smaller alia vessels; longline vessels >50 ft. exempted from 12 to 50 nm to improve the viability of the American Samoa longline fishery and achieve optimum yield from the fishery while preventing overfishing	Jan 29, 2016	-
Large Vessel Prohibited Area	Pelagic (American Samoa)	Swains Island	665.806 (b)(2) 81 FR 5619 Pelagic FEP	28,352.17	Vessels ≥ 50 ft. prohibited	Prevent gear conflict with smaller alia vessels; longline vessels over 50 ft. exempted between 12 and 50 nm due to improve the viability of the American Samoa longline fishery and achieve optimum yield from the fishery while preventing overfishing	Jan 29, 2016	-

Name	FEP	Island	50 CFR / FR / Amendment Reference	Marine (km^2) Area	Fishing Restriction	Goals	Most Recent Evaluation	Review Deadline
Rose Atoll No-Take MPA/Rose Atoll Marine National Monument	American Samoa Archipelago/ Pelagic	Rose Atoll	665.99 and 665.799(a)(2) 69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 American Samoa FEP Am. 3	-	All Take Prohibited	Minimize adverse human impacts on coral reef resources; commercial fishing prohibited within 12 nmi	June 3, 2013	June 3, 2016 (PPT deferred in 2017; Council took no action in 2018)

2.7.4 Fishing Activities and Facilities

There are no aquaculture activities occurring in the waters of American Samoa at this time.

2.7.5 Non-Fishing Activities and Facilities

There are no alternative energy facilities or military training and testing activities occurring in the Federal or territorial waters of American Samoa at this time. The Plan Team will add to this section as new facilities are proposed and/or built.

2.7.6 Pacific Islands Regional Planning Body Report

The Council was a member of the Pacific Islands RPB and as such, the interests of the Council were incorporated into the 2018 American Samoa Ocean Plan (ASOP). The ASOP was finalized in December 2018, and includes two goals: 1) healthy ocean and coastal ecosystems, and 2) sustainable ocean and coastal uses. Objectives, actions, and tasks are associated with each goal. The Council is a partner on several tasks in the ASOP. It provided valuable input as a partner on the American Samoa Ocean Planning Team during development of the ASOP. The ASOP can be found on the American Samoa Department of Commerce's website: http://doc.as.gov/official-release-american-samoa-ocean-plan-2018/.

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

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

2.7.7 References

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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. The archipelagic fisheries group developed nearly 30 potential fishery ecosystem relationships 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.

Brief introductory analyses, presented in this section and initially introduced in the 2017 report, were intended to be "proof of concept" such that similar evaluations could be carried out on remaining fishery data for American Samoa in the future. However, the Fishery Ecosystem Plan Team determined that the quantitative analyses were not sufficient to act as a model for future evaluations. Using the direction from the Plan Team, the data integration module was updated for the Hawaii Archipelagic Annual SAFE Report, but each of the remaining archipelagic reports still contain data integration assessments from 2017. The Annual SAFE Report for the Mariana Archipelago will be updated in the following year similar to the Annual SAFE Report for the Hawaii Archipelago pending PPT approval.

Going forward, relationships deemed potentially relevant will be emphasized and recommended for further analysis. In subsequent years, this chapter will be updated with these analyses through the SAFE report process as the strength of certain fishery ecosystem relationships relevant to advancing ecosystem-based fishery management are determined.

To begin, this chapter described feedback from the Plan Team, SSC, and Council members on the initial drafts of the data integration module. Next, the chapter includes 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 evaluation by participants of the Workshop using current data streams from American Samoa. The evaluations completed were exploratory in nature, being the first step of analyses to know which comparisons may be more useful to focus on going forward.

Going forward with the analyses and presentation of results for the data integration chapter of the American Samoa Annual SAFE Report, 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. Many of these recommendations were applied to datasets from Hawaii in 2018, and will similarly be done for American Samoa data integration analyses in the upcoming report cycles. Implementation of these suggestions will allow for the preparation of a more finalized version of the data integration chapter in the coming report cycles.

3.1.2 2018 Recommendations and Direction for Chapter Development

At the FEP Team Meeting held on April 30th and 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;
- There should be additional phase lag implemented in the analyses;
- Local knowledge of fishery dynamics, especially pertaining to shifting gear preferences, should be utilized. Changes in dynamics that may have impacted observed fishery trends over the course of available time series, both discreetly and long-term for taxa-specific and general changes should be emphasized; and
- Spatial specificity and precision should be increased for analyses of environmental variables in relation to areas commonly fished.

The analyses presented in the data integration chapter of the 2018 Hawaii Annual SAFE Report are a reflection of a thoughtful re-approaching to these data integration evaluations based on this feedback. Additional data can be added to either time series as they are made available. Incorporating such recommendations into the 2018 version of the American Samoa 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.

3.2 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 2.5.4). The evaluation of environmental variables showed that certain climate parameters (e.g. SST anomaly, sea level height, precipitation, and tropical storm days) are likely linked to fishery performance. It 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).

3.3 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 2.5.4). 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). Future work will utilize time series of SST described in Section 2.5.4in hopes of better integrating analyses that have already been completed as well as avoiding redundant effort. Available catch and effort data streams were supplied from creel surveys completed by the American Samoa Department of Marine and Wildlife and submitted for organization by WPacFIN. These surveys, while not able to entirely capture the noncommercial aspect of reef fisheries in the WPR, represent the best data available for these sorts of analyses. Efforts are being made to improve information streams in data-poor fisheries across the U.S. Western Pacific.

A time series of SST for American Samoa from 1989-2016 is shown in Figure 33. The SST for American Samoa over this period had relatively little variability (CV = 1.15). SST has been seemingly increasing over the course of available data, though its variability appeared to be decreasing in the last decade. This decrease followed the hottest observed temperatures in the last three decades at just over 29°C in 2005. The lowest recorded SST over the course of the time series was approximately 28°C in the first year of evaluated data.

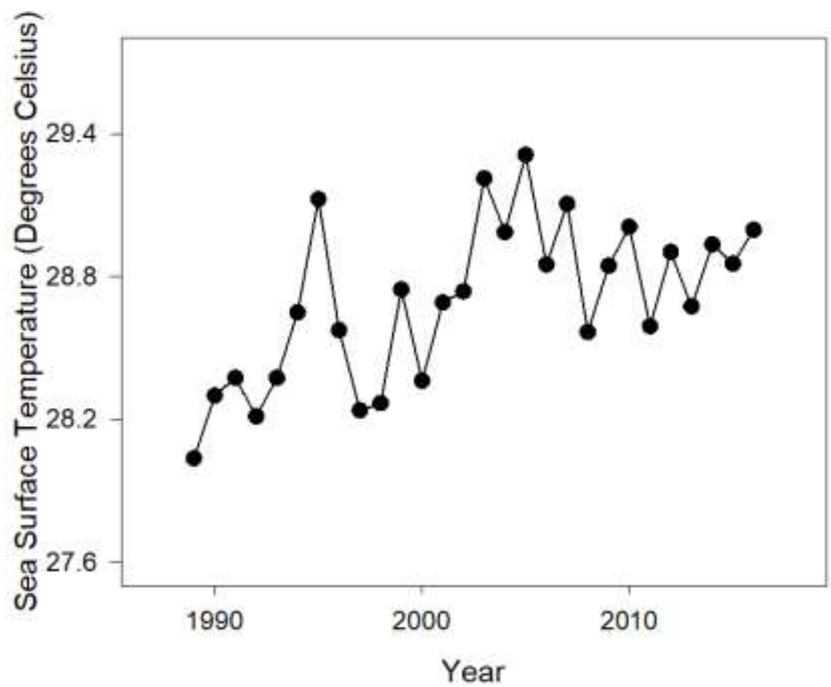

Figure 33. Average annual SST (°C) in American Samoa from 1985-2016 (CV = 1.15)

3.3.1 Evaluating relationship for entire recreational reef fishery

Figure 34 shows a plot depicting the relationship between SST and catch time series for the recreational coral reef fishery in American Samoa from 1989-2016. Landings were notably variable over the course of the time series (CV = 91.4), likely attributed to a large multi-year inflation in catch from 1993 to 2000. Total annual catch in the fishery had been observably decreasing over the last decade despite following an abrupt maximum in the late 1990s (~965,000 lbs.). Recent recorded catch levels (i.e. 2016) are among the lowest for the fishery through the available time series of data (~105,000 lbs.; Figure 34).

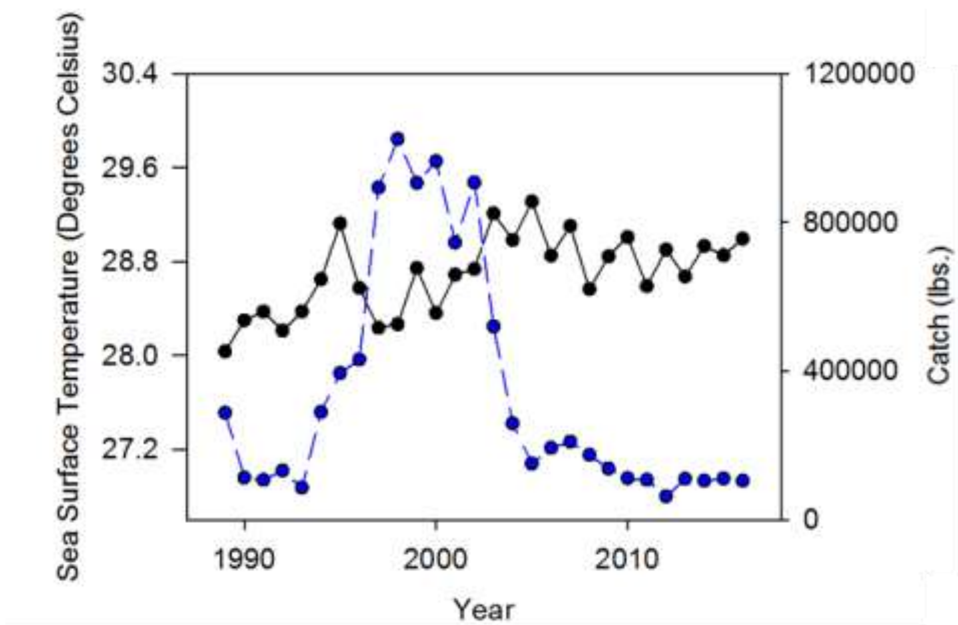

Figure 34. Total annual catch (lbs.; blue) for the American Samoa recreational coral reef fishery plotted with average annual SST (°C; black) from 1989-2016

In performing comparisons between fishery parameters and environmental variables such as SST, data were grouped into categories based on family due to data scarcity for species-level analyses in many cases. Table 48 displays the different dominant family groups considered in this evaluation alongside their common names. Note that because fishery performance with respect to participation/effort has not changed in large amounts over the past three decades, analyzing the only species-level information available in terms of creel survey catch can give some indication as to the potential for a fishery ecosystem relationship.

