# ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT: AMERICAN SAMOA ARCHIPELAGO FISHERY ECOSYSTEM PLAN 2022



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 FISHERY ECOSYSTEM PLAN 2022 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council (WPRFMC), National Marine Fisheries Service (NMFS) Pacific Island Fisheries Science Center (PIFSC) and Pacific Islands Regional Office (PIRO), Hawaii Division of Aquatic Resources (HDAR), American Samoa Department of Marine and Wildlife Resources (DMWR), Guam Division of Aquatic and Wildlife Resources (DAWR), and Commonwealth of the Mariana Islands (CNMI) Division of Fish and Wildlife (DFW).*

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

A report of the Western Pacific Regional Fishery Management Council
1164 Bishop Street, Suite 1400, Honolulu, HI 96813

Edited by Thomas Remington (Lynker); Matthew Seeley and Asuka Ishizaki, (WPRFMC).



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**American Samoa Department of Marine and Wildlife Resources:** Domingo Ochavillo.

**NMFS Pacific Islands Fisheries Science Center:** Marc Nadon, Felipe Carvalho, Jenny Suter, Joseph O'Malley, Eva Schemmel, Kisei Tanaka, Thomas Oliver, Hui Shi, Frank Parrish, Tye Kindinger, Robert Ahrens, Keith Bigelow, T. Todd Jones, Marlowe Sabater, Minling Pan, Danika Kleiber, Justin Hospital, Adam Ayers, and Kirsten Leong.

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# EXECUTIVE SUMMARY

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

The Fishery Performance chapter of this report first presents a general description of the local fisheries within American Samoa, focusing on the management unit species (MUS), particularly bottomfish MUS (BMUS), accompanied by monitoring of ecosystem component species (ECS). The fishery data collection system is explained, encompassing creel surveys and commercial receipt books. Fishery meta-statistics for BMUS and ECS are organized into summary dashboard tables showcasing the values for the most recent fishing year and a comparison to short-term (10-year) and long-term (20-year) averages. Time series for catch and effort statistics are also provided and catches are tracked against implemented annual catch limits (ACLs).

In 2019, NMFS developed a stock assessment for the American Samoa BMUS stock complex and determined the complex to be both overfished and experiencing overfishing (Langseth et al. 2019). For 2020 and 2021 in American Samoa, NMFS did not implement an ACL for American Samoa BMUS, but NMFS did implement an interim catch limit (ICL) of 13,000 lb alongside an interim management measure for the American Samoa bottomfish fishery (86 FR 32361, June 21, 2021) while the Council developed a rebuilding plan to end overfishing and rebuild the stock complex from its overfished designation. The rebuilding plan implemented an ACL of 5,000 lb effective June 1, 2022 (87 FR 25590, May 2, 2022).

Total estimated catch for American Samoa BMUS in 2022 (2,583 lb) did not exceed the rebuilding ACL of 5,000 lb. There are no other MUS in American Samoa, as an amendment to the American Samoa Archipelago FEP in early 2019 reclassified most of the MUS as ECS except for select bottomfish (84 FR 2767, February 8, 2019). ECS do not require management under ACLs or accountability measures but are still to be monitored regularly in the annual SAFE report through a one-year snapshot of the ten most-caught ECS, complete catch time series of prioritized ECS as selected by the American Samoa Department of Marine and Wildlife Resources (DMWR), as well as trophic and functional group biomass estimates from fishery-independent surveys where available.

American Samoa bottomfish fishery performance had mixed trends in 2022, some of which may still be partially attributed to continuing direct and indirect impacts of the novel coronavirus (COVID-19) pandemic. Total estimated BMUS catch from creel survey data expansion was 2,583 lb with a large portion derived from the shore-based creel surveys (1,544 lb) with the second highest catch estimate over the course of the time series. The total estimated catch value for 2022 represents an 78% reduction from the short-term (10-year) average and 80% reduction from the long-term (20-year) average. Similar to 2021, commercial BMUS catch from commercial purchase data were confidential in 2022 due to fewer than three dealers and/or vendors reporting fish sales. Catch-per-unit-effort (CPUE) for BMUS in 2022, measured in both pounds per trip and pounds per gear hour, was greater than last year but generally lower than the 10- and 20-year averages for both metrics with the exception of pounds per gear hour relative to its short-term trend. There were 30 lb/trip of BMUS harvested by bottomfish fishing, which was a 17% reduction from the short-term trend and 42% reduction from the long-term trend. The estimated 1.38 lb/gear hour of BMUS harvested by bottomfish fishing was 41% greater than the 10-year average but represented a 5% decrease from the 20-year average. Effort in the fishery also continued to decline; there were just seven tallied fishing trips that harvested BMUS with bottomfish fishing gear in 2022, which was an 88% decrease from the 10-year trend and an 89% decrease from the 20-year trend. Tallied gear hours bottomfish fishing for BMUS were 151, a 95% and 94% reduction from the short- and long-term trends, respectively. Participation in the bottomfish fishery also represented a decrease from historical trends in 2022, with just four unique vessels recorded as harvesting BMUS with bottomfish fishing (a decrease of 56% and 64% from the 10- and 20-year averages, respectively). There was no recorded bycatch in American Samoa boat-based bottomfish fisheries in 2022.

The ECS harvested the most in American Samoa in 2022 were the same as last year, with available information showing that the redlip parrotfish (*Scarus rubroviolaceus*) had the most catch in the creel survey data (1,845 lb) and the blue-banded surgeonfish (*Acanthurus lineatus*) had the most catch in commercial invoice data (1,089 lb). The second most caught species in the boat-based creel surveys was again the bluespine unicornfish (*Naso unicornis*), while spotted reef crab (*Carpilius maculatus*) and generic groups of parrotfish were the second and third highest, respectively, in the commercial purchase data. Many remaining top ten ECS from commercial purchase data were multi-species or family groups (e.g., unknown reef fishes and inshore groupers) due to how the species are organized by vendors during data documentation.

For prioritized ECS in American Samoa (i.e., those selected as priorities for monitoring by DMWR), creel survey catch estimates in 2022 for two of the six species were zero. The four species with catch estimates for the year were *Panulirus penicillatus* (562 lb), *Sargocentron tiere* (47 lb), *Crenimugil crenilabis* (23 lb) and *Epinephelus melanostigma* (91 lb). Catch values are relatively low for these species from boat-based creel surveys because they are typically harvested using shore-based fishing methods. In American Samoa commercial purchase data, five of the six species had zero recorded catch. The only species with catch data in 2022 was *P. penicillatus*, but these data were non-disclosed due to data confidentiality rules associated with reporting data from fewer than three sources (e.g., dealers and/or vendors).

There were no federal permits issued for American Samoa lobster or deepwater shrimp fisheries in 2022, and no catch or effort have been reported associated with these permits over the course of the available time series.

An Ecosystem Considerations chapter was added to the annual SAFE reports following the Council's review of its FEPs and revised management objectives. Fisher observations, fishery-independent ecosystem survey data, socioeconomics, protected species, climate and oceanographic indicators, essential fish habitat, and marine planning information are included in this chapter. A special section that was previously added to the report in 2020 and 2021 describing the impacts of COVID-19 on American Samoa archipelagic fisheries and fishing communities was no longer included in the 2022 report.

Fisher observations over the course of 2022 included that bottomfish were rare in the markets, with many being imported from Samoa. While there were many different bottomfish species present, they were of moderate size and fishers continued to be impacted by shark depredation. Regarding ECS, there was a strong masi run in August and September 2022, and fishers noted abundance parrotfish, crabs, and lobsters. Fishers also noted that the distribution of relief associated with the pandemic experienced delays. With respect to environmental conditions, fishers observed warmer water temperatures and winds that made it difficult to fish deep waters. Fishers stated that an earthquake in 2022 may have pushed deep species into shallower waters.

Fishery independent ecosystem data were acquired through visual surveys conducted by the National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) Ecosystem Sciences Division (ESD) under the National Coral Reef Monitoring Program (NCRMP) in the Commonwealth of the Northern Mariana Islands (CNMI), the Pacific Remote Island Area (PRIA), American Samoa, Guam, the Main Hawaiian Islands (MHI), and the Northwestern Hawaiian Islands (NWHI). This report describes mean fish biomass of functional, taxonomic, and trophic groups for coral reefs as well as habitat condition using mean coral coverage per island for each of these locations. However, there were no new data reported for 2020 through 2022 due to the cancellation of surveys associated with impacts from the COVID-19 pandemic. Surveys in 2022 were conducted in the Mariana Archipelago, with surveys in 2023 scheduled for American Samoa and Baker Island. Coral coverage at locations in American Samoa ranged from just over 3% (at South Bank) to nearly 30.5% (at Swains Island) averaged from 2010 to 2019, however there were only two surveys done at South Bank in that period. Total estimated fish biomass in American Samoa averaged from 2010 to 2019 was lowest at South Bank and highest at Ofu and Olosega, which also had the highest biomass for mid-to-large target surgeonfish, species of the family Scaridae, herbivores, and mobile invertebrate feeders. Biomass of non-planktivorous butterflyfish was highest at Tau, while Tutuila had the highest biomass for corallivores. Swains Island had the highest observed biomass for planktivores, and Rose Atoll had the highest biomass for species of the families Serranidae and Lutjanidae.

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 length-weight regression, and length-weight coefficients. Values for six reef-associated species and 11 species of bottomfish are presented for American Samoa where available. No new life history research on American Samoa fishery species was completed in 2022.

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 FEP for the American Samoan Archipelago. It meets the objective "Support Fishing Communities" adopted at the 165$^{th}$ 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 American Samoan fisheries, presents available socioeconomic data (including annual data for revenue, fish price, and cost of fishing), and lists relevant studies for American Samoa. Data on pounds sold, estimated revenue, and average price per pound for catches in the

American Samoan bottomfish fishery in 2022 were non-disclosed due to data confidentiality rules, as there were less than three vendors and/or dealers reporting.

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 ecosystem component 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. In 2022, there were updates the section associated with information from the new biological opinion conducted for regional bottomfish fisheries. The consultation concluded that the American Samoa bottomfish fishery is not likely to adversely affect oceanic whitetip sharks, and additional information on this document was added to the protected species section of this report.

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 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 considering changing climate, provide historical context, and identify patterns and trends.

The trend of atmospheric concentration of carbon dioxide ($CO_2$) is increasing exponentially with a time series maximum at 419 ppm in 2022. Since 1989, the oceanic pH at Station ALOHA in Hawaii has shown a significant linear decrease of -0.045 pH units, or roughly a 10.9% increase in acidity ([H+]), and was 8.05 in 2021. The Oceanic Niño Index, which is a measure of the El Niño – Southern Oscillation (ENSO) phase, indicated La Niña conditions throughout 2022. The Pacific Decadal Oscillation (PDO) was negative in 2022. The Accumulated Cyclone Energy (ACE) Index (x $10^4$ $kt^2$) was average in the Eastern and Western North Pacific, below average in the Central North and South Pacific; there were four named storms in the South Pacific in 2022, none of which became cyclones or major cyclones. Annual mean sea surface temperature (SST) was 28.5 ºC in 2022, and over the period of record, annual SST has increased at a rate of 0.020 ºC/year. The annual anomaly was 0.06 ºC cooler than average with areas that were warmer than average in the southwest part of the region. American Samoa experienced no coral heat stress in 2022 after a series of stress events from 2014 to 2017 and 2019 to 2020. Annual mean chlorophyll-*a* was 0.058 mg/$m^3$ in 2022, and the annual anomaly was 0.0017 mg/$m^3$ higher than average. Precipitation anomalies were relatively negative over the course of the year, especially after the early months of the year. The local trend in sea level rise is 2.45 millimeters/year, equivalent to a change of 0.80 feet in 100 years.

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 2022 annual SAFE report addresses these requirements. The National Standard guidelines require a report on the condition of the habitat. In the 2022 report, information on benthic cover is included pending development of habitat condition indicators for the American Samoa not otherwise represented in other sections of this report. No benthic surveys were able to be completed in recent years, and these benthic indicators are not presented. The annual report is also meant to address any Council directives toward its Plan Team, but there were no Council recommendations specific to EFH in American Samoa in 2022.

The marine planning section of the annual report tracks activities with multi-year planning horizons and begins to monitors the impact of established facilities. No ocean activities with multi-year planning horizons were identified for American Samoa in 2022. Information was added to this section of the report regarding the Council's recent FEP amendment regarding implementation of a management framework for regional aquaculture operations.

The Data Integration chapter of this report is under development. The chapter explores the potential association between fishery parameters and ecologically-associated variables that may be able to explain a portion of the variance in fishery-dependent data. A contractor completed preliminary evaluations in 2017, and results of exploratory analyses were included for the first time in the 2017 report. Going forward with the data integration analyses and presentation of results for Chapter 3 of the annual SAFE reports, the Council's Archipelagic Fishery Ecosystem Plan Team (Plan Team) suggested several improvements to implement in the future, including standardizing and correcting values in the 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 this annual SAFE report. Many of these recommendations were applied to a revisited analysis in the Hawaii annual SAFE report in 2018 with similar plans for American Samoa data integration analyses in future report cycles. Implementation of these suggestions will allow for the preparation of a more finalized version of the data integration chapter in the future, and the chapter will be updated going forward as resources allow.

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

*Regarding the bycatch summary improvements*, the APT

1. Recommends the Council approve the inclusion of new archipelagic bycatch summaries that describe both the amount and type of bycatch in Hawaii's bottomfish fisheries in the fishery performance module of the Hawaii Archipelago annual SAFE report.

*Regarding the development of the territorial non-commercial modules for the American Samoa and Mariana Archipelago annual SAFE reports*, the APT

2. Recommends the Council request NMFS PIFSC continue its effort to develop the territorial non-commercial module and related R scripts for approval and inclusion in the annual SAFE reports for 2023, noting that other time series data streams (e.g., commercial receipt book) may also be updated in pursuit of a single data summarization and/or expansion process for the Western Pacific region.

*Regarding the draft Hawaii non-commercial module*, the APT

3. Recommends the Council approve the inclusion of the draft Hawaii non-commercial module based on HMRFS data into the Hawaii Archipelago annual SAFE report as presented, noting that additional investigation is needed to determine if there may be biases in the interview-derived data.

*Regarding the refinement of uku EFH in the MHI*, the APT

4. Recommends the Council select Option 5 to refine the EFH designation for uku in the Hawaii Archipelago FEP based on an overlay of Level 1 and 2 modeling products alongside fishery-dependent CPUE data. The APT noted that there may also be forthcoming information on the spatial distribution of egg and post-hatch pelagic life stages of uku for further refinement of the EFH designations for the species in the next one to three years.

*Regarding the establishment of SDC for MHI Kona crab*, the APT

5. Recommends the Council select Alternative 2 to establish SDC for Kona Crab in the Hawaii Archipelago FEP based on the SDC utilized in the previous stock assessment (Kapur et al. 2019) and NMFS technical guidance (Restrepo et al. 1998).

*Regarding the territorial BMUS revision*, the APT

6. Recommends the Council select Alternative 2 to revise the American Samoa BMUS list in the American Samoa FEP based on the results of the hierarchical cluster analysis by PIFSC, a review of the ten non-exhaustive factors for determining which species require federal conservation and management as specified in National Standard 1, and the life history synthesis, as well as the five related Magnuson-Stevens Act management components (i.e., SDC, ACLs/AMs, EFH, monitoring and bycatch, and fishing communities) based on the generation of MSA component reports developed by the APT. The APT agreed to move forward with territorial BMUS revisions in alignment with the current schedule stock assessments for each island area such that the list revisions will occur separately for each jurisdiction.

*Regarding CNMI BMUS ACL specifications*, the APT

7. Recommends the Council select Option 3 that would retain the previous risk of overfishing of 39% based on the previous P* analysis, associated with an ACL of 82,000 lb and an ACT of 75,000 lb for 2024-2025. The APT noted that the risk of overfishing was presented by the SSC and Council through their standardized P* and SEEM processes, though these processes are subject to change based on the availability of new fishery information.

*Regarding Kona crab ACL specifications*, the APT

8. Recommends the Council select Option 2 that would rollover the previous ACL of 30,802 lb alongside an ACT of 25,491 lb for 2024-2025, maintaining the risk of overfishing of 38% and 20%, respectively, from the previous P* and SEEM evaluations. The APT noted that the current ACT of 25,491 lb have not been reached since their implementation in 2020 and are unlikely to in the next two years.

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

| Acronym | Meaning |
|---|---|
| EA | Environmental Assessment |
| ECS | Ecosystem Component Species |
| EEZ | Exclusive Economic Zone |
| EFH | Essential Fish Habitat |
| ENSO | El Niño - Southern Oscillation |
| EO | Executive Order |
| ESA | Endangered Species Act |
| ESRL | Earth Systems Research Laboratory (NOAA) |
| F | Fishing Mortality |
| FL | Fork Length |
| FR | Federal Register |
| FAO | Food and Agriculture Organization |
| FEP | Fishery Ecosystem Plan |
| FMP | Fishery Management Plan |
| FONSI | Finding of No Significant Impact |
| GLM | General Linear Modeling |
| GOES | Geostationary Operational Environmental Satellite (NOAA) |
| GPS | Global Positioning System |
| H | Harvest |
| HAPC | Habitat Area of Particular Concern |
| HOT | Hawaii Ocean Time Series (UH) |
| HURL | Hawaii Undersea Research Laboratory (NOAA and UH) |
| ICL | Interim Catch Limit |
| k | von Bertalanffy Growth Coefficient |
| $L_{50}$ | Length at 50% Maturity |
| $L\Delta_{50}$ | Length at 50% Sex Reversal |
| $L_{\infty}$ | Asymptotic Length |
| $L_{bar}$ | Mean Fish Length |
| $L_{max}$ | Maximum Fish Length |
| LAA | Likely to Adversely Affect |
| LOC | Letter of Concurrence |
| LOF | List of Fisheries |
| LVPA | Large Vessel Prohibited Area |
| M | Natural Mortality |
| MBTA | Migratory Bird Treaty Act |
| MFMT | Maximum Fishing Mortality Threshold |
| MHI | Main Hawaiian Islands |
| MMA | Marine Managed Area |
| MMPA | Marine Mammal Protection Act |
| MNM | Marine National Monument |
| MODIS | Moderate Resolution Imaging Spectroradiometer (NASA) |
| MPA | Marine Protected Area |
| MPCC | Marine Planning and Climate Change |
| MPCCC | MPCC Committee (WPRFMC) |
| MSA | Magnuson-Stevens Fishery Conservation and Management Act |

| Acronym | Meaning |
|---|---|
| MSL | Mean Sea Level |
| MSST | Minimum Stock Size Threshold |
| MSU | Microwave Sounding Unit |
| MSY | Maximum Sustainable Yield |
| MUS | Management Unit Species |
| n | Sample Size |
| $N_{L-W}$ | Sample Size for Length-Weigh Regression |
| N/A | Not Applicable |
| NAF | No Active Fishery |
| NASA | National Aeronautics and Space Administration |
| NCADAC | National Climate Assessment and Development Advisory Committee |
| NCDC | National Climatic Data Center (NOAA) |
| ND | Not Detected |
| NEPA | National Environmental and Policy Act |
| NESDIS | National Environmental Satellite, Data, and Information Service (NOAA) |
| NLAA | Not Likely to Adversely Affect |
| NMFS | National Marine Fisheries Service (NOAA) |
| NMS | Non-metric Multidimensional Scaling |
| NMSAS | National Marine Sanctuary of American Samoa |
| NOAA | National Oceanic and Atmospheric Administration |
| NOS | National Ocean Service (NOAA) |
| NS | National Standard |
| NWHI | Northwestern Hawaiian Islands |
| NWS | National Weather Service |
| OEO | Office of Economic Opportunity (American Samoa) |
| OFL | Overfishing Limits |
| ONI | Ocean Niño Index |
| OPI | OLR Precipitation Index (NOAA) |
| OLR | Outgoing Longwave Radiation |
| OY | Optimum Yield |
| PacIOOS | Pacific Islands Ocean Observing System |
| PCMUS | Precious Coral Management Unit Species |
| PDO | Pacific Decadal Oscillation |
| Pelagic FEP | Fishery Ecosystem Plan for the Pacific Pelagic Fisheries |
| PIBHMC | Pacific Island Benthic Habitat Mapping Center (UH) |
| PIFSC | Pacific Island Fisheries Science Center (NMFS) |
| PIRCA | Pacific Islands Regional Climate Assessment |
| PIRO | Pacific Islands Regional Office (NMFS) |
| PMEL | Pacific Marine Environmental Laboratory (NOAA) |
| PMUS | Pelagic Management Unit Species |
| POES | Polar Operational Environmental Satellite (NOAA |
| PRIA | Pacific Remote Island Areas |
| RAMP | Reef Assessment and Monitoring Program (CRED) |

| Acronym | Meaning |
|---|---|
| ROV | Remotely Operated Underwater Vehicle |
| RPB | Regional Planning Body |
| SAFE | Stock Assessment and Fishery Evaluation |
| SBRM | Standardized Bycatch Reporting Methodologies |
| SD | Standard Deviation |
| SEEM | Social, Economic, Ecological, Management (Uncertainty) |
| SFA | Sustainable Fisheries Act |
| SODA | Simple Ocean Data Assimilation |
| SPC | Stationary Point Count |
| SSC | Scientific and Statistical Committee (WPRFMC) |
| SSM/I | Special Sensor Microwave/Imager |
| SST | Sea Surface Temperature |
| SSBPR | Spawning Stock Biomass Proxy Ratio |
| $t_0$ | Hypothetical Age at Length Zero |
| $T_{max}$ | Maximum Age |
| TA | Total Alkalinity |
| TALFF | Total Allowable Level of Foreign Fishing |
| TBA | To Be Assigned |
| TBD | To Be Determined |
| UH | University of Hawaii |
| USFWS | United States Fish and Wildlife Service |
| VBGF | von Bertalanffy Growth Function |
| VFP | Visual Fox Pro |
| WPacFIN | Western Pacific Fishery Information Network |
| WPR | Western Pacific Region |
| WPRFMC | Western Pacific Regional Fishery Management Council |
| WPSAR | Western Pacific Stock Assessment Review |

# 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° 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 and is divided into two political entities: 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. Aunu’u is a small island close to Tutuila. Ofu and Olosega (13 $km^2$ together) are twin volcanic islands separated by a strait which is a shallow and narrow break in the reef flat between the islands. Ta’u 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 Ta’u 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 Ta’u 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 40 years (Esau in 1981; Tusi in 1987; Ofa in 1990; Val in 1991; Heta in 2004; Olaf in 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 bottomfish fishermen mainly targeting snappers, emperors, and groupers. Bottomfish fishing utilizing traditional canoes by the indigenous residents of American Samoa has been a subsistence practice since the Samoans settled on the Tutuila, Manu'a, 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 deep-water snappers to Hawaii initiated another notable increase in bottomfish landings and revenue. Between 1982 and 1988, the bottomfish 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 the bottomfish fishery occurred as many skilled and full-time commercial fishermen converted to trolling. Additionally, profits and revenue in bottomfish fishing suffered from four separate hurricanes, Tusi in 1987, Ofa in February of 1990, Val in December of 1991, and Heta in January of 2004, as well as 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 recent 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, and 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 bottomfish fishing to trolling. In recent years, the dominant fishing method has been longlining (by weight). Bottomfish fishing 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, and the fuel price has lowered since then.

### 1.1.2 Ecosystem Component 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 deep water 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). Bottomfish fishing is a combination of mesophotic reef fishing (i.e., spearfishing) 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 in 1998, and finally banned in 2002 following recommendations by biologists from the DMWR and local scientists.

In 2018, the Council drafted an Amendment 4 to the American Samoa FEP that reclassified a large number of MUS as Ecosystem Component Species (ECS; WPRFMC 2018). The final rule was posted in the Federal Register in early 2019 (84 FR 2767, February 8, 2019). This amendment reduces the number of MUS from 205 species/families to 11 in the American Samoa FEP. All former coral reef ecosystem management unit species (CREMUS) were reclassified as ECS that do not require ACL specifications or accountability measures but are still to be monitored regularly to prioritize conservation and management efforts and to improve efficiency of fishery management in the region. All existing management measures, including reporting and record keeping, prohibitions, and experimental fishing regulations apply to the associated ECS. If an ECS stock becomes a target of a federal fishery in the future, NMFS and the Council may consider including that stock as a MUS to actively manage it. These species are still regularly monitored via other means (see Sections 1.5.3 and 2.3).

## 1.2 FISHERY DATA COLLECTION SYSTEM

American Samoa has been regularly conducting fishery-dependent monitoring since 1982 for its boat-based fisheries. The boat-based fisheries mostly involve trolling for tuna, skipjacks, and trevally, and bottomfish fishing mostly targets snappers, emperors, and groupers. Boat-based data collection involve two runs: first is the participation run used to determine the number of boats/fishermen out to fish and identify the type of gear being used, and the second is the interview run where the fishermen are interviewed for 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. Boat-based data collection is also being conducted in Manu’a. Boat-based data collection in both Ofu-Olosega and Ta’u is 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, which 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 16th 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 were enough 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 number 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:

# Sample days: Count of the total number of unique dates found in the boat log sampling date data in boat-based creel surveys.

# Catch Interviews: In boat-based creel surveys, 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 boat-based creel survey meta-data**

| Year | # Sample Days | # Catch Interviews | |
|---|---|---|---|
| | | Regular | Opportunistic |
| 1986 | 186 | 532 | 1 |
| 1987 | 110 | 338 | 0 |
| 1988 | 158 | 366 | 0 |
| 1989 | 160 | 389 | 0 |
| 1990 | 160 | 191 | 0 |
| 1991 | 134 | 169 | 0 |
| 1992 | 127 | 137 | 0 |
| 1993 | 140 | 126 | 0 |
| 1994 | 209 | 234 | 0 |
| 1995 | 239 | 333 | 0 |
| 1996 | 222 | 389 | 3 |
| 1997 | 226 | 888 | 1 |
| 1998 | 229 | 852 | 1 |
| 1999 | 207 | 659 | 0 |
| 2000 | 206 | 457 | 0 |
| 2001 | 205 | 249 | 2 |
| 2002 | 194 | 212 | 0 |
| 2003 | 220 | 489 | 0 |

| Year | # Sample Days | # Catch Interviews | |
|---|---|---|---|
| | | Regular | Opportunistic |
| 2004 | 239 | 485 | 5 |
| 2005 | 238 | 330 | 0 |
| 2006 | 238 | 319 | 7 |
| 2007 | 251 | 484 | 6 |
| 2008 | 225 | 303 | 11 |
| 2009 | 165 | 174 | 9 |
| 2010 | 188 | 168 | 2 |
| 2011 | 240 | 203 | 1 |
| 2012 | 269 | 285 | 14 |
| 2013 | 262 | 245 | 0 |
| 2014 | 236 | 353 | 27 |
| 2015 | 233 | 247 | 26 |
| 2016 | 224 | 165 | 47 |
| 2017 | 222 | 139 | 33 |
| 2018 | 215 | 176 | 11 |
| 2019 | 218 | 166 | 12 |
| 2020 | 230 | 164 | 2 |
| 2021 | 206 | 77 | 6 |
| 2022 | 170 | 57 | 2 |
| **10-year avg.** | **222** | **179** | **17** |
| **10-year SD** | **22** | **82** | **15** |
| **20-year avg.** | **224** | **251** | **11** |
| **20-year SD** | **26** | **125** | **12** |

In summary, there has been a general decline in boat-based surveys for the last ten years with respect to the number of sample days, regular interviews, and opportunistic interviews except for the notable uptick in 2020. The decline in creel survey effort in 2022 can be attributed COVID-19 restrictions that lasted approximately four months of the year. The decline of the bottomfish fishery since 2019 likely also contributes to the decline of creel survey interviews.

### 1.3.2 Commercial Receipt Book Statistics

Calculations:

# Vendors: Count of the number of unique buyer codes found in the commercial purchase header data from the Commercial Receipt Book, BMUS vendors are only from vendors that landed BMUS species.

# Invoices: Count of the number of unique invoice numbers found in the commercial header data from the Commercial Receipt Book, BMUS vendors are only from vendors that landed BMUS species.

**Table 2. Summary of American Samoa commercial receipt book meta-data**

| Year | # Vendors | # Invoices Collected | # BMUS Vendors | # BMUS Invoices Collected |
|---|---|---|---|---|
| 1990 | 18 | 441 | 10 | 56 |
| 1991 | 17 | 707 | 10 | 119 |
| 1992 | 11 | 445 | 8 | 51 |
| 1993 | 17 | 695 | 11 | 88 |
| 1994 | 21 | 1,415 | 13 | 138 |
| 1995 | 39 | 2,403 | 16 | 187 |
| 1996 | 17 | 1,737 | 8 | 83 |
| 1997 | 18 | 1,740 | n.d. | n.d. |
| 1998 | 22 | 1,704 | 3 | 10 |
| 1999 | 19 | 1,496 | 7 | 30 |
| 2000 | 19 | 1,151 | 7 | 61 |
| 2001 | 33 | 1,331 | 13 | 158 |
| 2002 | 26 | 1,055 | 9 | 127 |
| 2003 | 31 | 1,249 | 13 | 123 |
| 2004 | 28 | 934 | 14 | 118 |
| 2005 | 65 | 970 | 14 | 93 |
| 2006 | 59 | 1,170 | 13 | 109 |
| 2007 | 63 | 1,282 | 10 | 135 |
| 2008 | 46 | 1,001 | 11 | 100 |
| 2009 | 45 | 806 | 14 | 114 |
| 2010 | 34 | 620 | 9 | 54 |
| 2011 | 30 | 776 | 7 | 28 |
| 2012 | 30 | 827 | 11 | 28 |
| 2013 | 35 | 779 | 4 | 19 |
| 2014 | 42 | 1,126 | 9 | 37 |
| 2015 | 45 | 1,577 | 6 | 53 |
| 2016 | 50 | 1,396 | 6 | 18 |
| 2017 | 58 | 1,372 | 6 | 21 |
| 2018 | 62 | 1,342 | 3 | 16 |
| 2019 | 64 | 1,491 | 6 | 41 |
| 2020 | 63 | 867 | 5 | 11 |
| 2021 | 57 | 768 | n.d. | n.d. |
| 2022 | 54 | 520 | n.d. | n.d. |
| **10-year avg.** | **53** | **1,124** | **5** | **22** |
| **10-year SD** | **9** | **346** | **2** | **15** |
| **20-year avg.** | **48** | **1,044** | **8** | **56** |
| **20-year SD** | **13** | **296** | **4** | **44** |

'n.d.' indicates data were not disclosed due to confidentiality rules.

In summary, there has been a decline in the number of engaged vendors, invoices collected, and invoices collected containing BMUS in recent years. The decline has been especially notable over the last three years, which coincides with when the stocks were declared overfished and experiencing overfishing according to the most recent stock assessment (Langseth et al. 2019). Further, COVID-19 restrictions also negatively affected commerce for BMUS and fish generally. There were fewer than three vendors that sold BMUS in 2021 and 2022, and thus, the data are not disclosed due to confidentiality rules.

## 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 the American Samoa BMUS fishery describing performance and comparing 2022 estimates with short- (10-year) and long-term (20-year) averages**

| Fishery | Fishery statistics | Short-term (10 years) | Long-term (20 years) |
|---|---|---|---|
| **Bottomfish** | **Total estimated catch (lb)** | | |
| All gears (BMUS only) | All BMUS from creel survey data | **2,583[▼78%]** | **2,583[▼80%]** |
| | All BMUS from commercial purchase data | **n.d.** | **n.d.** |
| | **Catch-per-unit-effort (from boat-based creel surveys)** | | |
| Bottomfish fishing (BMUS only) | Bottomfish lb/trip | **30[▼17%]** | **30[▼42%]** |
| | Bottomfish lb/gr-hr | **1.38[▲41%]** | **1.38[▼5%]** |
| | **Fishing effort (from boat-based creel surveys)** | | |
| | Tallied bottomfish trips | **7[▼88%]** | **7[▼89%]** |

| Fishery | Fishery statistics | Short-term (10 years) | Long-term (20 years) |
|---|---|---|---|
| Bottomfish fishing (BMUS only) | Tallied bottomfish gear hours | **151[▼95%]** | **151[▼94%]** |
| | **Fishing participation (from boat-based creel surveys)** | | |
| Bottomfish fishing (BMUS only) | Tallied number of bottomfish vessels | **4[▼56%]** | **4[▼64%]** |
| | Estimated average number of fishermen per bottomfish trip | **3[no change]** | **3[no change]** |
| | **Bycatch (from boat-based creel surveys)** | | |
| Bottomfish fishing (BMUS only) | # fish caught | **89[▼92%]** | **89[▼96%]** |
| | # fish discarded/released | **0[no change]** | **0[no change]** |
| | % bycatch | **0[no change]** | **0[no change]** |

'n.d.' indicates data were not disclosed due to confidentiality rules.

**Table 4. Annual indicators for American Samoa ECS fisheries describing performance and comparing 2022 estimates with short- (10-year) and long-term (20-year) averages**

| Fishery | Fishery statistics | Short-term (10 years) | Long-term (20 years) |
|---|---|---|---|
| **ECS** | **Total estimated boat-based catch (lb)** | | |
| Prioritized ECS | *Sargocentron tiere* from creel survey data | **47[▲57%]** | **47[▲213%]** |
| | *Sargocentron tiere* from commercial purchase data | **0[no change]** | **0[no change]** |
| | *Crenimugil crenilabis* from creel survey data | **23[▼57%]** | **23[▼15%]** |
| | *Crenimugil crenilabis* from commercial purchase data | **0[no change]** | **0[no change]** |
| | *Panulirus penicillatus* from creel survey data | **562[▲16%]** | **562[▼52%]** |
| | *Panulirus penicillatus* from commercial purchase data | **n.d.** | **n.d.** |
| | Clams from creel survey data | **0[no change]** | **0[no change]** |
| | Clams from commercial purchase data | **0[no change]** | **0[no change]** |
| | *Octopus cyanea* from creel survey data | **0[no change]** | **0[no change]** |
| | *Octopus cyanea* from commercial purchase data | **0[no change]** | **0[no change]** |
| | *Epinephelus malanostigma* from creel survey data | **91[▼8%]** | **91[▲82%]** |
| | *Epinephelus malanostigma* from commercial purchase data | **0[no change]** | **0[no change]** |

'n.d.' indicates data were not disclosed due to confidentiality rules.

## 1.5 CATCH STATISTICS

The following section summarizes the catch statistics for bottomfish, a one-year snapshot of the top ten landed species, and the top six prioritized species (and species groups) in American Samoa as determined by DMWR. The six species are the bluelined squirrelfish (*Sargocentron tiere*), fringelip mullet (*Crenimugil crenilabis*), green spiny lobster (*Panulirus penicillatus*), clams, day octopus (*Octopus cyanea*), and one-blotch grouper (*Epinephelus melanostigma*). 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 bottomfish fisheries in addition to the top ten landed species and top six prioritized species.

### 1.5.1 Catch by Data Stream

This section describes the estimated total catch from the 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 can capture fishery data better than the creel surveys.

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

**Table 5. Summary of American Samoa BMUS total catch (lb) from expanded boat-based and shore-based creel surveys and the commercial purchase system for all gear types**

| Year | Boat-Based Creel Survey Estimates | Shore-Based Creel Survey Estimates | Total Creel Survey Estimates | Commercial Landings |
|---|---|---|---|---|
| 1986 | 11,036 | - | 11,036 | - |
| 1987 | 935 | - | 935 | - |
| 1988 | 23,704 | - | 23,704 | - |
| 1989 | 26,143 | - | 26,143 | - |
| 1990 | 9,765 | 2,009 | 11,774 | 1,304 |
| 1991 | 11,199 | 345 | 11,544 | 2,116 |
| 1992 | 8,361 | 1,132 | 9,493 | 1,895 |
| 1993 | 9,368 | 403 | 9,771 | 3,464 |
| 1994 | 21,616 | 560 | 22,176 | 2,375 |
| 1995 | 22,228 | 262 | 22,490 | 4,855 |
| 1996 | 20,831 | 1,040 | 21,871 | 1,082 |
| 1997 | 27,380 | - | 27,380 | n.d. |
| 1998 | 7,661 | - | 7,661 | 492 |
| 1999 | 9,925 | - | 9,925 | 1,701 |

| Year | Boat-Based Creel Survey Estimates | Shore-Based Creel Survey Estimates | Total Creel Survey Estimates | Commercial Landings |
|---|---|---|---|---|
| 2000 | 13,114 | - | 13,114 | 3,693 |
| 2001 | 29,847 | - | 29,847 | 3,447 |
| 2002 | 24,888 | - | 24,888 | 1,448 |
| 2003 | 12,872 | - | 12,872 | 2,511 |
| 2004 | 10,760 | 10 | 10,770 | 3,233 |
| 2005 | 9,580 | 46 | 9,626 | 2,490 |
| 2006 | 3,029 | 343 | 3,372 | 2,203 |
| 2007 | 10,499 | 161 | 10,660 | 4,001 |
| 2008 | 23,170 | 256 | 23,426 | 3,171 |
| 2009 | 48,229 | 194 | 48,423 | 3,035 |
| 2010 | 9,335 | 4 | 9,339 | 1,084 |
| 2011 | 15,981 | 3 | 15,984 | 711 |
| 2012 | 2,125 | 7 | 2,132 | 1,161 |
| 2013 | 6,272 | 1 | 6,273 | 882 |
| 2014 | 16,319 | 0 | 16,319 | 3,140 |
| 2015 | 22,787 | 8 | 22,795 | 2,047 |
| 2016 | 19,502 | 6 | 19,508 | 566 |
| 2017 | 15,131 | 190 | 15,321 | 1,131 |
| 2018 | 11,519 | 283 | 11,802 | 838 |
| 2019 | 10,848 | 551 | 11,399 | 1,749 |
| 2020 | 7,408 | 289 | 7,697 | 336 |
| 2021 | 1,361 | 702 | 2,063 | n.d. |
| 2022 | 1,039 | 1,544 | 2,583 | n.d. |
| **10-year avg.** | **10,997** | **201** | **11,576** | **1,128** |
| **10-year SD** | **6,382** | **202** | **6,633** | **881** |
| **20-year avg.** | **12,868** | **166** | **13,118** | **1,744** |
| **20-year SD** | **7,959** | **173** | **10,194** | **1,135** |

"-" indicates no data are available. 'n.d.' indicates data were not disclosed due to confidentiality rules.