Table 48. Families recorded in creel survey data in the U.S. Western Pacific evaluated in these analyses

Four-letter code	Family	Common Name
LUTJ	Lutjanidae	snappers
LETH	Lethrinidae	emperors
CARA	Carangidae	jacks/mackerel/trevally
ACAN	Acanthuridae	unicornfish/tang
SERR	Serranidae	Sea bass/grouper
SIGA	Siganidae	rabbitfish
SCAR	Scaridae	parrotfish
MULL	Mullidae	goatfish
MUGI	Mugilidae	mullet
LABR	Labridae	wrasse
HOLO	Holocentridae	squirrelfish/soldierfish
BALI	Balistidae	triggerfish

Linear regressions and correlation analyses on time series of recreational coral reef fishery catch and annual mean SST from American Samoa were performed (Table 49). Assessments measuring this potential relationship for the entirety of the recreational coral reef fishery catch in American Samoa showed no general relationship between 1989 and 2016 ($R^2 = 0.06$, $p = 0.20$; Table 49; Figure 35). The observed association between the two parameters appeared to associate negatively over time despite the lack of a statistically significant trend (Figure 35).

Table 49. Correlation coefficients (*r*) between recreational coral reef fishery catch (lbs.) and SST (°C) in American Samoa for 12 taxa harvested from 1989-2016; significant correlations are indicated in bold (α=0.05)

Taxa Code	Total Catch	LUTJ	LETH	CARA	ACAN	SERR	SIGA	SCAR	MULL	MUGI	LABR	HOLO	BALI
n = 24													
p	0.20	0.43	0.24	0.96	0.052	0.30	0.78	**0.02**	**0.03**	0.22	0.78	0.15	0.17
r	-0.25	0.17	0.25	0.01	-0.40	-0.22	-0.06	**-0.47**	**0.44**	0.26	-0.06	-0.30	0.29
R^2	0.06	0.03	0.06	0.00	0.16	0.05	0.00	**0.22**	**0.19**	0.07	0.00	0.09	0.09

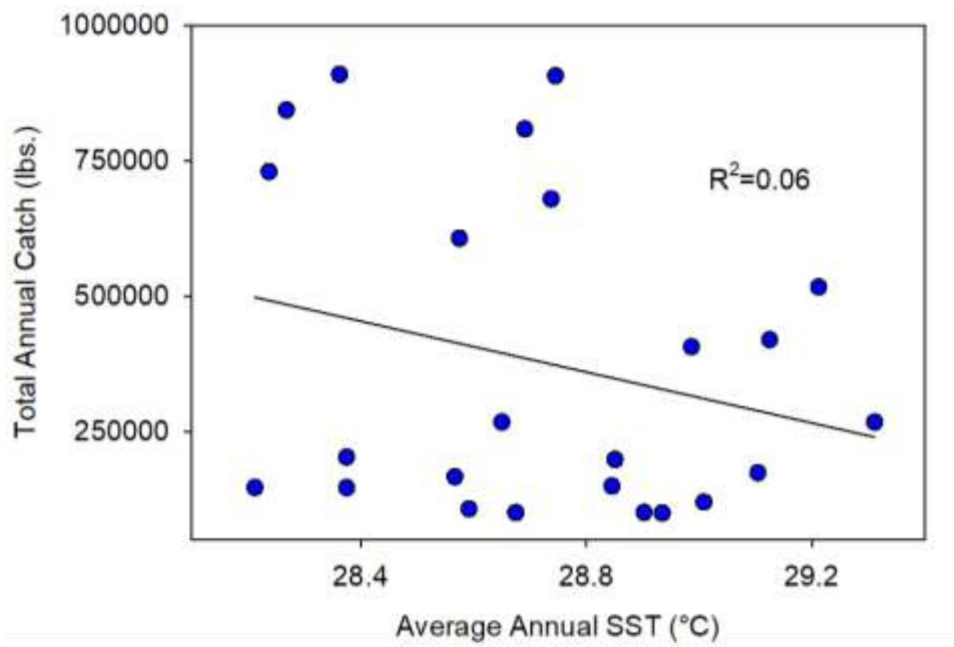

Figure 35. Linear regression showing the correlation between total annual catch (lbs.) for the recreational coral reef fishery and average annual sea surface temperature (°C) in American Samoa from 1989-2016

3.3.2 Evaluating relationships for dominant taxa

Similar linear regressions were performed for the time series of SST with catch for dominant family groups in American Samoa as well, and it was found that two of the 12 evaluated families had statistically significant relationships with average annual temperature in the surface waters surrounding the archipelago (Table 49). The strongest relationship observed was between SST and annual Scaridae catch and negative, where the regression suggested that for every degree Celsius of temperature increase, catch would decrease by approximately 5,000 lbs. ($R^2 = 0.22$, $p = 0.02$; Table 49; Figure 36a). Note that because participation statistics could not be taken into consideration for these types of analyses on a family- and gear-specific level, it is always possible that changes in catch could be reflective of changes in effort over time that could not be observed in the available data. This section will be updated with more integrated forms of analysis in upcoming years as resources allow.

The next strongest association observed was for the Mullidae family, which was shown to have catch levels with positive statistical significance to SST such that every increase in one degree Celsius would hypothetically increase annual catch by less than 100 lbs. (~67 lbs.; $R^2 = 0.19$, $p = 0.03$; Table 49; Figure 36b) The third strongest fishery ecosystem relationship identified in this region between catch and SST was for the Acanthurids, which fell short of the threshold of significance by 0.002 (R^2=0.16, p=0.052; Table 49; Figure 36c). Despite the narrow miss for statistical significance at the $\alpha = 0.05$ level, the generated regression equation suggested that landings of this family would decrease by almost ~10,000 lbs. for every 1°C increase temperature.

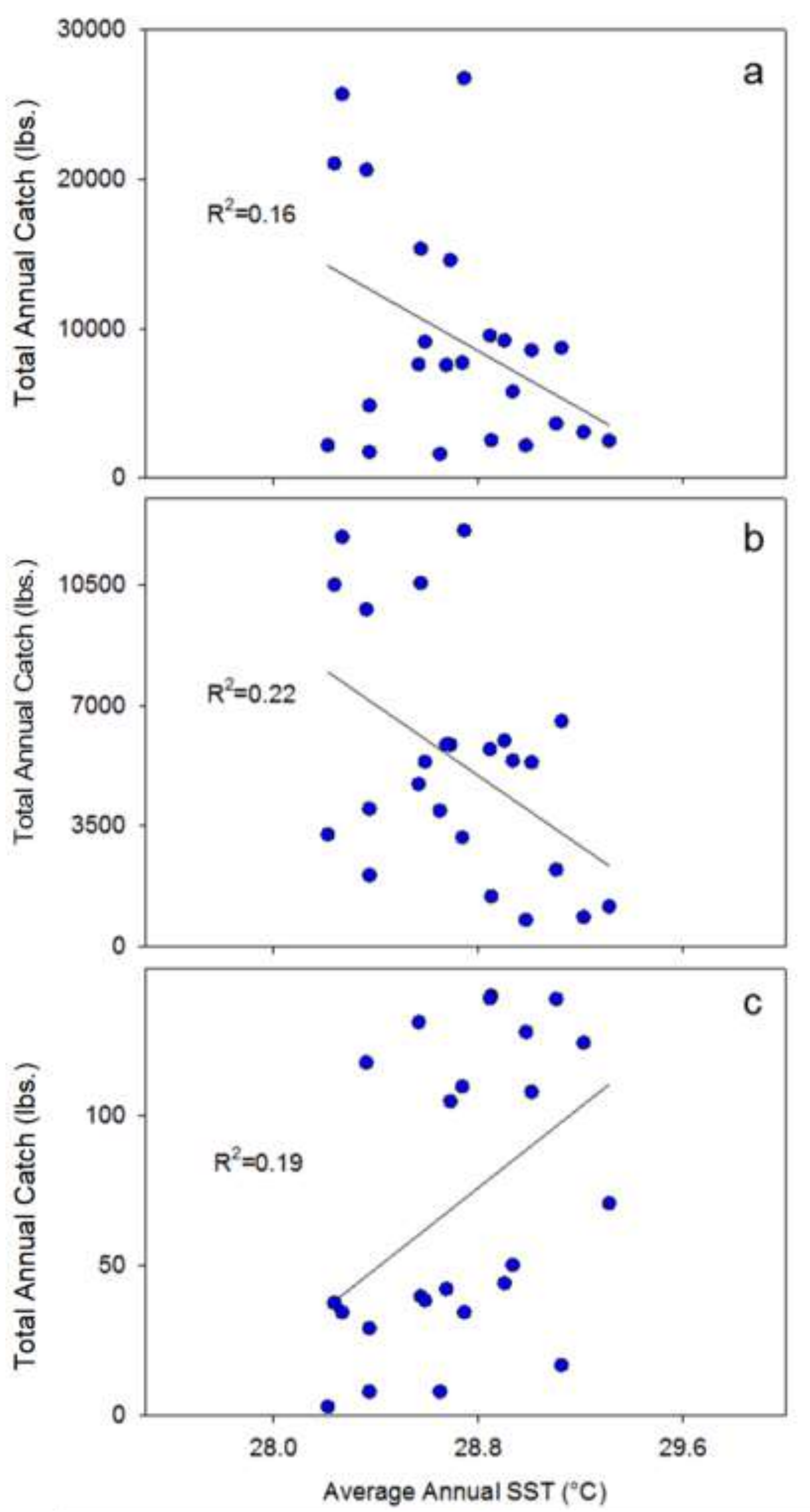

Figure 36. Linear regressions showing the three top correlations between total annual catch (lbs.) for the recreational coral reef fishery and average annual SST (°C) in American Samoa for (a) Acanthurids, (b) Scarids, and (c) Mullids from 1989-2016

3.4 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 physio-chemistry 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 ESA Ocean Colour Climate Change Initiative dataset version 3.1.

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 interdecadal 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.

Time series of fluorometric chlorophyll-*a* concentrations (mg/m^3) from 1998 to 2016 in American Samoa is shown in Figure 37. The chlorophyll levels had relatively low variability over the course of evaluated data (CV = 4.90; Figure 37). Local chlorophyll-*a* concentrations appeared to be increasing over the course of the time series, despite the non-significant nature of the trend. Given the 17 available years of data, the average chlorophyll-*a* concentration was 0.039 mg/m^3, and the lowest recorded level was seen at the inception of the time series in 2005 at 0.036 mg/m^3 (Figure 37).