In summary, bottomfish and BMUS landings have steadily declined since 2015, with a steeper decline in 2021 and 2022 possibly associated with COVID-19 restrictions. Total estimated BMUS catch decreased more notably in 2021 and 2022 with reductions of nearly 80% relative to 2020. Commercial data were non-disclosed due to data confidentiality rules.

### 1.5.2 Expanded Catch Estimates by Fishing Method

Catch information is provided for boat-based fishing methods that contribute most of the annual catch for American Samoa.

Calculations: The creel survey catch time series are the sum of the estimated weight for selected gear in all strata for all species and all BMUS species.

**Table 6. Total catch time series estimates (lb) for all species and BMUS only using American Samoa expanded boat-based creel survey data for bottomfish fishing gears**

| Year | Bottomfish Fishing | | Bottom-Troll Mixed | | Spearfishing | |
|---|---|---|---|---|---|---|
| | All | BMUS | All | BMUS | All | BMUS |
| 1986 | 61,092 | 8,599 | 60,052 | 2,419 | 32,186 | 0 |
| 1987 | 8,650 | 334 | 38,299 | 601 | 31,014 | 0 |
| 1988 | 27,392 | 15,714 | 35,774 | 7,495 | 53,718 | 42 |
| 1989 | 20,248 | 11,862 | 41,279 | 13,624 | 43,281 | 617 |
| 1990 | 8,467 | 4,843 | 12,194 | 4,855 | 3,221 | 0 |
| 1991 | 14,522 | 7,305 | 14,562 | 3,894 | 0 | 0 |
| 1992 | 15,552 | 8,361 | 0 | 0 | 0 | 0 |
| 1993 | 18,273 | 7,852 | 4,876 | 1,471 | 0 | 0 |
| 1994 | 46,341 | 20,010 | 7,936 | 1,492 | 26,279 | 0 |
| 1995 | 20,895 | 11,282 | 37,376 | 10,850 | 0 | 0 |
| 1996 | 37,774 | 16,941 | 12,829 | 3,890 | 0 | 0 |
| 1997 | 38,373 | 22,029 | 10,411 | 4,957 | 59,724 | 394 |
| 1998 | 10,717 | 7,248 | 723 | 338 | 48,762 | 75 |
| 1999 | 14,506 | 9,577 | 823 | 219 | 53,643 | 129 |
| 2000 | 25,207 | 12,063 | 1,950 | 1,013 | 27,067 | 38 |
| 2001 | 53,698 | 28,891 | 2,459 | 956 | 9,104 | 0 |
| 2002 | 50,701 | 24,120 | 1,774 | 768 | 7,516 | 0 |
| 2003 | 28,437 | 12,286 | 1,510 | 586 | 4,444 | 0 |
| 2004 | 29,539 | 9,335 | 3,260 | 1,422 | 371 | 0 |
| 2005 | 20,643 | 8,126 | 3,944 | 1,454 | 30 | 0 |
| 2006 | 11,834 | 2,515 | 1,169 | 494 | 2,799 | 20 |
| 2007 | 33,957 | 9,934 | 1,009 | 483 | 15,969 | 81 |
| 2008 | 54,102 | 22,648 | 1,566 | 497 | 7,797 | 25 |
| 2009 | 114,910 | 47,503 | 3,104 | 726 | 22,267 | 0 |
| 2010 | 21,792 | 9,286 | 0 | 0 | 51,528 | 49 |
| 2011 | 33,735 | 14,612 | 6,933 | 1,358 | 28,389 | 12 |
| 2012 | 14,854 | 2,100 | 406 | 18 | 10,192 | 1 |
| 2013 | 27,577 | 5,724 | 1,994 | 482 | 32,125 | 62 |
| 2014 | 37,946 | 15,420 | 4,444 | 879 | 17,453 | 5 |
| 2015 | 47,789 | 21,030 | 8,265 | 1,666 | 16,150 | 72 |
| 2016 | 32,785 | 14,795 | 16,285 | 4,456 | 6,677 | 252 |
| 2017 | 34,348 | 12,810 | 7,070 | 2,136 | 11,370 | 185 |
| 2018 | 20,902 | 10,878 | 2,998 | 511 | 6,625 | 99 |
| 2019 | 21,856 | 10,451 | 1,965 | 348 | 6,952 | 48 |
| 2020 | 15,959 | 5,678 | 6,987 | 1,379 | 11,500 | 190 |
| 2021 | 998 | 435 | 5,487 | 880 | 8,359 | 46 |

| Year | Bottomfish Fishing | | Bottom-Troll Mixed | | Spearfishing | |
|---|---|---|---|---|---|---|
| | All | BMUS | All | BMUS | All | BMUS |
| 2022 | 1,538 | 822 | 84 | 66 | 9,467 | 122 |
| **10-year avg.** | **24,170** | **9,804** | **5,558** | **1,280** | **12,668** | **108** |
| **10-year SD** | **14,386** | **6,287** | **4,360** | **1,219** | **7,420** | **74** |
| **20-year avg.** | **30,275** | **11,819** | **3,924** | **992** | **13,523** | **63** |
| **20-year SD** | **23,394** | **10,112** | **3,756** | **979** | **12,046** | **71** |

In summary, BMUS landings have closely tracked landings for all bottomfish and account for 40% of the total bottomfish landings. However, the mixed bottomfish-trolling gear classification displays a different trend, with a decline in BMUS landings relative to all bottomfish. The 26% decline in bottomfish landings and 45% decline in BMUS landings in 2020 are attributed to impacts associated with COVID-19; however, landings from bottomfish-trolling increased in 2020. The fishery decline continued in 2021 with a 90% reduction of BMUS catch and a 25% decline of BMUS mixed bottomfishing-trolling catch. There was a slight increase in bottomfishing, including BMUS fishing in 2022. However, there was a notable decline in mixed bottomfishing-trolling in 2022 as part of a continuous decline since 2020.

### 1.5.3 Top and Prioritized Species in 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. A one-year reflection of the top ten harvested species (by weight) is included to monitor which ECS are being caught the most annually. Additionally, DMWR selected six species/groups that were reclassified as ECS that are still of priority for regular monitoring, and complete catch time series of these species are included in the report as well.

Calculations: Catch tallied from the boat-based expanded species composition data combining gear types for all species excluding BMUS and pelagic MUS species.

**Table 7a. Top ten landed ECS in American Samoa from boat-based creel survey data in 2022**

| Common Name | Scientific Name | Catch (lb) |
|---|---|---|
| Redlip parrotfish | *Scarus rubroviolaceus* | 1,845 |
| Bluespine unicornfish | *Naso unicornis* | 1,060 |
| Blue-banded surgeonfish | *Acanthurus lineatus* | 988 |
| Redtail parrotfish | *Chlorurus japanensis* | 902 |
| Spiny lobster | *Panulirus pencillatus* | 562 |
| Orangespine unicornfish | *Naso lituratus* | 439 |
| Bridled parrotfish | *Scarus frenatus* | 424 |
| Dark-capped parrotfish | *Scarus oviceps* | 326 |
| Bigeye bream | *Monotaxis grandoculis* | 288 |
| Yellowlip emperor | *Lethrinus xanthochilus* | 284 |

Calculations: Catch tallied from commercial receipt data combining gear types for all species excluding BMUS and pelagic MUS species.

**Table 7b. Top ten landed ECS in American Samoa from estimated commercial landings data in 2022**

| Common Name | Scientific Name | Catch (lb) |
|---|---|---|
| Blue-banded surgeonfish | *Acanthurus lineatus* | 1,089 |
| Spotted reef crab | *Carpillius maculatus* | 434 |
| Parrotfishes (misc.) | *Scarus* spp. | 427 |
| Bottomfishes (misc.) | Multi-genera multi-species | 339 |
| Pacific sailfin tang | *Zebrasoma veliferum* | 240 |
| Unicornfishes (misc.) | *Naso* spp. | 207 |
| Striped bristletooth | *Ctenochaetus striatus* | 124 |
| Tilapia | *Tilapia zillii* | 120 |
| Squirrelfishes (misc.) | *Sargocentron* spp. | 67 |
| Snubnose pompano | *Trachinotus blochii* | 40 |

In summary, species groupings and catch are expectedly different for ECS between the creel survey and commercial invoice data. *Acanthurus lineatus* was the top ECS from commercial invoices while *Scarus rubroviolaceus* was the most harvested in the creel surveys. It is also notable that various species are aggregated into larger taxonomic groupings in the commercial invoices, such as surgeonfish as *Naso* spp., parrotfish as *Scarus* spp., squirrelfish as *Sargocentron* spp., and more coarsely as multi-species and multi-genera groups such as "bottomfishes." The spotted reef crab had relatively high catches in commercial invoices. Lobsters also had high catches in the creel survey data but were notably absent in the commercial invoices. Pompano and tilapia are imported as frozen seafood but are not local to the area.

Calculations: Catch tallied from boat-based expanded species composition data for species identified as priority ECS (Appendix A).

**Table 8a. Catch (lb) from boat-based creel survey expansion data for prioritized species in American Samoan ECS fisheries**

| Year | *Sargocentron tiere* | *Crenimugil crenilabis* | *Panulirus penicillatus* | Clams (multi-species) | *Octopus cyanea* | *Epinephelus melanostigma* |
|---|---|---|---|---|---|---|
| 1986 | 0 | 0 | 1,762 | 0 | 0 | 0 |
| 1987 | 0 | 0 | 2,437 | 0 | 0 | 0 |
| 1988 | 0 | 0 | 6,043 | 0 | 0 | 0 |
| 1989 | 0 | 0 | 4,460 | 0 | 0 | 0 |
| 1990 | 0 | 0 | 416 | 0 | 0 | 0 |
| 1991 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1992 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1994 | 0 | 0 | 976 | 0 | 0 | 0 |
| 1995 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1997 | 0 | 0 | 3,172 | 0 | 0 | 0 |
| 1998 | 0 | 0 | 2,459 | 0 | 0 | 0 |

| Year | *Sargocentron tiere* | *Crenimugil crenilabis* | *Panulirus penicillatus* | Clams (multi-species) | *Octopus cyanea* | *Epinephelus melanostigma* |
|---|---|---|---|---|---|---|
| 1999 | 0 | 0 | 1,707 | 0 | 0 | 0 |
| 2000 | 0 | 0 | 1,197 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 1,450 | 0 | 0 | 0 |
| 2002 | 0 | 0 | 622 | 0 | 0 | 0 |
| 2003 | 0 | 0 | 772 | 0 | 0 | 0 |
| 2004 | 0 | 0 | 65 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 0 | 245 | 0 | 0 | 0 |
| 2007 | 0 | 2 | 1,417 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 1,079 | 0 | 0 | 0 |
| 2009 | 0 | 0 | 3,639 | 0 | 0 | 0 |
| 2010 | 0 | 0 | 8,583 | 0 | 0 | 0 |
| 2011 | 0 | 0 | 2,552 | 0 | 0 | 0 |
| 2012 | 0 | 0 | 389 | 0 | 0 | 0 |
| 2013 | 67 | 5 | 1,800 | 0 | 0 | 14 |
| 2014 | 9 | 0 | 143 | 0 | 0 | 58 |
| 2015 | 1 | 0 | 5 | 0 | 0 | 42 |
| 2016 | 13 | 64 | 221 | 0 | 0 | 64 |
| 2017 | 45 | 42 | 941 | 0 | 0 | 218 |
| 2018 | 24 | 179 | 147 | 0 | 0 | 179 |
| 2019 | 18 | 127 | 0 | 0 | 0 | 119 |
| 2020 | 14 | 14 | 295 | 0 | 0 | 153 |
| 2021 | 61 | 82 | 727 | 0 | 0 | 52 |
| 2022 | 47 | 23 | 562 | 0 | 0 | 91 |
| **10-yr avg.** | **30** | **54** | **484** | **0** | **0** | **99** |
| **10-yr SD** | **23** | **60** | **558** | **0** | **0** | **66** |
| **20-yr avg.** | **15** | **27** | **1,179** | **0** | **0** | **50** |
| **20-yr SD** | **22** | **50** | **1,983** | **0** | **0** | **68** |

Calculations: Catch tallied from commercial purchase data for species identified as priority ECS (Appendix A).

**Table 8b. Catch (lb) from commercial purchase data for prioritized species in American Samoan ECS fisheries**

| Year | *Sargocentron tiere* | *Crenimugil crenilabis* | *Panulirus penicillatus* | Clams (multi-species) | *Octopus cyanea* | *Epinephelus melanostigma* |
|---|---|---|---|---|---|---|
| 1990 | 0 | 0 | 1,307 | 0 | 0 | 0 |
| 1991 | 0 | 0 | 1,389 | 0 | 0 | 0 |

| Year | *Sargocentron tiere* | *Crenimugil crenilabis* | *Panulirus penicillatus* | Clams (multi-species) | *Octopus cyanea* | *Epinephelus melanostigma* |
|---|---|---|---|---|---|---|
| 1992 | 0 | 0 | 482 | 0 | 0 | 0 |
| 1993 | 0 | 0 | 1,487 | 0 | 0 | 0 |
| 1994 | 0 | 0 | 2,488 | 0 | 0 | 0 |
| 1995 | 0 | 0 | 3,927 | 0 | 0 | 0 |
| 1996 | 0 | 0 | 3,104 | 0 | 0 | 0 |
| 1997 | 0 | 0 | n.d. | 0 | 0 | 0 |
| 1998 | 0 | 0 | 3,088 | 0 | 0 | 0 |
| 1999 | 0 | 0 | 2,255 | 0 | 0 | 0 |
| 2000 | 0 | 0 | 808 | 0 | 0 | 0 |
| 2001 | 0 | 0 | 1,105 | 0 | 0 | 0 |
| 2002 | 0 | 0 | 762 | 0 | 0 | 0 |
| 2003 | 0 | 0 | 779 | 0 | 0 | 0 |
| 2004 | 0 | 0 | 506 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 3,238 | 0 | 0 | 0 |
| 2006 | 0 | 0 | 5,380 | 0 | 0 | 0 |
| 2007 | 0 | 0 | 1,649 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 1,417 | 0 | 0 | 0 |
| 2009 | 0 | 0 | 680 | 0 | 0 | 0 |
| 2010 | 0 | 0 | 1,464 | 0 | 0 | 0 |
| 2011 | 0 | 0 | 974 | 0 | 0 | 0 |
| 2012 | 0 | 0 | 621 | 0 | 0 | 0 |
| 2013 | 0 | 0 | 899 | 0 | 0 | 0 |
| 2014 | 0 | 0 | 1,292 | 0 | 0 | 0 |
| 2015 | 0 | 0 | 989 | 0 | 0 | 0 |
| 2016 | 0 | 0 | 1,102 | 0 | 0 | 0 |
| 2017 | 0 | 0 | 767 | 0 | 0 | 0 |
| 2018 | 0 | 3 | 743 | 0 | 0 | 0 |
| 2019 | 0 | 0 | 1,256 | 0 | 0 | 0 |
| 2020 | 0 | 0 | 228 | 0 | 0 | 0 |
| 2021 | 0 | 0 | n.d. | 0 | 0 | 0 |
| 2022 | 0 | 0 | n.d. | 0 | 0 | 0 |
| **10-yr avg.** | **0** | **0.30** | **910** | **0** | **0** | **0** |
| **10-yr SD** | **0** | **0.95** | **343** | **0** | **0** | **0** |
| **20-yr avg.** | **0** | **0.15** | **1,332** | **0** | **0** | **0** |
| **20-yr SD** | **0** | **0.67** | **1,199** | **0** | **0** | **0** |

'n.d.' indicates data were not disclosed due to confidentiality rules.

In summary, the priority ECS for American Samoa are the soldierfish (*Sargocentron tiere*), the giant clams (*Tridacna* spp.), the nearshore grouper (*Epinephelus melanostigma*), the nearshore mullet (*Crenimugil crenilabis*), the octopus (*Octopus cyanea*), and the spiny lobster (*Panulirus penicillatus*). However, only the spiny lobster has substantial data throughout the years since it is caught by boat-based spearfishing. The rest of the priority ECS are primarily harvested by various nearshore fisheries.

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

This section summarizes the estimates for CPUE in the boat-based fisheries both for all species and for BMUS only. The boat-based fisheries include bottomfish fishing (handline gear), spearfishing (snorkel), and bottom-trolling mixed that comprise a majority of the total bottomfish catch. Trolling is primarily a pelagic fishing method but also catches coral reef fishes including jacks and gray jobfish. CPUE is reported as both pounds per gear hour and pounds per trip in the boat-based methods.

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

All - lb/trip: All catch and trips are tallied from landings by gear level, including non-BMUS species.

All - lb/gr-hr.: All catch and trips are tallied from trips with data on the number of gears used and numbers of hours fished, including non-BMUS species.

BMUS - lb/trip: Only BMUS catch and trips that landed BMUS species are tallied from landings by gear level.

BMUS - lb/gr-hr.: Only BMUS catch and trips that landed BMUS are tallied from trips with data on the number of gears used and numbers of hours fished.

In summary, CPUE in lb/trip has declined for bottomfish overall as well as BMUS since 2014. This is also reflected when comparing 10- and 20-year averages. There has been variability in CPUE over time, and there has been no robust analysis of potential variables that could account for this interannual variability.

**Table 9. CPUE (lb/trip and lb/gear hour) for bottomfish fishing gears in the American Samoa boat-based fishery for all species and BMUS only**

| Year | Bottomfish Fishing | | | | Bottom-Troll Mixed | | | | Spearfishing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | | BMUS | | All | | BMUS | | All | | BMUS | |
| | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr |
| 1986 | 136 | 3.16 | 189 | 3.42 | 217 | 5.08 | 130 | 2.10 | 257 | 5.08 | 0 | 0.00 |
| 1987 | 138 | 4.83 | 13 | 0.58 | 210 | 5.12 | 61 | 1.20 | 191 | 5.24 | 0 | 0.00 |
| 1988 | 175 | 6.65 | 107 | 4.08 | 285 | 6.10 | 96 | 2.40 | 215 | 5.44 | 13 | 0.33 |
| 1989 | 159 | 6.87 | 103 | 4.21 | 326 | 4.56 | 107 | 1.50 | 332 | 7.02 | 66 | 0.94 |
| 1990 | 127 | 4.12 | 83 | 2.60 | 248 | 4.32 | 95 | 1.66 | 170 | 5.27 | 0 | 0.00 |
| 1991 | 121 | 2.99 | 69 | 1.58 | 219 | 5.69 | 81 | 1.99 | 358 | 6.28 | 0 | 0.00 |
| 1992 | 139 | 4.00 | 80 | 2.29 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| 1993 | 124 | 2.75 | 62 | 1.39 | 255 | 4.90 | 100 | 1.93 | 70 | - | 0 | 0.00 |
| 1994 | 125 | 2.62 | 53 | 1.10 | 193 | 3.37 | 30 | 0.53 | 247 | 2.40 | 0 | 0.00 |
| 1995 | 121 | 3.11 | 67 | 1.50 | 160 | 3.42 | 49 | 1.00 | 0 | 0.00 | 0 | 0.00 |
| 1996 | 143 | 5.58 | 61 | 2.27 | 283 | 6.69 | 72 | 1.67 | 0 | 0.00 | 0 | 0.00 |
| 1997 | 139 | 5.07 | 79 | 2.87 | 151 | 6.42 | 63 | 2.65 | 294 | 10.47 | 10 | 0.61 |
| 1998 | 175 | 4.83 | 116 | 3.20 | 35 | 1.46 | 0 | 0.00 | 393 | 10.90 | 0 | 0.00 |
| 1999 | 151 | 5.12 | 103 | 3.44 | 103 | 8.58 | 0 | 0.00 | 186 | 7.16 | 0 | 0.00 |
| 2000 | 122 | 4.11 | 61 | 2.08 | 36 | 3.00 | 5 | 0.42 | 0 | 0.00 | 0 | 0.00 |
| 2001 | 140 | 5.58 | 76 | 2.94 | 0 | 0.00 | 0 | 0.00 | 164 | 6.24 | 0 | 0.00 |
| 2002 | 81 | 2.62 | 40 | 1.27 | 0 | 0.00 | 0 | 0.00 | 177 | 3.75 | 0 | 0.00 |
| 2003 | 105 | 5.26 | 50 | 2.53 | 157 | 6.57 | 61 | 2.01 | 179 | 5.00 | 0 | 0.00 |
| 2004 | 77 | 1.54 | 32 | 1.06 | 151 | 6.24 | 73 | 2.88 | 154 | 6.91 | 0 | 0.00 |
| 2005 | 97 | 4.72 | 53 | 2.82 | 138 | 7.64 | 53 | 2.93 | 30 | 3.00 | 0 | 0.00 |
| 2006 | 81 | 3.47 | 32 | 1.03 | 97 | 4.30 | 41 | 1.82 | 86 | 2.11 | 4 | 0.00 |
| 2007 | 147 | 4.20 | 50 | 1.41 | 87 | 3.68 | 49 | 2.09 | 104 | 2.99 | 4 | 0.10 |
| 2008 | 191 | 4.43 | 82 | 1.83 | 107 | 2.93 | 32 | 0.87 | 106 | 3.43 | 2 | 0.06 |

| Year | Bottomfish Fishing | | | | Bottom-Troll Mixed | | | | Spearfishing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | | BMUS | | All | | BMUS | | All | | BMUS | |
| | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr | lb/trip | lb/gr-hr |
| 2009 | 320 | 5.71 | 135 | 2.39 | 278 | 4.17 | 65 | 0.97 | 330 | 9.21 | 0 | 0.00 |
| 2010 | 190 | 3.73 | 94 | 1.61 | 507 | 7.68 | 308 | 4.67 | 246 | 6.21 | 17 | 0.52 |
| 2011 | 194 | 4.65 | 89 | 2.03 | 292 | 8.22 | 68 | 1.79 | 326 | 8.49 | 10 | 0.19 |
| 2012 | 54 | 4.66 | 61 | 2.65 | 227 | 2.87 | 55 | 2.19 | 123 | 11.93 | 0 | 0.00 |
| 2013 | 81 | 1.91 | 34 | 0.52 | 162 | 3.94 | 49 | 1.13 | 247 | 7.43 | 5 | 0.13 |
| 2014 | 118 | 3.50 | 56 | 1.54 | 153 | 5.25 | 31 | 1.07 | 124 | 2.88 | 1 | 0.01 |
| 2015 | 109 | 2.98 | 51 | 1.36 | 140 | 0.63 | 31 | 0.14 | 147 | 3.49 | 14 | 0.28 |
| 2016 | 87 | 0.59 | 41 | 0.28 | 166 | 3.24 | 46 | 1.03 | 49 | 1.32 | 9 | 0.26 |
| 2017 | 91 | 1.13 | 36 | 0.44 | 145 | 0.31 | 58 | 0.19 | 45 | 0.13 | 3 | 0.00 |
| 2018 | 65 | 1.73 | 35 | 0.94 | 75 | 3.52 | 19 | 0.84 | 32 | 0.92 | 2 | 0.06 |
| 2019 | 66 | 2.39 | 33 | 1.11 | 138 | 4.22 | 27 | 0.84 | 31 | 0.83 | 1 | 0.07 |
| 2020 | 58 | 2.82 | 26 | 1.15 | 114 | 5.06 | 25 | 1.07 | 59 | 1.46 | 4 | 0.07 |
| 2021 | 49 | 2.55 | 21 | 1.11 | 154 | 4.22 | 25 | 0.68 | 55 | 1.03 | 2 | 0.03 |
| 2022 | 41 | 1.83 | 30 | 1.38 | 56 | 1.90 | 31 | 1.07 | 53 | 1.35 | 3 | 0.07 |
| **10-year avg.** | **77** | **2.14** | **36** | **0.98** | **130** | **3.23** | **34** | **0.80** | **84** | **2.09** | **4** | **0.10** |
| **10-year SD** | **24** | **0.84** | **10** | **0.41** | **35** | **1.65** | **12** | **0.35** | **65** | **2.01** | **4** | **0.09** |
| **20-year avg.** | **111** | **3.19** | **52** | **1.46** | **167** | **4.33** | **57** | **1.51** | **126** | **4.01** | **5** | **0.13** |
| **20-year SD** | **66** | **1.43** | **28** | **0.71** | **97** | **2.12** | **60** | **1.05** | **93** | **3.22** | **5** | **0.13** |

"-" indicates no data are available.

## 1.7 EFFORT STATISTICS

This section summarizes the effort trends in the American Samoa bottomfish fishery. Fishing effort trends provide insights on the level of fishing pressure through time. Effort information is provided for the top boat-based fishing methods that comprise most of the annual catch.

Calculations: Effort estimates (in both trips and gear hours) are calculated from boat-based interview data. Trips are tallied according to the interview data in boat-based creel surveys. Gear hours are generated by summing the data on number of gears used*number of hours fished collected from interviews by gear type. For the boat-based estimates, data collection started in 1982, but is reported here from 1986.

All - Trips: All trips tallied by gear type.

All - Gear-hr: Gear hours tallied by gear type.

BMUS - Trips: Trips that landed BMUS tallied by gear type.

BMUS - Gear-hr: Gear hours tallied by gear type for trips landed BMUS with data on both number of gears used and numbers of hours fished.

In summary, the number of bottomfish fishing trips have continued their decreasing trend since 2014 with a slight uptick in 2022. The number of bottomfish-trolling trips has had a similar decline starting in 2016.

**Table 10. Effort (trips and gear hours) for bottomfish fishing gears in the American Samoa boat-based fishery for all species and BMUS only**

| Year | Bottomfish Fishing | | | | Bottom-Troll Mixed | | | | Spearfishing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | | BMUS | | All | | BMUS | | All | | BMUS | |
| | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr |
| 1986 | 135 | 5,341 | 13 | 346 | 80 | 3,385 | 5 | 260 | 39 | 1,976 | 0 | 0 |
| 1987 | 19 | 544 | 4 | 90 | 57 | 2,337 | 3 | 152 | 51 | 1,860 | 0 | 0 |
| 1988 | 41 | 1,082 | 37 | 974 | 34 | 1,589 | 22 | 879 | 73 | 2,887 | 1 | 40 |
| 1989 | 30 | 694 | 28 | 681 | 34 | 2,435 | 34 | 2,435 | 40 | 1,893 | 3 | 210 |
| 1990 | 19 | 587 | 16 | 512 | 15 | 863 | 15 | 863 | 8 | 258 | 0 | 0 |
| 1991 | 32 | 1,300 | 29 | 1,256 | 19 | 730 | 14 | 571 | 2 | 114 | 0 | 0 |
| 1992 | 26 | 902 | 24 | 841 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1993 | 38 | 1,719 | 33 | 1,475 | 3 | 156 | 3 | 156 | 1 | 0 | 0 | 0 |
| 1994 | 40 | 1,917 | 37 | 1,784 | 9 | 514 | 8 | 451 | 4 | 411 | 0 | 0 |
| 1995 | 23 | 896 | 19 | 842 | 25 | 1,165 | 22 | 1,090 | 0 | 0 | 0 | 0 |
| 1996 | 37 | 949 | 34 | 916 | 10 | 423 | 8 | 343 | 0 | 0 | 0 | 0 |
| 1997 | 46 | 1,261 | 45 | 1,241 | 14 | 330 | 14 | 330 | 31 | 871 | 5 | 83 |
| 1998 | 17 | 614 | 17 | 614 | 2 | 48 | 0 | 0 | 2 | 72 | 0 | 0 |
| 1999 | 15 | 442 | 14 | 418 | 1 | 12 | 0 | 0 | 4 | 104 | 0 | 0 |
| 2000 | 10 | 297 | 9 | 265 | 1 | 12 | 1 | 12 | 0 | 0 | 0 | 0 |
| 2001 | 37 | 886 | 35 | 878 | 0 | 0 | 0 | 0 | 9 | 237 | 0 | 0 |
| 2002 | 44 | 1,343 | 44 | 1,343 | 0 | 0 | 0 | 0 | 7 | 330 | 0 | 0 |
| 2003 | 83 | 1,103 | 82 | 1,103 | 10 | 99 | 10 | 99 | 7 | 110 | 0 | 0 |
| 2004 | 103 | 4,882 | 92 | 2,631 | 20 | 484 | 19 | 484 | 3 | 67 | 0 | 0 |
| 2005 | 56 | 743 | 53 | 687 | 29 | 455 | 28 | 455 | 1 | 10 | 0 | 0 |
| 2006 | 88 | 1,779 | 56 | 1,451 | 12 | 272 | 12 | 272 | 7 | 88 | 1 | 0 |
| 2007 | 127 | 4,147 | 121 | 4,085 | 13 | 306 | 11 | 258 | 71 | 2,282 | 10 | 366 |
| 2008 | 105 | 4,349 | 102 | 4,311 | 10 | 366 | 10 | 366 | 35 | 1,051 | 6 | 241 |

| Year | Bottomfish Fishing | | | | Bottom-Troll Mixed | | | | Spearfishing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | All | | BMUS | | All | | BMUS | | All | | BMUS | |
| | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr | Trips | Gr-hr |
| 2009 | 109 | 6,046 | 107 | 6,032 | 8 | 534 | 8 | 534 | 27 | 961 | 0 | 0 |
| 2010 | 42 | 2,132 | 36 | 2,086 | 1 | 66 | 1 | 66 | 94 | 3,533 | 2 | 64 |
| 2011 | 55 | 2,173 | 52 | 2,135 | 18 | 608 | 16 | 569 | 58 | 2,158 | 1 | 54 |
| 2012 | 99 | 1,088 | 14 | 269 | 5 | 277 | 2 | 42 | 55 | 513 | 1 | 0 |
| 2013 | 75 | 3,160 | 36 | 2,276 | 11 | 399 | 8 | 252 | 68 | 2,171 | 6 | 202 |
| 2014 | 125 | 4,081 | 107 | 3,818 | 22 | 642 | 22 | 642 | 64 | 2,761 | 2 | 160 |
| 2015 | 122 | 4,045 | 116 | 3,997 | 27 | 5,542 | 25 | 5,498 | 26 | 1,093 | 4 | 190 |
| 2016 | 63 | 8,127 | 62 | 8,119 | 46 | 1,785 | 46 | 1,785 | 35 | 1,230 | 7 | 228 |
| 2017 | 73 | 5,650 | 72 | 5,650 | 18 | 7,420 | 13 | 3,780 | 35 | 10,195 | 9 | 7,117 |
| 2018 | 58 | 2,083 | 57 | 2,083 | 16 | 280 | 11 | 249 | 46 | 1,577 | 10 | 392 |
| 2019 | 58 | 1,469 | 57 | 1,469 | 7 | 229 | 7 | 229 | 41 | 1,446 | 6 | 115 |
| 2020 | 43 | 881 | 39 | 871 | 17 | 357 | 16 | 339 | 48 | 1,933 | 14 | 675 |
| 2021 | 8 | 152 | 8 | 152 | 4 | 146 | 4 | 146 | 30 | 1,611 | 5 | 262 |
| 2022 | 9 | 203 | 7 | 151 | 3 | 88 | 3 | 88 | 30 | 1,143 | 6 | 287 |
| **10-year avg.** | **63** | **2,985** | **56** | **2,859** | **17** | **1,689** | **16** | **1,301** | **42** | **2,516** | **7** | **963** |
| **10-year SD** | **37** | **2,433** | **34** | **2,432** | **12** | **2,476** | **12** | **1,775** | **14** | **2,606** | **3** | **2,057** |
| **20-year avg.** | **75** | **2,915** | **64** | **2,669** | **15** | **1,018** | **14** | **808** | **39** | **1,797** | **5** | **518** |
| **20-year SD** | **34** | **2,125** | **34** | **2,119** | **10** | **1,879** | **10** | **1,355** | **24** | **2,137** | **4** | **1,523** |

## 1.8 PARTICIPANTS

This section summarizes the estimated participation in each fishery. The information presented here can be used in the impact analysis of potential amendments in the FEPs associated with the bottomfish fisheries. The trend in participation over time can also be used as an indicator of fishing pressure.

Calculations: For boat-based data, the estimated number of unique vessels is calculated by tallying the number of vessels recorded in the interview data via vessel registration or name.

All: Total unique vessels by gear type.

BMUS: Unique vessels from trips that landed BMUS by gear type.

**Table 11a. Estimated number of unique vessels for bottomfish fishing gears in the American Samoa boat-based fishery for all species and BMUS only**

| Year | Bottomfish Fishing | | Bottom-Troll Mixed | | Spearfishing | |
|---|---|---|---|---|---|---|
| | All | BMUS | All | BMUS | All | BMUS |
| 1986 | 20 | 5 | 20 | 3 | 7 | 0 |
| 1987 | 11 | 3 | 14 | 3 | 8 | 0 |
| 1988 | 12 | 12 | 11 | 9 | 9 | 1 |
| 1989 | 14 | 13 | 13 | 13 | 4 | 1 |
| 1990 | 5 | 4 | 6 | 6 | 2 | 0 |
| 1991 | 13 | 12 | 9 | 7 | 1 | 0 |
| 1992 | 9 | 9 | 0 | 0 | 0 | 0 |
| 1993 | 10 | 9 | 3 | 3 | 1 | 0 |
| 1994 | 8 | 7 | 6 | 6 | 2 | 0 |
| 1995 | 10 | 8 | 12 | 12 | 0 | 0 |
| 1996 | 15 | 14 | 8 | 6 | 0 | 0 |
| 1997 | 13 | 12 | 8 | 8 | 4 | 3 |
| 1998 | 9 | 9 | 1 | 0 | 2 | 0 |
| 1999 | 9 | 8 | 1 | 0 | 1 | 0 |
| 2000 | 8 | 7 | 1 | 1 | 0 | 0 |
| 2001 | 12 | 11 | 0 | 0 | 5 | 0 |
| 2002 | 13 | 13 | 0 | 0 | 3 | 0 |
| 2003 | 14 | 14 | 4 | 4 | 4 | 0 |
| 2004 | 21 | 21 | 7 | 6 | 3 | 0 |
| 2005 | 13 | 12 | 5 | 5 | 1 | 0 |
| 2006 | 20 | 14 | 1 | 1 | 2 | 1 |
| 2007 | 21 | 19 | 6 | 4 | 3 | 3 |
| 2008 | 18 | 16 | 8 | 8 | 3 | 2 |
| 2009 | 14 | 14 | 4 | 4 | 3 | 0 |
| 2010 | 11 | 8 | 1 | 1 | 5 | 1 |
| 2011 | 8 | 7 | 5 | 5 | 2 | 1 |

| Year | Bottomfish Fishing | | Bottom-Troll Mixed | | Spearfishing | |
|---|---|---|---|---|---|---|
| | All | BMUS | All | BMUS | All | BMUS |
| 2012 | 11 | 6 | 4 | 2 | 2 | 1 |
| 2013 | 13 | 10 | 5 | 3 | 3 | 2 |
| 2014 | 16 | 13 | 9 | 9 | 4 | 1 |
| 2015 | 14 | 14 | 10 | 9 | 4 | 2 |
| 2016 | 15 | 15 | 10 | 10 | 3 | 2 |
| 2017 | 11 | 11 | 8 | 7 | 6 | 3 |
| 2018 | 9 | 9 | 6 | 5 | 3 | 3 |
| 2019 | 6 | 6 | 3 | 3 | 5 | 2 |
| 2020 | 7 | 6 | 6 | 6 | 3 | 3 |
| 2021 | 3 | 3 | 2 | 2 | 4 | 2 |
| 2022 | 5 | 4 | 2 | 2 | 5 | 3 |
| **10-year avg.** | **10** | **9** | **6** | **6** | **4** | **2** |
| **10-year SD** | **4** | **4** | **3** | **3** | **1** | **1** |
| **20-year avg.** | **13** | **11** | **5** | **5** | **3** | **2** |
| **20-year SD** | **5** | **5** | **3** | **3** | **1** | **1** |

In summary, the number of operating vessels has been affected by natural disasters and access to the government-provided fuel subsidy over the recent years in the midst of a declining trend. The number of bottomfishing and mixed bottomfishing-trolling vessels has been declining since 2015-2016.

Calculations: For boat-based data, the estimated number of fishermen per trip is calculated by filtering interviews that recorded the number of fishers, and then ∑fishers/∑trips. A blank cell indicates insufficient data to generate an estimate of average fishers.

All: Average fishers from all trips by gear type.

BMUS: Average fishers from trips that landed BMUS by gear type.

**Table 11b. Estimated number of fishermen per trip for bottomfish fishing gears in the American Samoa boat-based fishery for all species and BMUS only**

| Year | Bottomfish Fishing | | Bottom-Troll Mixed | | Spear | |
|---|---|---|---|---|---|---|
| | All | BMUS | All | BMUS | All | BMUS |
| 1986 | 3 | 2 | 2 | 2 | 5 | 0 |
| 1987 | 3 | 2 | 2 | 2 | 5 | 0 |
| 1988 | 2 | 2 | 3 | 3 | 4 | 4 |
| 1989 | 3 | 3 | 4 | 4 | 5 | 6 |
| 1990 | 2 | 2 | 3 | 3 | 4 | 0 |
| 1991 | 3 | 3 | 3 | 3 | 5 | 0 |
| 1992 | 2 | 2 | 0 | 0 | 0 | 0 |

| Year | Bottomfish Fishing | | Bottom-Troll Mixed | | Spear | |
|---|---|---|---|---|---|---|
| | **All** | **BMUS** | **All** | **BMUS** | **All** | **BMUS** |
| 1993 | 2 | 2 | 3 | 3 | 5 | 0 |
| 1994 | 2 | 2 | 3 | 3 | 4 | 0 |
| 1995 | 3 | 2 | 2 | 3 | 0 | 0 |
| 1996 | 3 | 3 | 3 | 2 | 0 | 0 |
| 1997 | 3 | 3 | 3 | 3 | 5 | 3 |
| 1998 | 3 | 3 | 3 | 0 | 6 | 0 |
| 1999 | 2 | 2 | 3 | 0 | 4 | 0 |
| 2000 | 3 | 3 | 3 | 3 | 0 | 0 |
| 2001 | 3 | 3 | 0 | 0 | 3 | 0 |
| 2002 | 3 | 3 | 0 | 0 | 5 | 0 |
| 2003 | 3 | 3 | 3 | 3 | 4 | 0 |
| 2004 | 3 | 3 | 3 | 3 | 6 | 0 |
| 2005 | 3 | 3 | 3 | 3 | 5 | 0 |
| 2006 | 3 | 4 | 3 | 3 | 4 | 6 |
| 2007 | 3 | 3 | 3 | 3 | 5 | 5 |
| 2008 | 3 | 3 | 3 | 3 | 4 | 5 |
| 2009 | 4 | 4 | 4 | 4 | 6 | 0 |
| 2010 | 3 | 4 | 3 | 3 | 6 | 5 |
| 2011 | 3 | 3 | 3 | 3 | 7 | 9 |
| 2012 | 2 | 3 | 5 | 3 | 5 | 0 |
| 2013 | 3 | 3 | 4 | 4 | 6 | 6 |
| 2014 | 3 | 3 | 3 | 3 | 6 | 7 |
| 2015 | 3 | 3 | 3 | 3 | 5 | 5 |
| 2016 | 3 | 3 | 3 | 3 | 5 | 4 |
| 2017 | 6 | 6 | 7 | 4 | 7 | 14 |
| 2018 | 3 | 3 | 3 | 2 | 5 | 5 |
| 2019 | 3 | 3 | 3 | 3 | 5 | 4 |
| 2020 | 2 | 2 | 2 | 2 | 5 | 5 |
| 2021 | 3 | 3 | 3 | 3 | 7 | 6 |
| 2022 | 3 | 3 | 3 | 3 | 5 | 5 |
| **10-year avg.** | **3** | **3** | **3** | **3** | **6** | **6** |
| **10-year SD** | **1** | **1** | **1** | **1** | **1** | **3** |
| **20-year avg.** | **3** | **3** | **3** | **3** | **5** | **5** |
| **20-year SD** | **1** | **1** | **1** | **0** | **1** | **3** |

## 1.9 BYCATCH ESTIMATES

This section focuses on Magnuson-Stevens Fishery Conservation and Management Act (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 discarded or released is number of individuals marked as bycatch. Percent bycatch is the sum of all released divided by the number caught.

In summary, there is generally zero bycatch in bottomfishing, whether BMUS or non-BMUS.

**Table 12. Time series of catch and bycatch in the American Samoa boat-based BMUS and non-BMUS fisheries**

| Year | BMUS | | | Non-BMUS | | | BMUS + Non-BMUS | | |
|---|---|---|---|---|---|---|---|---|---|
| | # Caught | # Discard or Release | % Bycatch | # Caught | # Discard or Release | % Bycatch | # Caught | # Discard or Release | % Bycatch |
| 1992 | 1,803 | 0 | 0 | 637 | 0 | 0 | 2,440 | 0 | 0 |
| 1993 | 1,534 | 0 | 0 | 860 | 0 | 0 | 2,394 | 0 | 0 |
| 1994 | 5,447 | 0 | 0 | 2,210 | 0 | 0 | 7,657 | 0 | 0 |
| 1995 | 2,397 | 0 | 0 | 1,008 | 0 | 0 | 3,405 | 0 | 0 |
| 1996 | 3,940 | 0 | 0 | 2,059 | 0 | 0 | 5,999 | 0 | 0 |
| 1997 | 2,910 | 0 | 0 | 2,283 | 0 | 0 | 5,193 | 0 | 0 |
| 1998 | 998 | 0 | 0 | 846 | 0 | 0 | 1,844 | 0 | 0 |
| 1999 | 3,213 | 0 | 0 | 2,417 | 0 | 0 | 5,630 | 0 | 0 |
| 2000 | 3,386 | 0 | 0 | 3,052 | 0 | 0 | 6,438 | 0 | 0 |
| 2001 | 3,499 | 0 | 0 | 2,703 | 0 | 0 | 6,202 | 0 | 0 |
| 2002 | 3,362 | 0 | 0 | 3,597 | 0 | 0 | 6,959 | 0 | 0 |
| 2003 | 3,778 | 0 | 0 | 4,019 | 1 | 0.025 | 7,797 | 1 | 0.013 |
| 2004 | 2,970 | 0 | 0 | 3,764 | 0 | 0 | 6,734 | 0 | 0 |
| 2005 | 1,807 | 0 | 0 | 1,877 | 0 | 0 | 3,684 | 0 | 0 |
| 2006 | 1,573 | 0 | 0 | 4,260 | 0 | 0 | 5,833 | 0 | 0 |
| 2007 | 2,752 | 0 | 0 | 4,184 | 0 | 0 | 6,936 | 0 | 0 |
| 2008 | 4,616 | 0 | 0 | 3,972 | 0 | 0 | 8,588 | 0 | 0 |
| 2009 | 11,080 | 0 | 0 | 8,441 | 0 | 0 | 19,521 | 0 | 0 |
| 2010 | 2,902 | 0 | 0 | 2,119 | 0 | 0 | 5,021 | 0 | 0 |
| 2011 | 4,229 | 0 | 0 | 3,130 | 0 | 0 | 7,359 | 0 | 0 |
| 2012 | 775 | 0 | 0 | 4,362 | 0 | 0 | 5,137 | 0 | 0 |
| 2013 | 1,031 | 0 | 0 | 3,494 | 0 | 0 | 4,525 | 0 | 0 |
| 2014 | 3,123 | 0 | 0 | 3,504 | 0 | 0 | 6,627 | 0 | 0 |
| 2015 | 3,602 | 0 | 0 | 3,666 | 0 | 0 | 7,268 | 0 | 0 |

| Year | BMUS | | | Non-BMUS | | | BMUS + Non-BMUS | | |
|---|---|---|---|---|---|---|---|---|---|
| | # Caught | # Discard or Release | % Bycatch | # Caught | # Discard or Release | % Bycatch | # Caught | # Discard or Release | % Bycatch |
| 2016 | 888 | 0 | 0 | 1,234 | 0 | 0 | 2,122 | 0 | 0 |
| 2017 | 926 | 0 | 0 | 1,425 | 0 | 0 | 2,351 | 0 | 0 |
| 2018 | 630 | 0 | 0 | 742 | 0 | 0 | 1,372 | 0 | 0 |
| 2019 | 771 | 0 | 0 | 823 | 0 | 0 | 1,594 | 0 | 0 |
| 2020 | 404 | 0 | 0 | 632 | 0 | 0 | 1,036 | 0 | 0 |
| 2021 | 124 | 0 | 0 | 108 | 0 | 0 | 232 | 0 | 0 |
| 2022 | 89 | 0 | 0 | 88 | 0 | 0 | 177 | 0 | 0 |
| **10-yr avg.** | **1,159** | **0** | **0** | **1,572** | **0** | **0** | **2,730** | **0** | **0** |
| **10-yr SD** | **1,148** | **0** | **0** | **1,357** | **0** | **0** | **2,414** | **0** | **0** |
| **20-yr avg.** | **2,404** | **0** | **0** | **2,792** | **0** | **0.001** | **5,196** | **0** | **0.001** |
| **20-yr SD** | **2,434** | **0** | **0** | **1,963** | **0** | **0.005** | **4,215** | **0** | **0.003** |

## 1.10 FEDERAL LOGBOOK DATA

### 1.10.1 Number of Federal Permit Holders

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

#### 1.10.1.1 Special Coral Reef Ecosystem Permit

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

#### 1.10.1.2 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.

#### 1.10.1.3 Western Pacific Crustacean Permit

Regulations require a permit for the owner of a U.S. fishing vessel used to fish for lobster (now ECS) or deepwater shrimp in the EEZ around American Samoa, Guam, Hawaii, and the Pacific Remote Islands Area (PRIA), and in the EEZ seaward of three nautical miles of the shoreline of the 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 13. Table 13 provides the number of permits issued to American Samoa FEP fisheries between 2013 and 2022. Data are from the Pacific Islands Regional Office (PIRO) Sustainable Fisheries Division (SFD) permits program.

**Table 13. Number of federal permit holders in American Samoa crustacean fisheries**

| Crustacean Fishery[1] | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| Lobster | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Shrimp | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

[1] Source: PIRO SFD unpublished data.

### 1.10.2 Summary of Catch and Effort for FEP Fisheries

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

Federal permits are not required to fish for bottomfish in American Samoa, and NMFS has never issued a federal permit for precious coral or coral reef fishing in federal waters around American Samoa. Therefore, catch and effort data is not presented for these fisheries.

#### 1.10.2.1 Spiny and Slipper Lobster

**Table 14. Summary of available federal logbook data for lobster fisheries in American Samoa**

| Year | No. of Federal Lobster Permits Issued[1] | No. of Federal Lobster Permits Reporting Catch | No. of Trips in AS EEZ | Total Reported Logbook Catch (lb) | | Total Reported Logbook Release/Discard (#) | |
|---|---|---|---|---|---|---|---|
| | | | | *Spiny lobster ECS*[2] | *Slipper lobster ECS*[2] | *Spiny lobster ECS*[2] | *Slipper lobster ECS*[2] |
| 2004 | 0 | - | | | | | |

| Year | No. of Federal Lobster Permits Issued[1] | No. of Federal Lobster Permits Reporting Catch | No. of Trips in AS EEZ | Total Reported Logbook Catch (lb) | | Total Reported Logbook Release/Discard (#) | |
|---|---|---|---|---|---|---|---|
| | | | | *Spiny lobster ECS[2]* | *Slipper lobster ECS[2]* | *Spiny lobster ECS[2]* | *Slipper lobster ECS[2]* |
| 2005 | 0 | - | | | | | |
| 2006 | 2 | 0 | | | | | |
| 2007 | 2 | 0 | | | | | |
| 2008 | 7 | 0 | | | | | |
| 2009 | 0 | - | | | | | |
| 2010 | 0 | - | | | | | |
| 2011 | 0 | - | | | | | |
| 2012 | 0 | - | | | | | |
| 2013 | 0 | - | | | | | |
| 2014 | 1 | 0 | | | | | |
| 2015 | 0 | - | | | | | |
| 2016 | 0 | - | | | | | |
| 2017 | 0 | - | | | | | |
| 2018 | 0 | - | | | | | |
| 2019 | 0 | - | | | | | |
| 2020 | 0 | - | | | | | |
| 2021 | 0 | - | | | | | |
| 2022 | 0 | - | | | | | |

[1] Source: PIRO SFD unpublished data.
[2] On February 8, 2019, NMFS published a final rule (84 FR 2767) to reclassify all crustacean MUS in American Samoa as ECS.

#### 1.10.2.2 Deepwater Shrimp

**Table 15. Summary of available federal logbook data for deepwater shrimp fisheries in American Samoa**

| Year | No. of Federal Shrimp Permits Issued[1] | No. of Federal Shrimp Permits Reporting Catch | No. of Trips in American Samoa EEZ | Total Reported Logbook Shrimp ECS[2] Catch (lb) | Total Reported Logbook Shrimp ECS[2] Release/Discard (lb) |
|---|---|---|---|---|---|
| 2009 | 0 | - | | | |
| 2010 | 0 | - | | | |
| 2011 | 0 | - | | | |
| 2012 | 0 | - | | | |
| 2013 | 0 | - | | | |
| 2014 | 1 | 0 | | | |
| 2015 | 0 | - | | | |
| 2016 | 0 | - | | | |
| 2017 | 0 | - | | | |

| Year | No. of Federal Shrimp Permits Issued[1] | No. of Federal Shrimp Permits Reporting Catch | No. of Trips in American Samoa EEZ | Total Reported Logbook Shrimp ECS[2] Catch (lb) | Total Reported Logbook Shrimp ECS[2] Release/Discard (lb) |
|---|---|---|---|---|---|
| 2018 | 0 | - | | | |
| 2019 | 0 | - | | | |
| 2020 | 0 | - | | | |
| 2021 | 0 | - | | | |
| 2022 | 0 | - | | | |

[1] Source: PIRO SFD unpublished data.
[2] On February 8, 2019, NMFS published a final rule (84 FR 2767) to reclassify all crustacean MUS in American Samoa as ECS.
Note: Federal permit and reporting requirements for deepwater shrimp fisheries became effective on June 29, 2009 (74 FR 25650, May 29, 2009).

## 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 BMUS 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 currently used for the bottomfish multi-species stock complexes. Instead, the control rules are applied to the stock complex as a whole.

The maximum sustainable yield (MSY) control rule is used as the maximum fishing mortality threshold (MFMT). The MFMT and minimum stock size threshold (MSST) are specified based on the recommendations of Restrepo et al. (1998) and both are dependent on the natural mortality rate (*M*). The value of *M* used to determine the reference point values is not specified in this section. The latest estimate is published in the most recent stock assessment (Langseth et al. 2019), 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 16.

**Table 16. Overfishing threshold specifications for BMUS**

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

Standardized values of fishing effort (E) and CPUE can be used as proxies for fishing mortality (F) and biomass (B), respectively, so $E_{MSY}$, $CPUE_{MSY}$, and $CPUE_{FLAG}$ can be 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 can 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 would be used.

Since the MSY control rule specified here applies to multi-species stock complexes, it is important to ensure that no species within the complex has a mortality rate that leads to excessive depletion. In order to accomplish this, a secondary set of reference points is specified to evaluate stock status with respect to recruitment overfishing. A secondary "recruitment overfishing" control rule is specified to control fishing mortality with respect to that status. The rule applies only to those component stocks (species) for which adequate data are available. The ratio of a current spawning stock biomass proxy ($SSBP_t$) to a given reference level ($SSBP_{REF}$) is used to determine if individual stocks are experiencing recruitment overfishing. SSBP is CPUE scaled by percent mature fish in the catch. When the ratio $SSBP_t/SSBP_{REF}$, or the "SSBP ratio" (SSBPR) for any species drops below a certain limit ($SSBPR_{MIN}$), that species is considered to be recruitment overfished and management measures will be implemented to reduce fishing mortality on that species. The rule applies only when the SSBP ratio drops below the $SSBPR_{MIN}$, but it will continue to apply until the ratio achieves the "SSBP ratio recovery target" ($SSBPR_{TARGET}$), which is set at a level no less than $SSBPR_{MIN}$. These two reference points and their associated recruitment overfishing control rule, which prescribe a target fishing mortality rate ($F_{RO-REBUILD}$) as a function of the SSBP ratio, are specified as indicated in Table 17. Again, $E_{MSY}$ is used as a proxy for $F_{MSY}$.

**Table 17. Recruitment overfishing control rule specifications for BMUS**

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

### 1.11.2 Current Stock Status

#### 1.11.2.1 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 CPUE for the multi-species complexes as a whole. At this time, it is not possible to partition these effort measures among the various BMUS. The most recent stock assessment (Langseth et al. 2019) for the American Samoa bottomfish MUS complex (comprised of 11 species of shallow and deep species of snapper, grouper, jacks, and emperors) was based on estimates of total catch and an abundance index derived from the nominal CPUE generated from the creel surveys. The assessments used a state-space Bayesian surplus production model within the modeling framework Just Another Bayesian Biomass Assessment (JABBA), which included biological information and fishery-dependent data through 2017. Determinations of overfishing and overfished status can then be made by comparing current biomass and harvest rates to MSY-level reference points (Table 16). The American Samoa BMUS were determined to be both undergoing overfishing and in an overfished state (Table 18).

**Table 18. Stock assessment parameters for the BMUS complex (from Langseth et al. 2019)**

| Parameter | Value | Notes | Status |
|---|---|---|---|
| MSY | 28.8 (16.4-55.9) | Expressed in 1000 lb (with 95% confidence interval) | |
| $H_{2017}$ | 0.15 | Expressed in percentage | |
| $H_{CR}$ | 0.107 (0.044-0.228) | Expressed in percentage (with 95% confidence interval) | |
| $H/H_{CR}$ | 2.75 | | Overfishing occurring |
| $B_{2017}$ | 102.6 | Expressed in 1000 lb | |
| $B_{MSY}$ | 272.8 (120.8-687.4) | Expressed in 1000 lb (with 95% confidence interval) | |
| $B/B_{MSY}$ | 0.38 | | Overfished |

## 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 papers, reports, and/or available data. These data are categorized into the different tiers in the control rule ranging from Tier 1 (i.e., most information available, typically a stock assessment) to Tier 5 (i.e., catch-only information). The control rules are applied to the BSIA. Tiers 1 to 3 involve conducting a Risk of Overfishing Analysis (denoted by P*) to quantify the scientific uncertainties associated with the assessment to specify the Acceptable Biological Catch (ABC), lowering the MSY-based OFL to the ABC. A Social, Ecological, Economic, and Management (SEEM) Uncertainty Analysis is performed to quantify the uncertainties associated with the SEEM factors, and a buffer is used to lower the ABC to an ACL. For Tier 4, which is comprised of stocks with MSY estimates but no active fisheries, the control rule is 91 percent of MSY. For Tier 5, which has catch-only information, the control rule is a one-third reduction in the median catch depending on a qualitative evaluation of stock status via expert opinion. ACL specification can choose from a variety of methods including the above mentioned SEEM analysis or a percentage buffer (i.e., percent reduction from ABC based on expert opinion) or the use of an Annual Catch Target (ACT). ACLs can be updated on an annual basis, but the Council normally produces a multi-year ACL for implementation.

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

### 1.12.2 Current OFL, ABC, ACL, and Recent Catch

No ACLs were implemented by NMFS for American Samoa BMUS in 2020 or 2021. However, NMFS did implement an interim catch limit (ICL) of 13,000 lb for 2020 associated with an interim management measure for the American Samoa bottomfish fishery effective through May 17, 2021 (85 FR 73003, November 16, 2020). NMFS subsequently extended the interim measure to be effective from June 21, 2021 through November 18, 2021 (86 FR 32361, June 21, 2021). Consistent with Magnuson-Stevens Act sections 304(e)(6) and 305(c), the Council requested that NMFS implement this interim measure to reduce overfishing of BMUS while the Council develops management measures to end overfishing and rebuild the American Samoa bottomfish stock complex from its overfished designation. The rebuilding plan for the American Samoa bottomfish fishery was completed by the Council, implemented an ACL of 5,000 lb, and became effective June 1, 2022 (87 FR 25590, May 2, 2022).

The catch shown in Table 19 presents the 2022 catch estimate against the rebuilding ACL.

**Table 19. American Samoa ACL table with 2022 total estimated catch (lb)**

| Fishery | MUS | OFL* | ABC | ACL** | Catch |
|---|---|---|---|---|---|
| Bottomfish | Bottomfish multi-species complex | 8,000 | N.A. | 5,000 | 2,583 |

* OFL derived from the stock assessment (Langseth et al. 2019) with 2025 as the terminal year.
** The catch limit for 2022 was an rebuilding ACL implemented by NMFS as part of the rebuilding plan for American Samoa BMUS (87 FR 25590, May 2, 2022).

## 1.13 BEST SCIENTIFIC INFORMATION AVAILABLE

### 1.13.1 Bottomfish fishery

#### 1.13.1.1 Stock Assessment Benchmark

The benchmark stock assessment for the territorial BMUS complexes, including American Samoa, was developed and finalized by Langseth et al. (2019). The assessments used a state-space Bayesian surplus production model within the modeling framework Just Another Bayesian Biomass Assessment (JABBA). Estimates of harvest rate ($H$), annual biomass ($B$), the harvest rate associated with overfishing as determined by the harvest control rule ($H_{CR}$), maximum sustainable yield ($MSY$), and the biomass at maximum sustainable yield ($B_{MSY}$) allowed for determination of stock status relative to reference points determining overfishing ($H/H_{CR} > 1$) and overfished ($B < 0.7 \times B_{MSY}$) status. Stock projections were conducted for 2020-2025 for a range of hypothetical six-year catches, and the corresponding risk of overfishing was calculated.

#### 1.13.1.2 Stock Assessment Updates

Updates to the previous benchmark stock assessment from 2007 were done in 2012 (Brodziak et al. 2012) and 2015 (Yau et al. 2016). 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. (2016) was considered the best scientific information available for the territorial BMUS complexes after undergoing a Western Pacific Stock Assessment Review (WPSAR) Tier 3 panel review (Franklin et al. 2015) prior to the Langseth et al. (2019) benchmark stock assessment. This was the previous basis for P* and SEEM analyses that determined the risk levels to specify past ABCs and ACLs. The next stock assessment is scheduled to be completed in 2023.

#### 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.

PIFSC and the Council conducted a workshop with various stakeholders in CNMI to identify factors and quantify uncertainties associated with the social, economic, ecological, and management of the coral reef fisheries (Sievanen and McCaskey 2014). This was the basis for the SEEM analyses that determine the risk levels to specify ACLs. However, species targeted by coral reef fisheries in American Samoa are no longer classified as MUS.

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

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

The harvest extent, in this case, is defined as the level of catch harvested in a fishing year relative to the ACL or OY. The harvest capacity is the level of catch remaining in the annual catch limit that can potentially be used for the total allowable level of foreign fishing (TALFF).

Table 20 summarizes the harvest extent and harvest capacity information for American Samoa tracking annual catch against the ACL. The current ACL of 5,000 lb is derived from the rebuilding plan for the American Samoa bottomfish fishery that became effective June 1, 2022 (87 FR 25590, May 2, 2022).

**Table 20. American Samoa ACL proportion of harvest capacity and extent in 2022**

| Fishery | MUS | ACL* | Catch | Harvest extent (%) | Harvest capacity (%) |
|---|---|---|---|---|---|
| Bottomfish | Bottomfish multi-species complex | 5,000 | 2,583 | 51.7 | 49.3 |

* The catch limit for 2022 was a rebuilding ACL implemented by NMFS as part of the rebuilding plan for American Samoa BMUS (87 FR 25590, May 2, 2022).

## 1.15 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions NMFS implemented for insular fisheries in American Samoa during calendar year 2022.

On May 2, 2022, NMFS published the final rule for Amendment 5 to the Fishery Ecosystem Plan for the American Samoa Archipelago. Amendment 5 implements a rebuilding plan for overfished bottomfish that includes a 5,000 lb annual catch limit starting in 2022. As an in-season accountability measure, if NMFS projects that the fishery will reach the ACL in any year, then NMFS will close the fishery in Federal waters for the remainder of that year. As a higher performance standard, if the total annual catch exceeds the ACL during a year, NMFS will close the fishery in Federal waters until NMFS and the American Samoa government implement a coordinated management regime to ensure that the catch is maintained at levels that allow the stock to rebuild. This action was necessary to rebuild the overfished stock consistent with the requirements of the Magnuson-Stevens Act and became effective June 1, 2022. NMFS and the Council will review the rebuilding plan every two years and modify it, as necessary, per section 304(e)(7) of the Magnuson-Stevens Act.

# 2 ECOSYSTEM CONSIDERATIONS

## 2.1 FISHER OBSERVATIONS

Hawai‘i fishermen Clay Tam and Roy Morioka started the fisher observations initiative in 2020 to add traditional and local ecological knowledge, and on-the-water observations to fisheries dependent data sources in the Annual SAFE reports. Fisher observations from 2021 can be found in the pelagic and respective Archipelagic reports published last year (WPRFMC 2022a; WPRFMC 2022b; WPRFMC 2022c; WPRFMC 2022d).

During 2022, the Council collected archipelagic fisher observations during quarterly advisory panel meetings for American Samoa. Input collected by fishers during these meetings was limited to Advisory Panel (AP) members. Data from American Samoa archipelagic fisher observations from 2022 was limited to one meeting late in the year, which was summarized in the American Samoa Archipelagic SAFE report (WPRFMC 2022c). In 2023, the American Samoa AP provided fisher observations during two meetings. The fisher observations were also collected by a meeting convened by the Western Pacific Regional Fishery Management Council (Council) on February 14, 2023 from 6-8pm Samoa Standard Time. This meeting was facilitated by Roy Morioka and Clay Tam and was attended by eight American Samoa fishers. The following narrative summarizes 2022 fisher observations collected during AP meetings and the February 2023 meeting.

### 2.1.1 Information from Advisory Panel Meetings

From April to June, AP members reported that COVID lockdowns and mandates reduced the number of boat fishing trips as well as shore-based fishing. Community members from Manu‘a reported good fishing during the second quarter of 2022.

From July to September, rough wind and weather limited non-commercial fishing effort and fishing trips from alia vessels. One AP member reported Manu’a fishers have observed deepwater fish (palu malau) closer to shore, which may have been caused by volcanic/seismic activity.

### 2.1.2 Information from the Annual Summit

The Fisher Observations 2023 meeting was held in person in American Samoa on February 14, 2023 from 6-8pm Samoa Standard Time and was attended by eight American Samoa fishers, with remote attendance by four Council staff members and one social scientist from PIFSC. The meeting was remotely facilitated by Clay Tam and Roy Morioka and notes were taken by a Council staff member and the PIFSC social scientist. Discussions were based upon an interview guide streamlined by Roy Morioka and Zach Yamada. Although the interview guide was streamlined from the previous year, it did not substantially change participant responses. At the beginning of the meeting, facilitators Tam and Morioka welcomed the group, introduced participants, and invited fishers to share their 2022 fishing experiences. Participants were asked follow up questions as needed related to different social, economic, ecological, and management (SEEM) aspects of the fishery to facilitate their use in fisheries science and management. These four SEEM categories constitute a qualitative construct that can be used to complement the quantitative P* construct and process, and provide additional information and guidance when setting annual catch limits (Hospital et al. 2019).

The American Samoa fisher observations meeting was not recorded, but PIFSC staff along with Council staff took detailed notes during the meeting and captured attendee quotes as closely as possible. Quotations were coded thematically using the SEEM categories, then further categorized into sub-themes to add further detail on fisher observations from American Samoa fishers in 2022. Below, their observations of archipelagic fisheries are separated and described using the SEEM categories.

#### 2.1.2.1 Social

American Samoa fishers reported continued impacts from COVID-19 and delays in funding relief from the CARES Act. They also conveyed a need to upgrade boat ramps. They reported productive fishing and good turnout for their bottomfish tournament.

#### 2.1.2.2 Economic

Many fishers mentioned the alia program, where local fishers receive government assistance to purchase an alia fishing vessel. Another mentioned the Super alia program, which was announced 6-7 years ago, and is still in development. One attendee reported that ice availability is an issue for alia fishers, which may decrease market demand for their catch due to spoilage. Another fisher reported that roadside sales for coral reef species remain strong.

#### 2.1.2.3 Ecological (Biological and Physical/Oceanographic)

American Samoa fishers indicated that 2022 was a good year for bottomfishing, crustaceans, and ecosystem component species (ECS). They also reported that fish were good sized, but shark depredation remains a problem. Fishers also reported that weather conditions limited fishing trips. An earthquake affected outer island fisheries, which stirred up deep bottomfish as well as shark activity. Another fisher reported very warm water temperatures, much warmer than usual.

#### 2.1.2.4 Management Uncertainty

Fishers expressed concern with the bottomfish stock assessment and also lamented a lack of support for the Council Catchit Logit smartphone application. Other fishers expressed an apprehension about the impacts of potential fishing closures related to the Biden Administration 30x30 marine management plan. One fisher reported an extended village closure to fishing activities in adjacent nearshore waters for months following a funeral.

## 2.2 CORAL REEF FISH ECOSYSTEM PARAMETERS

### 2.2.1 Regional Reef Fish Biomass and Habitat Condition

**Description:** 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2022. Hard Coral cover is mean cover derived from visual estimates by divers of sites where reef fish surveys occurred. No new surveys occurred in 2020 or 2021 due to COVID-19 and surveys have not been conducted since; the numbers presented here are identical to the 2019 report.

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

**Data Category:** Fishery-independent

**Timeframe:** Triennial

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

**Spatial Scale:** Regional

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

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

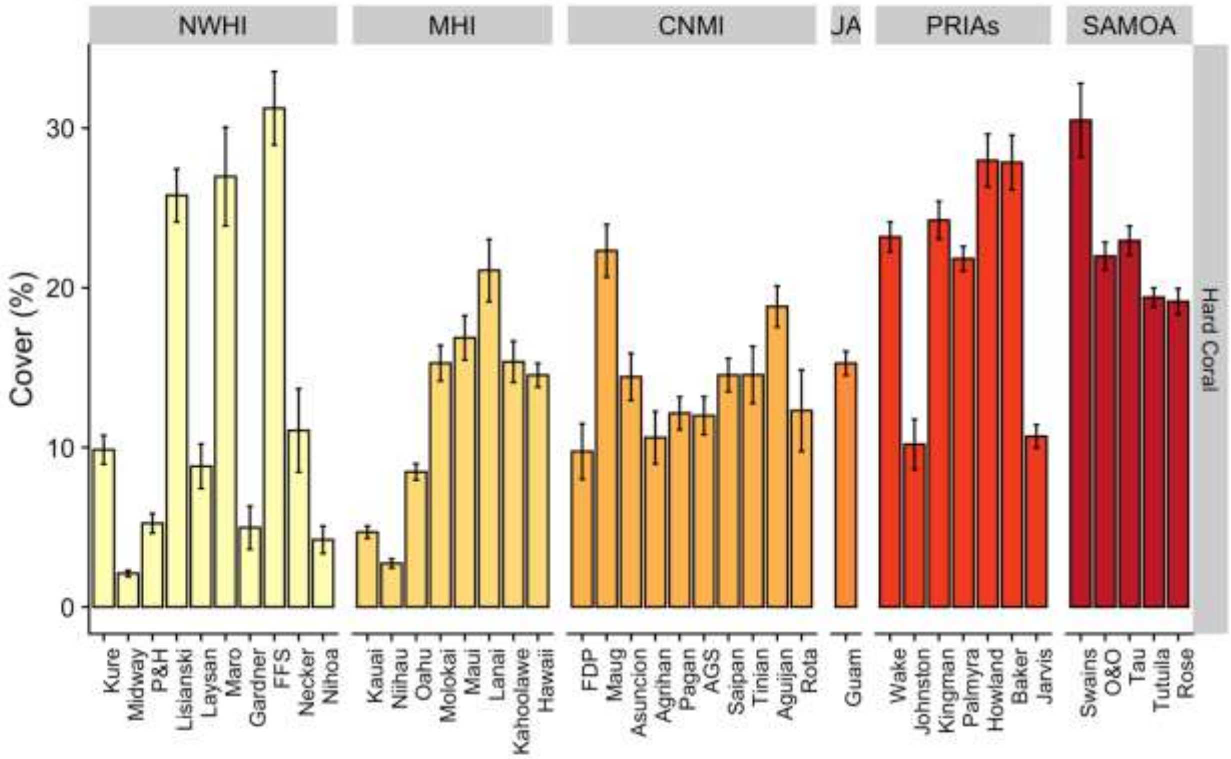


**Figure 1. Mean coral cover (%± SEM) per U.S. Pacific Island averaged over the years 2010-2022 by latitude**

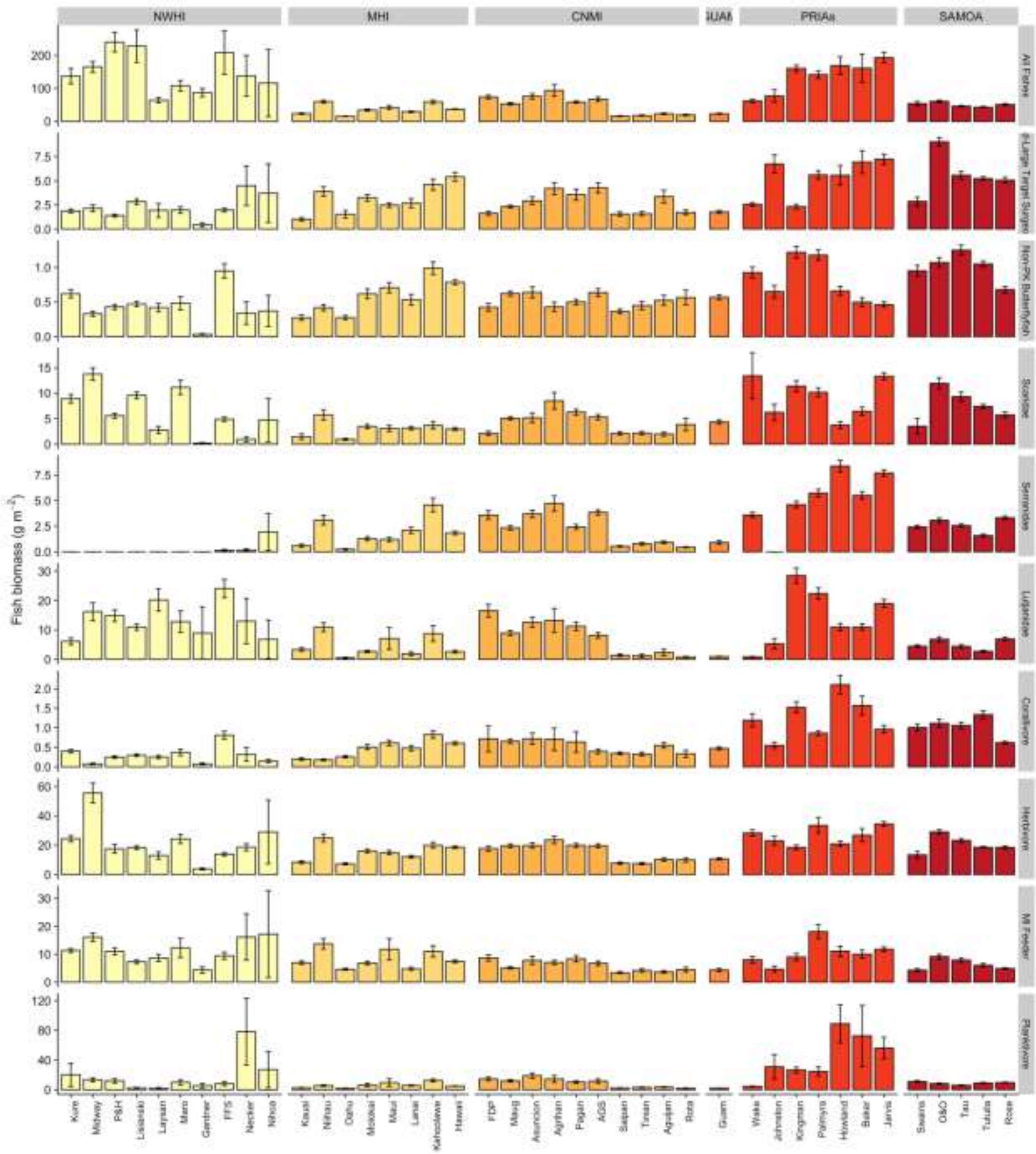


**Figure 2. Mean fish biomass (g/m$^2$ ± SEM) of functional, taxonomic, and trophic groups by U.S. Pacific reef area from the years 2010-2022 by latitude. The group 'Serranidae' excludes planktivorous members of that family (i.e., anthias, which can by hyper-abundant in some regions). Similarly, the bumphead parrotfish, *Bolbometopon muricatum,* has been excluded from the corallivore group. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates, 'Butterflyfish' are non-planktivorous butterflyfish species, and 'Surgeonfish' are mid-large target surgeonfish species**

### 2.2.2 Archipelagic Reef Fish Biomass and Habitat Condition

**Description:** 'Reef fish biomass' is mean biomass of reef fishes per unit area derived from visual survey data between 2010 and 2022. Hard Coral cover is mean cover derived from visual estimates by divers of sites where reef fish surveys occurred. No new surveys occurred in 2020 or 2021 due to COVID-19 and surveys have not been conducted since; the numbers presented here are identical to the 2019 report.

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

**Data Category:** Fishery-independent

**Timeframe:** Triennial

**Jurisdiction:** American Samoa

**Spatial Scale:** Island

**Data Source:** Data used to generate biomass and cover estimates comes from visual surveys conducted by NMFS PIFSC ESD and partners, as part of the Pacific NCRMP. Survey methods and sampling design, and methods to generate reef fish biomass are described in Section 2.3.1.