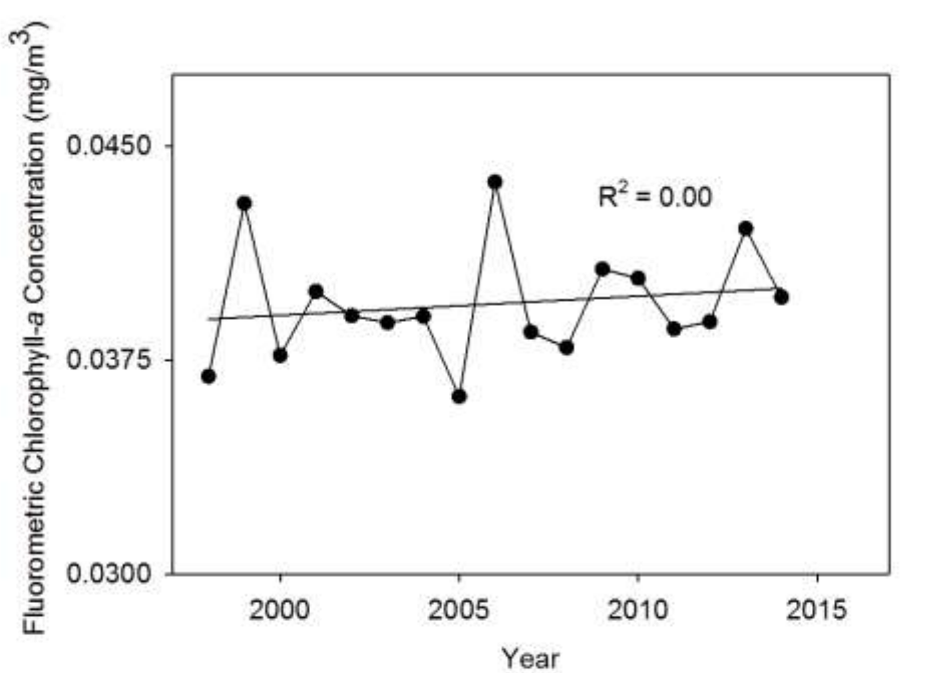

Figure 37. Fluorometric chlorophyll-a concentrations (mg/m^3) from 1998–2016 (CV = 4.90)

3.4.1 Evaluating relationship for entire recreational reef fishery

A comparison plot depicting the relationship between chlorophyll-*a* concentrations and catch time series gathered through creel surveys measuring American Samoa's recreational coral reef fishery from 1998 to 2014 is depicted in Figure 43. Catch for this region was relatively variable (CV=91.6) likely due to a large spike seen at the beginning of evaluated data in the early 2000s. Despite the abrupt maximum in 1998 (>1 million lbs.), total annual catch for the noncommercial reef fishery in American Samoa has been in decline through recent years. Current recorded catch levels (i.e. averaged over 2014 to 2016) are among the lowest for the fishery through the available time series of data (less than 100,000 lbs.; Figure 38).

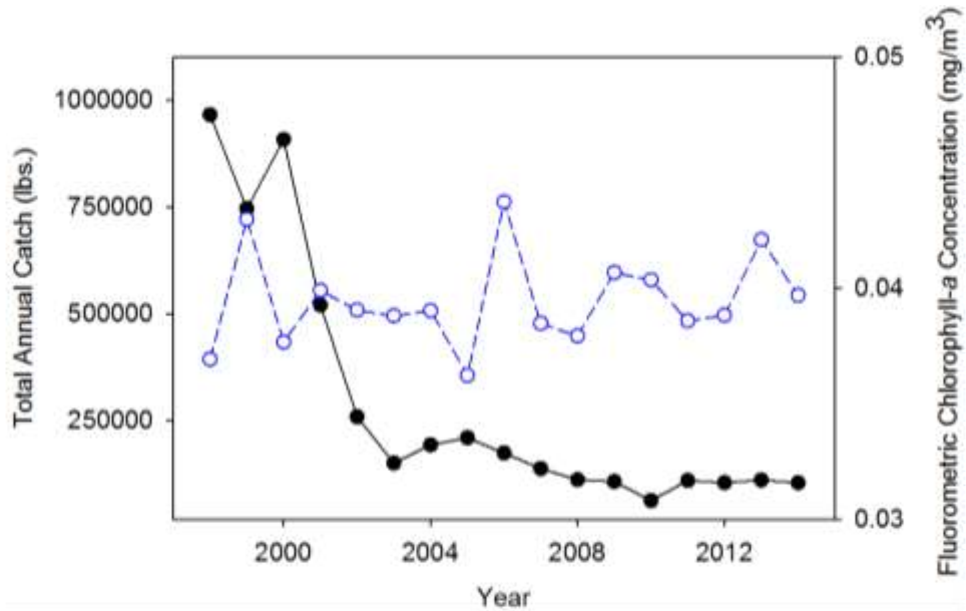

Figure 38. Comparison of American Samoa recreational reef fish catch (lbs.; black) and chlorophyll-*a* concentrations (mg/m^3; blue) from 1998 – 2014 and two years of time lag

The linear regressions performed between noncommercial reef catch in American Samoa and fluorometric chlorophyll-*a* concentrations (mg/m^3) are shown in Figure 39. The chlorophyll-*a* concentrations and total annual catch for the all harvested taxa in the American Samoa noncommercial reef fishery had a negative relationship, but the association was not statistically significant to warrant further analysis especially with such a short time series of available data (r = -0.15, p = 0.57; Table 50; Figure 39). Several outliers in catch (from 1998 to 2001, the beginning of available primary productivity information) aided in complicating evaluation of the relationship between the parameters.

Table 50. Correlation coefficients (*r*) from comparisons of time series of American Samoa recreational coral reef fishery annual catch (lbs.) and fluorometric chlorophyll-*a* concentrations (mg/m^3) for 12 top taxa harvested from 1998–2014

Taxa Code	Total Catch	LUTJ	LETH	CARA	ACAN	SERR	SIGA	SCAR	MULL	MUGI	LABR	HOLO	BALI
n = 17													
p	0.57	0.25	0.29	0.62	0.28	0.99	0.17	0.54	0.82	0.65	0.37	0.13	0.09
r	-0.15	0.32	0.27	-0.13	-0.28	0.00	0.35	-0.16	0.06	0.12	-0.23	-0.38	-0.42
R^2	0.02	0.10	0.08	0.02	0.08	0.00	0.12	0.03	0.00	0.01	0.05	0.14	0.18

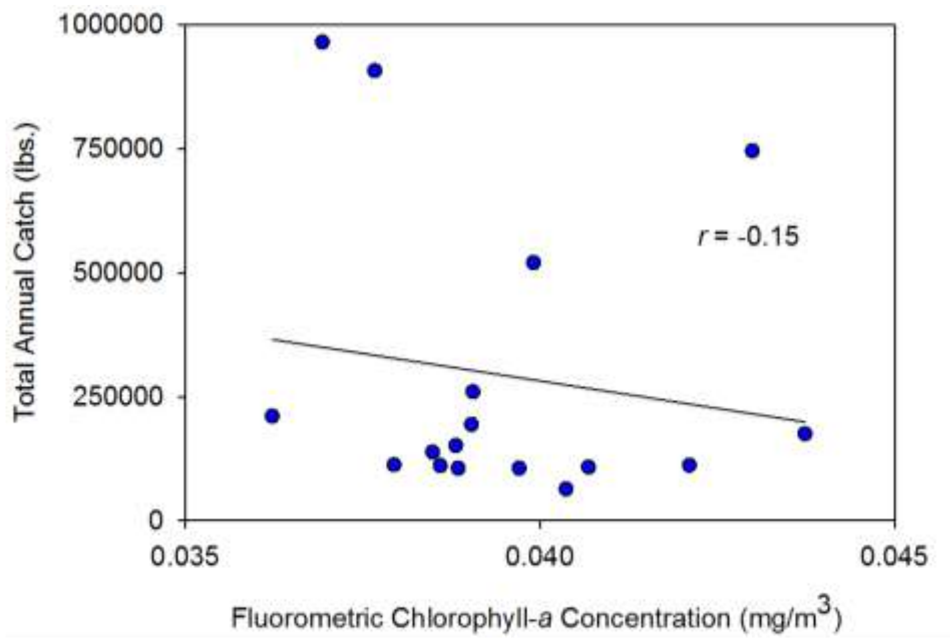

Figure 39. Linear regression showing between total annual catch (lbs.) for the American Samoa recreational coral reef fishery with phase lag (t+2 years) and fluorometric chlorophyll-*a* concentrations (mg/m^3) from 1998-2014

3.4.2 Evaluating relationships with dominant taxa

After performing similar comparison analyses on the catch time series of the evaluated taxa for American Samoa, it was discovered that zero of the 12 displayed a statistically significant relationship with fluorometric chlorophyll-*a* concentrations in the area (Table 50). The strongest associations identified, though non-significant, were between estimated pigment levels and the catch time series of the Lutjanids ($R^2 = 0.10$; $p = 0.25$), Holocentrids ($R^2 = 0.10$; $p = 0.25$), and Acanthurids ($R^2 = 0.08$; $p = 0.28$); the relationships for Holocentridae and Acanthuridae were trending negative despite the lack of statistical significance (Table 50; Figure 40a-c).