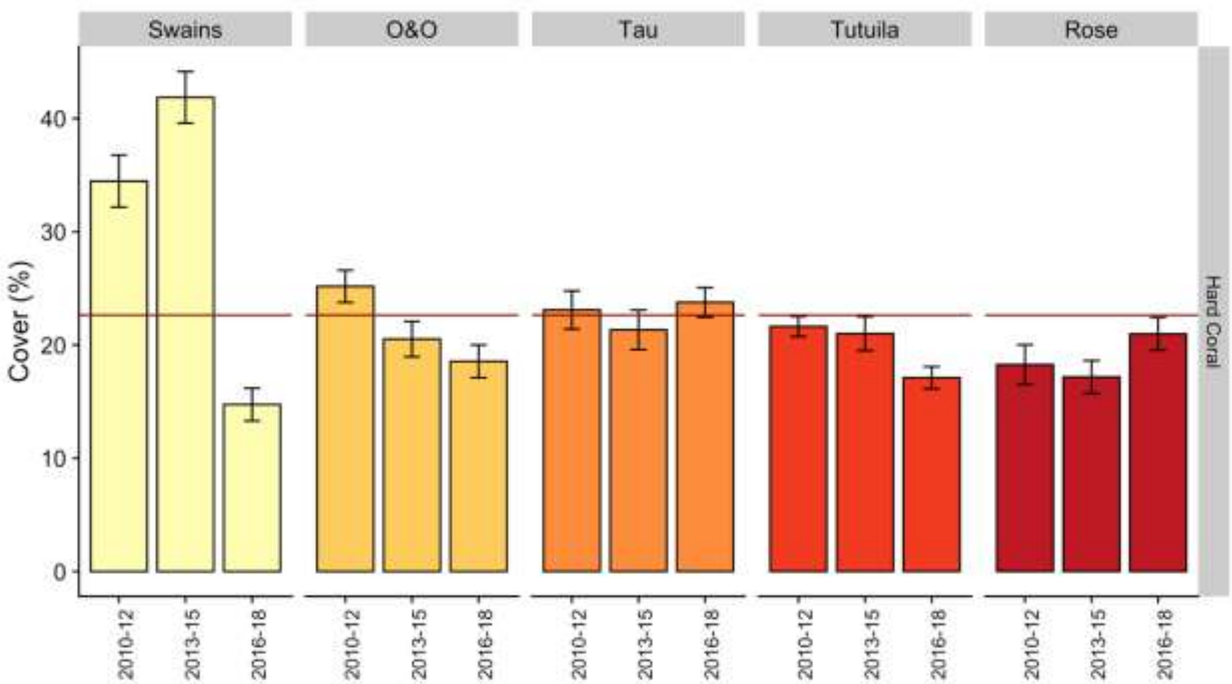


**Figure 3. Mean coral cover (%± SEM) per island over the years 2010-2022 by latitude with American Samoa archipelago mean estimates plotted for reference (horizontal red line)**

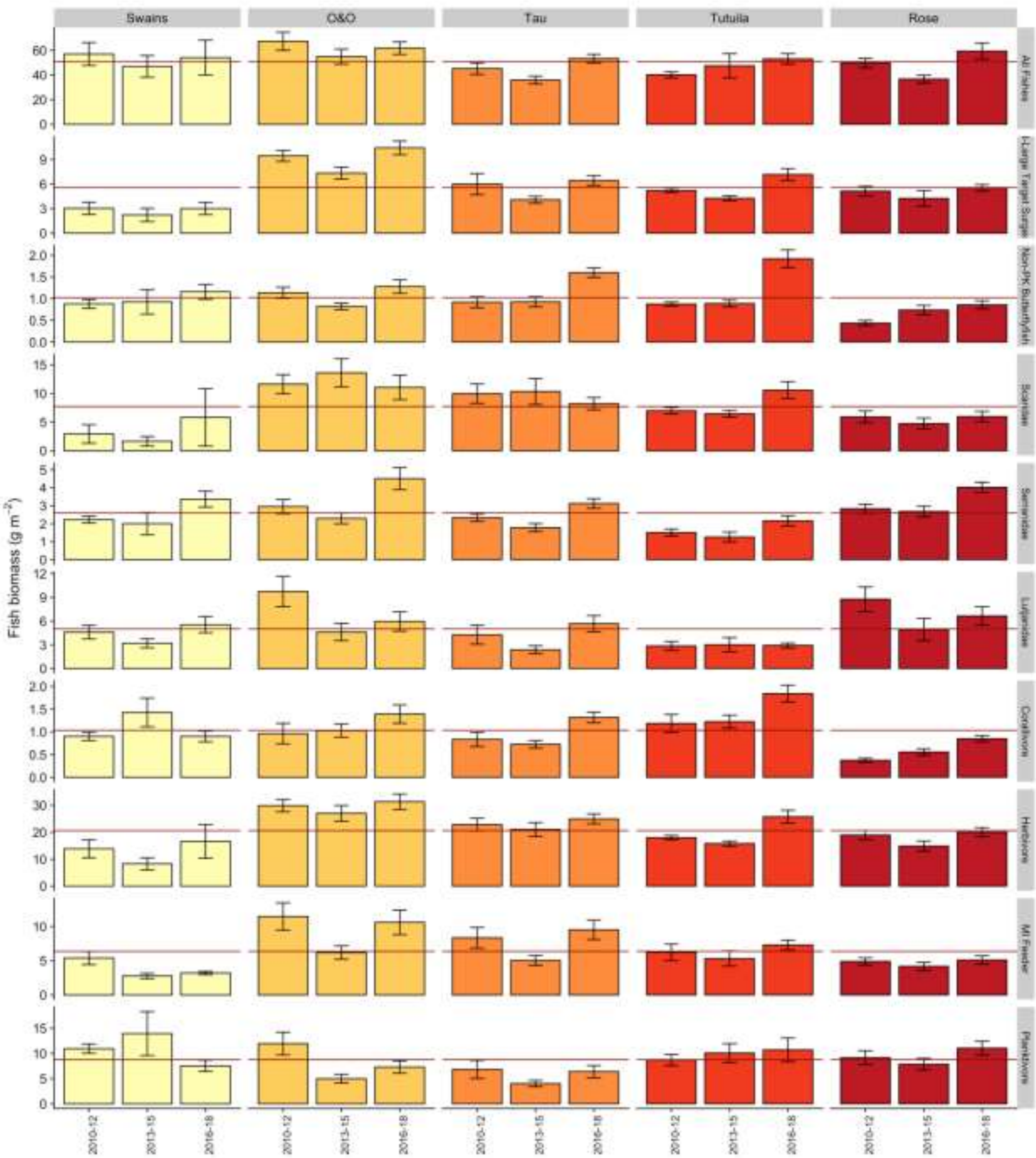


**Figure 4. Mean fish biomass (g/m$^2$ ± standard error) of American Samoa functional, taxonomic, and trophic groups over the years 2010-2022 by island. The group 'Serranidae' excludes planktivorous members of that family (i.e., anthias, which can by hyper-abundant in some regions). Similarly, the bumphead parrotfish, *Bolbometopon muricatum,* has been excluded from the corallivore group. The group 'MI Feeder' consists of fishes that primarily feed on mobile invertebrates, 'Butterflyfish' are non-planktivorous butterflyfish species, and 'Surgeonfish' are mid-large target surgeonfish species. Red horizontal lines are the region-wide mean estimates for reference**

## 2.3 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 stock assessments on fish productivity and population dynamics. Some assessments, particularly for data poor stocks, utilize information from other areas that introduces biases and increases uncertainties in the population estimates. An archipelago-specific life history parameter ensures accuracy in the input parameters used in the assessment.

The NMFS PIFSC Bio-Sampling Program allows for the 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 examined, will contribute to the body of scientific information for the two data poor fisheries in the region (coral reef fish and bottomfish). 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) prioritized coral reef ecosystem component species (ECS), and 2) bottomfish management unit species (BMUS). The prioritized coral reef species list was developed by the American Samoa Department of Marine and Wildlife Resources (DMWR) in 2019. The BMUS are the species that are listed in the federal ecosystem plan and are managed on a federal level. 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. Length-weight conversion coefficients provide area-specific values to convert length from fishery-dependent and fishery-independent data collection to weight or biomass.

### 2.3.1 American Samoa Coral Reef Ecosystem – Life History

#### 2.3.1.1 Age, Growth, and Reproductive Maturity

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

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex, and these data are fitted to a three- or four-parameter logistic function to determine the best fit 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 age at 50% sex reversal ($A\Delta_{50}$) is typically derived by referencing the VBGF for that species and using the corresponding $L_{50}$ and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age 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 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 (LHP). Refer to the “Reference” column in Table 21 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.

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

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

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

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

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

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

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

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

**Rationale:** These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. These parameters are also used as direct inputs into stock assessments. 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 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 21. Available age, growth, and reproductive maturity information for prioritized coral reef ecosystem component species in American Samoa**

| Species | Age, growth, reproductive maturity parameters | | | | | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| | $T_{max}$ | $L_\infty$ | $k$ | $t_0$ | $M$ | $A_{50}$ | $A\Delta_{50}$ | $L_{50}$ | $L\Delta_{50}$ | |
| *Crenimugil crenilabis* | | | | | | | | | | |
| *Epinephelus melanostigma* | | | | | | | | | | |
| *Octopus cyanea* | | | | | | | | | | |
| *Panulirus penicillatus* | | | | | | | | | | |
| *Sargocentron tiere* | | | | | | | | | | |
| *Tridacna maxima* | | | | | | | | | | |

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; $L_\infty$, $L_{50}$, 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 the "Reference" column.

#### 2.3.1.2 Fish Length Derived Parameters

**Description:** The NMFS Commercial Fishery Bio-Sampling Program started in 2010 and ended in 2015. This program had two components: first was the Field/Market Sampling Program and the second was the Lab Sampling Program, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program were to:

- Broad scale looks 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 Program 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:**

***n* – *sample size*** is the total number of samples accumulated for each species recorded in the Bio-Sampling Program database from the commercial spear fishery.

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

**$N_{L\text{-}W}$ – *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 by 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 an important component of fisheries monitoring and data poor stock assessment approaches. Maximum length ($L_{max}$) is used to derive missing species- and location-specific life history information (Nadon et al. 2015; Nadon and Ault 2016; Nadon 2019). 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 is 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 American Samoa coral reef ecosystem component fisheries.

**Table 22. Available length-derived information for prioritized coral reef ecosystem component species in American Samoa**

| Species | Length-derived parameters | | | | | Reference |
|---|---|---|---|---|---|---|
| | *n* | $L_{max}$ | $N_{L\text{-}W}$ | *a* | *b* | |
| *Crenimugil crenilabis* | 380 | 48.2 | 380 | 0.0388 | 2.73 | Matthews et al. (2019) |
| *Epinephelus melanostigma* | 2,662 | 54.9 | 2,662 | 0.0109 | 3.10 | Matthews et al. (2019) |
| *Octopus cyanea* | | | | | | |
| *Panulirus penicillatus* | 3,384 | 15.8 | 3,384 | 2.6004 | 2.41 | Matthews et al. (2019) |
| *Sargocentron tiere* | 3,002 | 25.0 | 3,002 | 0.069 | 2.62 | Matthews et al. (2019) |
| *Tridacna maxima* | | | | | | |

### 2.3.2 American Samoa Ecosystem – Management Unit Species Life History

#### 2.3.2.1 Age, Growth, and reproductive Maturity

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

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex, and these data are fitted to a three- or four-parameter logistic function to determine the best fit 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 age at 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 species have achieved reproductive maturity ($A_{50}$) and sex reversal ($A\Delta_{50}$).

**Category:** Biological

**Timeframe:** N/A

**Jurisdiction:** American Samoa

**Spatial Scale:** Archipelagic

**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 LHP. Refer to the "Reference" column in Table 23 for specific details on data sources by species.

**Parameter definitions:** Identical to Section 2.4.1.1.

**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 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 multi-species assessments.

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; $L_\infty$, $L_{50}$, and $L\Delta_{50}$ are in mm 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; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are shown in the "Reference" column.

**Table 23. Available age, growth, and reproductive maturity information for BMUS targeted for otoliths and gonads sampling in American Samoa**

| Species | Age, growth, and reproductive maturity parameters | | | | | | | | | Reference |
|---|---|---|---|---|---|---|---|---|---|---|
| | $T_{max}$ | $L_\infty$ | $k$ | $t_0$ | $M$ | $A_{50}$ | $A\Delta_{50}$ | $L_{50}$ | $L\Delta_{50}$ | |
| *Aphareus rutilans* | | | | | | | NA | | NA | |
| *Aprion virescens* | | | | | | | NA | | NA | |
| *Caranx lugubris* | | | | | | | NA | | NA | |
| *Etelis carbunculus*[1] | | | | | | | NA | | NA | |
| *Etelis coruscans* | | | | | | | NA | | NA | |
| *Lethrinus rubrioperculatus* | f=10[d]<br>m=10[d] | f=27.3[d]<br>m=29.1[d] | f=0.74[d]<br>m=0.71[d] | f=-0.16[d]<br>m=-0.15[d] | | | | f=21.2[d,e] | | Pardee et al. (2020) |
| *Lutjanus kasmira* | | | | | | | NA | | NA | |
| *Pristipomoides filamentosus* | | | | | | | NA | | NA | |
| *Pristipomoides flavipinnis* | 28[d] | 41.15[d] | 0.47[d] | | 0.22[d] | | NA | | NA | O'Malley et al. (2019) |
| *Pristipomoides zonatus* | | | | | | | NA | | NA | |
| *Variola louti* | | | | | | | | | | |

[1] *E. carbunculus* is now known to be comprised of two distinct, non-interbreeding lineages (Andrews et al. 2016). Both species occur in the Samoa Archipelago and were likely both captured by fishermen in the 1980s but reported as one species.
[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).
[e] $L_{50}$ was derived from the published literature based on the relationship between $L_\infty$ and $L_{50}$

#### 2.3.2.2 Fish Length Derived Parameters

**Description:** The NMFS Commercial Fishery Bio-Sampling Program started in 2010 and ended in 2015. This program had two components: first was the Field/Market Sampling Program and the second was the Lab Sampling Program, details of which are described in a separate section of this report. The goals of the Field/Market Sampling Program were:

- Broad scale looks 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 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 was 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 Bio-Sampling Program

**Parameter Definition:** Identical to Section 2.4.1.2

**Rationale:** Length-derived information is an important component of fisheries monitoring and data poor stock assessment approaches. Maximum length ($L_{max}$) is used to derive missing species- and location-specific life history information (Nadon et al. 2015; Nadon and Ault 2016; Nadon 2019). 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 is 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 American Samoa BMUS fishery.

**Table 24. Available length-derived information for BMUS in American Samoa**

| Species | Length derived parameters | | | | | Reference |
|---|---|---|---|---|---|---|
| | *n* | $L_{max}$ | $N_{L-W}$ | *a* | *b* | |
| *Aphareus rutilans* | 173 | 85.0 | 173 | 0.0395 | 2.73 | Matthews et al. (2019) |
| *Aprion virescens* | 952 | 73.4 | 952 | 0.0157 | 2.99 | Matthews et al. (2019) |
| *Caranx lugubris* | 164 | 86.0 | 164 | 0.0404 | 2.80 | Matthews et al. (2019) |
| *Etelis carbunculus*[1] | | | | | | |
| *Etelis coruscans* | 106 | 89.5 | 106 | 0.0322 | 2.81 | Matthews et al. (2019) |
| *Lethrinus rubrioperculatus* | 2,349 | 57.0 | 2,349 | 0.0287 | 2.86 | Matthews et al. (2019) |
| *Lutjanus kasmira* | 461 | 35.0 | 461 | 0.0176 | 3.01 | Matthews et al. (2019) |

| **Species** | **Length derived parameters** | | | | | **Reference** |
|---|---|---|---|---|---|---|
| | ***n*** | $L_{max}$ | $N_{L-W}$ | ***a*** | ***b*** | |
| *Pristipomoides flavipinnis* | 262 | 56.5 | 262 | 0.0249 | 2.90 | Matthews et al. (2019) |
| *Pristipomoides zonatus* | | | | | | |
| *Pristipomoides filamentosus* | | | | | | |
| *Variola louti* | | 50.5 | 365 | 0.0135 | 3.08 | Matthews et al. (2019) |

[1] *E. carbunculus* is now known to be comprised of two distinct, non-interbreeding lineages (Andrews et al. 2016). Both species occur in the Samoa Archipelago and were likely both captured by fishermen in the 1980s but reported as one species.

## 2.4 SOCIOECONOMICS

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

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 5).


**Figure 5. Settlement of the Pacific Islands, courtesy Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Polynesian_Migration.svg.**

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

### 2.4.1 Response to Previous Council Recommendations

At its 192nd meeting held via web conference and in Honolulu, HI in September 2022, the Council directed staff to incorporate scenario planning for extreme environmental events into EBFM-related planning. PIFSC, PIRO, and Council staff initiated a contract and began coordinating a training to build scenario planning capacity, which would be held in early 2023.

### 2.4.2 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 (WPRFMC 2009). 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 last published Statistical Yearbook, main imports include fish brought in for processing (American Samoa Government 2022). Exports are primarily canned tuna and associated products. In 2019, domestic exports from American Samoa were valued at $353,215,000, of which $351, 470,000 (over 99%) came from canned tuna sale (American Samoa Government 2022). 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 2020, the ASG employed 6,614 people accounting for 40% of the total workforce in the Territory (American Samoa Government 2022), and the private sector employed 7,424 people (Figure 6). The canneries employed 2,361 people, accounting for 14% of the workforce. Ancillary businesses involved in re-provisioning the fishing fleet also generated a notable number of jobs and income for 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 principal 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, and there are currently no plans to reopen (Pacific Islands Report 2017). Starkist Samoa is currently the only cannery operating in American Samoa and is the largest private employer with about 2,000 workers.

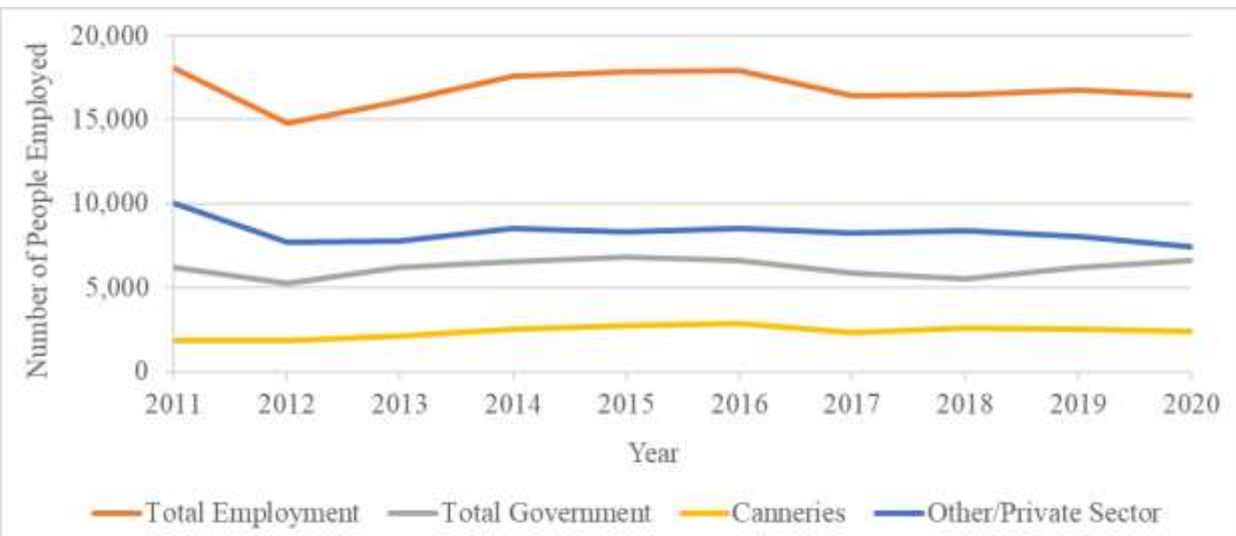


**Figure 6. American Samoa Employment Estimates from 2011-2020; sourced from American Samoa Government (2022)**

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 had also expressed concerns about the impact of National Marine Sanctuary of American Samoa (NMSAS) expansion in 2012 and management of the Rose Atoll Marine National Monument, which was established in 2009. In both of these cases, the local communities have been concerned about the impacts on fishing practices as well as broader social and cultural issues, such as traditional marine tenure and the ability of villages to manage their own resources.

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, 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 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). The Council took action to provide a four-year exemption for vessels permitted under the

American Samoa Longline Limited Entry permit, which reduced the area closed to large vessels from 25.5 to 11.5%. In September 2020, the Ninth Circuit Court of Appeals reversed the District Court decision in favor of NMFS. In February 2021, the ASG appealed to the Supreme Court of the United States, but the writ of certiorari was denied June 21, 2021. NMFS published the original 2016 LVPA exemption as a final rule, effective July 6, 2021.

### 2.4.3 Equity and Environmental Justice

NOAA Fisheries equity and environmental justice (EEJ) goals are to 1) Prioritize identification, equitable treatment, and meaningful involvement of underserved communities, 2) Provide equitable delivery of services and 3) Prioritize EEJ in our mandated and mission work with demonstrable progress.

NOAA Fisheries commitment to EEJ is particularly relevant to the Pacific Islands Region. While every community is a fishing community in the Pacific Islands Region, there are specific features of these communities that can create barriers to EEJ. While some are shared across the region such as comparatively smaller populations and geographic isolation for NOAA Fisheries headquarters, others are specific to the cultural and political context of each archipelago, territory and commonwealth.

In this first year of adding EEJ to the SAFE report we will report a synthesis of feedback from partners and communities collected in informal listening sessions conducted in 2022. We have also included information from the NOAA Climate and Economic Justice Screening Tool Index of disadvantaged communities.

Going forward, we will work to further develop this section to highlight the social and cultural impacts of fisheries science and management and highlight the EEJ issues specific to archipelagic fisheries.

#### 2.4.3.1 2022 Listening Sessions

With the support of NOAA Fisheries leadership, meetings relating to EEJ were conducted in person in American Samoa from August 11-18, 2022. The purpose of these meetings was to meet with key members of fishing communities, partners, and potentially underserved communities for feedback on the draft National Strategy for EEJ, and begin to build the foundation for developing the regional EEJ implementation plan. From these meetings PIFSC social scientists synthesized key EEJ barriers and issues.

Staff from the NOAA PIRO and PIFSC met with approximately 80 people on the island of Tutuila, including: the Office of Samoan Affairs (OSA) Paramount Chief, District Chiefs, and Village Mayors; American Samoa Government agencies; members of key commercial and non-commercial fishing organizations; community organizations; other NOAA line offices; and federal and territorial agency partners.

Prior to travel, we met virtually with NOAA Fisheries staff in American Samoa to identify relevant community members and appropriate engagement strategies, including hand delivering formal invitations and notice of the project. In part due to the length of the visit and lead time, we were not able to visit the islands of Manu’a, which are key underserved communities and a cultural center for Polynesia. Instead, we focused on building important foundations on this trip that will be necessary for engagement in developing the regional EEJ implementation plan, which will include future visits to the islands of Manu'a.

All key themes were reviewed by partners prior to sharing.

#### 2.4.3.2 Key EEJ themes

- American Samoa is in between being fully recognized as a state and being acknowledged as another country, so it doesn't see the full benefits of either status.
- The remote location results in logistical challenges that aren't accounted for in many U.S. standards.
- Cross-cultural considerations need to be better included.
- The fisheries are dying and regulations are not helping fishers.
- There is demand for fresh local seafood but the supply for local markets is not reliable.
- Many processes are set up as a competition between agencies, fisheries, and other organizations. NOAA should be looking for ways to work together and consider effects on the community.
- There is a need for assistance with capacity building and retention that helps recruit and train people to stay in American Samoa.
- There is a lack of meaningful public engagement.
- There is a lack of transparency throughout the decision making process, from results of public input to clear understanding of how decisions are made and how benefits are distributed.
- Lack of inclusion in the scientific process results in mistrust of data and its application.
- There is a need for follow-through on projects and consistency over time.
- Develop partnerships with local organizations and agencies.
- Coordinate among federal agencies and NOAA line offices.
- For planning a visit, remember that people work "on island time" and many interactions are based on oral communication.
- The Office of Samoan Affairs has a major role in communication outreach, via the Village Council.
- NOAA's work is based on science and research but OSA representatives and local people see outcomes via traditional knowledge.
- Translations can be seen as a sign of respect. It is important to know when and when not to use them.

#### 2.4.3.3 Index of Disadvantage

The NOAA Climate and Economic Justice Screening Tool has identified 100% (N=18) of census tract communities in American Samoa as disadvantaged.

### 2.4.4 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, many 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 is 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 several 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).

However, during the COVID-19 pandemic, the local focus of American Samoa fisheries played a vital role in supporting local food systems, nutrition, food security, and community social cohesion (Kleiber et al. 2022).

#### 2.4.4.1 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 bottomfish fishing 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 bottomfish fishing, and spearfishing, netting, and vertical longlining were used on occasion. Bottomfish fishing 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.

#### 2.4.4.2 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 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 offshore. 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 several 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 DMWR has 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).

#### 2.4.4.3 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.

#### 2.4.4.4 Precious Corals

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

### 2.4.5 Fishery Economic Performance

#### 2.4.5.1 Bottomfish Fishery Commercial Landings, Revenues, Price

This section describes trends in commercial pounds sold, revenue, and price for the American Samoa bottomfish fishery. Figure 7 presents the trends for commercial pounds sold and revenue for the bottomfish fishery (i.e., BMUS only) from 2003 to 2022, and Figure 8 presents the trends in fish price for bottomfish sold from 2003 to 2022. Supporting data for Figure 7 and Figure 8 are shown in Table 25. The table also includes the percentage of pounds sold relative to estimates of total pounds landed for the bottomfish fishery. Both nominal and adjusted values are included.

Commercial landings data in 2021 and 2022 are confidential due to fewer than three participating vendors, so no detailed figures are presented. The 18-year average (i.e., 2002-2020) for the proportion of commercial landings to total landings was 20%. Revenue trends tend to follow a similar pattern to pounds sold. BMUS commercial landings and revenue have fluctuated over the period of 2003 to 2020, but in 2020, both revenue and pounds sold decreased considerably, possibly due to impacts associated with COVID-19. Average BMUS price was steady over most of the time period, but it increased substantially in 2017 before decreasing in subsequent years. The nominal bottomfish price in 2020 of $3.45 decreased from $4.24 in 2019. Low commercial landings and fish prices resulted in a historical low for bottomfish revenue in 2020.

It is worth noting that the data for pounds caught and pounds sold are collected by two different data collection methods. The data for pounds sold are collected through the "Commercial Sales Receipt Books" Program, while the data for pounds caught are collected through Boat- and Shore-based creel surveys. Both data series are generated from an expansion algorithm built on a non-census data collection program, and the survey coverage rates of two data collection methods may change independently across individual years. Therefore, the two time series may not move coherently with each other. For example, the low percentage of pounds sold compared to pounds caught could be due to low coverage of dealer participation in the Commercial Receipt Books Program.

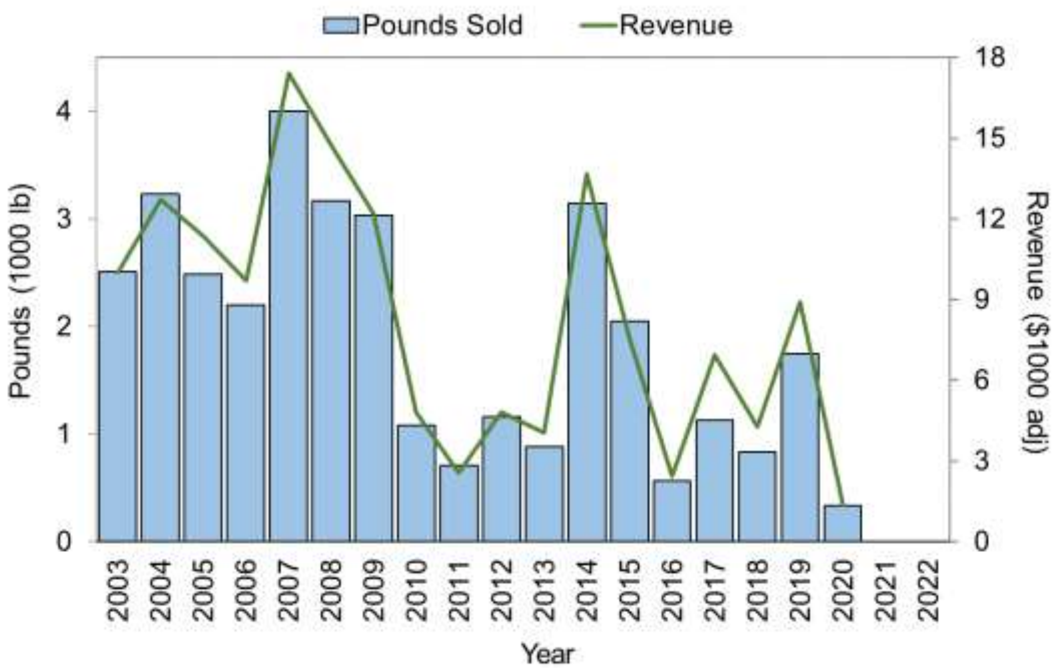


**Figure 7. Pounds sold and revenue for the American Samoa bottomfish fishery***

* Data were confidential in 2021 and 2022 due to fewer than three participating vendors.

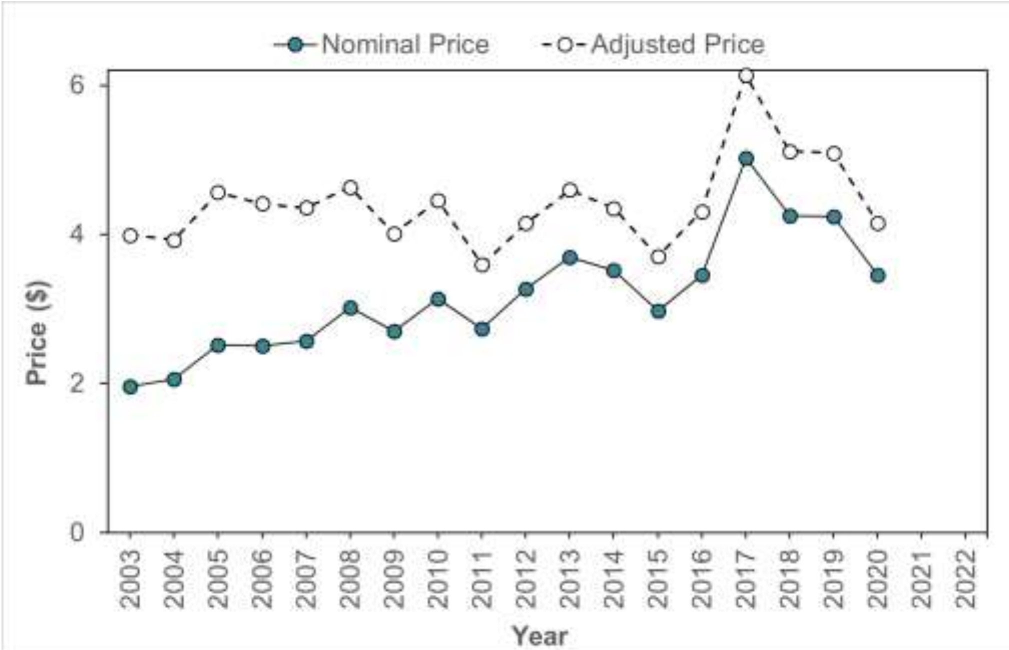


**Figure 8. Price BMUS in the American Samoa bottomfish fishery**

* Data were confidential in 2021 and 2022 due to fewer than three participating vendors.

**Table 25. Commercial landings and revenue for the American Samoa bottomfish fishery**

| Year | Estimated pounds caught (lb) | Estimated pounds sold (lb) | % of sold | Estimated revenue ($) | Estimated revenue ($ adjusted) | Fish price ($) | Fish price ($ adjusted) | CPI adjustor |
|---|---|---|---|---|---|---|---|---|
| 2003 | 12,872 | 2,511 | 20% | 4,921 | 10,024 | 1.96 | 3.99 | 2.037 |
| 2004 | 10,762 | 3,234 | 30% | 6,675 | 12,716 | 2.06 | 3.92 | 1.905 |
| 2005 | 9,579 | 2,489 | 26% | 6,270 | 11,355 | 2.52 | 4.56 | 1.811 |
| 2006 | 3,029 | 2,203 | 73% | 5,522 | 9,708 | 2.51 | 4.41 | 1.758 |
| 2007 | 10,499 | 4,001 | 38% | 10,265 | 17,409 | 2.57 | 4.36 | 1.696 |
| 2008 | 23,170 | 3,171 | 14% | 9,590 | 14,721 | 3.02 | 4.64 | 1.535 |
| 2009 | 48,228 | 3,036 | 6% | 8,207 | 12,196 | 2.70 | 4.01 | 1.486 |
| 2010 | 9,338 | 1,083 | 12% | 3,397 | 4,817 | 3.14 | 4.45 | 1.418 |
| 2011 | 15,981 | 711 | 4% | 1,949 | 2,555 | 2.74 | 3.59 | 1.311 |
| 2012 | 2,124 | 1,162 | 55% | 3,797 | 4,818 | 3.27 | 4.15 | 1.269 |
| 2013 | 6,272 | 882 | 14% | 3,258 | 4,056 | 3.69 | 4.59 | 1.245 |
| 2014 | 16,319 | 3,140 | 19% | 11,051 | 13,659 | 3.52 | 4.35 | 1.236 |
| 2015 | 22,787 | 2,048 | 9% | 6,073 | 7,573 | 2.97 | 3.70 | 1.247 |
| 2016 | 19,502 | 565 | 3% | 1,948 | 2,431 | 3.45 | 4.31 | 1.248 |
| 2017 | 15,132 | 1,130 | 7% | 5,676 | 6,942 | 5.02 | 6.14 | 1.223 |
| 2018 | 11,519 | 838 | 7% | 3,558 | 4,280 | 4.25 | 5.11 | 1.203 |
| 2019 | 10,847 | 1,749 | 16% | 7,423 | 8,915 | 4.24 | 5.09 | 1.201 |
| 2020 | 7,408 | 336 | 5% | 1,160 | 1,395 | 3.45 | 4.15 | 1.203 |
| 2021 | 1,361 | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | 1.097 |
| 2022 | 1,039 | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. | 1 |

‘n.d.’ = Confidential due to fewer than three participating vendors.

#### 2.4.5.2 Bottomfish 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 American Samoa DMWR and WPacFIN. Figure 9 shows the average trip costs for American Samoa bottomfish trips from 2009-2022. Trip cost data are not available prior to 2009 when the trip data collection program began.

In 2022, the average cost for a bottomfish trip was $123 (i.e., lower than $172 in nominal trip costs in 2021). Fuel price increased notably in 2022, but trip cost went down due to reduced fuel usage. Supporting data for Figure 9 are presented in Table 26. The cost data summaries were generated by excluding outliners (i.e., cases with >10 gallons/hour fished).

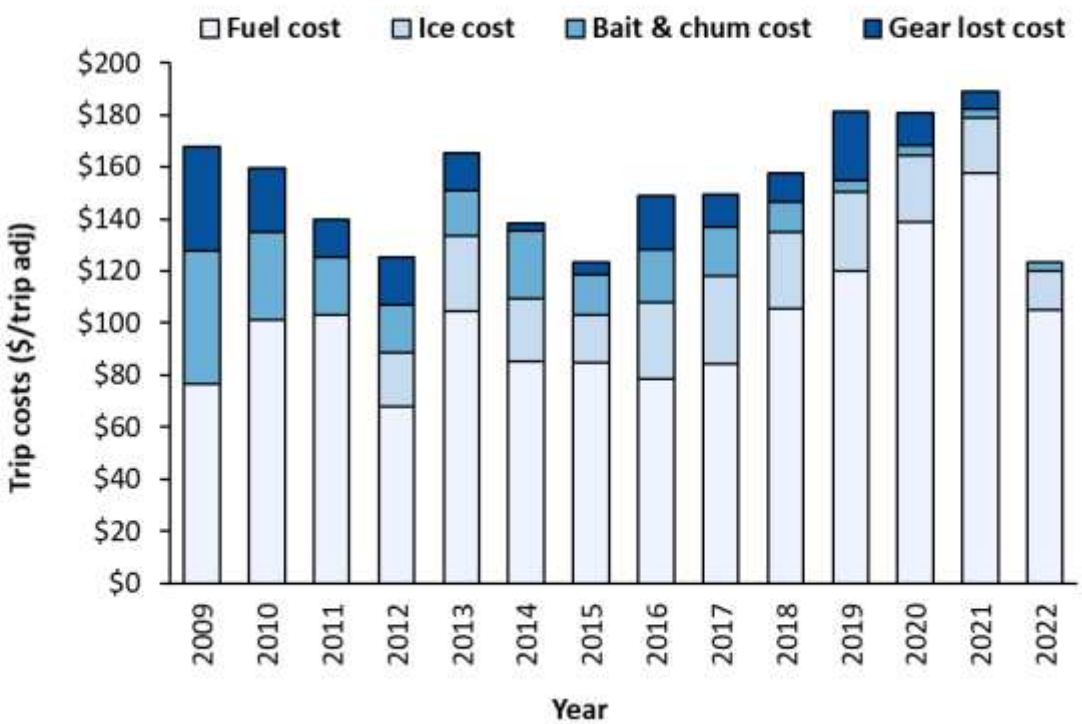


**Figure 9. Average costs for American Samoa bottomfish trips (adjusted to 2022 dollars)**

Data source: PIFSC Continuous Cost Data Collection Program (Chan and Pan 2019). Trip cost data are not available prior to 2009 when the trip data collection program began.

**Table 26. Average and itemized costs for American Samoa bottomfish trips (adjusted to 2022 dollars)**

| Year | Total trip costs ($) | Total trip cost adj. ($) | Fuel cost adj. ($) | Ice cost adj. ($) | Bait cost adj. ($) | Gear losted adj. ($) | Fuel price adj. ($/gallon) | CPI Adjustor |
|---|---|---|---|---|---|---|---|---|
| 2009 | 113 | 168 | 77 | - | 51 | 40 | 4.54 | 1.486 |
| 2010 | 112 | 159 | 101 | - | 34 | 24 | 4.79 | 1.418 |
| 2011 | 106 | 140 | 103 | - | 22 | 14 | 5.32 | 1.311 |
| 2012 | 99 | 125 | 68 | 21 | 19 | 18 | 5.32 | 1.269 |
| 2013 | 133 | 165 | 105 | 29 | 17 | 15 | 5.34 | 1.245 |
| 2014 | 112 | 138 | 85 | 24 | 26 | 3 | 3.15 | 1.236 |
| 2015 | 99 | 124 | 85 | 18 | 15 | 5 | 2.48 | 1.247 |
| 2016 | 119 | 149 | 79 | 29 | 20 | 21 | 2.75 | 1.248 |
| 2017 | 122 | 149 | 84 | 34 | 18 | 13 | 2.80 | 1.223 |
| 2018 | 131 | 158 | 106 | 29 | 11 | 11 | 3.84 | 1.203 |
| 2019 | 151 | 181 | 120 | 30 | 4 | 27 | 3.91 | 1.201 |
| 2020 | 150 | 181 | 139 | 26 | 4 | 12 | 3.79 | 1.203 |
| 2021 | 172 | 189 | 158 | 21 | 3 | 7 | 3.79 | 1.097 |
| 2022 | 123 | 123 | 105 | 15 | 4 | 0 | 4.99 | 1.000 |

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

#### 2.4.5.3 Ecosystem Component Species

Based on new guidelines for the archipelagic SAFE report from the Council, this section highlights the top 10 ecosystem component species (ECS) sorted by landings and the priority ECS as identified by the American Samoa DMWR caught by small boats or shoreline fishing. Please note the top 10 species list and the priority species list reported in this socioeconomic module may not be consistent with the lists reported in the fishery module in the previous sections. The inconsistencies result from several factors: 1) differences in data sources, 2) differences in level of species groupings, 3) differences in commercial landing and total landings.

Firstly, the data for pounds caught and pounds sold are gathered by two different data collection methods. The data for pounds sold (commercial landings) reported in this socioeconomics module were collected through the commercial receipt book program, while the data for pounds caught were collected through the boat-based creel survey. The survey coverage rates of two data collection methods may change independently in individual years. Secondly, the species groups used in the two data collection programs were different, as the species in the commercial receipt books are usually lumped into family levels or species groups while the species reported in the creel survey are more often detailed at the species level. Third, fish species with higher total pounds caught may not necessarily lead to higher pounds sold in the markets. Therefore, the two series may not move coherently with each other.

Table 27 shows the commercial landings and revenue of the top 10 ECS in American Samoa. The total commercial landings (pounds sold) of the top 10 species/species groups were 3,087 pounds (valued at $7,118) in 2022. The data from 2021 are also presented in the table. The commercial landings and revenue in 2022 were lower than in 2021. The commercial landings ratio was difficult to estimate because the commercial landings (in pounds sold) were collected through the commercial receipt book program where species are often lumped into species groups or families, and the data of pounds caught were collected through the creel survey where species are more specifically identified.

Table 28 shows the priority ECS. Six fish species have been suggested as priority species (species of interest) for the area by American Samoa DMWR. Only one species (green spiny lobster) of the six appeared in the commercial receipt books in 2021 and 2022.