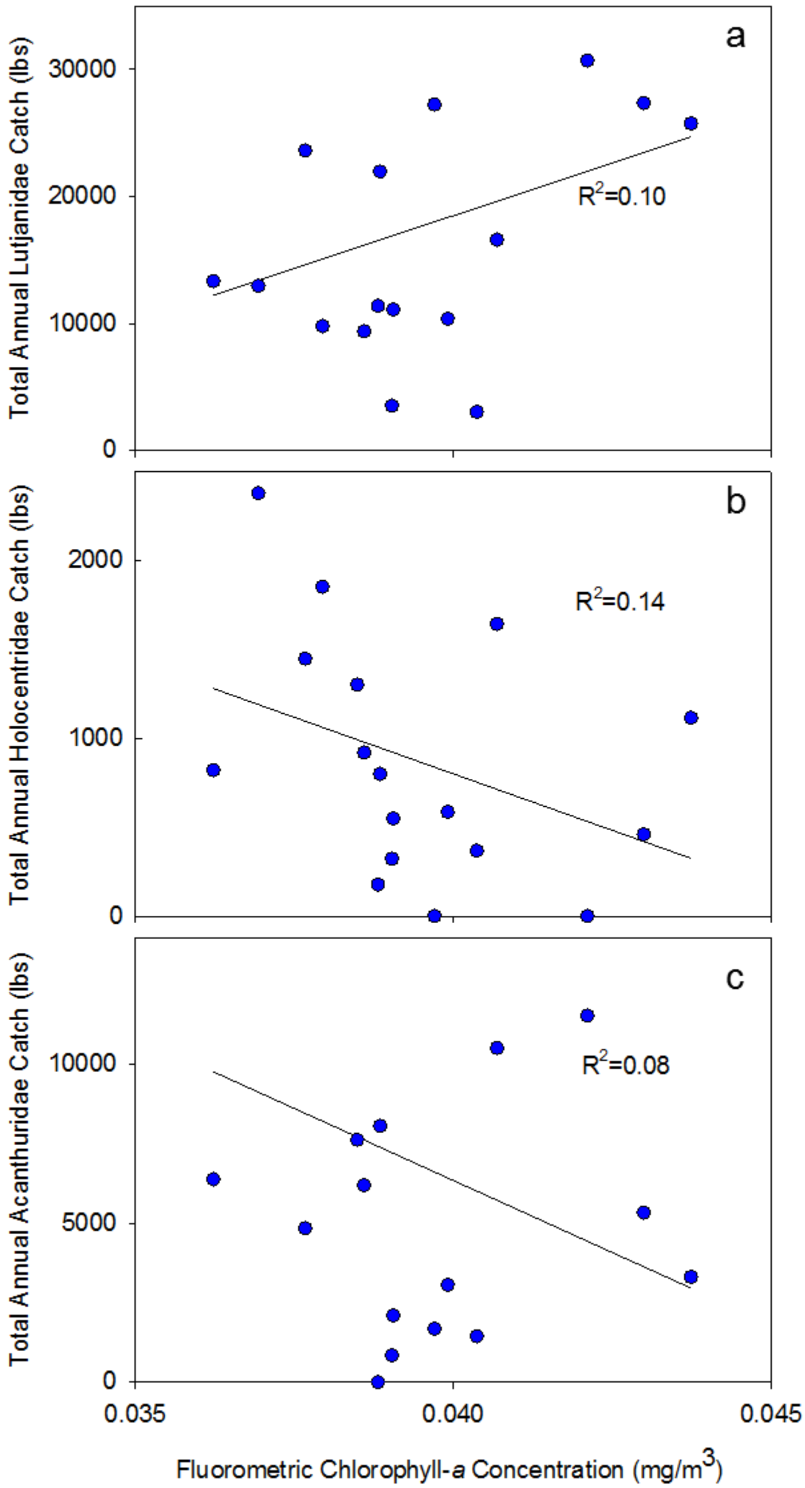

Figure 40. Linear regressions showing three correlations between total annual catch (lbs.) for the American Samoa recreational coral reef fishery and fluorometric chlorophyll-*a* concentrations (mg/m^3) for (a) Lutjanids, (b) Holocentrids, and (c) Acanthurids from 1998–2014 with phase lag (t+2 years)

3.5 MULTIVARIATE ASSESSMENTS OF ADDITIONAL ENVIRONMENTAL 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 2.5.4. 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 heterogenous 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 American Samoa test, data from 12 families from 1989-2014 (26 years) were included along with eight variables of environmental data collected during the same time period.

The resulting ordination scores from the NMS analysis performed on boat-based expanded creel survey catch records and the previously mentioned environmental parameters selected two completely orthogonal ordination axes in the final solution, accounting for 94.7% of variance observed in the American Samoa boat-based creel survey data (Figure 41). The NMS final stress was low for the real runs (8.05) relative to stress from the randomization runs (15.1), suggesting interpretable results (Figure 41).

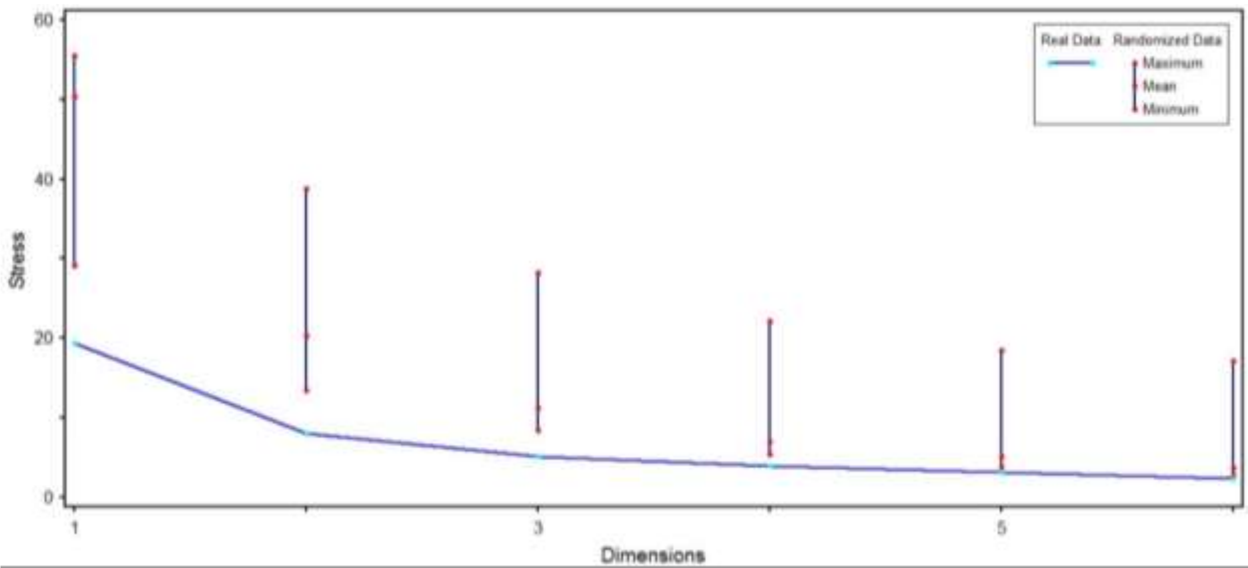

Figure 41. NMS scree plot showing the stress test to determine dimensionality for the final solution for the American Samoa multivariate analysis

The final ordination scores for the families considered were relatively tightly clustered in a positive gradient relative to the two ordination axes, though two prominent groupings are observable with more traditional reef species in the lower left and bottomfish/shallow lagoon species comprising the upper right cluster (Figure 42). While this evaluation was not able to identify any significant levels of association between expanded creel catch data and several environmental parameters, the first axis ($r^2 = 0.91$), illustrated the strongest relationships with salinity (tau = -0.23) and rainfall (tau = 0.21; Figure 42). Analyses including time series of precipitation levels in American Samoa may be useful going forward.

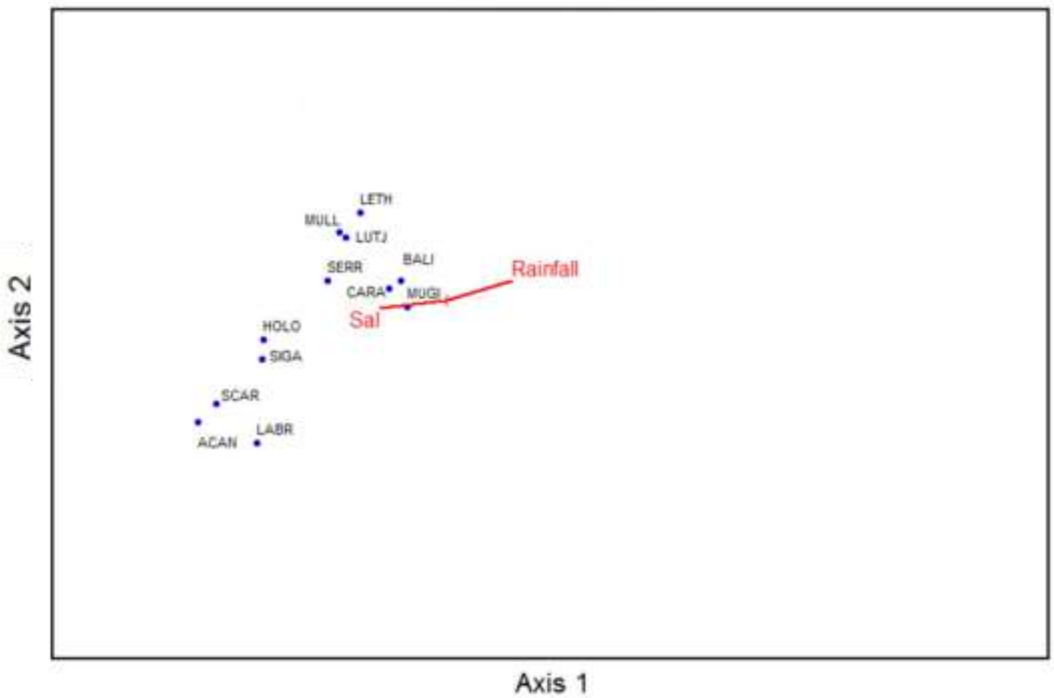

Figure 42. Two-dimensional scatterplot overlaid with a joint biplot depicting ordination scores resulting from an NMS analysis on creel survey expanded catch data and prominent environmental parameters in American Samoa from 1989-2014

Time series of catch from prominent species and species complexes from American Samoa generally showed weak associations with environmental variable data gathered over the same time period. 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 though little indication of existing fishery ecosystem relationships could be identified. 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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APPENDIX A: LIST OF MANAGEMENT UNIT SPECIES

AMERICAN SAMOA

1. Bottomfish Multi-species Stock Complex (FSSI)

DMWR Creel Species Code	Species Name	Scientific Name
247	red snapper, silvermouth (lehi) (silverjaw jobfish)	*Aphareus rutilans*
239	grey snapper, jobfish	*Aprion virescens*
119	giant trevally, jack	*Caranx ignoblis*
111	black trevally, jack	*Caranx lugubris*
221	blacktip grouper	*Epinephelus fasciatus*
229	lunar tail grouper (yellow edge lyretail)	*Variola laoti*
249	red snapper	*Etelis carbunculus*
248	longtail snapper	*Etelis coruscans*
262	ambon emperor	*Lethrinus amboinensis*
267	redgill emperor	*Lethrinus rubrioperculatus*
231	blueline snapper	*Lutjanis kasmira*
246	yellowtail snapper (goldflag jobfish)	*Pristipomoides auricilla*
242	pink snapper (paka)	*Pristimpomoides filamentosus*
241	yelloweye snapper	*Pristipomoides flavipinnis*
none	pink snapper (kalekale)	*Pristipomoides seiboldi*
245	flower snapper (gindai)	*Pristipomoides zonatus*
126	amberjack	*Seriola dumerili*

2. Crustacean deep-water shrimp complex (non-FSSI)

DMWR Creel Species Code	Species Name	Scientific Name
none	deepwater shrimp	*Heterocarpus* spp.