**Table 27. Top 10 ECS commercial landings, revenue, and price**

| Top 10 landings (Boat base) | Pounds kept | Top 10 commercial landings (receipt books) | Pounds sold | Revenue ($) | Price ($/lb) |
|---|---|---|---|---|---|
| Redlip parrotfish | 1,845 | Blue-banded surgeonfish | 1,089 | 4,343 | 3.99 |
| Bluespine unicornfish | 1,060 | Parrotfishes | 427 | 2,193 | 5.14 |
| Blue-banded surgeonfish | 988 | Spotted/7-11reef crab | 434 | 1,628 | 3.75 |
| Redtail parrotfish | 902 | Bottomfishes (unknown) | 339 | 1,273 | 3.76 |
| Spiny lobster | 562 | Pacific sailfin tang | 240 | 853 | 3.55 |
| Orangespine unicornfish | 439 | Unicornfishes | 207 | 839 | 4.05 |
| Bridled parrotfish | 424 | Striped bristletooth | 124 | 503 | 4.06 |
| Dark-capped parrotfish | 326 | Tilapia | 120 | 288 | 2.40 |
| Bigeye bream | 288 | Squirrelfishes | 67 | 255 | 3.81 |
| Yellowlip emperor | 284 | Snubnose pompano | 40 | 135 | 3.38 |
| Sum 2022 | **7,118** | | **3,087** | **12,310** | 3.99 |
| Sum 2021 | **7,296** | | **7,749** | **27,702** | 3.57 |

Data source: WPacFIN, commercial receipt books.

**Table 28. Priority ECS commercial landings, revenue, and price**

| Year | Common Name | Landings Boat Based Estimated (lbs) | Estimated com. landings (lbs) | Estimated revenue | Price ($/lb) |
|---|---|---|---|---|---|
| 2022 | Green spiny lobster | 562 | 58 | 232 | 4.00 |
| 2022 | Bluelined squirrelfish | 47 | | | |
| 2022 | Fringelip mullet | 23 | | | |
| 2021 | Green spiny lobster | 727 | 311 | 1,668 | 5.36 |
| 2021 | Bluelined squirrelfish | 61 | | | |
| 2021 | Fringelip mullet | 82 | | | |
| 2021 | One-blotch grouper | 52 | | | |

Data source: WPacFIN commercial receipt books (some data confidential in 2022 due to fewer than three participating vendors).

### 2.4.6 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/](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 2022. Entries for American Samoa archipelagic 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 29. Pacific Islands Region 2022 Commercial Fishing Economic Assessment Index**

| | 2022 Projected CFEAI | | | | |
|---|---|---|---|---|---|
| | 2022 Reporting Year (e.g. 1/2022-12/2022) | | | | |
| | Data | | | Assessment | |
| Pacific Islands Fisheries | Fishing Revenue Most Recent Year | Operating Cost Most Recent Year | Fixed Cost Most Recent Year | Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year | Profit Assessment Most Recent Year |
| HI Longline | 2022 | 2022 | 2013 | 2022 | 2016 |
| ASam Longline | 2022 | 2022 | 2016 | 2022 | 2019 |
| HI Offshore Handline | 2022 | 2014 | 2014 | 2019 | 2019 |
| HI Small Boat (pelagic) | 2022 | 2021 | 2021 | 2017 | 2019 |
| HI Small Boat (bottomfish) | 2022 | 2021 | 2021 | 2017 | 2019 |
| HI Small Boat (reef) | 2022 | 2021 | 2021 | 2017 | 2019 |
| Guam Small boat | 2022 | 2022 | 2019 | 2019 | |
| CNMI Small boat | 2022 | 2022 | 2019 | 2019 | |
| **ASam Small boat** | **2022** | **2022** | **2021** | **2019** | |

PIFSC maintained the ongoing economic data collection in American Samoa for small boat fisheries (Chan and Pan 2019) during 2022. Additionally, a cost-earnings survey of the American Samoa small boat fishery was completed during 2021. This survey provides updated data on fishing revenues, operating costs, and fixed costs, as well as numerous elements related to fishing behavior, market participation, and fishery demographics for American Samoa boat-based fisheries. PIFSC hopes to have survey results published during 2023.

PIFSC also generates projections for upcoming fiscal years, and the table below provides the projected CFEAI report for 2023 (*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 small boat fisheries (Chan and Pan 2019) during 2023.

**Table 30. Pacific Islands Region 2023 Commercial Fishing Economic Assessment Index**

| | 2023 CFEAI | | | | |
|---|---|---|---|---|---|
| | 2023 Reporting Year (e.g. 1/2023-12/2023) | | | | |
| | Data | | | Assessment | |
| Pacific Islands Fisheries | Fishing Revenue Most Recent Year | Operating Cost Most Recent Year | Fixed Cost Most Recent Year | Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year | Profit Assessment Most Recent Year |
| HI Longline | 2023 | 2023 | 2023 | 2023 | 2016 |
| ASam Longline | 2023 | 2023 | 2016 | 2023 | 2019 |
| HI Offshore Handline | 2023 | 2014 | 2014 | 2019 | 2019 |
| HI Small Boat (pelagic) | 2023 | 2021 | 2021 | 2023 | 2023 |
| HI Small Boat (bottomfish) | 2023 | 2021 | 2021 | 2023 | 2023 |
| HI Small Boat (reef) | 2023 | 2021 | 2021 | 2023 | 2023 |
| Guam Small boat | 2023 | 2023 | 2019 | 2019 | |
| CNMI Small boat | 2023 | 2023 | 2019 | 2019 | |
| **ASam Small boat** | **2023** | **2023** | **2021** | **2019** | |

Community social indicators have been generated for American Samoa (Kleiber et al. 2018) in accordance with a national project to describe and evaluate community well-being in terms of environmental justice, economic vulnerability, and gentrification pressure. However, these indicators rely on Census data, and cannot be updated until 2020 Census data becomes available, likely during 2023.

### 2.4.7 Relevant PIFSC Economics and Human Dimensions Publications: 2022

| **Publication** | **MSRA priority** |
|---|---|
| Freitag A, Blake S, Clay PM, Haynie AC, Kelble C, Jepson M, Kasperski S, Leong KM, Moss JH, Regan SD. 2022. Scale matters - Relating Wetland Loss and Commercial Fishing Activity in Louisiana across Spatial Scales. Nature and Culture, 17(2):144-169. https://doi.org/10.3167/nc.2022.170202 | HC2.1.2<br>HC3.1.3 |
| Kleiber D, Iwane M, Kamikawa K, Leong K, Hospital J. 2022. Pacific Islands Region Fisheries and COVID-19: Impacts and adaptations. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-130. https://doi.org/10.25923/2fpm-c128 | HC2.2.4 |
| Smith SL, Cook S, Golden A, Iwane MA, Kleiber D, Leong KM, Mastitski A, Richmond L, Szymkowiak M, Wise S. 2022. Review of adaptations of U.S. commercial fisheries in response to the COVID-19 pandemic using the Resist-Accept-Direct (RAD) framework. Fisheries Management and Ecology:1-17. https://doi.org/10.1111/fme.12567 | HC2.2.4 |

## 2.5 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.

### 2.5.1 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.

#### 2.5.1.1 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.

#### 2.5.1.2 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 ESA-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 31.

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 distinct population segment (DPS) of scalloped hammerhead shark or ESA-listed reef-building corals.

**Table 31. Summary of ESA consultations for American Samoa FEP Fisheries**

| Fishery | Consultation date | Consultation type[a] | Outcome[b] | Species |
|---|---|---|---|---|
| All fisheries | 4/9/2015 | LOC | NLAA | Reef-building corals, scalloped hammerhead shark (Indo-West Pacific DPS) |
| Bottomfish | 3/3/2002 | 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 |
| | 8/26/2022 | BiOp | NLAA | Oceanic whitetip shark, giant manta ray, chambered nautilus |
| 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. |
| | 9/18/2018 | No effect memo | No effect | Oceanic whitetip shark, giant manta ray |
| 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 |
| | 9/18/2018 | No effect memo | No effect | Oceanic whitetip shark, giant manta ray |
| 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 |
| | 9/18/2018 | No effect memo | No effect | Oceanic whitetip shark, giant manta ray |

[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).

On August 26, 2022, NMFS completed a BiOp initiated in response to the 2018 ESA listings of the oceanic whitetip shark, giant manta ray, and chambered nautilus for the American Samoa bottomfish fishery. This BiOp did not re-evaluate species previously consulted on because NMFS determined that reinitiation has not been triggered for those species in a Biological Evaluation dated June 5, 2019. NMFS determined that American Samoa bottomfish fishery is not likely to adversely affect giant manta rays, the chambered nautilus, or the oceanic whitetip shark.

*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).

On September 18, 2018, NMFS concluded the American Samoa crustacean fisheries will have no effect on the oceanic whitetip shark and giant manta ray.

*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).

On September 18, 2018, NMFS concluded the American Samoa coral reef ecosystem fisheries will have no effect on the oceanic whitetip shark and giant manta ray.

*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.

On September 18, 2018, NMFS concluded the American Samoa precious coral fisheries will have no effect on the oceanic whitetip shark and giant manta ray.

#### 2.5.1.3 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 2023 LOF (88 FR 16899, March 21, 2023) 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).

### 2.5.2 Status of Protected Species Interactions in the American Samoa FEP Fisheries

*Bottomfish and Coral Reef Fisheries*

As described in Section 2.6.1.2, NMFS determined that bottomfish and coral reef fisheries operating under the American Samoa FEP are not expected to interact with any ESA-listed species in federal waters around American Samoa.

The 2022 biological opinion determined that the American Samoa bottomfish fishery is not likely to adversely affect the oceanic whitetip shark, giant manta rays, or chamber nautilus, and there are currently no known reported interactions. 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.

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 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 MMPA.

There are also no observer data available for the American Samoa bottomfish or coral reef fisheries.

*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 MMPA.

### 2.5.3 Identification of Emerging Issues

Table 32 summarizes current candidate ESA species, recent listing status, and post-listing activity (critical habitat designation and recovery plan development). Impacts from FEP-managed fisheries on any new listings and critical habitat designations will be considered in future versions of this report.

**Table 32. Status of candidate ESA species, recent ESA listing processes, and post-listing activities**

| Species | | Listing Process | | | Post-Listing Activity | |
|---|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **90-Day Finding** | **12-Month Finding / Proposed Rule** | **Final Rule** | **Critical Habitat** | **Recovery Plan** |
| **Oceanic whitetip shark** | *Carcharhinus longimanus* | Positive (81 FR 1376, 1/12/2016) | Positive, threatened (81 FR 96304, 12/29/2016) | Listed as threatened (83 FR 4153, 1/30/2018) | Designation not prudent; no areas within U.S. jurisdiction that meet definition of critical habitat (85 FR 12898, 3/5/2020) | Draft Recovery Plan published January 25, 2023 (88 FR 4817) |
| **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) | Designation not prudent; no areas within U.S. jurisdiction that meet definition of critical habitat (85 FR 5197, 01/29/2020) | TBA |
| **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) | Designation not prudent; no areas within U.S. jurisdiction that meet definition of critical habitat (84 FR 66652, 12/5/2019) | Recovery outline published 12/4/19 to serve as interim guidance until full recovery plan is developed; recovery planning workshop planned for 2021. |
| **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) | Critical habitat proposed (85 FR 76262, 11/27/2020), comment period extended through 5/26/2021 (86 FR 16325) | In development, interim recovery outline in place; recovery workshops convened in May 2021. |

| Species | | Listing Process | | | Post-Listing Activity | |
|---|---|---|---|---|---|---|
| **Common Name** | **Scientific Name** | **90-Day Finding** | **12-Month Finding / Proposed Rule** | **Final Rule** | **Critical Habitat** | **Recovery Plan** |
| **Giant clams** | *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 summer 2023 | TBA |
| **Shortfin Mako Shark** | *Isurus oxyrinchus* | Positive (86 FR 19863. 4/15/2021) | Not warranted (87 FR 68236, 11/14/2022) | N/A | 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.

### 2.5.4 Identification of Research, Data, and Assessment Needs

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

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

## 2.6 CLIMATE AND OCEANIC INDICATORS

### 2.6.1 Introduction

Over the past several years, the Council has incorporated climate change into the overall management of the fisheries over which it has jurisdiction. This 2022 annual SAFE report includes a now standard chapter on indicators of climate and oceanic conditions in the Western Pacific region. These indicators reflect global climate variability and change as well as trends in local oceanographic conditions.

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

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

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

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

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

### 2.6.2 Response to Previous Plan Team and Council Recommendations

There were no Council recommendations relevant to the climate and oceanic indicators section of the annual SAFE report for the American Samoa Archipelago in 2022.

### 2.6.3 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 10).

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

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

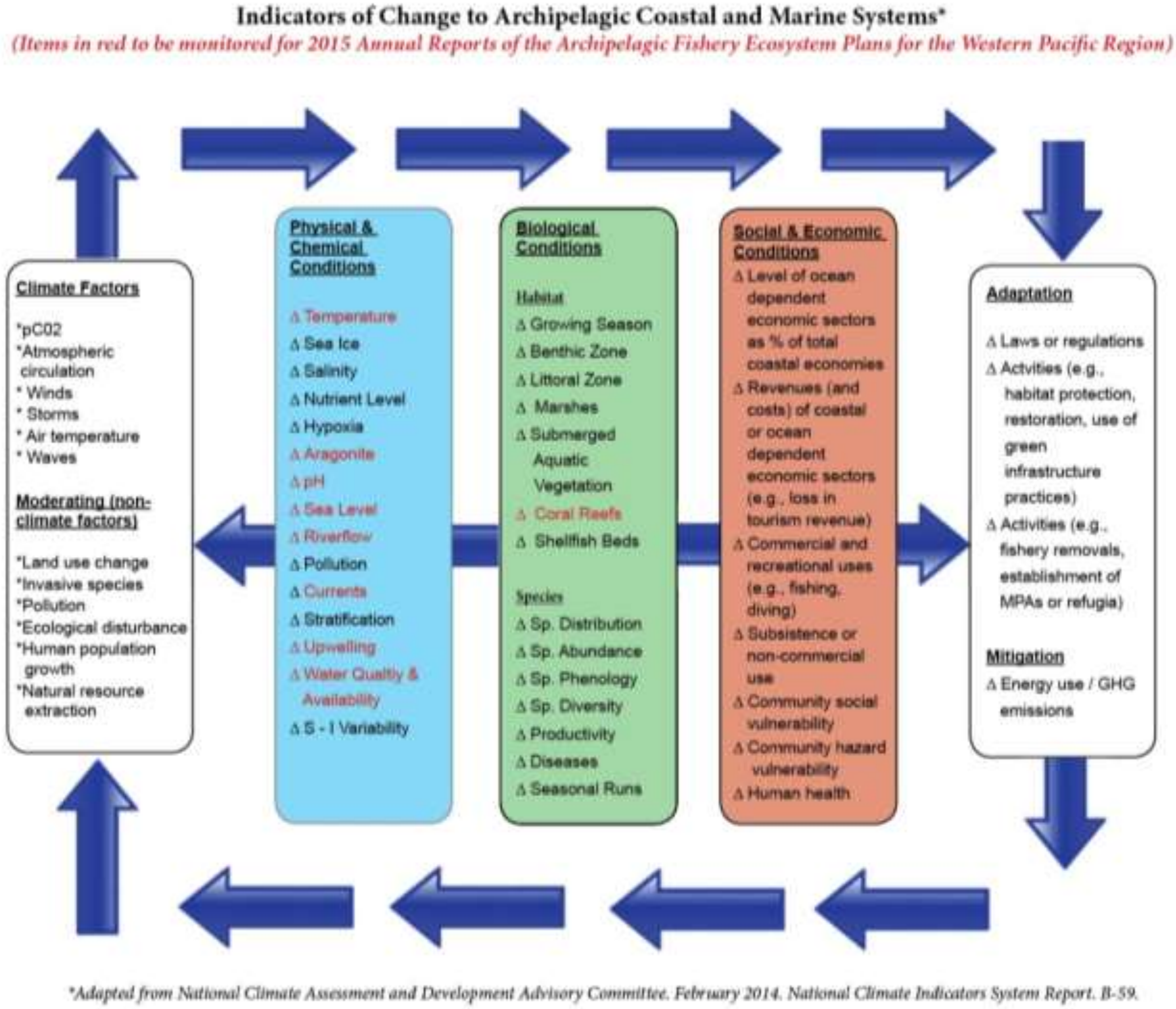


**Figure 10. Indicators of change of archipelagic coastal and marine systems; conceptual model**

### 2.6.4 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 considering 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 11 and Figure 12 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.

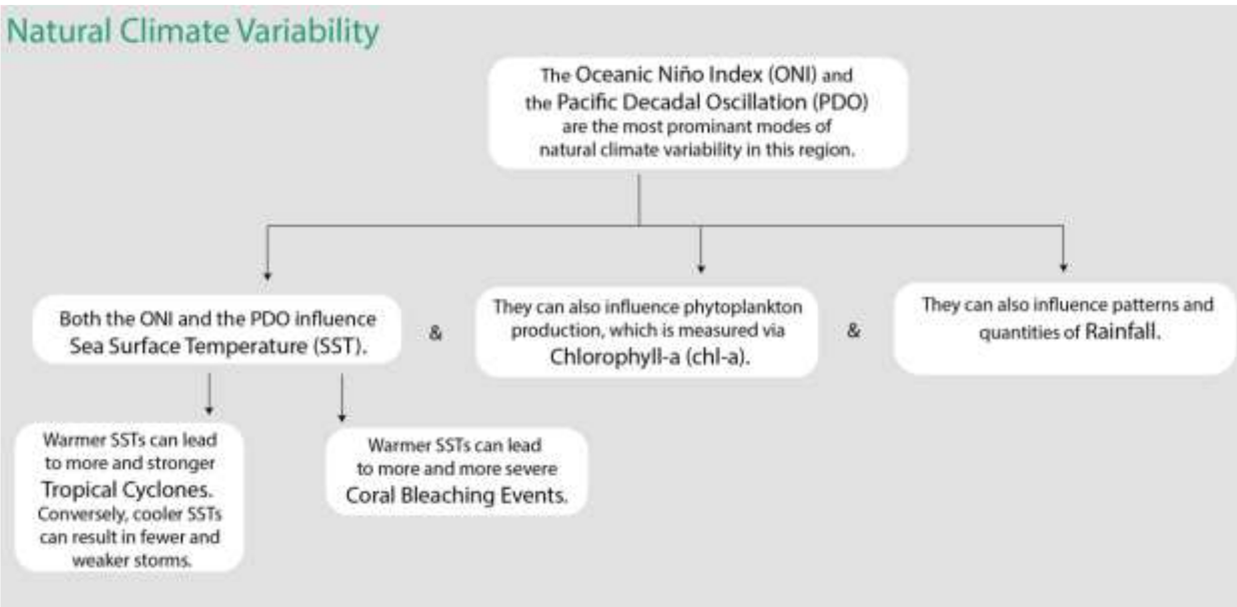


**Figure 11. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability**

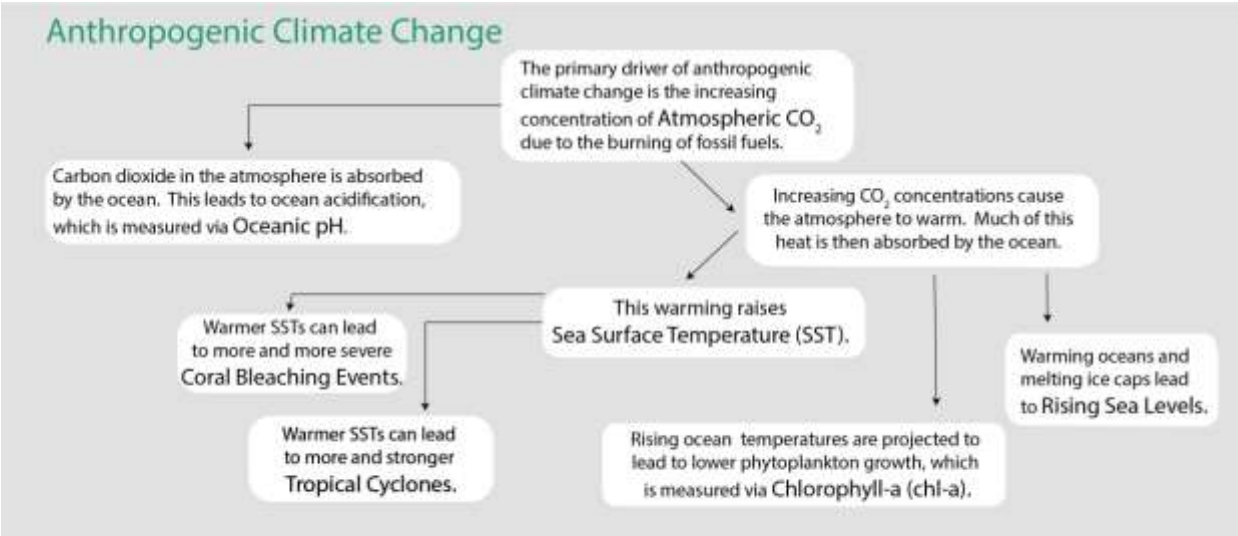


**Figure 12 Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of anthropogenic climate change**

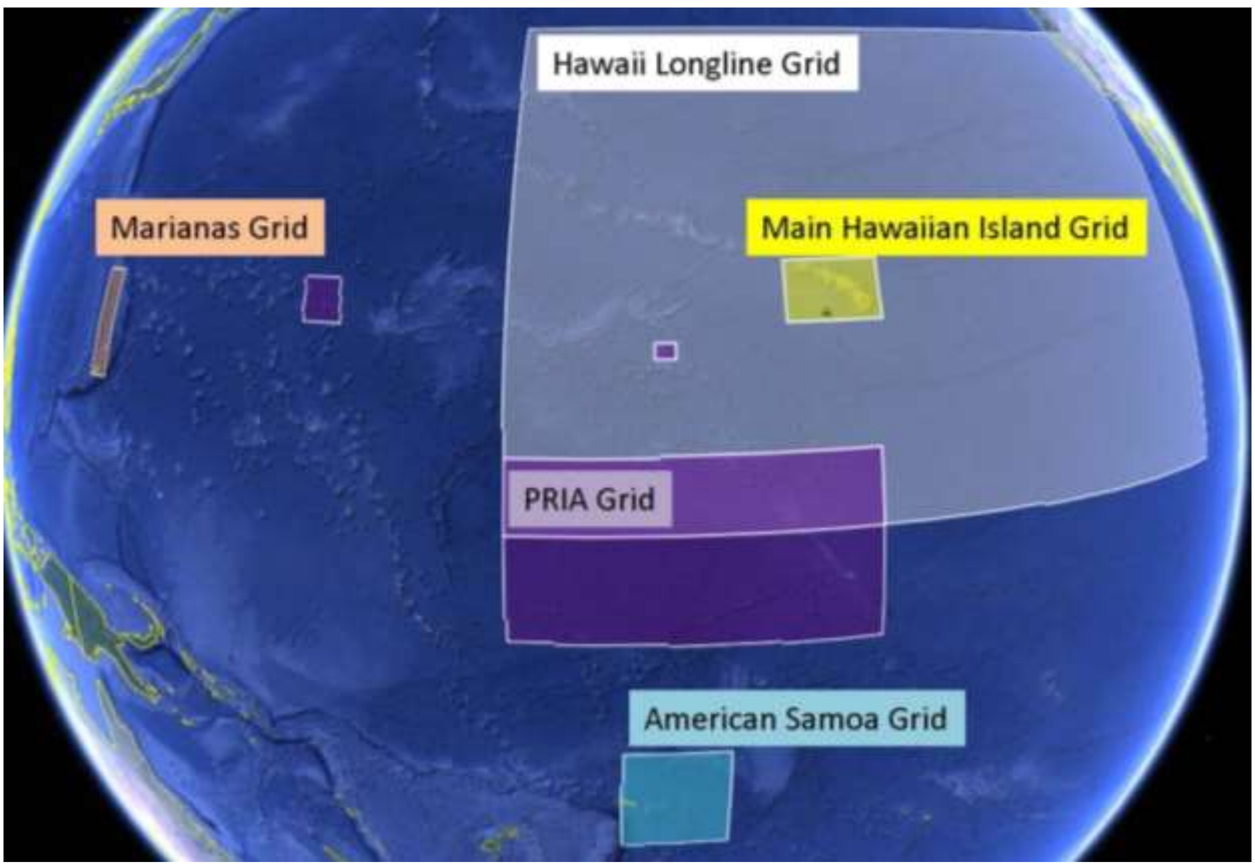


**Figure 13. Regional spatial grids representing the scale of the climate change indicators being monitored**

#### 2.6.4.1 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 more quickly over time. In 2022, the annual mean concentration of $CO_2$ was 418.56 ppm. This is the highest annual value recorded. This year also saw the highest monthly value, which was 420.99 ppm. In 1959, the first year full of the time series, the atmospheric concentration of $CO_2$ was 316 ppm. The annual mean passed 350 ppm in 1988 and 400 ppm in 2015.

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

Timeframe: Annual, monthly.

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

Measurement Platform: *In-situ* station.

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

Sourced from: Keeling et al. (1976), Thoning et al. (1989), and NOAA (2023a). Graphics produced in part using Stawitz (2022).

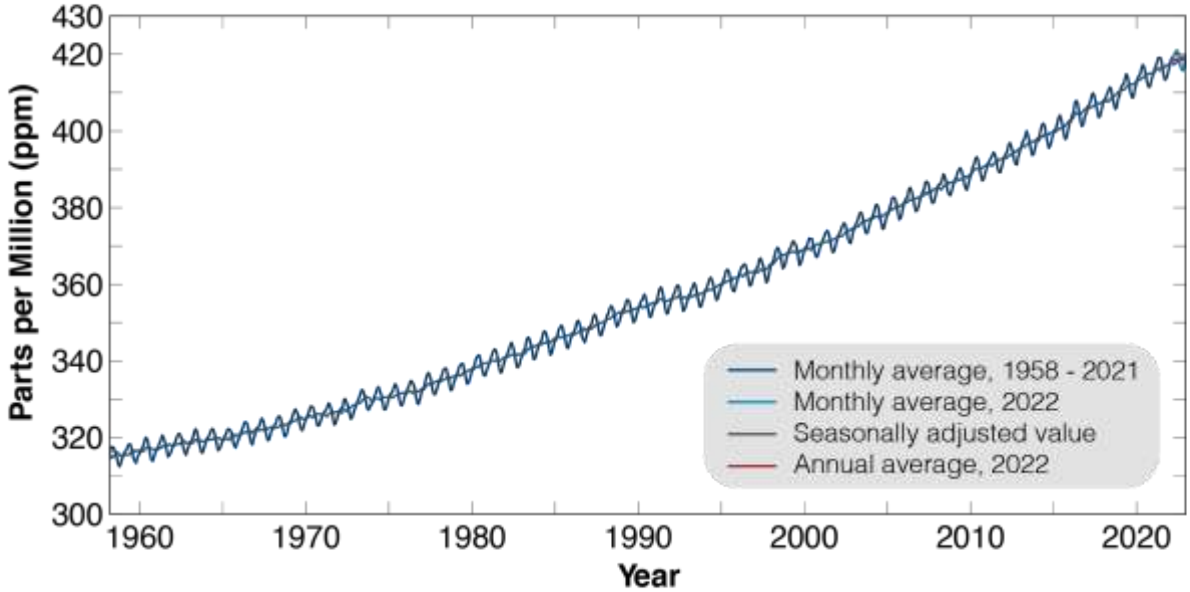


**Figure 14. Monthly mean (black) and seasonally corrected (blue) atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii**

#### 2.6.4.2 Oceanic pH

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

Status: The ocean is roughly 10.9% more acidic than it was 30 years ago at the start of this time series. Over this time, pH has declined by 0.045 at a constant rate. In 2021, the most recent year for which data are available, the average pH was 8.05. Additionally, for the 6th year, small variations seen over the course of the year are outside the range seen in the first year of the time series. The highest pH value reported for the most recent year (8.069) is lower than the lowest pH value reported in the first year of the time series (8.083).

Description: Trends in surface (5 m) pH at Station ALOHA, north of Oahu (22.75°N, 158°W), collected by the Hawaii Ocean Time Series (HOT) from October 1988 to 2021 (2022 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.

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

Sourced from: Fabry et al. (2008), Feely et al. (2016), and the Hawai‘i Ocean Time Series as described in Karl and Lukas (1996) and on its website (HOT 2023) using the methodology provided by Zeebe and Wolf-Gladrow (2001). Graphics produced in part using Stawitz (2022).

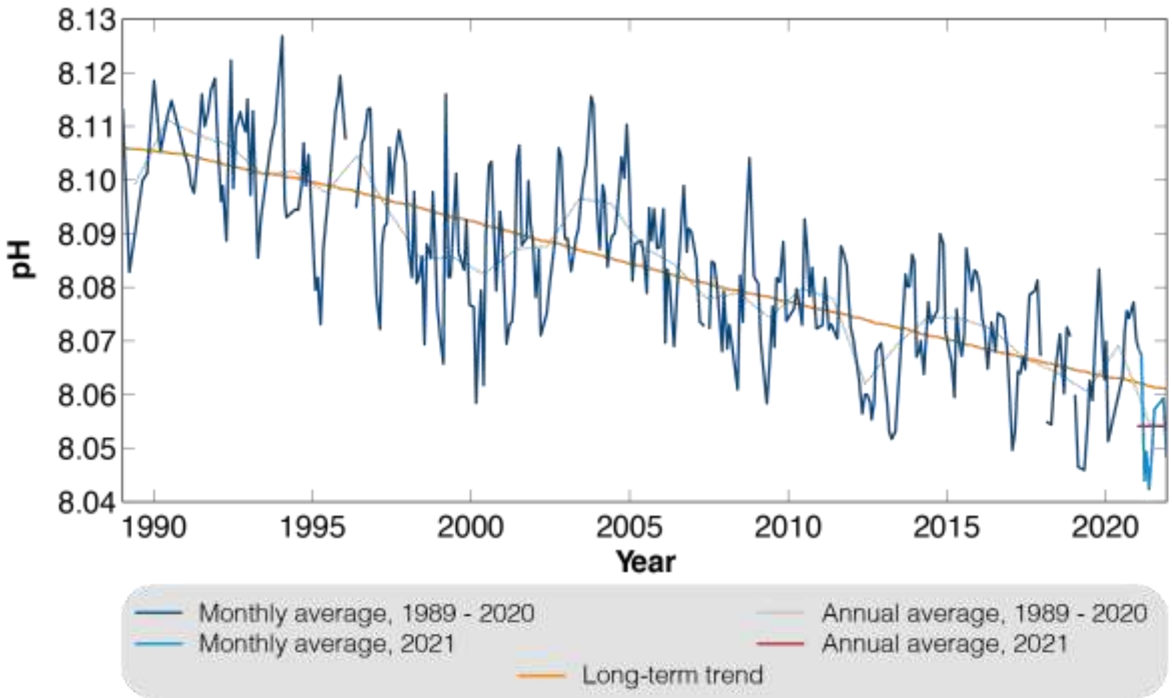


**Figure 15. Time series and long-term trend of oceanic pH measured at Station ALOHA from 1989-2021**

### 2.6.4.3 Oceanic Niño Index

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

Status: The ONI indicated La Niña conditions throughout 2022. In 2022, the ONI ranged from -1.06 to -0.81. This is within the range of values observed previously in the time series.

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

Timeframe: Every three months.

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

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

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

Sourced from NOAA CPC (2023). Graphics produced in part using Stawitz (2022).

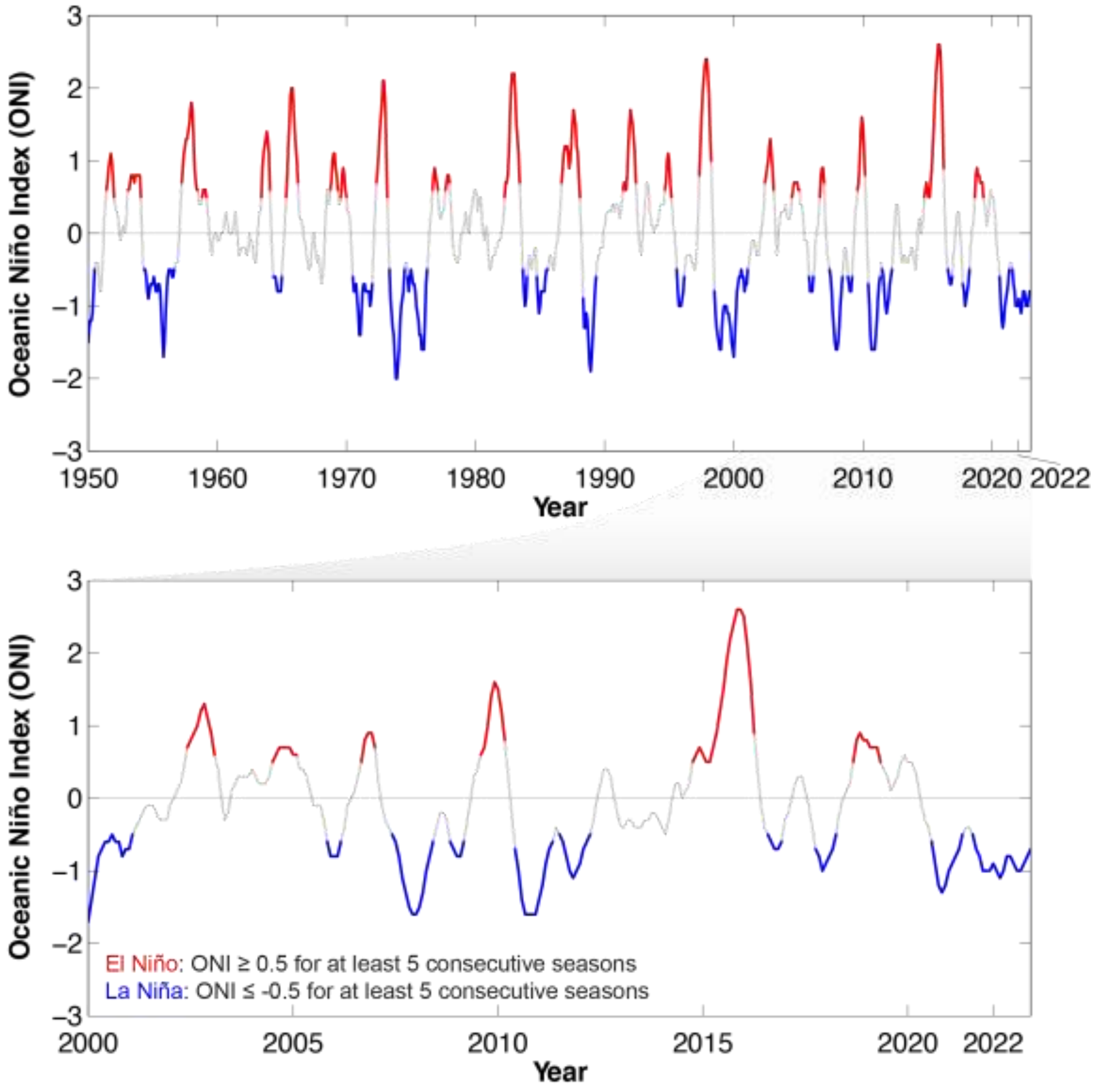


**Figure 16. Oceanic Niño Index from 1950-2022 (top) and 2000-2022 (bottom) with El Niño periods in red and La Niña periods in blue**

#### 2.6.4.4 Pacific Decadal Oscillation

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

Status: The PDO was negative in 2022. The index ranged from -2.22 to -1.35 over the course of the year. This is within the range of values observed previously in the time series.

Description: The PDO is often described as a long-lived El Niño-like pattern of Pacific climate variability. As seen with the better-known ENSO, extremes in the PDO pattern are marked by widespread variations in the Pacific Basin and the North American climate. In parallel with the ENSO phenomenon, the extreme cases of the PDO have been classified as either warm or cool, as defined by ocean temperature anomalies in the northeast and tropical Pacific Ocean. When SST is below average in the [central] North Pacific and warm along the North American coast, and when sea level pressures are below average in the North Pacific, the PDO has a positive value. When the climate patterns are reversed, with warm SST anomalies in the interior and cool SST anomalies along the North American coast, or above average sea level pressures over the North Pacific, the PDO has a negative value. Description inserted from NOAA (2023b).

Timeframe: Annual, monthly.

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

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

Data available at: https://psl.noaa.gov/pdo/.

Sourced from: NOAA (2023b), Mantua (1997), and Newman (2016). Graphics produced in part using Stawitz (2022).

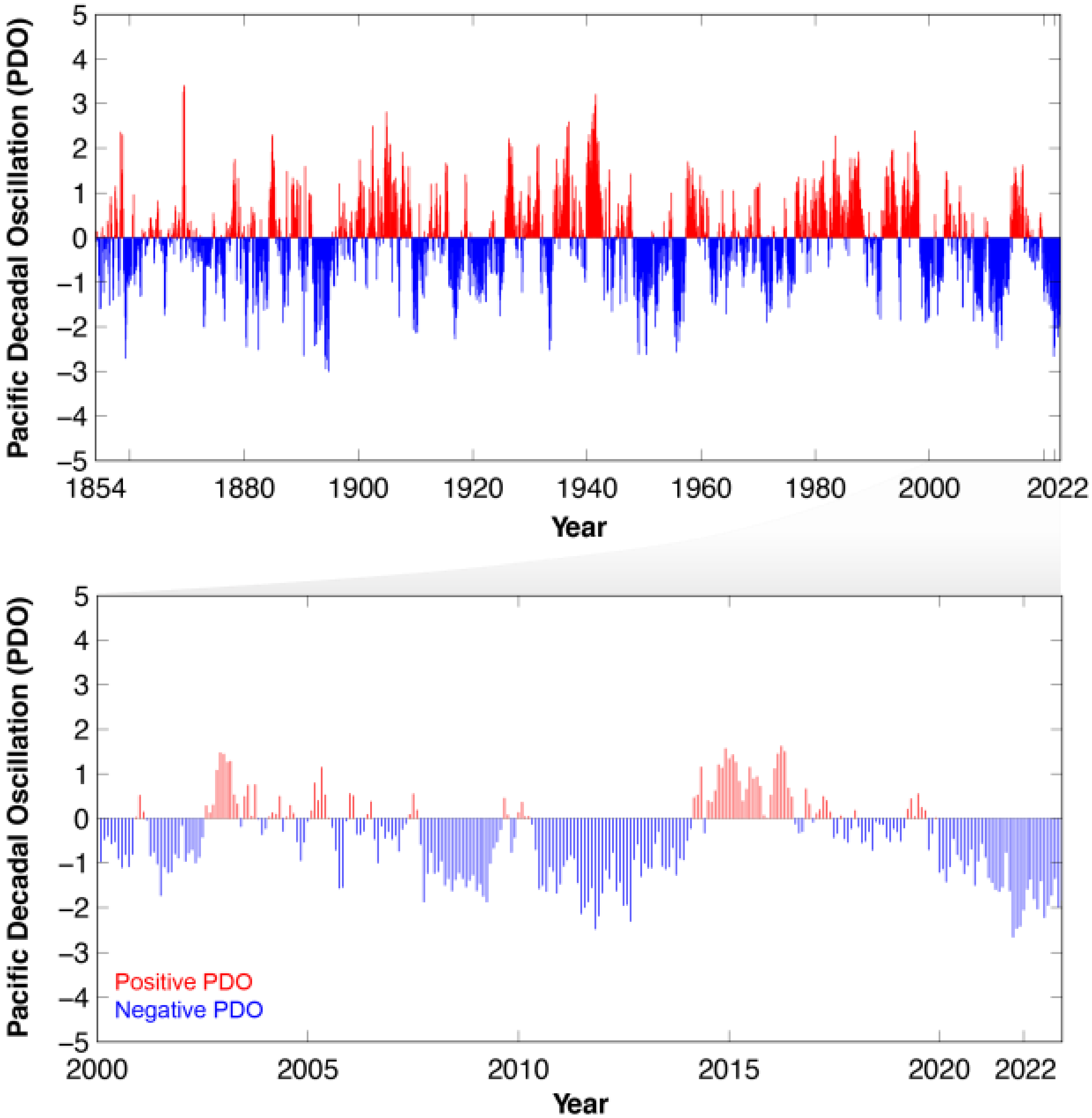


**Figure 17. Pacific Decadal Oscillation from 1950-2022 (top) and 2000-2022 (bottom) with positive warm periods in red and negative cool periods in blue**

#### 2.6.4.5 Tropical Cyclones

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

Status:

*Eastern North Pacific.* Tropical cyclone activity was near normal in the Eastern Pacific in 2022. There were 19 named storms, 10 of which were hurricanes. There were 4 major hurricanes (category 3 or higher), which is also near normal. The Accumulated Cyclone Energy (ACE) was near the 1991-2020 average. After four straight years of named storms forming in the Eastern Pacific in November (which is unusually high), conditions returned to normal this November with no storms, named or otherwise. Portions of this summary inserted from https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202211.

*Central North Pacific*. Central Pacific tropical cyclone activity was below the 1991–2020 average in 2022. There was 1 named storm, which reached hurricane status, and no major hurricanes. A weakened Hurricane Darby entered the Central Pacific in July, passing south of the Island of Hawaii as a tropical depression. On average (1991-2020), the central Pacific sees four named storms, two hurricanes, and one major hurricane each year. The 2022 ACE index was about ten percent of the 1991–2020 average. Portions of this summary inserted from https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202207.

*Western North Pacific.* Tropical cyclone activity got off to a slow but strong start in the Western Pacific, with no storms occurring until Super Typhoon Malakas formed in April. The season overall saw below normal activity for the third year in a row. Tropical cyclone activity was below the 1991–2020 average in 2022. The 22 named storms, 12 typhoons, and 5 major typhoons were all below average (1991-2020), as was the ACE. Portions of the summary inserted from https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202203, https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202204, and https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202213.

*South Pacific.* South Pacific tropical cyclone activity was below average in 2022. There were 4 named storms, none of which became cyclones or major cyclones. The 2022 ACE was also below the 1991–2020 average. Portions of the summary inserted from https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202213.

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

The annual frequency of storms passing through each basin is tracked and Figure 18 shows the representative breakdown of Saffir-Simpson hurricane categories.

Every cyclone has an ACE Index value, which is a number based on the maximum wind speed measured at six-hourly intervals over the entire time that the cyclone is classified as at least a tropical storm (wind speed of at least 34 knots; 39 mph). Therefore, a storm's ACE Index value accounts for both strength and duration. Figure 19 shows the ACE values for each hurricane/typhoon season and has a horizontal line representing the average annual ACE value.

Timeframe: Annual.

Region/Location:

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

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

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

South Pacific: south of the equator.

Measurement Platform: Satellite.

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

Sourced from: Knapp et al. (2010), Knapp et al. (2018), and NOAA (2023c).

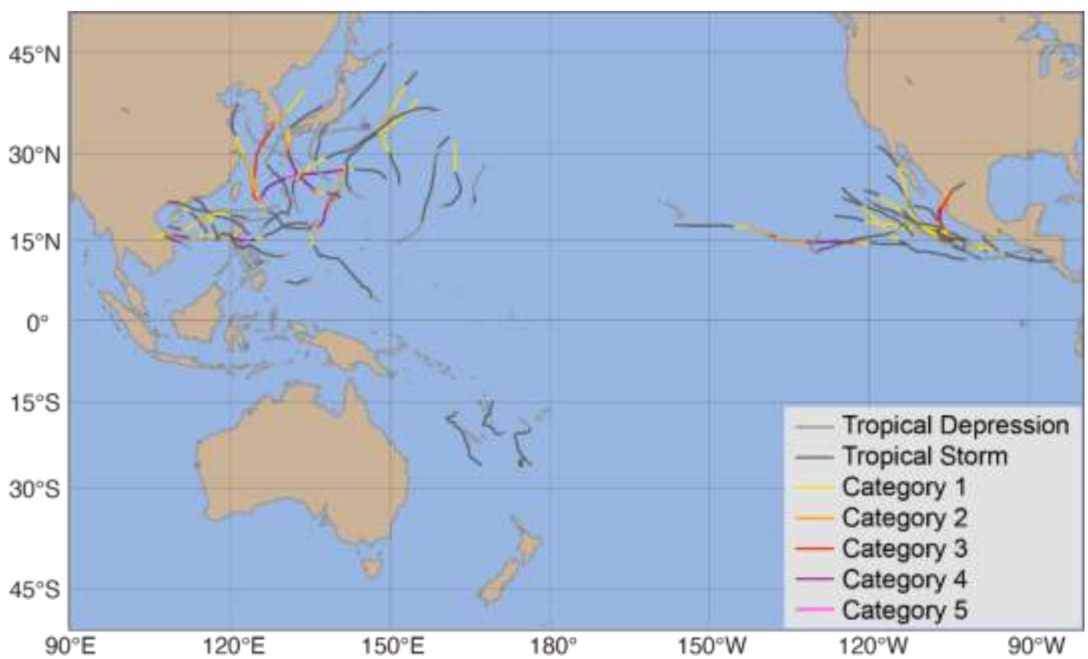


**Figure 18. 2022 Pacific basin tropical cyclone tracks**

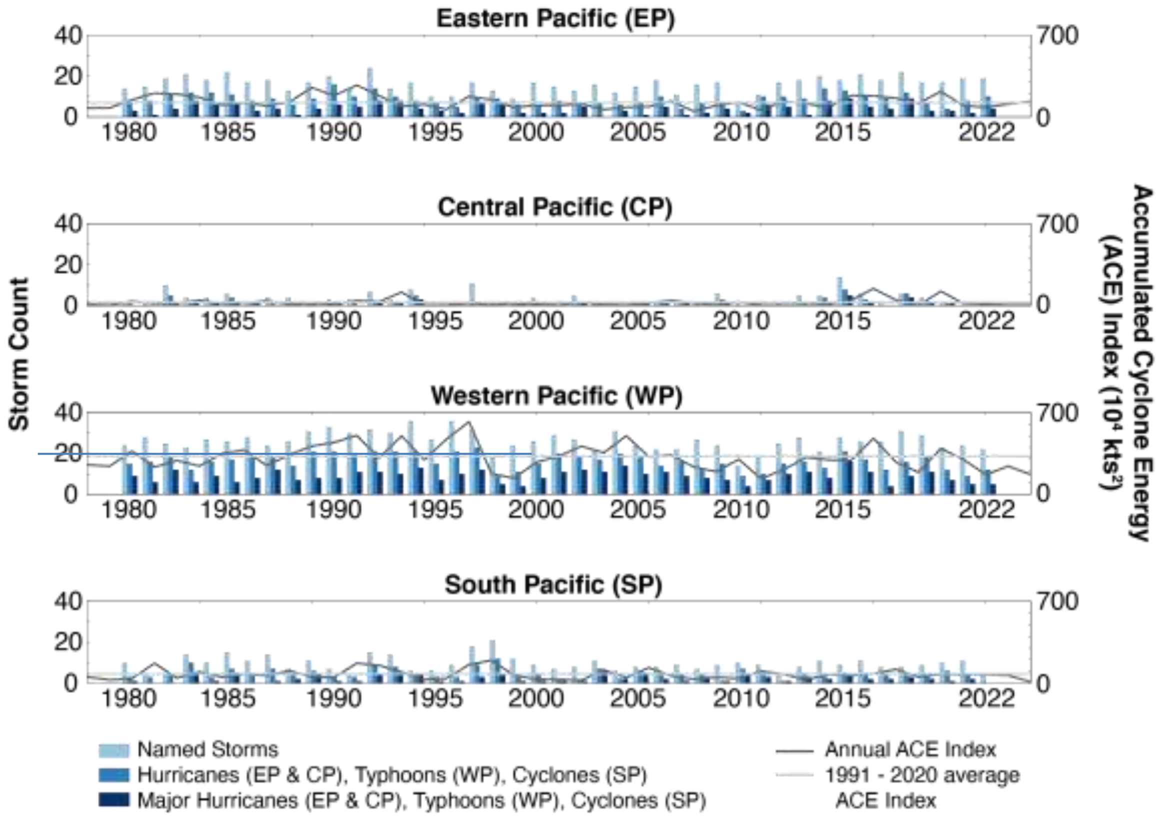


**Figure 19. Storm counts (bars) and Accumulated Cyclone Energy (ACE) index values (lines) in each region of the Pacific. Both annual ACE index (black lines) and 1991–2020 average ACE index (grey lines) are shown**

#### 2.6.4.6 Sea Surface Temperature and Anomaly

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

Status: Annual mean SST was 28.50 ºC in 2022. Over the period of record, annual SST has increased at a rate of 0.020 ºC/yr. Monthly SST values in 2022 ranged from 27.48–29.23 ºC, within the climatological range of 26.56–29.97 ºC. The annual anomaly was 0.06 ºC cooler than average, with areas that were warmer than the average in the southwest part of the region.

Note that from the top to bottom in Figure 20, panels show climatological SST (1985-2021), 2022 SST anomaly, time series of monthly mean SST, and time series of monthly SST anomaly.

Description: Satellite remotely-sensed monthly sea surface temperature (SST) is averaged across the 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 climatology and anomalies are shown. Data are sourced from NOAA Coral Reef Watch CoralTemp v3.1 (NOAA 2023c).

Timeframe: Monthly.

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

Measurement Platform: Satellite.

Sourced from: NOAA OceanWatch (2023a).

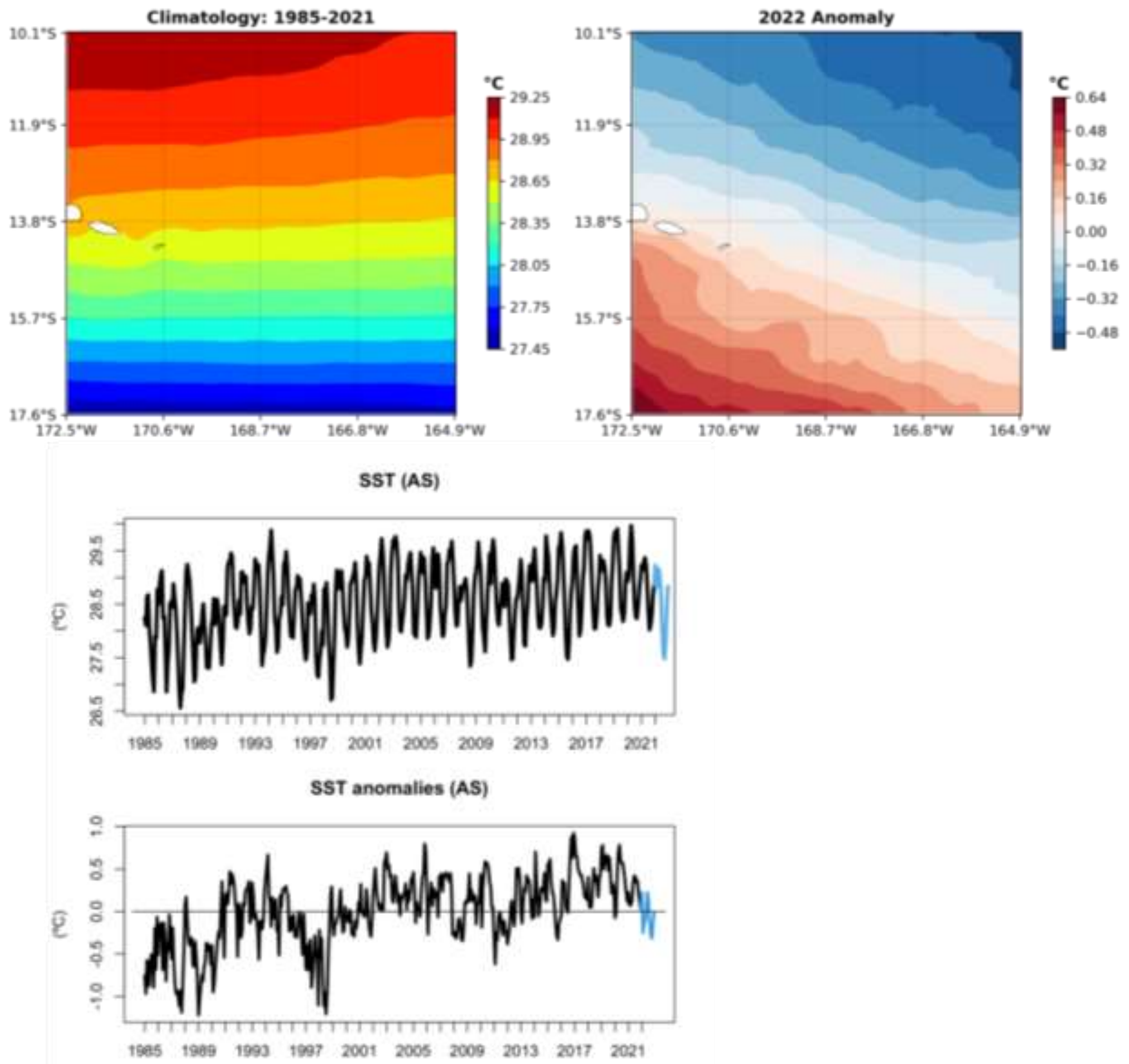


**Figure 20. Sea surface temperature climatology and anomalies from 1985–2022**

#### 2.6.4.7 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 2014–2017, 2019, and 2020, the Samoas experienced no coral heat stress in 2022.

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 2023).

Timeframe: 2014–2022, daily data.

Region/Location: Global.

Sourced from: NOAA Coral Reef Watch (2023).

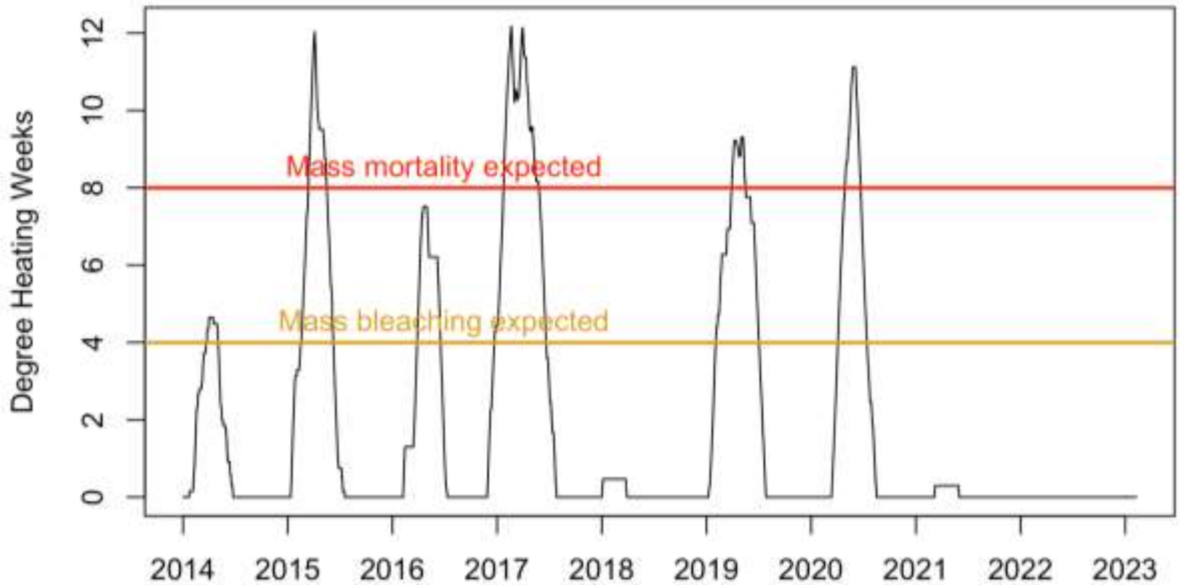


**Figure 21. Coral Thermal Stress Exposure measured at Samoa Virtual Station 2014–2022 (Coral Reef Watch Degree Heating Weeks)**

#### 2.6.4.8 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 0.058 mg/m$^3$ in 2022. Over the period of record, annual chlorophyll-*a* has shown no significant temporal trend. Monthly chlorophyll-*a* values in 2022 ranged from 0.047–0.067 mg/m$^3$, within the climatological range of 0.037–0.088 mg/m$^3$. The annual anomaly was 0.0017 mg/m$^3$ higher than average, with an area of below average chlorophyll concentration in the central section of the region.

Description: Chlorophyll-*a* concentration from 1998–2022 were derived from the ESA Ocean Color Climate Change Initiative dataset, v6.0. A monthly climatology was generated across the entire period (1998-2021) to provide both a 2022 spatial anomaly and an anomaly time series.

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

Timeframe: 1998–2022, daily data available, monthly means shown.

Region/Location: Global.

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

Sourced from: NOAA OceanWatch (2023b).

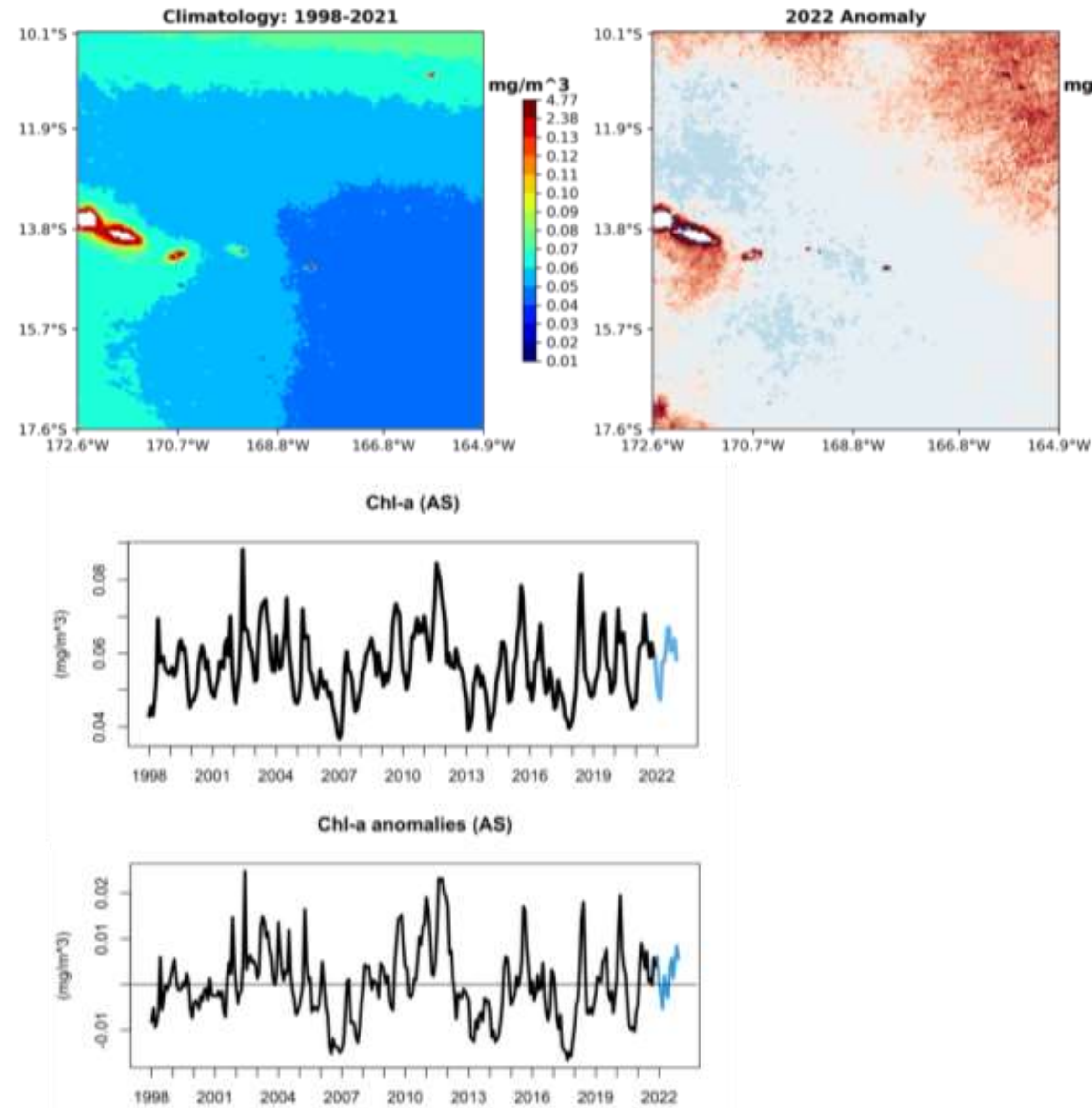


**Figure 22. Chlorophyll-*a* and Chlorophyll-*a* Anomaly from 1998–2022**

#### 2.6.4.9 Rainfall

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

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

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

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

Timeframe: Monthly.

Region/Location: Global.

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

Sourced from: NOAA ESRL (2023).

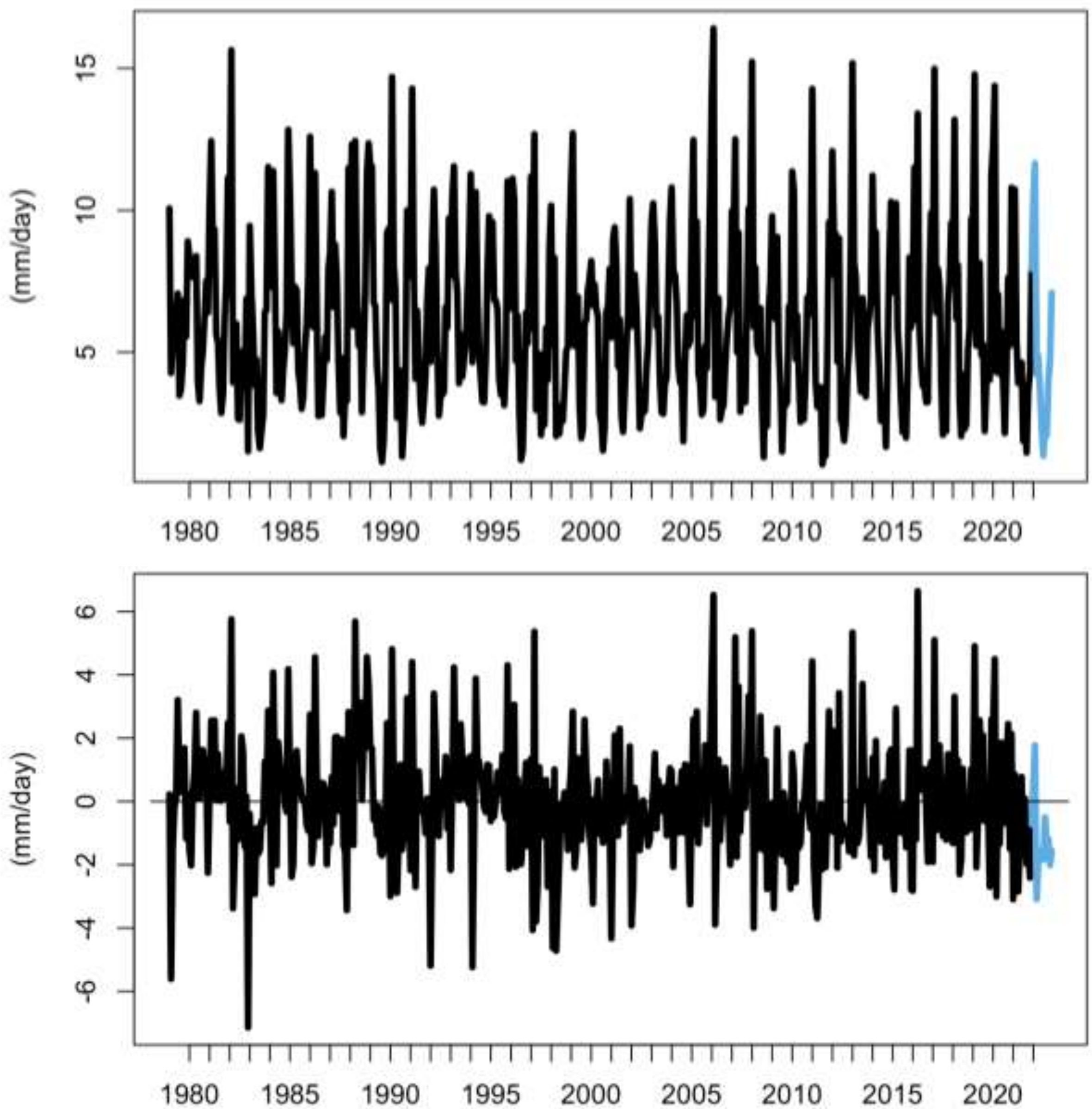


**Figure 23. CMAP precipitation (top) and anomaly (bottom) across the American Samoa Longline Grid with 2022 values in blue**

### 2.7.4.10 Sea Level (Sea Surface Height and Anomaly)

Rationale: Coastal rising sea levels can result in several 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 (2023), NOAA (2023d), and NOAA CoastWatch (2023).

#### 2.7.4.10.1 Basin-Wide Perspective

This image of the mean sea level anomaly for March 2022 compared to 1993-2016 climatology from satellite altimetry provides a glimpse into the 2022 continued La Niña conditions across the Pacific Basin. The image captures the fact that sea level is higher in the Western Pacific and lower in the Central and Eastern Pacific (this basin-wide perspective provides a context for the location-specific sea level/sea surface height images that follow).

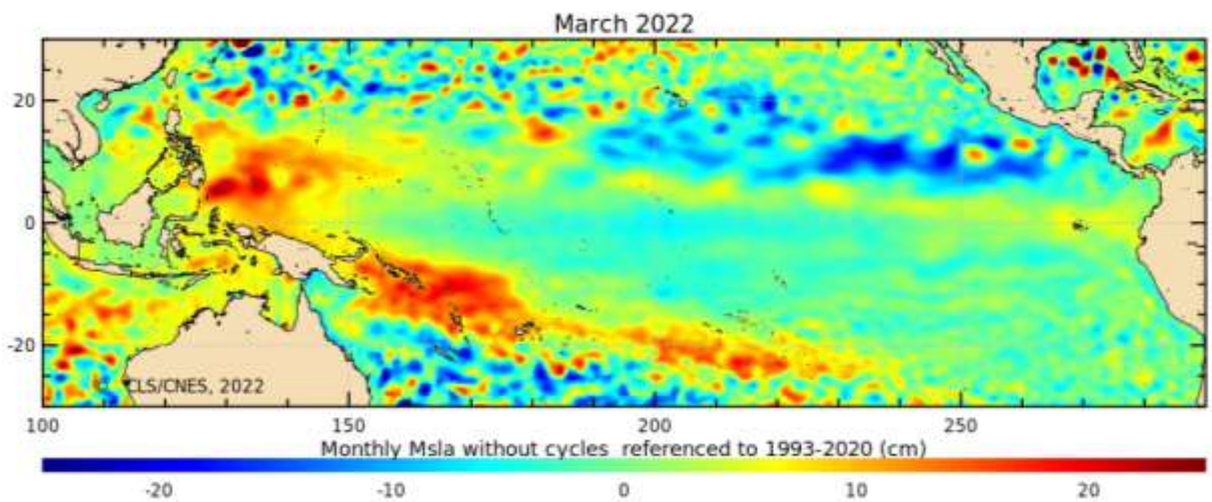


**Figure 24a. Sea surface height and anomaly**

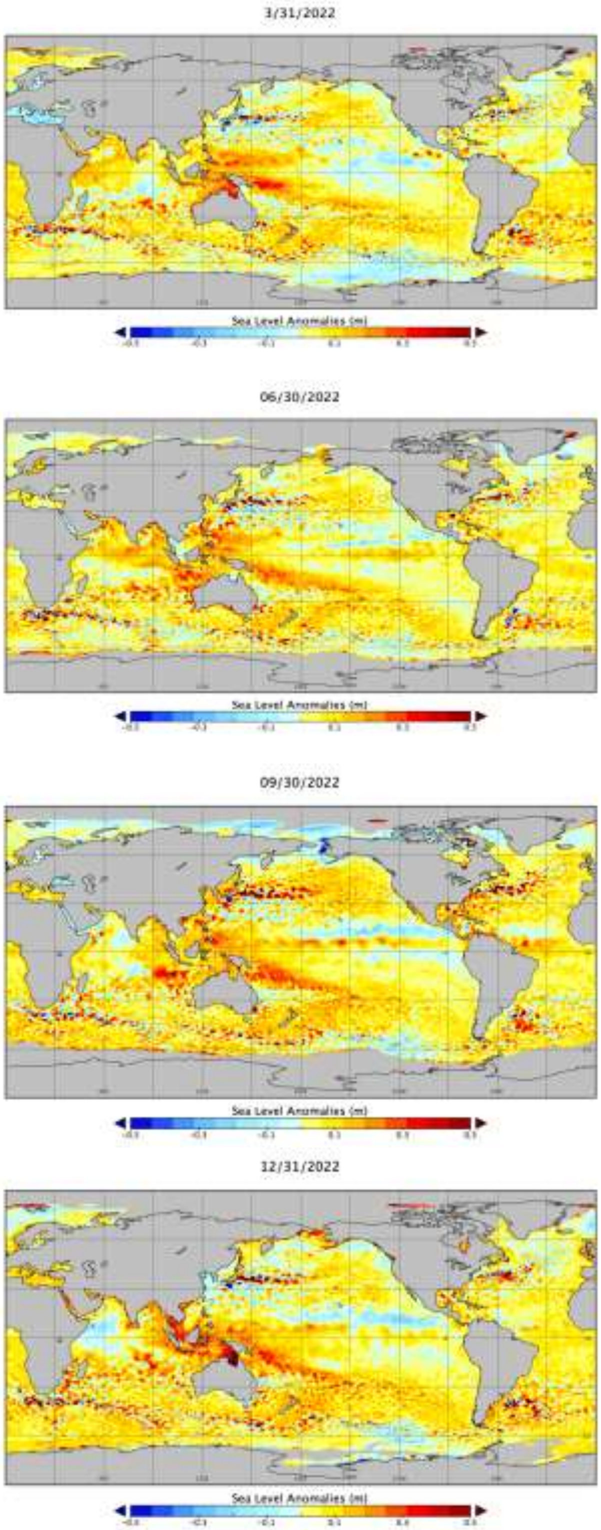


**Figure 24b. Quarterly time series of mean sea level anomalies during 2022**

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

### 2.7.4.10.2 Local Sea Level

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

The following figures and descriptive paragraphs were inserted from the NOAA Tides and Currents website (NOAA 2023d). Figure 25 shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS. The calculated trends for all stations are available as a table in millimeters/year and in feet/century. If present, solid vertical lines indicate times of any major earthquakes in the vicinity of the station and dashed vertical lines bracket any periods of questionable data or datum shift.

The relative sea level trend is 2.45 millimeters/year with a 95% confidence interval of +/- 0.8 mm/yr based on monthly mean sea level data from 1948 to 2009 which is equivalent to a change of 0.80 feet in 100 years. The trend is based only on data before September 2009 earthquake. Following the earthquake, relative sea level rose about 0.25 meters (about 10 inches) until January 2020, when the gauge had to be temporarily removed due to construction. The cause of this rise is rapid post-seismic land subsidence which will likely continue, although at a slower rate over the next two to three decades (NOAA 2023d).

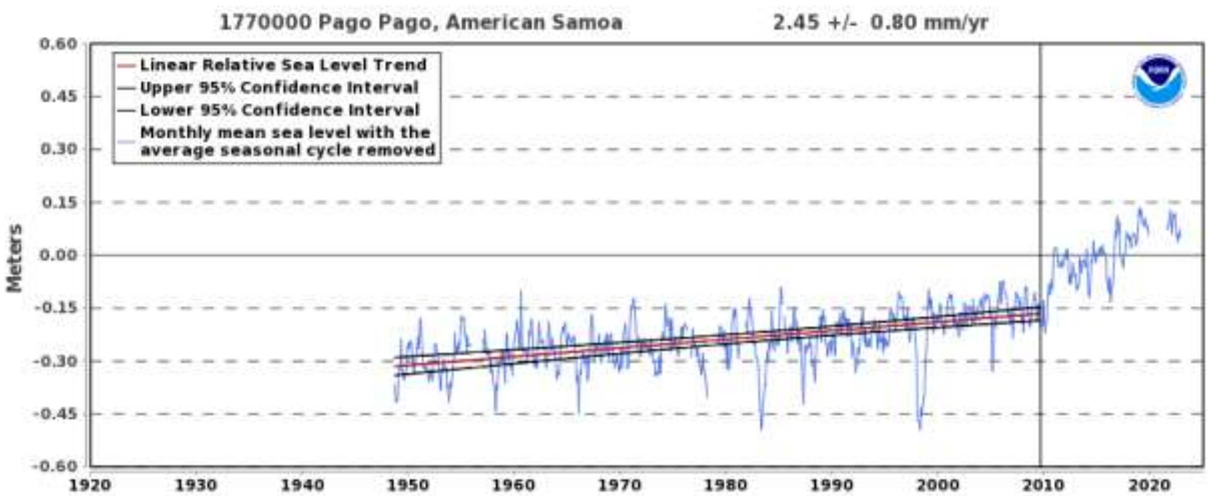


**Figure 25. Monthly mean sea level without regular seasonal variability due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents**

## 2.7 ESSENTIAL FISH HABITAT

### 2.7.1 Introduction

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

NMFS and the regional fishery management councils must describe and identify EFH in fishery management plans (FMPs) or fishery ecosystem plans (FEPs), minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. Federal agencies that authorize, fund, or undertake actions that may adversely affect EFH must consult with NMFS, and NMFS must provide conservation recommendations to federal and state agencies regarding actions that would adversely affect EFH. Councils also have the authority to comment on federal or state agency actions that would adversely affect the habitat, including EFH, of managed species. Fishery management actions must be evaluated for impacts to all EFH and HAPC in the area of effect and not just the EFH and HAPC for the fishery to which the management action applies.

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

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

#### 2.7.1.1 EFH Information

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

The Council has described EFH for five management unit species (MUS) under its management authority, most of which are no longer MUS: pelagic (PMUS), bottomfish (BMUS), crustaceans (CMUS), former coral reef ecosystem species (CREMUS), and precious corals (PCMUS). Only bottomfish remain designated as MUS after Amendment 4 to the American Samoa FEP that reduced the number of MUS from 205 species/families to 11, with the other species being classified as ECS (84 FR 2767, February 8, 2019).

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

- Updated species descriptions, which can be found appended to the SAFE report. These can be used to directly update the FEP;
- Updated EFH levels of information tables, which can be found in Section 0;
- Updated research and information needs, which can be found in Section 0. 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.

#### 2.7.1.2 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; and
- Identify and prioritize research to assess adverse impacts to EFH and HAPC from fishing (including aquaculture) and non-fishing activities, including, but not limited to, activities that introduce land-based pollution into the marine environment.

#### 2.7.1.3 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 182nd meeting in June 2020, the Council requested that NMFS work with the Council to determine “non-essential” fish habitat to look at ways to remove areas that are degraded from being considered EFH.

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

At its 190th meeting in March 2022, the Council discussed the revision of the BMUS list in the American Samoa FEP, which would involve a review of essential fish habitat (EFH) for listed species, among other elements. The Council discussed two options, one of which involved revising the BMUS list based on cluster analysis and life history synthesis, leading to the possible redefinition of EFH for deepwater snappers included as BMUS in the FEP. The other option would maintain the status quo and disregard changes in EFH definitions, for species monitoring, etc. The Council plans to finalize a decision by December 2023.

### 2.7.2 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 $km^2$) surrounding the island that extend between one and nine km offshore (according to the 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 26). 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.

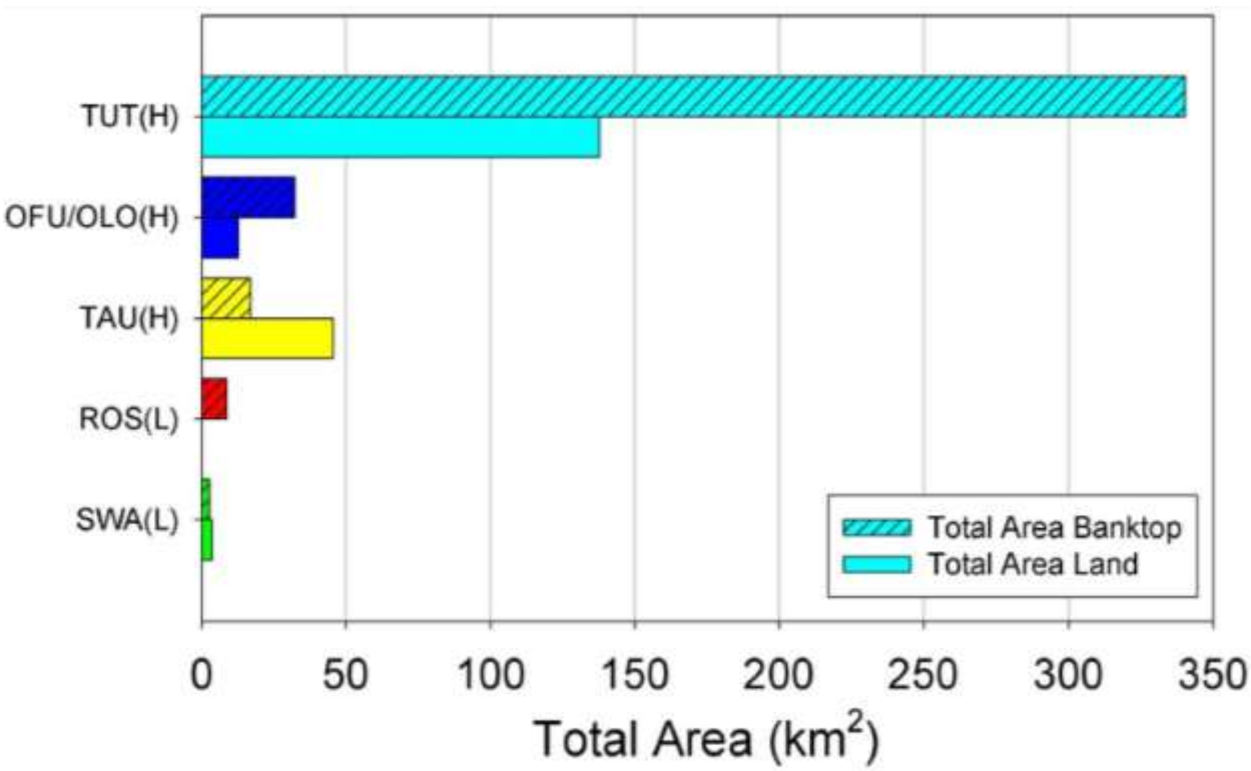


**Figure 26. Bank top and terrestrial land area on high (H) or low (L) islands of Tutuila and Aunu'u (TUT), Ofu and Olosega (OFU/OLU), Ta'u (TAU), Rose (ROS), and Swains (SWA)**

While the coral reef ecosystems surrounding the islands in the American Samoa archipelago have been the subject of a comprehensive monitoring program through the PIFSC Coral Reef Ecosystem Division (CRED) biennially since 2002, surveys are focused on the nearshore environments surrounding the islands, atolls, and reefs and 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. PIFSC CRED was replaced by the Coral Reef Ecosystem Program (CREP) within the PIFSC Ecosystem Sciences Division (ESD) before being shifted to the Archipelagic Research Program (ARP). No new data were collected in 2022 that would allow for updates to habitat use by MUS or trends in habitat condition.