3. Crustacean spiny lobster complex (non-FSSI)

DMWR Creel Species Code	Species Name	Scientific Name
504	spiny lobster	*Panulirus marginatus*
504	spiny lobster	*Panulirus penicillatus*

4. Crustacean slipper lobster complex (non-FSSI)

DMWR Creel Species Code	Species Name	Scientific Name
505	Slipper lobster	Scyllaridae

5. Crustacean Kona crab complex (non-FSSI)

DMWR Creel Species Code	Species Name	Scientific Name
502	Kona crab	*Ranina ranina*

6. Precious coral black coral complex (non-FSSI)

DMWR Creel Species Code	Species Name	Scientific Name
none	Black Coral	*Anitpathes dichotoma*
none	Black Coral	*Antipathes grandis*
none	Black Coral	*Antipathes ulex*

7. Exploratory area precious coral (except black coral) (non-FSSI)

DMWR Creel Species Code	Species Name	Scientific Name
none	Pink coral	*Corallium secundum*
none	Pink coral	*Corallium regale*
none	Pink coral	*Corallium laauense*
none	Bamboo coral	*Lepidisis olapa*
none	Bamboo coral	*Acanella* spp.

none	Gold Coral	*Gerardia* spp.
none	Gold Coral	*Callogorgia gilberti*
none	Gold Coral	*Narella* spp.
none	Gold Coral	*Calyptrophora* spp.

8. Coral reef ecosystem (non-FSSI)

DMWR Creel Species Code	**Species Name**	**Scientific Name**	**Grouping**
328	Achilles tang	*Acanthurus achilles*	Acanthuridae
337	Barred unicornfish	*Naso thynnoides*	Acanthuridae
3311	Bignose unicornfish	*Naso vlamingii*	Acanthuridae
336	Black tongue unicornfish	*Naso hexacanthius*	Acanthuridae
3205	Blackstreak surgeonfish	*Acanthurus nigricauda*	Acanthuridae
321	Blue-banded surgeonfish	*Acanthurus lineatus*	Acanthuridae
3206	Bluelined surgeonfish	*Acanthurus nigroris*	Acanthuridae
339	Bluespine unicornfish	*Naso unicornis*	Acanthuridae
326	Brown surgeonfish	*Acanthurus nigrofuscus*	Acanthuridae
323	Convict tang	*Acanthurus triostegus*	Acanthuridae
3203	Elongate surgeonfish	*Acanthurus mata*	Acanthuridae
3201	Eye-striped surgeonfish	*Acanthurus dussumeiri*	Acanthuridae
335	Gray unicornfish	*Naso caesius*	Acanthuridae
333	Humpback unicornfish	*Naso brachycentron*	Acanthuridae
338	Humpnose unicornish	*Naso tuberosus*	Acanthuridae
3208	Mimic surgeonfish	*Acanthurus pyorferus*	Acanthuridae
327	Naso tang	*Naso* spp.	Acanthuridae
332	Orangespine unicornfish	*Naso lituratus*	Acanthuridae
3207	Orange-spot surgeonfish	*Acanthurus olivaceus*	Acanthuridae
3281	Pacific sailfin tang	*Zebrasoma veliferum*	Acanthuridae
329	Ringtail surgeonfish	*Acanthurus blochii*	Acanthuridae
334	Spotted unicornfish	*Naso brevirostris*	Acanthuridae
322	Striped bristletooth	*Ctenochaetus striatus*	Acanthuridae
320	Surgeonfishes/tangs	*Acanthurus* sp.	Acanthuridae
3221	Twospot bristletooth	*Ctenochaetus binotatus*	Acanthuridae
330	Unicornfishes (misc.)	*Naso* spp.	Acanthuridae
3202	Whitebar surgeonfish	*Acanthurus leucopareius*	Acanthuridae
3204	Whitecheek surgeonfish	*Acanthurus nigricans*	Acanthuridae
331	Whitemargin unicornfish	*Naso annulatus*	Acanthuridae
325	Whitespotted surgeonfish	*Acanthurus guttatus*	Acanthuridae

3222	Yellow-eyed bristletooth	*Ctenochaetus strigosus*	Acanthuridae
324	Yellowfin surgeonfish	*Acanthurus xanthopterus*	Acanthuridae
390	Inshore snappers	Lutjanidae	Lutjanidae
238	Brown jobfish	*Aphareus furca*	Lutjanidae
256	Scarlet snapper	*Etelis radiosus*	Lutjanidae
392	Red snapper	*Lutjanus bohar*	Lutjanidae
235	Twinspot/red snapper	*Lutjanus bohar*	Lutjanidae
233	Yellow margined snapper	*Lutjanus fulvus*	Lutjanidae
236	Humpback snapper	*Lutjanus gibbus*	Lutjanidae
234	Onespot snapper	*Lutjanus monostigma*	Lutjanidae
232	Rufous snapper	*Lutjanus rufolineatus*	Lutjanidae
237	Blood snapper	*Lutjanus sanguineus*	Lutjanidae
257	Timor snapper	*Lutjanus timorensis*	Lutjanidae
251	Black snapper	*Macolor niger*	Lutjanidae
253	Kusakar's snapper	*Paracaesio kusakarii*	Lutjanidae
252	Stone's snapper	*Paracaesio stonei*	Lutjanidae
250	Multidens snapper	*Pristipomoides multidens*	Lutjanidae
102	Bigeye scad	*Selar crumenophthalmus*	Atule
524	Mangrove clam	*Anodontia edentula*	Mollusk
522	Pen shell clam	*Atrina rigida*	Mollusk
523	Pipi clam	*Donax deltoides*	Mollusk
510	Squid	*Teuthida*	Mollusk
521	Clams (misc.)	*Bivalvia*	Mollusk
531	Cone snail	*Conus* sp.	Mollusk
5061	Octopus (cyanea)	*Octopus cyanea*	Mollusk
5062	Octopus (ornatus)	*Octopus ornatus*	Mollusk
506	Octopus	*Octopus* sp.	Mollusk
520	Giant clam	*Tridacna* sp.	Mollusk
530	Turban snail	*Trochus* sp.	Mollusk
536	Green snails	*Turbo* sp.	Mollusk
116	Blue kingfish trevally	*Carangoides caeruleopinnatus*	Carangidae
114	Goldspot trevally	*Carangoides orthogrammus*	Carangidae
109	Trevally (misc.)	*Carangoides* sp.	Carangidae
110	Jacks (misc.)	*Caranx* sp.	Carangidae
113	Bluefin trevally	*Caranx melampygus*	Carangidae
115	Brassy trevally	*Caranx papuensis*	Carangidae
112	Bigeye trevally	*Caranx sexfasciatus*	Carangidae
410	Rainbow runner	*Elagatis bipinnulatus*	Carangidae
106	Leatherback	*Scomberoides lysan*	Carangidae

127	Snubnose pompano	*Trachinotus blochii*	Carangidae
117	Whitemouth trevally	*Uraspis secunda*	Carangidae
104	Mackerel scad (opelu)	*Decapterus* sp.	Carangidae
260	Emperors (misc.)	Lethrinidae	Lethrinidae
255	Goldenline bream	*Gnathodentex aureolineatus*	Lethrinidae
264	Yellowspot emperor	*Gnathodentex aurolineatus*	Lethrinidae
263	Blueline bream	*Gymnocranius grandoculis*	Lethrinidae
266	Orangespot emperor	*Lethrinus erythracanthus*	Lethrinidae
261	Longnose emperor	*Lethrinus elongatus*	Lethrinidae
254	Bigeye emperor	*Monotaxis grandoculis*	Lethrinidae
2601	Sweetlip emperor	*Lethrinus miniatus*	Lethrinidae
3501	Stareye parrotfish	*Calotomus carolinus*	Scaridae
3503	Longnose parrotfish	*Hipposcarus longiceps*	Scaridae
3502	Yellowband parrotfish	*Scarus schlegeli*	Scaridae
350	Parrotfishes (misc.)	*Scarus* sp.	Scaridae
380	Inshore groupers	Serranidae	Serranidae
211	Eightbar grouper	*Epinephelus octofasciatus*	Serranidae
206	Giant grouper	*Epinephelus lanceolatus*	Serranidae
202	Golden hind	*Cephalopholis aurantia*	Serranidae
212	Greasy grouper	*Epinephelus tauvina*	Serranidae
210	Groupers (misc.)	*Epinephelus* sp.	Serranidae
224	Hexagon grouper	*Epinephelus hexagonatus*	Serranidae
209	Honeycomb grouper	*Epinephelus merra*	Serranidae
207	Longspine grouper	*Epinephelus longispinnis*	Serranidae
228	Netfin grouper	*Epinephelus miliaris*	Serranidae
208	One-bloch grouper	*Epinephelus melanostigma*	Serranidae
213	Peacock grouper	*Cephalopholis argus*	Serranidae
205	Pygmy grouper	*Cephalopholis spiloparaea*	Serranidae
217	Saddleback grouper	*Plectropomus laevis*	Serranidae
204	Six-banded grouper	*Cephalopholis sexmaculatus*	Serranidae
201	Slender grouper	*Anyperodon leucogrammicus*	Serranidae
227	Smalltooth grouper	*Epinephelus microdon*	Serranidae
226	Spotted grouper	*Epinephelus maculatus*	Serranidae
216	Squaretail grouper	*Plectropomus areolatus*	Serranidae
223	Striped grouper	*Epinephelus morrhua*	Serranidae
215	Tomato grouper	*Cephalopholis sennerati*	Serranidae
203	Ybanded grouper	*Cephalopholis igarashiensis*	Serranidae
222	Yellowspot grouper	*Epinephelus timorensis*	Serranidae
218	Leopard coral trout	*Plectropomus leopardus*	Serranidae

219	Powell's grouper	*Saloptia powelli*	Serranidae
220	White-edged lyretail	*Variola albimarginata*	Serranidae
345	Bigscale soldierfish	*Myripristis berndti*	Holocentridae
348	Blackfin squirrelfish	*Neoniphon opercularis*	Holocentridae
359	Blackspot squirrelfish	*Sargocentron melanospilos*	Holocentridae
3414	Blotcheye soldierfish	*Myripristis murdjan*	Holocentridae
3511	Bluelined squirrelfish	*Sargocentron tiere*	Holocentridae
3411	Brick soldierfish	*Myripristis amaena*	Holocentridae
342	Bronze soldierfish	*Myripristis adusta*	Holocentridae
353	Crown squirrelfish	*Sargocentron diadema*	Holocentridae
3413	Double tooth soldierfish	*Myripristis hexagona*	Holocentridae
356	Filelined squirrelfish	*Sargocentron microstoma*	Holocentridae
3513	Hawaiian squirrelfish	*Sargocentron xantherythrum*	Holocentridae
343	Pearly soldierfish	*Myripristis kuntee*	Holocentridae
354	Peppered squirrelfish	*Sargocentron punctatissimum*	Holocentridae
3512	Pink squirrelfish	*Sargocentron tieroides*	Holocentridae
341	Saber squirrelfish	*Sargocentron spiniferum*	Holocentridae
351	Sammara squirrelfish	*Neoniphon sammara*	Holocentridae
344	Scarlet soldierfish	*Myripristis pralinius*	Holocentridae
340	Squirrelfish	*Sargocentron* sp.	Holocentridae
352	Tailspot squirrelfish	*Sargocentron caudimaculatum*	Holocentridae
346	Violet soldierfish	*Myripristis violaceus*	Holocentridae
358	Violet squirrelfish	*Sargocentron violaceum*	Holocentridae
3415	Whitetip soldierfish	*Myripristis vittata*	Holocentridae
3412	Yellowfin soldierfish	*Myripristis chryseres*	Holocentridae
347	Yellowstriped squirrelfish	*Neoniphon aurolineatus*	Holocentridae
130	Mullets	Mullets	Mugilidae
1301	Fringelip mullet	Mullets	Mugilidae
1303	Diamond scale mullet	Mullets	Mugilidae
1302	False mullet	Mullets	Mugilidae
	Crabs	Decapoda	CRE-crustacean
509	Grapsid crab	Graspidae	CRE-crustacean
5013	Pa'a crab	*Ocypode ceratopthalma*	CRE-crustacean
5011	Seven-11 crab	*Carpilius maculatus*	CRE-crustacean
5012	Small crab	Decapoda	CRE-crustacean
503	Mangrove crab	*Scylla serrate*	CRE-crustacean
5014	Large red crab	*Sesama erythrodactyla*	CRE-crustacean
507	Hermit crab	*Coenobita clypeatus*	CRE-crustacean
	Bumphead parrotfish	*Bolbometopon muricatum*	Bumphead parrotfish

3601	Napoleon wrasse	*Cheilius undulatus*	Napoleon wrasse
1540	Reef sharks (misc.)	Carcharhinidae	Carcharhinidae
1541	Silvertip shark	*Carcharhinus albimarginatus*	Carcharhinidae
1542	Grey reef shark	*Carcharhinus amblyrhynchos*	Carcharhinidae
1543	Galapagos shark	*Carcharhinus galapagenis*	Carcharhinidae
154	Blacktip reef shark	*Carcharhinus melanopterus*	Carcharhinidae
	White tip reef shark	*Carcharhinus triaenodon*	Carcharhinidae
158	Hammerhead shark	Sphyrnidae	Carcharhinidae
500	Invertebrates (misc.)	n/a	Invertebrate
550	Sea urchins (misc.)	Diadema	Invertebrate
553	Black sea urchin	Diadema	Invertebrate
552	White sea urchin	*Salmacis* spp.	Invertebrate
827	Cubed loli	*Holothuria atra* (cubed)	Invertebrate
828	Cubed leapord sea cucumber	*Bahadschia argus* (cubed)	Invertebrate
824	Surf redfish	*Actinopyga maurtiana*	Invertebrate
822	Sea cucumber (misc.)	Cucumariidae	Invertebrate
823	Sea cucumber - gau	Cucumariidae	Invertebrate
821	Sea cucumber gonads	Cucumariidae	Invertebrate
825	Leapord sea cucumber	*Bahadschia argus*	Invertebrate
820	Loli	*Holothuria atra*	Invertebrate
132	Flyingfish	Exocoetidae	Other CRE-Finfish
133	Cornetfish	*Fistularia commersonii*	Other CRE-Finfish
135	Mojarras	Gerreidae	Other CRE-Finfish
181	Gobies	Gobiidae	Other CRE-Finfish
357	Sweetlips	*Plectorhinchus* sp.	Other CRE-Finfish
136	Halfbeaks	Hemiramphidae	Other CRE-Finfish
363	Flagtails	Kuhliidae	Other CRE-Finfish
3631	Barred flagtail	*Kuhlia mugil*	Other CRE-Finfish
720	Mountain bass	*Kuhlia* sp.	Other CRE-Finfish
137	Ponyfish	Leiognathidae	Other CRE-Finfish
368	Tilefishes	Malacanthus sp.	Other CRE-Finfish
460	Sunfish	*Masturus lanceolatus*	Other CRE-Finfish
138	Filefishes	*Monacanthidae*	Other CRE-Finfish
139	Silver batfish	*Monodactylus argenteus*	Other CRE-Finfish
176	Moray eels	*Gymnothorax* sp.	Other CRE-Finfish
175	Dragon eel	*Enchelycore pardalis*	Other CRE-Finfish
1741	Yellowmargin moray eel	*Gymnothorax flavimarginatus*	Other CRE-Finfish
1742	Giant moray eel	*Gymnothorax javanicus*	Other CRE-Finfish
174	Spotted moray eels	*Gymnothorax* sp.	Other CRE-Finfish

1743	Undulated moray eel	*Gymnothorax undulatus*	Other CRE-Finfish
160	Rays	Batiodea	Other CRE-Finfish
162	Eagle ray	*Aetobatis narinari*	Other CRE-Finfish
906	Monogram monocle bream	*Scolopsis monogramma*	Other CRE-Finfish
152	Nurse shark	*Pempheris* sp.	Other CRE-Finfish
379	Sweepers	Pempheridae	Other CRE-Finfish
185	Prettyfins	Cyprinididae	Other CRE-Finfish
140	Threadfin	*Polynemus* sp.	Other CRE-Finfish
143	Angelfishes	*Centropyge flavissimus*	Other CRE-Finfish
1431	Emperor angelfish	*Pomacanthus imperator*	Other CRE-Finfish
3181	Banded sergeant	*Abudefduf septemfasciatus*	Other CRE-Finfish
318	Sergeant major	*Abudefduf sp.*	Other CRE-Finfish
142	Damselfish	*Dascyllus trimaculatus*	Other CRE-Finfish
365	Bigeyes	Priacanthidae	Other CRE-Finfish
367	Glasseye	*Heteropriacanthus cruentatus*	Other CRE-Finfish
366	Paeony bulleye	*Priacanthus blochii*	Other CRE-Finfish
369	Moontail bullseye	*Priacanthus hamrur*	Other CRE-Finfish
349	Bigeye squirrelfish	Priacanthus sp.	Other CRE-Finfish
184	Dottybacks	Pseudochromidae	Other CRE-Finfish
144	Scorpionfishes	Scorpaenidae	Other CRE-Finfish
146	Lionfish	Pterois sp.	Other CRE-Finfish
145	Stonefish	Synaceia sp.	Other CRE-Finfish
122	Small barracuda	Sphyraenidae	Other CRE-Finfish
121	Great barracuda	*Sphyraena barracuda*	Other CRE-Finfish
123	Bigeye barracuda	*Sphyraena forsteri*	Other CRE-Finfish
124	Heller's barracuda	*Sphyraena helleri*	Other CRE-Finfish
125	Blackfin barracuda	*Sphyraena qenie*	Other CRE-Finfish
120	Barracudas (misc.)	*Sphyraena sp.*	Other CRE-Finfish
191	Seahorses	Sygnathidae	Other CRE-Finfish
147	Lizardfish	Synodontidae	Other CRE-Finfish
355	Terapon perch	*Terapon jarbua*	Other CRE-Finfish
388	Moorish Idol	*Zanclus cornutus*	Other CRE-Finfish
710	Freshwater eel	*Anguilla marmorata*	Other CRE-Finfish
187	Flashlightfishes	*Anomalopidae*	Other CRE-Finfish
189	Frogfishes	*Antennariidae*	Other CRE-Finfish
315	Cardinalfish	*Apogonidae*	Other CRE-Finfish
103	Silversides	*Hypoathernia temminckii*	Other CRE-Finfish
101	Trumpetfish	*Aulostomus chinensis*	Other CRE-Finfish
383	Triggerfish	Balistidae	Other CRE-Finfish

3821	Orangestripe triggerfish	*Balistapus undulatus*	Other CRE-Finfish
382	Clown triggerfish	*Balistoides conspicillum*	Other CRE-Finfish
387	Titan triggerfish	*Balistoides viridescens*	Other CRE-Finfish
134	Needlefish	Belonidae	Other CRE-Finfish
105	Blennies	Blennidae	Other CRE-Finfish
3051	Angler flatfish	*Asterorhombus fijiensis*	Other CRE-Finfish
107	Gold banded fusilier	*Caesio caerulaurea*	Other CRE-Finfish
186	Coral crouchers	*Caracanthus maculatus*	Other CRE-Finfish
385	Butterflyfishes (misc.)	*Chaetodon sp.*	Other CRE-Finfish
3851	Butterflyfish (auriga)	*Chaetodon auriga*	Other CRE-Finfish
3854	Saddleback butterflyfish	*Chaetodon ephippium*	Other CRE-Finfish
3852	Racoon butterflyfish	*Chaetodon lunula*	Other CRE-Finfish
3853	Butterflyfish (melanotic)	*Chaetodon melannotus*	Other CRE-Finfish
180	Milkfish	*Chanos chanos*	Other CRE-Finfish
700	Tilapia	*Tilapia zillii*	Other CRE-Finfish
319	Two spotted hawkfish	*Amplycirrhitus bimacula*	Other CRE-Finfish
3191	Stocky hawkfish	*Cirrhitus pinnalatus*	Other CRE-Finfish
3192	Flame hawkfish	*Neocirrhites armatus*	Other CRE-Finfish
131	Herrings	Clupeidae	Other CRE-Finfish
173	White eel	*Conger cinereus*	Other CRE-Finfish
172	Conger eels	*Conger sp.*	Other CRE-Finfish
386	Porcupinefish	*Diodon (Porcupine)* sp.	Other CRE-Finfish
183	Remoras	*Echeneidae*	Other CRE-Finfish
188	Anchovies	*Engraulidae*	Other CRE-Finfish
182	Batfishes	*Ephippidae*	Other CRE-Finfish
200	Bottomfish (misc.)	n/a	Misc. Bottomfish
300	Reef fish (misc.)	n/a	Misc. Reef Fish
3606	Arenatus wrasse	*Oxycheilinus arenatus*	Wrasse
3605	Bandcheck wrasse	*Oxycheilinus diagrammus*	Wrasse
3610	Barred thicklip	*Hemigymnus fasciatus*	Wrasse
3614	Bird wrasse	*Hemigymnus fasciatus*	Wrasse
3609	Blackeye thicklip	*Hemigymnus melapterus*	Wrasse
3616	Checkerboard wrasse	*Halichoeres hortulanus*	Wrasse
3615	Cheilinus wrasse (misc.)	*Cheilinus sp.*	Wrasse
361	Christmas wrasse	*Thalassoma trilobata*	Wrasse
3608	Cigar wrasse	*Cheilio inermus*	Wrasse
3613	Red ribbon wrasse	*Thalassoma quinquevittaitum*	Wrasse
3619	Rockmover wrasse	*Novaculichthys taeniorus*	Wrasse
3611	Sunset wrasse	*Thalassoma lutescens*	Wrasse