#### 2.7.2.1 Habitat Mapping

No new habitat mapping was conducted in 2022.

##### 2.7.2.1.1 Benthic Habitat

Juvenile and adult bottomfish EFH extends from the shoreline to the 400 m isobath (64 FR 19067, April 19, 1999).

##### 2.7.2.1.2 NCRMP Indicators

Benthic percent cover of coral, macroalgae, and crustose coralline algae are surveyed as a part of the National Coral Reef Monitoring Program (NCRMP) by the PIFSC ESD. No NCRMP field work was conducted in American Samoa in 2022.

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

The water column is also designated as EFH for selected 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 Climate and Oceanic Indicators section (Section 2.6.4) for information related to oceanography and water quality. While no substantial field research data efforts occurred in 2022, satellite and buoy data are continuously collected and archived. PIFSC staff recently developed an advanced data compilation tool, the Environmental Data Summary (EDS), that gives users a simple, consistent way to enhance existing *in situ* observations with external gridded environmental data. The EDS is written in R and provides users an interface to NOAA CoastWatch and OceanWatch datasets through the ERDDAP server protocol. The EDS allows users to download, filter, and/or extract large amounts of gridded and tabular data given user-defined time stamps and geographical coordinates. The various external environmental data summarized at individual survey sites can aid scientists in assessing and understanding how environmental variabilities impact living marine resources. The EDS outputs were summarized at the National Coral Reef Monitoring Program (NCRMP) Rapid Ecological Assessment (REA) site level from 2000 to 2020 across 57 islands covered by the survey. PIFSC is planning to expand the utility of EDS with a broader range of gridded NOAA CoastWatch and OceanWatch data products (e.g., wave, wind) at finer spatiotemporal scales (e.g., water columns). Target data content includes spatial data (e.g., remote sensing), modeled data (e.g., Regional Ocean Modeling Systems), and socioeconomic data, including human density.

### 2.7.3 Report on Review of EFH Information

There were no EFH reviews completed in 2022 for American Samoa. Non-fishing and cumulative impacts to EFH were reviewed in 2016 through 2017, which can be found in Minton (2017).

### 2.7.4 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 managed species' life stage. The existing level of data for individual MUS in each fishery are presented in tables per fishery.

#### 2.7.4.1 Bottomfish

EFH for bottomfish was originally designated in Amendment 6 to the Bottomfish and Seamount Groundfish FMP (64 FR 19067, April 19, 1999), and the levels of EFH information available for American Samoa BMUS are shown in Table 33. The designated areas of EFH and HAPC for American Samoa FEP bottomfish by life stage are summarized in Table 34. To analyze the potential effects of a proposed fishery management action on EFH, one must consider all designated EFH, but research examining depth and habitat requirements for most species is generally lacking (PIFSC 2021). The levels of information available for American Samoa BMUS did not change in 2022.

**Table 33. Level of EFH information available for American Samoa BMUS**

| Life History Stage | Eggs | Larvae | Juvenile | Adult |
|---|---|---|---|---|
| *Aphareus rutilans* (red snapper/silvermouth) | 0 | 0 | 0 | 1 |
| *Aprion virescens* (gray snapper/jobfish) | 0 | 0 | 1 | 1 |
| *Caranx lugubris* (black trevally/jack) | 0 | 0 | 0 | 1 |
| *Etelis carbunculus* (red snapper) | 0 | 0 | 1 | 1 |
| *E. coruscans* (red snapper) | 0 | 0 | 1 | 1 |
| *Lethrinus rubrioperculatus* (redgill emperor) | 0 | 0 | 0 | 1 |
| *Lutjanus kasmira* (blueline snapper) | 0 | 0 | 1 | 1 |
| *Pristipomoides filamentosus* (pink snapper) | 0 | 0 | 1 | 1 |
| *P. flavipinnis* (yelloweye snapper) | 0 | 0 | 0 | 1 |
| *P. zonatus* (snapper) | 0 | 0 | 0 | 1 |
| *Variola louti* (lunartail grouper) | 0 | 0 | 0 | 1 |

**Table 34. EFH and HAPC for American Samoa BMUS**

| American Samoa BMUS | EFH | HAPC |
|---|---|---|
| *Aphareus rutilans* (red snapper/silvermouth)<br>*Aprion virescens* (gray snapper/jobfish)<br>*Caranx lugubris* (black trevally/jack)<br>*Etelis carbunculus* (red snapper)<br>E. *coruscans* (red snapper)<br>*Lethrinus rubrioperculatus* (redgill emperor)<br>*Lutjanus kasmira* (blueline snapper)<br>*Pristipomoides filamentosus* (pink snapper)<br>*P*. *flavipinnis* (yelloweye snapper)<br>*P*. *zonatus* (snapper)<br>*Variola louti* (lunartail grouper) | **Eggs and larvae:** the water column extending from the shoreline to the outer limit of the EEZ down to a depth of 400 m (200 fm).<br><br>**Juvenile/adults:** the water column and all bottom habitat extending from the shoreline to a depth of 400 m (200 fm). | All slopes and escarpments between 40–280 m (20 and 140 fm). |

### 2.7.5 Project Updates

No field work related to EFH was conducted in American Samoa in 2022.

A WPRFMC SSC working group and PIFSC, American Samoa DMWR, and Council staff held two remote data evaluation workshops to improve information used in the stock assessment. PIFSC also completed a thorough evaluation of all published reports related to life history and habitat (depth, substrate, feeding) for BMUS species of shallow and deep water snappers found in American Samoa (PIFSC 2021). None of the data summarized in this report would support changes to the current EFH levels of information for American Samoa bottomfish.

Moving forward, a collaborative effort between the PIFSC Life History Program and Am. Samoa will take place in Tutuila and the Manu'a Islands as soon as travel and other research efforts resume. This plan hopes to conduct shore-based bottomfish research to provide life history (e.g., growth rate, size-at-maturity), population dynamics (e.g., mortality rate), and ecological (e.g., how the life history and population dynamics vary over space and time) information for a large variety of economical, recreational, and subsistence valued coral reef fishes, deepwater snappers and groupers, and pelagic fishes. Parts of this work should contribute to the understanding of bottomfish habitats in American Samoa.

### 2.7.6 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:

#### 2.7.6.1 All FMP Fisheries

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

#### 2.7.6.2 Bottomfish Fishery

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

## 2.8 MARINE PLANNING

### 2.8.1 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 SAFE 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.

### 2.8.2 Response to Previous Council Recommendations

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

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 previously scheduled 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 Pelagic 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 this report to the Council at its 173rd meeting in June 2018, from which no recommendations were generated. No further action was taken on the Rose Atoll MNM.

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 would 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. In 2016, NMFS published a final rule that allowed large, federally-permitted U.S. longline vessels to fish in specific areas of the LVPA (81 FR 5619, February 3, 2016). In July 2016, American Samoa sued NMFS and the Council in the Hawaii Federal District Court, claiming that NMFS did not consider the 1900 and 1904 Deeds of Cession with respect to the protection of the cultural fishing rights of the people of American Samoa. In 2017, the Hawaii Federal District Court deemed the final rule invalid and ordered NMFS to vacate the LVPA exemption rule (82 FR 43908, September 20, 2017).

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 U.S. 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. The Council also 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 nmi around Manu’a, 12 nm around Swains, and 2 nmi around the offshore banks, and recommended annual monitoring of the American Samoa longline and troll catch rates, small vessel participation, and local fisheries development.

NMFS appealed Hawaii Federal District Court’s 2017 decision that invalidated the 2016 LVPA reduction to the U.S. Ninth Circuit Court of Appeals. Oral arguments were in February 2020 in Honolulu, Hawaii, and the decision was reversed in a September 2020 ruling.

At its 184th meeting in December 2020, the Council directed staff to monitor the fishing operation and fishery performance of the American Samoa longline and alia fisheries and report back to the Council at its September 2021 meeting. Council staff provided this presentation to the Council as scheduled. On July 9, 2021, NMFS published a final rule reimplementing the 2016 regulations that the Council submitted to NMFS (86 FR 36239).

### 2.8.3 Marine Managed Areas established under the FEPs

Council-established MMAs are compiled in Table 35 from 50 CFR § 665, Western Pacific Fisheries, the Federal Register, and Council amendment documents. Geodesic areas were calculated in square kilometers in ArcGIS. All regulated fishing areas and large MMAs, including Rose Atoll Marine National Monument, are shown in Figure 27.

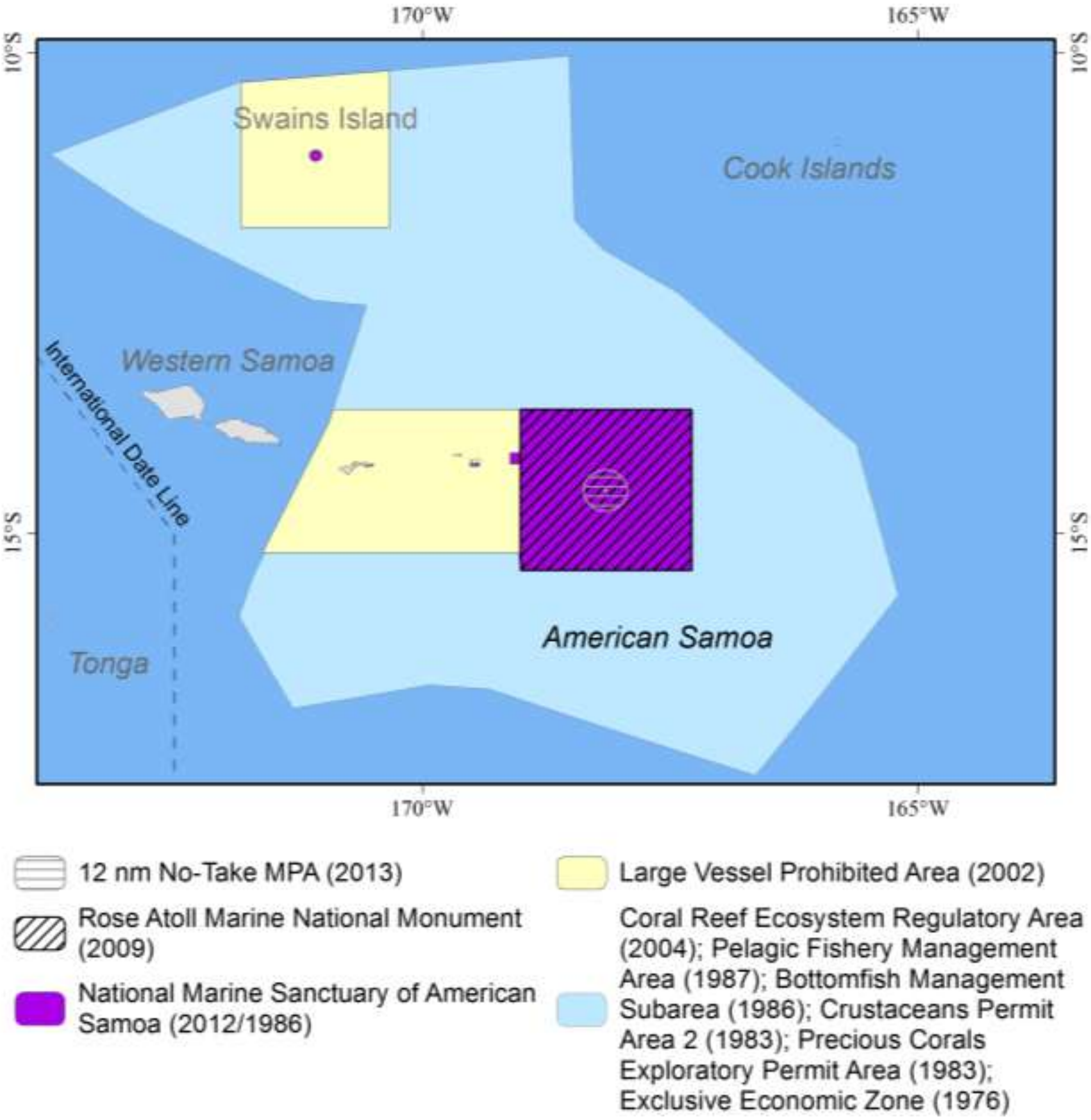


**Figure 27. Regulated fishing areas of American Samoa**

**Table 35. 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 82 FR 43908 | 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 82 FR 43908 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 | - |
| 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 FMP 78 FR 32996 American Samoa FEP Am. 3 | - | All Take Prohibited | Minimize adverse human impacts on coral reef resources; commercial fishing prohibited within 12 nm | June 3, 2013 | June 3, 2016 |

### 2.8.4 Fishing Activities and Facilities

There are no aquaculture activities currently occurring in the offshore waters of American Samoa.

### 2.8.5 Non-Fishing Activities and Facilities

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

### 2.8.6 American Samoa Spatial Planning Tools

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 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 to share information and data for coastal and marine spatial planning in American Samoa.

# 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 enough 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 reflect 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 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 of 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 of climate and/or ecosystem change on coral reefs fish stocks of American Samoa using climate and oceanic indicators (see Section 2.7.4). The evaluation of environmental variables showed that certain climate parameters (e.g., SST anomaly, sea level height, precipitation, and tropical storm days) are likely linked to fishery performance. It 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 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. 2011). 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 2.7.4). 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 Advanced Very High Resolution Radiometer (AVHRR) Pathfinder v5.0 through the OceanWatch program in the Central Pacific (NOAA/National Environmental Satellite, Data, and Information Service [NESDIS]/OceanWatch). Future work will utilize time series of SST described in Section 2.7.4in 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 28. 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.

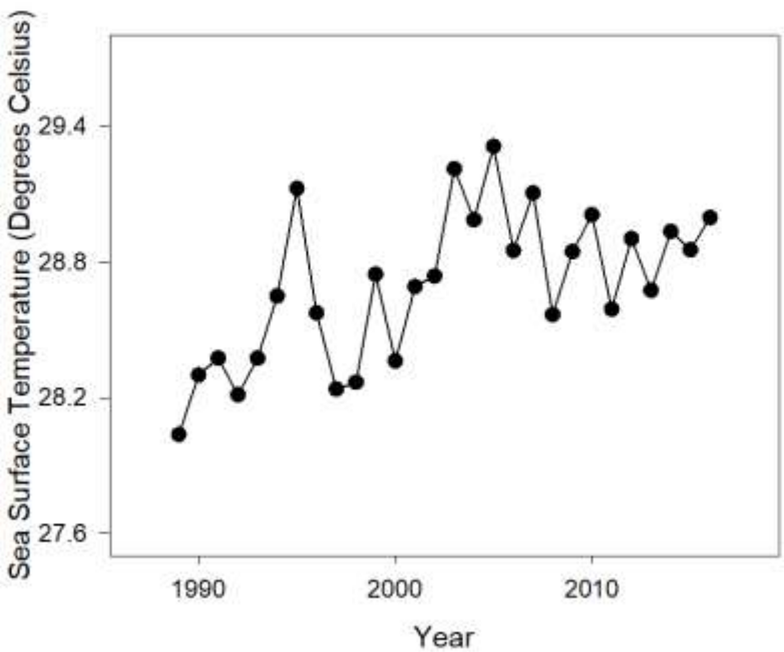


**Figure 28. Average annual SST (°C) in American Samoa from 1985-2016 (CV = 1.15)**

### 3.3.1 Evaluating relationship for entire coral reef fishery

Figure 29 shows a plot depicting the relationship between SST and catch time series for the 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 lb). Recent recorded catch levels (i.e., 2016) are among the lowest for the fishery through the available time series of data (~105,000 lb; Figure 29).

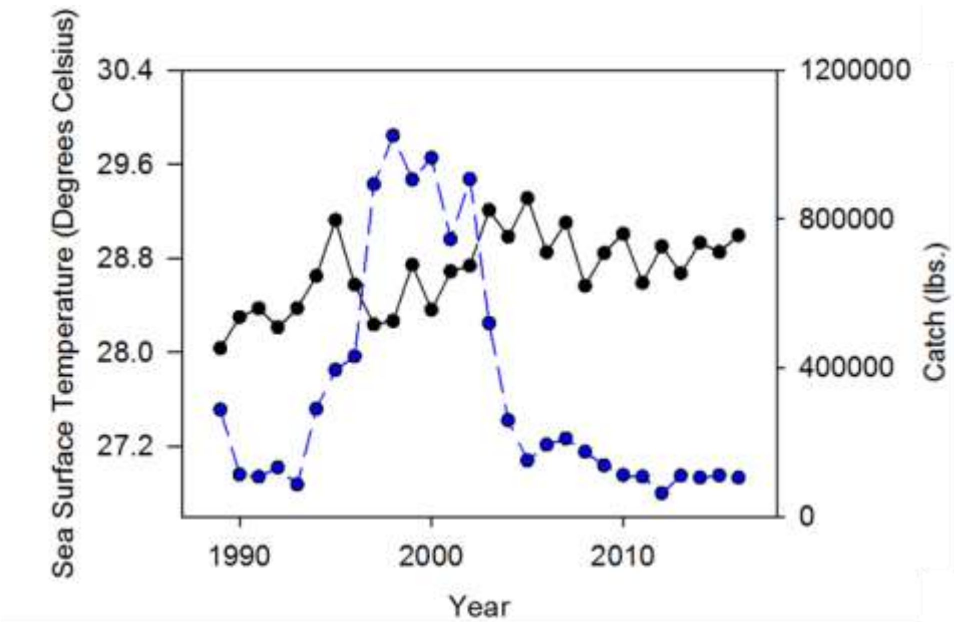


**Figure 29. Total annual catch (lb; blue) for the American Samoa coral reef fishery plotted with average annual SST (°C; black) from 1989-2016**

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 36 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 36. 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 coral reef fishery catch and annual mean SST from American Samoa were performed (Table 37). Assessments measuring this potential relationship for the entirety of the coral reef fishery catch in American Samoa showed no general relationship between 1989 and 2016 ($R^2 = 0.06$, $p = 0.20$; Table 37; Figure 30). The observed association between the two parameters appeared to associate negatively over time despite the lack of a statistically significant trend (Figure 30).

**Table 37. Correlation coefficients (*r*) between the coral reef fishery catch (lb) 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 |

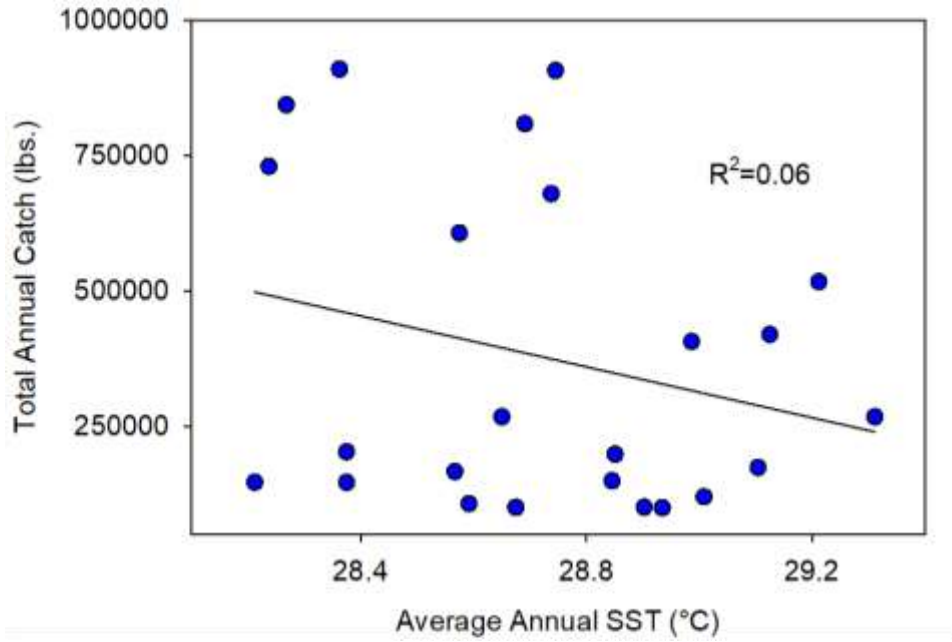


**Figure 30. Linear regression showing the correlation between total annual catch (lb) for the coral reef fishery and average annual sea surface temperature (°C) in American Samoa from 1989-2016**

### 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 37). 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 lb ($R^2 = 0.22$, $p = 0.02$; Table 37; Figure 31a). 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 lb (~67 lb; $R^2 = 0.19$, $p = 0.03$; Table 37; Figure 31b) 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 37; Figure 31c). 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 lb for every 1°C increase temperature.

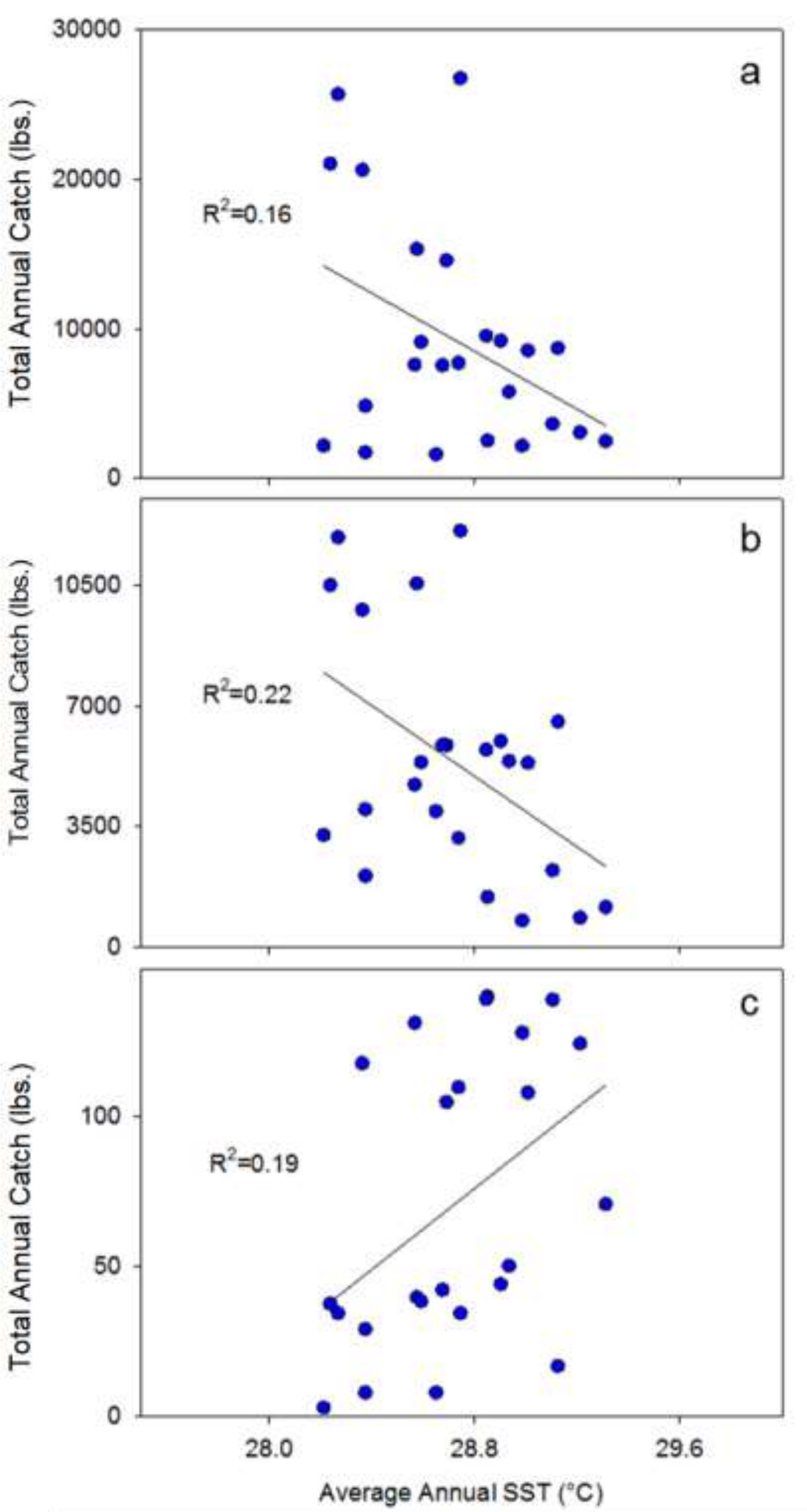


**Figure 31. Linear regressions showing the three top correlations between total annual catch (lb) for the coral reef fishery and average annual SST (°C) in American Samoa for (a) Acanthurids, (b) Scarids, and (c) Mullids from 1989-2016**

## 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 (Behrenfeld 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 32. The chlorophyll levels had relatively low variability over the course of evaluated data (CV = 4.90; Figure 32). 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 32).

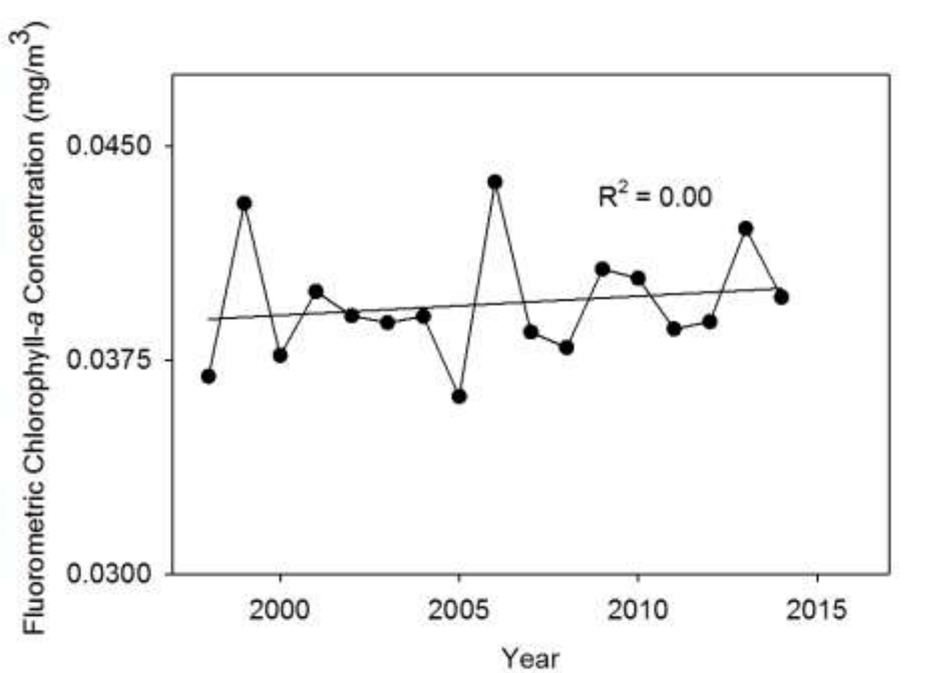


**Figure 32. Fluorometric chlorophyll-a concentrations (mg/m$^3$) from 1998–2016 (CV = 4.90)**

### 3.4.1 Evaluating relationship for entire coral reef fishery

A comparison plot depicting the relationship between chlorophyll-*a* concentrations and catch time series gathered through creel surveys measuring American Samoa's 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 lb), 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 lb; Figure 33).

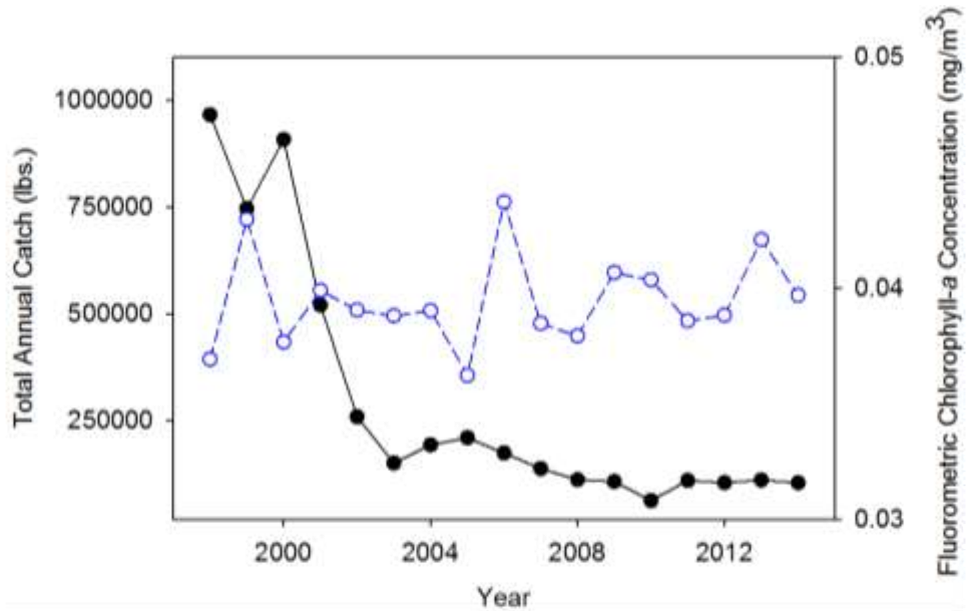


**Figure 33. Comparison of American Samoa reef fish catch (lb; black) and chlorophyll-*a* concentrations (mg/m$^3$; blue) from 1998 – 2014 and two years of time lag**

The linear regressions performed between noncommercial reef catch in American Samoa and fluorometric chlorophyll-*a* concentrations (mg/m$^3$) are shown in Figure 34. 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 38; Figure 34). 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 38. Correlation coefficients (*r*) from comparisons of time series of American Samoa coral reef fishery annual catch (lb) 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 |

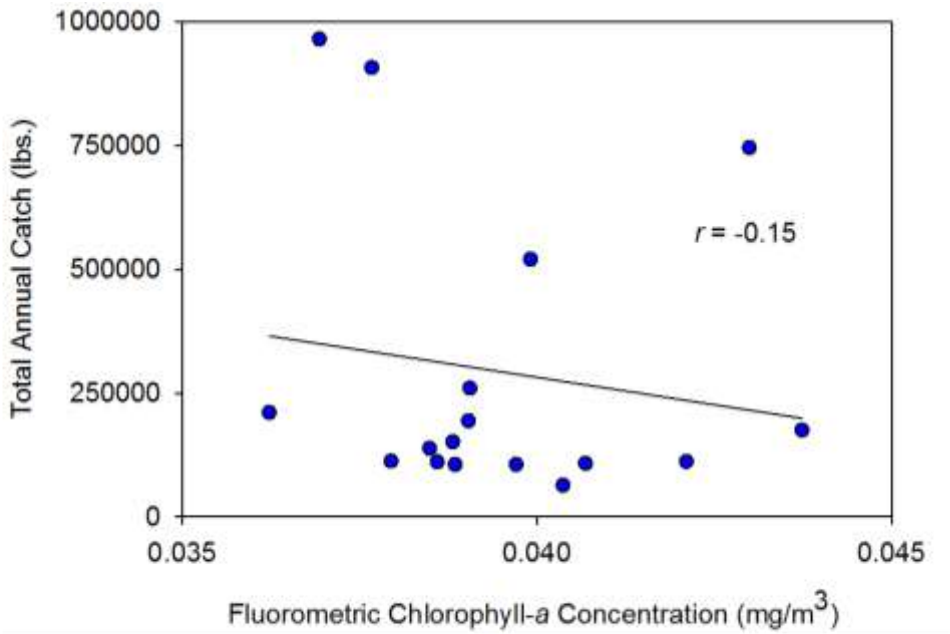


**Figure 34. Linear regression showing between total annual catch (lb) for the American Samoa coral reef fishery with phase lag (t+2 years) and fluorometric chlorophyll-*a* concentrations (mg/m$^3$) from 1998-2014**

### 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 38). 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 38; Figure 35a-c).

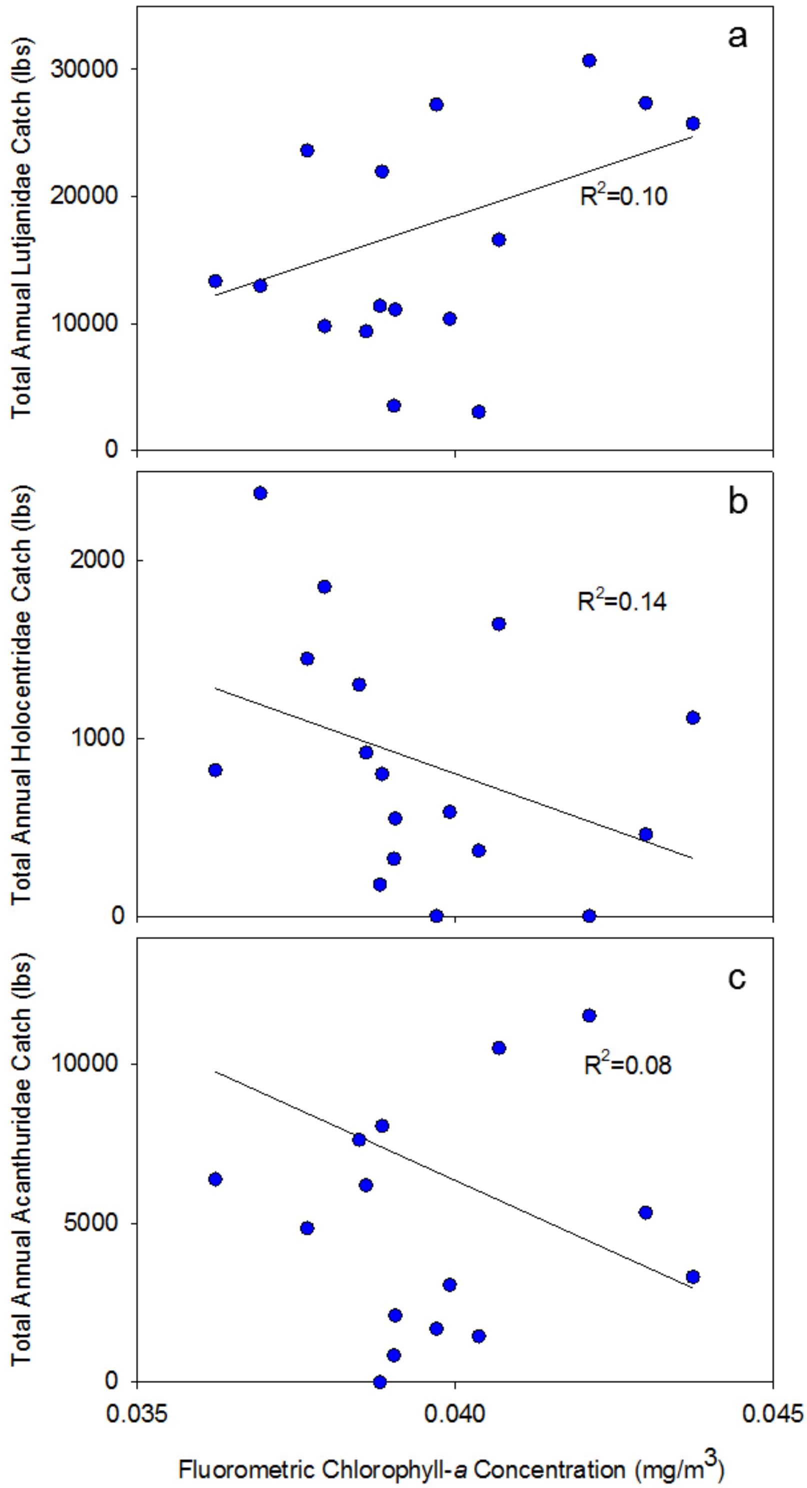


**Figure 35. Linear regressions showing three correlations between total annual catch (lb) for the American Samoa coral reef fishery and fluorometric chlorophyll-*a* concentrations (mg/m$^3$) for (a) Lutjanids, (b) Holocentrids, and (c) Acanthurids from 1998–2014 with phase lag (t+2 years)**

## 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 2.7.4. 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 (CPC 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 36). 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 36).