3612	Surge wrasse	*Thalassoma purpureum*	Wrasse
3602	Triple tail wrasse	*Cheilinus trilobatus*	Wrasse
3617	Weedy surge wrasse	*Halichoeres margaritaceus*	Wrasse
3607	Whitepatch wrasse	*Xyrichtys aneitensis*	Wrasse
360	Wrasses (misc.)	*Labridae*	Wrasse
3603	Floral wrasse	*Cheilinus chlorourus*	Wrasse
3604	Harlequin tuskfish	*Cheilinus fasciatus*	Wrasse
3033	Rudderfish (biggibus)	*Kyphosus bigibus*	Rudderfish
303	Rudderfish (cinerascens)	*Kyphosus cinerascens*	Rudderfish
3032	Western drummer	*Kyphosus cornelii*	Rudderfish
3034	Rudderfish	*Kyphosus sp.*	Rudderfish
3031	Lowfin drummer	*Kyphosus vaigiensis*	Rudderfish
3734	Goatfish (misc.)	*Mullidae*	Goatfish
371	Yellowstripe goatfish	*Mulloidichthys flavolineatus*	Goatfish
375	Orange goatfish	*Mulloidichthys pfluegeri*	Goatfish
370	Yellow goatfishes	*Mulloidichthys sp.*	Goatfish
372	Yellowfin goatfish	*Mulloidichthys vanicolensis*	Goatfish
373	Dash-and-dot goatfish	*Parupeneus barberinus*	Goatfish
3731	Doublebar goatfish	*Parupeneus bifasciatus*	Goatfish
3732	White-lined goatfish	*Parupeneus ciliatus*	Goatfish
374	Yellowsaddle goatfish	*Parupeneus cyclostomus*	Goatfish
376	Redspot goatfish	*Parupeneus heptacanthus*	Goatfish
377	Indian goatfish	*Parupeneus indicus*	Goatfish
378	Parupenus insularis	*Parupeneus insularis*	Goatfish
3733	Multi-barred goatfish	*Parupeneus multifasciatus*	Goatfish
381	Side spot goatfish	*Parupeneus pleurostigma*	Goatfish
3370	Banded goatfish (misc.)	*Parupeneus sp.*	Goatfish
310	Rabbitfish	*Siganidae*	Rabbitfish
3101	Forktail rabbitfish	*Siganus aregenteus*	Rabbitfish
311	Scribbled rabbitfish	*Siganus spinus*	Rabbitfish
801	Red algae	Red Algae	Rabbitfish
800	Seaweeds	Seaweeds	Rabbitfish

APPENDIX B: LIST OF PROTECTED SPECIES AND DESIGNATED CRITICAL HABITAT

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
	acutorostrata			Hawai`i	Rankin & Barlow 2005
North Pacific Right Whale	*Eubalaena japonica*	Endangered[a]	Strategic	Extremely rare in Hawai`i waters	35 FR 18319, 73 FR 12024, Rowntree et al. 1980, Herman et al. 1980
Northern Elephant Seal	*Mirounga angustirostris*	Not Listed	Non-strategic	Females migrate to central North Pacific to feed on pelagic prey	Le Beouf et al. 2000
Northern Fur Seal	*Callorhinus ursinus*	Not Listed	Non-strategic	Range across the north Pacific Ocean.	Gelatt et al. 2015
Pacific White-Sided Dolphin	*Lagenorhynchus obliquidens*	Not Listed	Non-strategic	Endemic to temperate waters of North Pacific Ocean. Occur both on the high seas and along continental margins.	Brownell et al. 1999
Pantropical Spotted Dolphin	*Stenella attenuata attenuata*	Not Listed	Non-strategic	Common and abundant throughout the Hawaiian archipelago. Pelagic stock occurs outside of insular stock areas (20 km for Oahu and 4-island stocks, 65 km for Hawai`i Island stock)	Baird et al. 2013, Oleson et al. 2013
Pygmy Killer Whale	*Feresa attenuata*	Not Listed	Non-strategic	Small resident population in Hawaiian waters. Found worldwide in tropical and subtropical waters.	McSweeney et al. 2009, Ross & Leatherwood 1994
Pygmy Sperm Whale	*Kogia breviceps*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Caldwell & Caldwell 1989
Risso's Dolphin	*Grampus griseus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide.	Perrin et al. 2009
Rough-Toothed Dolphin	*Steno bredanensis*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Occasionally found offshore of Hawai`i.	Perrin et al. 2009, Bradford et al. 2013, Barlow 2006, Baird et al. 2013
Sei Whale	*Balaenoptera borealis*	Endangered	Strategic	Rare in Hawai`i. Generally found in offshore temperate waters.	35 FR 18319, Barlow 2003, Bradford et al. 2013
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide. Commonly observed around MHI and present around NWHI.	Shallenberger 1981, Baird et al. 2013, Bradford et al. 2013

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Sperm Whale	*Physeter macrocephalus*	Endangered	Strategic	Found in tropical to polar waters worldwide, most abundant cetaceans in the region. Sighted off the NWHI and the MHI.	35 FR 18319, Rice 1960, Lee 1993, Barlow 2006, Mobley et al. 2000, Shallenberger 1981
Spinner Dolphin	*Stenella longirostris*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters. Pelagic stock found outside of island-associated boundaries (10 nm)	Perrin et al. 2009
Striped Dolphin	*Stenella coeruleoalba*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters throughout the world	Perrin et al. 2009
Elasmobranchs					
Giant manta ray	*Manta birostris*	Threatened	N/A	Found worldwide in tropical, subtropical, and temperate waters. Commonly found in upwelling zones, oceanic island groups, offshore pinnacles and seamounts, and on shallow reefs.	Dewar et al. 2008, Marshall et al. 2009, Marshall et al. 2011.
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	N/A	Found worldwide in open ocean waters from the surface to 152 m depth. It is most commonly found in waters > 20°C	Bonfil et al. 2008, Backus et al, 1956, Strasburg 1958, Compagno 1984
Scalloped hammerhead shark	*Sphyrna lewini*	Endangered (Eastern Pacific DPS)	N/A	Found in coastal areas from southern California to Peru.	Compagno 1984, Baum et al. 2007, Bester 2011
Scalloped hammerhead shark	*Sphyrna lewini*	Threatened (Indo-West Pacific DPS)	N/A	Occur over continental and insular shelves, and adjacent deep waters, but rarely found in waters < 22°C. Range from the intertidal and surface to depths up to 450–512 m.	Compagno 1984, Schulze-Haugen & Kohler 2003, Sanches 1991, Klimley 1993
Corals					
N/A	*Acropora globiceps*	Threatened	N/A	Occur on upper reef slopes, reef flats, and adjacent habitats in depths ranging from 0 to 8 m.	Veron 2014

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
N/A	*Acropora jacquelineae*	Threatened	N/A	Found in numerous subtidal reef slope and back-reef habitats, including but not limited to, lower reef slopes, walls and ledges, mid-slopes, and upper reef slopes protected from wave action, and depth range is 10 to 35 m.	Veron 2014
N/A	*Acropora retusa*	Threatened	N/A	Occur in shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons, and depth range is 1 to 5 m.	Veron 2014
N/A	*Acropora speciosa*	Threatened	N/A	Found in protected environments with clear water and high diversity of *Acropora* and steep slopes or deep, shaded waters. Depth range is 12 to 40 meters, and it has been found in mesophotic habitat (40-150 m).	Veron 2014
N/A	*Euphyllia paradivisa*	Threatened	N/A	Found in environments protected from wave action on at least upper reef slopes, mid-slope terraces, and lagoons in depths ranging from 2 to 25 m depth.	Veron 2014
N/A	*Isopora crateriformis*	Threatened	N/A	Found in shallow, high-wave energy environments, from low tide to at least 12 m deep, and have been reported from mesophotic depths (less than 50 m depth).	Veron 2014
N/A	*Seriatopora aculeata*	Threatened	N/A	Found in broad range of habitats including, but not limited to, upper reef slopes, mid-slope terraces, lower reef slopes, reef flats, and lagoons, and depth ranges from 3 to 40 m.	Veron 2014
Invertebrates					

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Chambered nautilus	*Nautilus pompilius*	Threatened	N/A	Found in small, isolated populations throughout the Indo-Pacific on steep-sloped forereefs with sandy, silty, or muddy bottom substrates from depths of 100 m to 500 m.	83 FR 48948, CITES 2016

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

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

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Seabirds					
Audubon's Shearwater	*Puffinus lherminieri*	Not Listed	N/A	Resident	Craig 2005
Black Noddy	*Anous minutus*	Not Listed	N/A	Resident	Craig 2005
Black-Naped Tern	*Sterna sumatrana*	Not Listed	N/A	Visitor	Craig 2005
Blue-Gray Noddy	*Procelsterna cerulea*	Not Listed	N/A	Resident	Craig 2005
Bridled Tern	*Onychoprion anaethetus*	Not Listed	N/A	Visitor	Craig 2005
Brown Booby	*Sula leucogaster*	Not Listed	N/A	Resident	Craig 2005
Brown Noddy	*Anous stolidus*	Not Listed	N/A	Resident	Craig 2005
Christmas Shearwater	*Puffinus nativitatis*	Not Listed	N/A	Resident?	Craig 2005
Collared Petrel	*Pterodroma brevipes*	Not Listed	N/A	Resident?	Craig 2005
White Tern	*Gygis alba*	Not Listed	N/A	Resident	Craig 2005
Greater Crested Tern	*Thalasseus bergii*	Not Listed	N/A	Visitor	Craig 2005
Gray-Backed Tern	*Onychoprion lunatus*	Not Listed	N/A	Resident	Craig 2005
Great Frigatebird	*Fregata minor*	Not Listed	N/A	Resident	Craig 2005
Herald Petrel	*Pterodroma heraldica*	Not Listed	N/A	Resident	Craig 2005
Laughing Gull	*Leucophaeus atricilla*	Not Listed	N/A	Visitor	Craig 2005
Lesser Frigatebird	*Fregata ariel*	Not Listed	N/A	Resident	Craig 2005
Masked Booby	*Sula dactylatra*	Not Listed	N/A	Resident	Craig 2005
Newell's Shearwater	*Puffinus auricularis newelli*	Threatened	N/A	Visitor	40 FR 44149, Craig 2005
Red-Footed Booby	*Sula sula*	Not Listed	N/A	Resident	Craig 2005

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Red-Tailed Tropicbird	*Phaethon rubricauda*	Not Listed	N/A	Resident	Craig 2005
Short-Tailed Shearwater	*Ardenna tenuirostris*	Not Listed	N/A	Visitor	Craig 2005
Sooty Shearwater	*Ardenna grisea*	Not Listed	N/A	Visitor	Craig 2005
Sooty Tern	*Sterna fuscata*	Not Listed	N/A	Resident	Craig 2005
Tahiti Petrel	*Pterodroma rostrata*	Not Listed	N/A	Resident	Craig 2005
Wedge-Tailed Shearwater	*Ardenna pacifica*	Not Listed	N/A	Resident?	Craig 2005
White-Necked Petrel	*Pterodroma cervicalis*	Not Listed	N/A	Visitor	Craig 2005
White-Faced Storm-Petrel	*Pelagodroma marina*	Not Listed	N/A	Visitor	Craig 2005
White-Tailed Tropicbird	*Phaethon lepturus*	Not Listed	N/A	Resident	Craig 2005
White-Throated Storm-Petrel	*Nesofregetta fuliginosa*	Not Listed	N/A	Resident?	Craig 2005
Laysan Albatross	*Phoebastria immutabilis*	Not Listed	N/A	Breed mainly in Hawai`i, and range across the North Pacific Ocean.	Causey 2008
Hawaiian Petrel	*Pterodroma sandwichensis (Pterodroma phaeopygia sandwichensis)*	Endangered	N/A	Breed in MHI, and range across the central Pacific Ocean.	32 FR 4001, Simons & Hodges 1998
Laysan Albatross	*Phoebastria immutabilis*	Not Listed	N/A	Breed mainly in Hawai`i, and range across the North Pacific Ocean.	Causey 2009
Northern Fulmar	*Fulmarus glacialis*	Not Listed	N/A	Breed and range across North Pacific Ocean.	Hatch & Nettleship 2012
Short-Tailed Albatross	*Phoebastria albatrus*	Endangered	N/A	Breed in Japan and NWHI, and range across the North Pacific Ocean.	35 FR 8495, 65 FR 46643, BirdLife International 2017
Sea turtles					
Green Sea Turtle	*Chelonia mydas*	Endangered (Central South Pacific DPS)	N/A	Frequently seen. Nest at Rose Atoll in small numbers.	43 FR 32800, 81 FR 20057, Balacz 1994
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered[a]	N/A	Frequently seen. Nest at Rose Atoll, Swain's Island, and Tutuila.	35 FR 8491, NMFS & USFWS 2013, Tuato'o-Bartley et al. 1993
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered[a]	N/A	Very rare. One juvenile recovered dead in experimental longline fishing.	35 FR 8491, Grant 1994

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Loggerhead Sea Turtle	*Caretta caretta*	Endangered (South Pacific DPS)	N/A	No known sightings. Found worldwide along continental shelves, bays, estuaries and lagoons of tropical, subtropical, and temperate waters.	43 FR 32800, 76 FR 58868, Utzurrum 2002, Dodd 1990
Olive Ridley Sea Turtle	*Lepidochelys olivacea*	Threatened (Entire species, except for the endangered breeding population on the Pacific coast of Mexico)	N/A	Rare. Three known sightings.	43 FR 32800, Utzurrum 2002
Marine mammals					
Blainville's Beaked Whale	*Mesoplodon densirostris*	Not Listed	Non-strategic	Found worldwide in tropical and temperate waters	Mead 1989
Blue Whale	*Balaenoptera musculus*	Endangered	Strategic	No known sightings. Occur worldwide, and are known to be found in the western South Pacific.	35 FR 18319, Olson et al. 2015
Bottlenose Dolphin	*Tursiops truncatus*	Not Listed	Non-strategic	Distributed worldwide in tropical and warm-temperate waters. Pelagic stock distinct from island-associated stocks.	Perrin et al. 2009, Martien et al. 2012
Bryde's Whale	*Balaenoptera edeni*	Not Listed	Unknown	Distributed widely across tropical and warm-temperate Pacific Ocean.	Leatherwood et al. 1982
Common Dolphin	*Delphinus delphis*	Not Listed	N/A	Found worldwide in temperate and subtropical seas.	Perrin et al. 2009
Cuvier's Beaked Whale	*Ziphius cavirostris*	Not Listed	Non-strategic	Occur worldwide.	Heyning 1989
Dwarf Sperm Whale	*Kogia sima*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Nagorsen 1985
False Killer Whale	*Pseudorca crassidens*	Not Listed	Unknown	Found in waters within the U.S. EEZ of A. Samoa	Bradford et al. 2015
Fin Whale	*Balaenoptera physalus*	Endangered	Strategic	No known sightings but reasonably expected to occur in A. Samoa. Found worldwide.	35 FR 18319, Hamilton et al. 2009
Fraser's Dolphin	*Lagenodelphis hosei*	Not Listed	Non-strategic	Found worldwide in tropical waters.	Perrin et al. 2009

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Guadalupe Fur Seal	*Arctocephalus townsendi*	Threatened	Strategic	No known sightings. Little known about their pelagic distribution. Breed mainly on Isla Guadalupe, Mexico.	50 FR 51252, Gallo-Reynoso et al. 2008, Fleischer 1987
Humpback Whale	*Megaptera novaeangliae*	Delisted Due to Recovery (Oceania DPS)	Strategic	Migrate through the archipelago and breed during the winter in American Samoan waters.	35 FR 18319, 81 FR 62259,, Guarrige et al. 2007, SPWRC 2008
Killer Whale	*Orcinus orca*	Not Listed	Non-strategic	Found worldwide. Prefer colder waters within 800 km of continents.	Leatherwood & Dalheim 1978, Mitchell 1975, Baird et al. 2006
Longman's Beaked Whale	*Indopacetus pacificus*	Not Listed	Non-strategic	Found in tropical waters from the eastern Pacific westward through the Indian Ocean to the eastern coast of Africa.	Dalebout 2003
Melon-Headed Whale	*Peponocephala electra*	Not Listed	Non-strategic	Found in tropical and warm-temperate waters worldwide, primarily found in equatorial waters.	Perryman et al. 1994
Minke Whale	*Balaenoptera acutorostrata*	Not Listed	Non-strategic	Uncommon in this region, usually seen over continental shelves in the Pacific Ocean.	Brueggeman et al. 1990
North Pacific Right Whale	*Eubalaena japonica*	Endangered[a]	Strategic	Extremely rare.	35 FR 18319, 73 FR 12024, Childerhouse et al. 2008, Wolman & Jurasz 1976, Herman & Antinoja 1977, Rice & Wolman 1978
Northern Elephant Seal	*Mirounga angustirostris*	Not Listed	Non-strategic	Females migrate to central North Pacific to feed on pelagic prey	Le Beouf et al. 2000
Pantropical Spotted Dolphin	*Stenella attenuata attenuata*	Not Listed	Non-strategic	Found in tropical and subtropical waters worldwide.	Perrin et al. 2009
Pygmy Killer Whale	*Feresa attenuata*	Not Listed	Non-strategic	Found in tropical and subtropical waters worldwide.	Ross & Leatherwood 1994
Pygmy Sperm Whale	*Kogia breviceps*	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Caldwell & Caldwell 1989

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Risso's Dolphin	*Grampus griseus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide.	Perrin et al. 2009
Rough-Toothed Dolphin	*Steno bredanensis*	Not Listed	Unknown	Found in tropical to warm-temperate waters worldwide. Common in A. Samoa waters.	Perrin et al. 2009, Craig 2005
Sei Whale	*Balaenoptera borealis*	Endangered	Strategic	Generally found in offshore temperate waters.	35 FR 18319, Barlow 2003, Bradford et al. 2013
Short-Finned Pilot Whale	*Globicephala macrorhynchus*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide	Shallenberger 1981, Baird et al. 2013, Bradford et al. 2013
Sperm Whale	*Physeter macrocephalus*	Endangered	Strategic	Found in tropical to polar waters worldwide, most abundant cetaceans in the region.	35 FR 18319, Rice 1960, Barlow 2006, Lee 1993, Mobley et al. 2000, Shallenberger 1981
Spinner Dolphin	*Stenella longirostris*	Not Listed	Unknown	Common in American Samoa, found in waters with mean depth of 44 m.	Reeves et al. 1999, Johnston et al. 2008
Striped Dolphin	*Stenella coeruleoalba*	Not Listed	Non-strategic	Found in tropical to warm-temperate waters throughout the world	Perrin et al. 2009
Elasmobranchs					
Giant manta ray	*Manta birostris*	Threatened	N/A	Found worldwide in tropical, subtropical, and temperate waters. Commonly found in upwelling zones, oceanic island groups, offshore pinnacles and seamounts, and on shallow reefs.	Dewar et al. 2008, Marshall et al. 2009, Marshall et al. 2011.
Oceanic whitetip shark	*Carcharhinus longimanus*	Threatened	N/A	Found worldwide in open ocean waters from the surface to 152 m depth. It is most commonly found in waters > 20°C.	Bonfil et al. 2008, Backus et al, 1956, Strasburg 1958, Compagno 1984
Scalloped hammerhead shark	*Sphyrna lewini*	Threatened (Indo-West Pacific DPS)	N/A	Occur over continental and insular shelves, and adjacent deep waters, but rarely found in waters < 22°C. Range from the intertidal and surface to depths up to 450–512 m.	Compagno 1984, Schulze-Haugen & Kohler 2003, Sanches 1991, Klimley 1993

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

Common name	Scientific name	ESA listing status	MMPA status	Occurrence	References
Chambered nautilus	*Nautilus pompilius*	Threatened	N/A	Found in small, isolated populations throughout the Indo-Pacific on steep-sloped forereefs with sandy, silty, or muddy bottom substrates from depths of 100 m to 500 m.	83 FR 48948, CITES 2016

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

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

Common Name	Scientific Name	ESA Listing Status	Critical Habitat	References
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered	None in the Pacific Ocean.	63 FR 46693
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	Approximately 16,910 square miles (43,798 square km) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles (64,760 square km) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour.	77 FR 4170
Hawaiian Monk Seal	*Neomonachus schauinslandi*	Endangered	Ten areas in the Northwestern Hawaiian Islands (NWHI) and six in the main Hawaiian Islands (MHI). These areas contain one or a combination of habitat types: Preferred pupping and nursing areas, significant haul-out areas, and/or marine foraging areas, that will support conservation for the species.	53 FR 18988, 51 FR 16047, 80 FR 50925
North Pacific Right Whale	*Eubalaena japonica*	Endangered	Two specific areas are designated, one in the Gulf of Alaska and another in the Bering Sea, comprising a total of approximately 95,200 square kilometers (36,750 square miles) of marine habitat.	73 FR 19000, 71 FR 38277

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

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