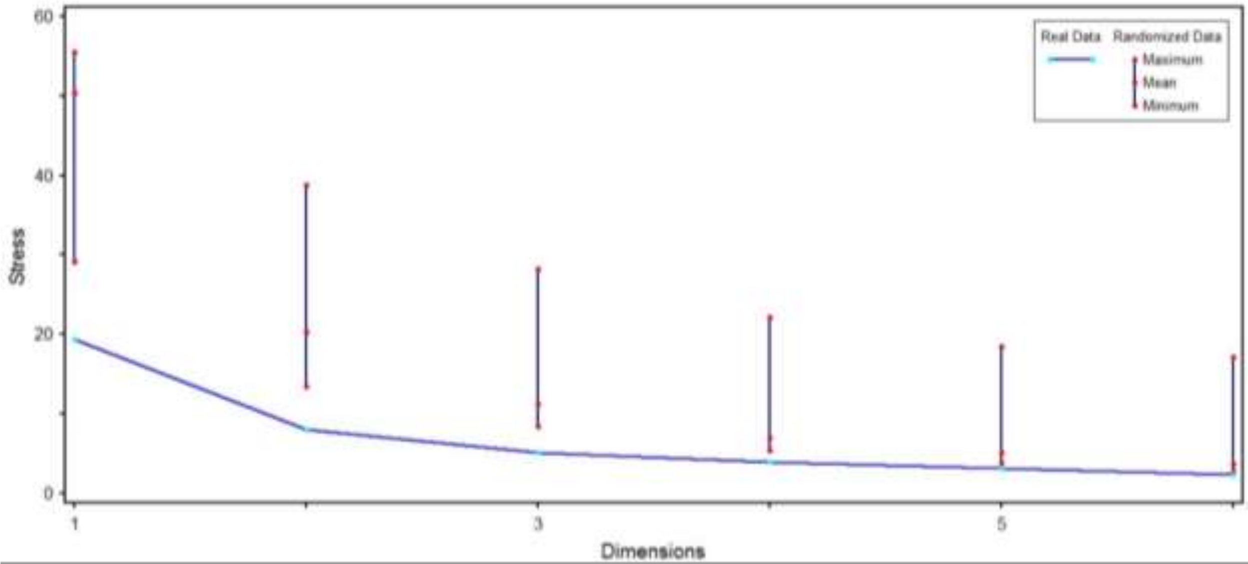


**Figure 36. NMS scree plot showing the stress test to determine dimensionality for the final solution for the American Samoa multivariate analysis**

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 37). 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 37). Analyses including time series of precipitation levels in American Samoa may be useful going forward.

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.

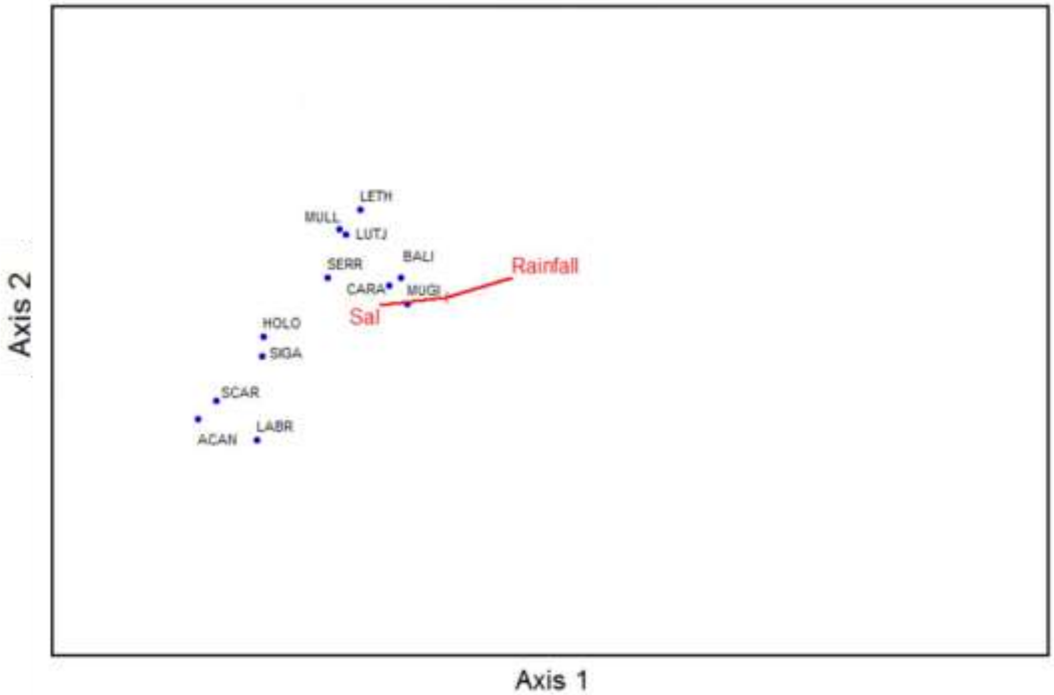


**Figure 37. Two-dimensional scatterplot overlaid with a joint biplot depicting ordination scores resulting from an NMS analysis on creel survey expanded catch data and prominent environmental parameters in American Samoa from 1989-2014**

## 3.6 RECENT RELEVANT ABSTRACTS

In this section, abstracts from primary journal articles published in 2022 and relevant to data integration are compiled. Collecting the abstracts of these articles is intended to further the goal of this section being as a guide for adaptive management.

**Arostegui MC, Gaube, P, Woodworth-Jefcoats PA, et al. 2022. Anticyclonic eddies aggregate pelagic predators in a subtropical gyre. Nature (2022) [https://doi.org/10.1038/s41586-022-05162-6](https://doi.org/10.1038/s41586-022-05162-6).**

Ocean eddies are coherent, rotating features that can modulate pelagic ecosystems across many trophic levels. These mesoscale features, which are ubiquitous at mid-latitudes1, may increase productivity of nutrient-poor regions, accumulate prey and modulate habitat conditions in the water column. However, in nutrient-poor subtropical gyres—the largest marine biome—the role of eddies in modulating behaviour throughout the pelagic predator community remains unknown despite predictions for these gyres to expand and pelagic predators to become increasingly important for food security. Using a large-scale fishery dataset in the North Pacific Subtropical Gyre, we show a pervasive pattern of increased pelagic predator catch inside anticyclonic eddies relative to cyclones and non-eddy areas. Our results indicate that increased mesopelagic prey abundance in anticyclone cores may be attracting diverse predators, forming ecological hotspots where these predators aggregate and exhibit increased abundance. In this energetically quiescent gyre, we expect that isolated mesoscale features (and the habitat conditions in them) exhibit primacy over peripheral submesoscale dynamics in structuring the foraging opportunities of pelagic predators. Our finding that eddies influence coupling of epi- to mesopelagic communities corroborates the growing evidence that deep scattering layer organisms are vital prey for a suite of commercially important predator species and, thus, provide valuable ecosystem services.

**Asner GP, Vaughn NR, Martin RE, Foo SA, Heckler J, Neilson BJ, Gove JM. 2022. Mapped coral mortality and refugia in an archipelago-scale marine heat wave. Proceedings of the National Academy of Sciences. 119(19) [https://doi.org/10.1073/pnas.2123331119](https://doi.org/10.1073/pnas.2123331119).**

Corals are a major habitat-building life-form on tropical reefs that support a quarter of all species in the ocean and provide ecosystem services to millions of people. Marine heat waves continue to threaten and shape reef ecosystems by killing individual coral colonies and reducing their diversity. However, marine heat waves are spatially and temporally heterogeneous, and so too are the environmental and biological factors mediating coral resilience during and following thermal events. This combination results in highly variable outcomes at both the coral bleaching and mortality stages of every event. This, in turn, impedes the assessment of changing reef-scale patterns of thermal tolerance or places of resistance known as reef refugia. We developed a large-scale, high-resolution coral mortality monitoring capability based on airborne imaging spectroscopy and applied it to a major marine heat wave in the Hawaiian Islands. While water depth and thermal stress strongly mediated coral mortality, relative coral loss was also inversely correlated with preheat-wave coral cover, suggesting the existence of coral refugia. Subsequent mapping analyses indicated that potential reef refugia underwent up to 40% lower coral mortality compared with neighboring reefs, despite similar thermal stress. A combination of human and environmental factors, particularly coastal development and sedimentation levels, differentiated resilient reefs from other more vulnerable reefs. Our findings highlight the role that coral mortality mapping, rather than bleaching monitoring, can play for targeted conservation that protects more surviving corals in our changing climate.

**Boland RC, Hyrenbach KD, DeMartini EE, Parrish FA, Rooney JJ. 2022. Quantifying mesophotic fish assemblages of Hawai`i`s Au`au channel: associations with benthic habitats and depth. Frontiers in Marine Science. Volume 8:1990. [https://doi.org/10.3389/fmars.2021.785308](https://doi.org/10.3389/fmars.2021.785308).**

Mesophotic reefs (30–150 m) occur in the tropics and subtropics at depths beyond most scientific diving, thereby making conventional surveys challenging. Towed cameras, submersibles, and mixed-gas divers were used to survey the mesophotic reef fish assemblages and benthic substrates of the Au‘au Channel, between the Hawaiian Islands of Maui and Lāna‘i. Non-parametric multivariate analysis: Non-metric Multidimensional Scaling (NMDS), Hierarchical Cluster Analysis (HCA), Multi-Response Permutation Procedure (MRPP), and Indicator Species Analysis (ISA) were used to determine the association of mesophotic reef fish species with benthic substrates and depth. Between 53 and 115-m depths, 82 species and 10 genera of fish were observed together with 10 types of benthic substrate. Eight species of fish (*Apolemichthys arcuatus*, *Centropyge potteri*, *Chaetodon kleinii*, *Chromis leucura*, *Chromis verater*, *Forcipiger* sp., *Naso hexacanthus*, and *Parupeneus multifasciatus*) were positively associated with increasing depth, *Leptoseris* sp. coral cover, and hard-bottom cover, and one species (*Oxycheilinus bimaculatus*) of fish was positively associated with increasing *Halimeda* sp. algae cover. Fish assemblages associated with rubble were not significantly different from those associated with sand, *Montipora* coral beds and *Leptoseris* coral beds, but were distinct from fish assemblages associated with hard bottom. The patterns in the data suggested two depth assemblages, one "upper mesophotic" between 53 and 95 m and the other deeper, possibly part of a "lower mesophotic" assemblage between 96 and 115 m at the edge of the rariphotic and bottomfish complex.

**Domokos R. 2022. Seamount effects on micronekton at a subtropical central Pacific seamount. Deep Sea Research Part I: Oceanographic Research Papers, Volume 186: 103829. https://doi.org/10.1016/j.dsr.2022.103829.**

Seamounts are globally ubiquitous features with potential for increased biodiversity and biomass, including those of economically important fish. Although their ecological and economical importance is well known, the mechanisms for supporting seamount-associated communities are not well understood. In this study, the effects of an intermediate depth seamount (Cross Seamount) on the micronekton communities, forage for economically important bigeye tuna, are investigated. Relative biomass and composition estimates were calculated from multi-frequency active acoustic data from surveys over 3 years. Mean micronekton biomass was significantly higher than in the ambient environment and its composition differed over the flanks and plateau of Cross Seamount. The effects of the seamount extended ~3.5 km away from the plateau's edge, possibly further below 400 m depth at the flanks. Micronekton occupied the water column from the surface to the 400 m deep plateau with dense aggregations immediately over the bottom at night. During the day, these micronekton migrated both horizontally and downward, occupying depths of 500–700 m, preferably along the upstream flank of the seamount. Descending micronekton from near-surface waters appeared to be temporarily blocked by the topography before swimming below the plateau at the flanks. Mechanisms supporting the increase in micronekton biomass are uncertain, although hydrographic data support topographic trapping of zooplankton and the existence of transient or semi-permanent Taylor caps.

**Giddens J, Kobayashi DR, Mukai GNM, Asher J, Birkeland C, Fitchett M, Hixon MA, Hutchinson M, Mundy BC, O'Malley JM, Sabater M Scott M, Stahl J, Toonen R, Trianni M, Woodworth-Jefcoats PA, Wren JLK, Nelson M. 2022. Assessing the vulnerability of marine life to climate change in the Pacific Islands region. PLoS One,17(7):e0270930. https://doi.org/10.1371/journal.pone.0270930.**

Our changing climate poses growing challenges for effective management of marine life, ocean ecosystems, and human communities. Which species are most vulnerable to climate change, and where should management focus efforts to reduce these risks? To address these questions, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Climate Science Strategy called for vulnerability assessments in each of NOAA's ocean regions. The Pacific Islands Vulnerability Assessment (PIVA) project assessed the susceptibility of 83 marine species to the impacts of climate change projected to 2055. In a standard Rapid Vulnerability Assessment framework, this project applied expert knowledge, literature review, and climate projection models to synthesize the best available science towards answering these questions. Here we: (1) provide a relative climate vulnerability ranking across species; (2) identify key attributes and factors that drive vulnerability; and (3) identify critical data gaps in understanding climate change impacts to marine life. The invertebrate group was ranked most vulnerable and pelagic and coastal groups not associated with coral reefs were ranked least vulnerable. Sea surface temperature, ocean acidification, and oxygen concentration were the main exposure drivers of vulnerability. Early Life History Survival and Settlement Requirements was the most data deficient of the sensitivity attributes considered in the assessment. The sensitivity of many coral reef fishes ranged between Low and Moderate, which is likely underestimated given that reef species depend on a biogenic habitat that is extremely threatened by climate change. The standard assessment methodology originally developed in the Northeast US, did not capture the additional complexity of the Pacific region, such as the diversity, varied horizontal and vertical distributions, extent of coral reef habitats, the degree of dependence on vulnerable habitat, and wide range of taxa, including data-poor species. Within these limitations, this project identified research needs to sustain marine life in a changing climate.

**Gulland FMD, Baker JD, Howe M, LaBrecque E, Leach L, Moore SE, Reeves RR, Thomas PO. 2022. A review of climate change effects on marine mammals in United States waters: Past predictions, observed impacts, current research and conservation imperatives. Climate Change Ecology. Volume 3: 100054. https://doi.org/10.1016/j.ecochg.2022.100054.**

We consider the current evidence of climate change effects on marine mammals that occur in U.S. waters relative to past predictions. Compelling cases of such effects have been documented, though few studies have confirmed population-level impacts on abundance or vital rates. While many of the observed effects had been predicted, some unforeseen and relatively acute consequences have also been documented. Effects often occur when climate-induced alterations are superimposed upon marine mammals' ecological (e.g., predator-prey) relationships or coincident human activities. As they were unanticipated, some of the unpredicted effects of climate change have strained the ability of existing conservation and management systems to respond effectively. The literature is replete with cases suggestive of climate change impacts on marine mammals, but which remain unconfirmed. This uncertainty is partially explained by insufficient research and monitoring designed to reveal the connections. Detecting and mitigating the impacts of climate change will require some realignment of research and monitoring priorities, coupled with rapid and flexible management that includes both conventional and novel conservation interventions.

**Hall R, Parke M. 2022. PIFSC-PIRO ecosystem-based fisheries management workshop April 6-7, 2021 final report. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-22-02, 42 p. https://doi.org/10.25923/5f6x-sk11.**

NOAA Fisheries strives to maintain and build productive and sustainable fisheries and healthy marine and aquatic ecosystems, as well as to protect threatened and endangered species, through use of an ecosystem-based approach to science and management. To further our goal of implementing ecosystem-based fisheries management (EBFM) in the Pacific Islands region, NOAA Fisheries Pacific Islands Fisheries Science Center (PIFSC) and Pacific Islands Regional Office (PIRO) held an EBFM Workshop on April 6 & 7, 2021.

**Huntington B, Vargas-Angel B, Couch CS, Barkley HC, Abecassis M. 2022. Oceanic productivity and high-frequency temperature variability -not human habitation- supports calcifier abundance on central Pacific coral reefs. Frontiers in Marine Science. 9:1075972. https://doi.org/10.3389/fmars.2022.1075972.**

Past research has demonstrated how local-scale human impacts—including reduced water quality, overfishing, and eutrophication—adversely affect coral reefs. More recently, global-scale shifts in ocean conditions arising from climate change have been shown to impact coral reefs. Here, we surveyed benthic reef communities at 34 U.S.-affiliated Pacific islands spanning a gradient of oceanic productivity, temperature, and human habitation. We re-evaluated patterns reported for these islands from the early 2000s in which uninhabited reefs were dominated by calcifiers (coral and crustose coralline algae) and thought to be more resilient to global change. Using contemporary data collected nearly two decades later, our analyses indicate this projection was not realized. Calcifiers are no longer the dominant benthic group at uninhabited islands. Calcifier coverage now averages 26.9% ± 3.9 SE on uninhabited islands (compared to 45.18% in the early 2000s). We then asked whether oceanic productivity, past sea surface temperatures (SST), or acute heat stress supersede the impacts of human habitation on benthic cover. Indeed, we found variation in benthic cover was best explained not by human population densities, but by remotely sensed metrics of chlorophyll-*a*, SST, and island-scale estimates of herbivorous fish biomass. Specifically, higher coral and CCA cover was observed in more productive waters with greater biomass of herbivores, while turf cover increased with daily SST variability and reduced herbivore biomass. Interestingly, coral cover was positively correlated with daily variation in SST but negatively correlated with monthly variation. Surprisingly, metrics of acute heat stress were not correlated with benthic cover. Our results reveal that human habitation is no longer a primary correlate of calcifier cover on central Pacific island reefs, and highlight the addition of oceanic productivity and high-frequency SST variability to the list of factors supporting reef builder abundance.

**Huntington B, Weible R, Halperin A, et al. 2022. Early successional trajectory of benthic community in an uninhabited reef system three years after mass coral bleaching. Coral Reefs (2022) https://doi.org/10.1007/s00338-022-02246-7.**

Severe thermal stress events occurring on the backdrop of globally warming oceans can result in mass coral mortality. Tracking the ability of a reef community to return to pre-disturbance composition is important to inform the likelihood of recovery or the need for active management to conserve these ecosystems. Here, we quantified annual, temporal changes in the benthic communities for the three years following mass coral mortality at Jarvis Island—an uninhabited island in the Pacific Remote Islands Marine National Monument. While Jarvis experienced catastrophic coral mortality in 2015 due to heat stress resulting from the 2015/16 El Niño, significant annual shifts were documented in the benthic community in the three years post-disturbance. Macroalgal and turf dominance of the benthos was temporary—likely reflecting the high biomass of herbivorous reef fishes post-bleaching—giving way to calcifiers such as crustose coralline algae and *Halimeda*, which may facilitate rather than impede coral recovery. By 2018, indications of recovery were detectable in the coral community itself as juvenile densities increased and stress-tolerant genera, such as *Pavona*, exceeded their pre-disturbance densities. However, densities of *Montipora* and *Pocillopora* remain low, suggesting recovery will be slow for these formerly dominant taxa. Collectively, the assemblage and taxon-specific shifts observed in the benthic and coral community support cautious optimism for the potential recovery of Jarvis Island's coral reefs to their pre-disturbance state. Continued monitoring will be essential to assess whether reassembly is achieved before further climate-related disturbance events affect this reef system.

**Iwane M, Hospital J. 2022. Hawai'i fishing communities' vulnerability to climate change: Climate vulnerable species and adaptive capacity. U.S. Dept. of Commerce, NOAA**

**Technical Memorandum NOAA-TM-NMFS-PIFSC-136, 34 p. https://doi.org/10.25923/4vvb-pv29.**

In this report, we propose a framework that could be useful to select candidate communities from the main Hawaiian Islands for future qualitative research on the vulnerability of fishing communities to climate change. We adopted the IPCC framework (2001) that defines climate change vulnerability as a function of sensitivity (S), exposure (E), and adaptive capacity (AC). We tested and finalized community selection criteria based on available quantitative data and CSVIs relevant to MHI communities' social and climate change vulnerability.

**Kinney MJ, Carvalho F, Kai M, Semba Y, Liu KM, Tsai WP, Leonardo CGJ, Horacio HA, Daniel CCL, Teo SLH. 2022. Cluster analysis used to re-examine fleet definitions of North Pacific fisheries with spatiotemporal consideration of blue shark size and sex data. Pacific Islands Fisheries Science Center, PIFSC Working Paper, WP-22-001, 18 p. https://doi.org/10.25923/zet2-sk13.**

This study looked at re-examining the North Pacific fleets that have been used for previous assessments of blue shark by investigating the size and sex composition data from observer records, port and scientific samples in greater detail. Our goal is to provide information that can be used by the ISC shark working group to more appropriately define fleet structure for the assessment based on size and sexual composition of the catch. Ultimately, refining fleet structure within the model with greater consideration for the spatiotemporal characteristics of blue shark catch may help reduce model misspecification in future assessments. We analyzed nearly 600,000 individual records of blue shark size and sex information divided across 240 5 x 5° grid cells covering the North Pacific. A clustering approach was taken to discern areas with related size and sex compositions. Results suggested four distinct clusters, where Clusters 1 and 4 (made up primarily of smaller immature animals) predominate in the catch at higher latitudes (north of ~25°N), especially in the eastern and western edges of the North Pacific (waters nearer the coasts). While Cluster 2 (mature males and females) and Cluster 3 (mostly males, both mature and immature) predominate in a band from ~ 20°N to near the equator. During fall and winter (seasons 1 and 4) this band of mature animals expands north in central Pacific waters, loosely around Hawaii, as high up as ~40°N. We suggest that this work, along with several other studies carried out by various members of the ISC shark working group over the years, be used to better define the fleets used in future assessments of blue sharks in the North Pacific

**Kleiber D, Iwane M, Kamikawa K, Leong K, Hospital J. 2022. Pacific Islands Region Fisheries and COVID-19: Impacts and adaptations. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-130, 36 p. https://doi.org/10.25923/2fpm-c128.**

The Pacific Islands Region has experienced a number of unique risks from COVID-19, and the measures put in place to stop its spread. In this report, we detail the impacts of COVID-19 on the Pacific Islands Region fisheries from March 2020 to February 2021, and highlight the adaptations made by the diverse fishers, marketers, and fishing communities of this region. We gathered information from different sources, including publicly available statistics, news reports, government rules, as well as short open-ended phone interviews.

**Lisi P, Hogan J.D, Holt G, Moody K, Wren J, Kobayashi D, Blum M, McIntyre P. 2022. Stream and ocean hydrodynamics mediate partial migration strategies in an amphidromous Hawaiian goby. Ecology, e3800. [https://doi.org/10.1002/ecy.3800](https://doi.org/10.1002/ecy.3800).**

Partial migration strategies, in which some individuals migrate but others do not, are widely observed in populations of migratory animals. Such patterns could arise via variation in migratory behaviors made by individual animals, via genetic variation in migratory predisposition, or simply by variation in migration opportunities mediated by environmental conditions. Here we use spatiotemporal variation in partial migration across populations of an amphidromous Hawaiian goby to test whether stream or ocean conditions favor completing its life cycle entirely within freshwater streams rather than undergoing an oceanic larval migration. Across 35 watersheds, microchemical analysis of otoliths revealed that most adult *Awaous stamineus* were freshwater residents (62% of $n$ = 316 in 2009, 83% of $n$ = 274 in 2011), but we found considerable variation among watersheds. We then tested the hypothesis that the prevalence of freshwater residency increases with the stability of stream flows and decreases with the availability of dispersal pathways arising from ocean hydrodynamics. We found that streams with low variation of daily discharge were home to a higher incidence of freshwater residents in each survey year. The magnitude of the shift in freshwater residency between survey years was positively associated with predicted interannual variability in the success of larval settlement in streams on each island based on passive drift in ocean currents. We built on these findings by developing a theoretical model of goby life history to further evaluate whether mediation of migration outcomes by stream and ocean hydrodynamics could be sufficient to explain the range of partial migration frequency observed across populations. The model illustrates that the proportion of larvae entering the ocean and differential survival of freshwater-resident versus ocean-going larvae are plausible mechanisms for range-wide shifts in migration strategies. Thus, we propose that hydrologic variation in both ocean and stream environments contributes to spatiotemporal variation in the prevalence of migration phenotypes in *A. stamineus*. Our empirical and theoretical results suggest that the capacity for partial migration could enhance the persistence of metapopulations of diadromous fish when confronted with variable ocean and stream conditions.

**Mazur MD, Tanaka KR, Shank B, Chang J, Hodgson CT, Reardon KM, Friedland KD, Chen Y. 2022. Incorporating spatial heterogeneity and environmental impacts into stock-recruitment relationships for Gulf of Maine lobster. ICES Journal of Marine Science.0:1-11. [https://doi.org/10.1093/icesjms/fsab266](https://doi.org/10.1093/icesjms/fsab266).**

Functional stock-recruitment relationships (SRRs) are often difficult to quantify and can differ over space. Additionally, climate change adds to the complexity of recruitment dynamics. This paper's aim was to incorporate spatial heterogeneity and environmental effects on productivity in SRRs with American lobster in the Gulf of Maine (GOM) as a case study. GOM lobster recruitment has substantially increased since the mid-2000s, due to improved survival rates of pre-recruits and increased spawning stock biomass (SSB). GOM bottom water temperatures have increased at a rate of 0.2ºC per decade, which caused lobster settlement area to expand and improved survival rates. We first estimated local SSB using bottom trawl survey data and a geostatistical model. Using estimated SSB, recruitment data from a ventless trap survey, and an interpolated bottom water temperature field, we developed modified Ricker stock-recruitment models accounting for spatial heterogeneity and temperature impacts with varying coefficient generalized additive models. Results showed that temperature significantly impacted recruitment. Changes in temperature mediated productivity differed between the eastern and western GOM. Our study demonstrated that the incorporation of spatial heterogeneity and environmental effects impacts our understanding of SRRs. These methods can be applied to other species to understand recruitment dynamics influenced by climate change.

**Panelo J, Wiegner TN, Colbert SL, Goldberg S, Abaya LM, Conklin E, Couch C, Falinski K, Gove J, Watson L, Wiggins C. 2022. Spatial distribution and sources of nutrients at two coastal developments in South Kohala, Hawai'i. Marine Pollution Bulletin. Volume 174:113143. https://doi.org/10.1016/j.marpolbul.2021.113143.**

Nutrient sources to coastal waters with coral reefs are not well-characterized. This study documented spatial distributions of nutrients within coastal waters along two developments with coral reefs, and identified nutrient sources through nutrient mixing plots, $\delta^{15}N$ measurements in macroalgal tissue, and $NO_3^-$ stable isotope mixing models. Nutrients decreased from fresh groundwaters to offshore waters, with some surface waters higher in concentrations than benthic ones. Conservative and non-conservative mixing between fresh and ocean waters occurred, the latter suggestive of local nutrient sources and biological removal. $\delta^{15}N$ in macroalgal tissue and $NO_3^-$ concurred that fresh groundwater, ocean water, and fertilizers were dominant nutrient sources. Benthic salinity and $NO_3^- + NO_2^-$ concentrations illustrated that submarine groundwater discharge delivered nutrients to reefs in pulses ranging from minutes to days. Information generated from this study is imperative for developing management actions to improve water quality and make coral reefs more resilient to stressors.

**Smith J, Halperin A, Barkley H. 2022. A 'perfect storm' of cumulative and acute heat stress, and a warming trend, lead to bleaching events in Tutuila, American Samoa. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-129, 52 p. https://doi.org/10.25923/yphg-pq04.**

To better understand vertical thermal structure of reefs at depth and identify predictors of mass bleaching events using high frequency time series data, we used long-term (2012–2018) in situ temperature data collected at multiple reefs and depths around the island of Tutuila in American Samoa. Located in the central South Pacific, Tutuila is 1 of 5 volcanic islands and 2 atolls that comprise American Samoa. Lying just a few kilometers from shore, Tutuila contains shallow fringing reefs and a deep offshore bank (Birkeland et al. 2008). American Samoa experienced severe bleaching in 1994, 2003, 2015 and 2017 (Coward et al. 2020). The objectives of our study are to (1) conduct a time series analysis on in situ temperature data (2012–2018) and calculate heating metrics and (2) determine whether heating metrics predicted coral bleaching prevalence during the 2015 bleaching event.

**Tanaka KR, Schmidt AL, Kindinger TL, Whitney JL, Samson JC. 2022. Spatiotemporal assessment of *Aprion virescens* density in shallow main Hawaiian Islands waters, 2010-2019. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-132, 33 p. https://doi.org/10.25923/f24q-k056.**

The Magnuson-Stevens Fishery Conservation and Management Act of 1996 directs regional fishery management councils and the National Marine Fisheries Service (NMFS) to identify and describe "essential fish habitat (EFH)" for all federally managed species to ensure conservation and sustainable management of living marine resources. This report summarizes the statistically-derived density patterns of *Aprion virescens* in shallow coastal waters of the main Hawaiian Islands (MHIs) from 2010 to 2019.

**Tanaka KR, Van Houtan KS. 2022. The recent normalization of historical marine heat extremes. PLOS Climate. 1(2): e0000007. https://doi.org/10.1371/journal.pclm.0000007.**

Climate change exposes marine ecosystems to extreme conditions with increasing frequency. Capitalizing on the global reconstruction of sea surface temperature (SST) records from 1870-present, we present a centennial-scale index of extreme marine heat within a coherent and comparable statistical framework. A spatially (1° × 1°) and temporally (monthly) resolved index of the normalized historical extreme marine heat events was expressed as a fraction of a year that exceeds a locally determined, monthly varying 98th percentile of SST gradients derived from the first 50 years of climatological records (1870–1919). For the year 2019, our index reports that 57% of the global ocean surface recorded extreme heat, which was comparatively rare (approximately 2%) during the period of the second industrial revolution. Significant increases in the extent of extreme marine events over the past century resulted in many local climates to have shifted out of their historical SST bounds across many economically and ecologically important marine regions. For the global ocean, 2014 was the first year to exceed the 50% threshold of extreme heat thereby becoming "normal", with the South Atlantic (1998) and Indian (2007) basins crossing this barrier earlier. By focusing on heat extremes, we provide an alternative framework that may help better contextualize the dramatic changes currently occurring in marine systems.

**Winston M, Oliver T, Couch C, Donovan MK, Asner GP, et al. 2022. Coral taxonomy and local stressors drive bleaching prevalence across the Hawaiian Archipelago in 2019. PLOS ONE 17(9): e0269068. https://doi.org/10.1371/journal.pone.0269068.**

The Hawaiian Archipelago experienced a moderate bleaching event in 2019—the third major bleaching event over a 6-year period to impact the islands. In response, the Hawaiʻi Coral Bleaching Collaborative (HCBC) conducted 2,177 coral bleaching surveys across the Hawaiian Archipelago. The HCBC was established to coordinate bleaching monitoring efforts across the state between academic institutions, non-governmental organizations, and governmental agencies to facilitate data sharing and provide management recommendations. In 2019, the goals of this unique partnership were to: 1) assess the spatial and temporal patterns of thermal stress; 2) examine taxa-level patterns in bleaching susceptibility; 3) quantify spatial variation in bleaching extent; 4) compare 2019 patterns to those of prior bleaching events; 5) identify predictors of bleaching in 2019; and 6) explore site-specific management strategies to mitigate future bleaching events. Both acute thermal stress and bleaching in 2019 were less severe overall compared to the last major marine heatwave events in 2014 and 2015. Bleaching observed was highly site- and taxon-specific, driven by the susceptibility of remaining coral assemblages whose structure was likely shaped by previous bleaching and subsequent mortality. A suite of environmental and anthropogenic predictors was significantly correlated with observed bleaching in 2019. Acute environmental stressors, such as temperature and surface light, were equally important as previous conditions (e.g. historical thermal stress and historical bleaching) in accounting for variation in bleaching during the 2019 event. We found little evidence for acclimation by reefs to thermal stress in the main Hawaiian Islands. Moreover, our findings illustrate how detrimental effects of local anthropogenic stressors, such as tourism and urban run-off, may be exacerbated under high thermal stress. In light of the forecasted increase in severity and frequency of bleaching events, future mitigation of both local and global stressors is a high priority for the future of corals in Hawai‘i.

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# APPENDIX A: LIST OF SPECIES

## AMERICAN SAMOA MANAGEMENT UNIT SPECIES

### 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* |
| 111 | black trevally, jack | *Caranx lugubris* |
| 229 | lunar tail grouper (yellow edge lyretail) | *Variola louti* |
| 249 | red snapper | *Etelis carbunculus* |
| 248 | longtail snapper | *Etelis coruscans* |
| 267 | redgill emperor | *Lethrinus rubrioperculatus* |
| 231 | blueline snapper | *Lutjanus kasmira* |
| 242 | pink snapper (paka) | *Pristipomoides filamentosus* |
| 241 | yelloweye snapper | *Pristipomoides flavipinnis* |
| 245 | flower snapper (gindai) | *Pristipomoides zonatus* |

## MONITORED ECOSYSTEM COMPONENT SPECIES

### 1. Species Selected for Monitoring by DMWR

| DMWR Creel Species Code | Species Name | Scientific Name |
|---|---|---|
| 3511 | Bluelined squirrelfish | *Sargocentron tiere* |
| 1301 | Fringelip mullet | *Crenimugil crenilabis* |
| 504 | Green spiny lobster | *Panulirus penicillatus* |
| None | Small giant clam | *Tridacna maxima* |
| 5061 | Day octopus | *Octopus cyanea* |
| 208 | One-blotch grouper | *Epinephelus melanostigma* |

## 2. Species Monitored by Trophic, Taxonomic, and Functional Groups

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

| **Family** | **Scientific Name** | **Trophic Group** | **Functional Group** |
|---|---|---|---|
| Acanthuridae | *Naso lituratus* | H | Browsing Surgeons |
| Acanthuridae | *Naso tonganus* | H | Browsing Surgeons |
| Acanthuridae | *Naso unicornis* | H | Browsing Surgeons |
| Acanthuridae | *Naso brachycentron* | H | Browsing Surgeons |
| Acanthuridae | *Ctenochaetus cyanocheilus* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Ctenochaetus strigosus* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Acanthurus nigroris* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Ctenochaetus hawaiiensis* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Ctenochaetus striatus* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Ctenochaetus marginatus* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Acanthurus lineatus* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Acanthurus blochii* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Acanthurus dussumieri* | H | Mid-Large Target Surgeons |
| Acanthuridae | *Acanthurus xanthopterus* | H | Mid-Large Target Surgeons |
| Chaetodontidae | *Chaetodon flavocoronatus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon multicinctus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon punctatofasciatus* | MI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon mertensii* | H | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon citrinellus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon pelewensis* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon lunulatus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon melannotus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon rafflesii* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon ulietensis* | MI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon fremblii* | SI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon quadrimaculatus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon meyeri* | Cor | Non-PK Butterflyfish |

| | | | |
|---|---|---|---|
| Chaetodontidae | *Chaetodon reticulatus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon trifascialis* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Heniochus chrysostomus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon bennetti* | MI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon tinkeri* | SI | Non-PK Butterflyfish |
| Chaetodontidae | *Heniochus varius* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon ornatissimus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon unimaculatus* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon lunula* | SI | Non-PK Butterflyfish |
| Chaetodontidae | *Forcipiger longirostris* | MI | Non-PK Butterflyfish |
| Chaetodontidae | *Forcipiger flavissimus* | SI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon ephippium* | MI | Non-PK Butterflyfish |
| Chaetodontidae | *Heniochus monoceros* | MI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon auriga* | SI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon vagabundus* | SI | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon semeion* | H | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodontidae* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Heniochus singularius* | Cor | Non-PK Butterflyfish |
| Chaetodontidae | *Chaetodon lineolatus* | SI | Non-PK Butterflyfish |
| Caracanthidae | *Caracanthus typicus* | MI | No Group |
| Gobiidae | *Eviota* sp. | MI | No Group |
| Pomacentridae | *Chrysiptera traceyi* | H | No Group |
| Apogonidae | *Ostorhinchus luteus* | Pk | No Group |
| Caracanthidae | *Caracanthus maculatus* | MI | No Group |
| Pseudochromidae | *Pseudochromis jamesi* | MI | No Group |
| Pomacentridae | *Chromis acares* | Pk | No Group |
| Serranidae | *Luzonichthys whitleyi* | Pk | No Group |
| Pomacentridae | *Pomachromis guamensis* | Pk | No Group |
| Pomacentridae | *Pomachromis richardsoni* | Pk | No Group |
| Gobiidae | *Fusigobius duospilus* | MI | No Group |
| Pomacentridae | *Plectroglyphidodon imparipennis* | MI | No Group |
| Microdesmidae | *Nemateleotris helfrichi* | Pk | No Group |
| Pomacentridae | *Chromis leucura* | Pk | No Group |
| Syngnathidae | *Doryrhamphus excisus* | Pk | No Group |
| Pomacentridae | *Pomacentrus coelestis* | Pk | No Group |
| Clupeidae | *Spratelloides delicatulus* | Pk | No Group |
| Pomacentridae | *Chrysiptera biocellata* | H | No Group |
| Pseudochromidae | *Pictichromis porphyreus* | MI | No Group |
| Pomacanthidae | *Centropyge fisheri* | H | No Group |

| | | | |
|---|---|---|---|
| Cirrhitidae | *Cirrhitops hubbardi* | MI | No Group |
| Gobiidae | *Amblyeleotris fasciata* | Pk | No Group |
| Pomacentridae | *Chromis lepidolepis* | Pk | No Group |
| Pomacentridae | *Chromis margaritifer* | Pk | No Group |
| Pomacentridae | *Chromis ternatensis* | Pk | No Group |
| Pomacentridae | *Chromis viridis* | Pk | No Group |
| Pomacentridae | *Chrysiptera cyanea* | Pk | No Group |
| Pomacentridae | *Dascyllus aruanus* | Pk | No Group |
| Pomacentridae | *Dascyllus reticulatus* | Pk | No Group |
| Engraulidae | *Encrasicholina purpurea* | Pk | No Group |
| Pomacentridae | *Neopomacentrus metallicus* | Pk | No Group |
| Pomacentridae | *Chromis amboinensis* | H | No Group |
| Pomacentridae | *Chromis iomelas* | H | No Group |
| Pomacentridae | *Chrysiptera glauca* | H | No Group |
| Pomacentridae | *Chrysiptera taupou* | H | No Group |
| Labridae | *Labroides pectoralis* | MI | No Group |
| Labridae | *Pseudocheilinus hexataenia* | MI | No Group |
| Labridae | *Pseudocheilinus tetrataenia* | MI | No Group |
| Scorpaenidae | *Sebastapistes cyanostigma* | MI | No Group |
| Labridae | *Wetmorella nigropinnata* | MI | No Group |
| Pseudochromidae | *Pseudochromis* sp. | MI | No Group |
| Monacanthidae | *Pervagor marginalis* | Om | No Group |
| Pomacentridae | *Chromis alpha* | Pk | No Group |
| Pomacentridae | *Plectroglyphidodon phoenixensis* | H | No Group |
| Gobiidae | *Amblyeleotris guttata* | Pk | No Group |
| Atherinidae | *Atherinomorus insularum* | Pk | No Group |
| Pomacentridae | *Chromis caudalis* | Pk | No Group |
| Pomacentridae | *Chromis hanui* | Pk | No Group |
| Labridae | *Cirrhilabrus katherinae* | Pk | No Group |
| Microdesmidae | *Nemateleotris magnifica* | Pk | No Group |
| Apogonidae | *Ostorhinchus angustatus* | Pk | No Group |
| Serranidae | *Pseudanthias bartlettorum* | Pk | No Group |
| Tetraodontidae | *Canthigaster jactator* | H | No Group |
| Tetraodontidae | *Canthigaster janthinoptera* | H | No Group |
| Tetraodontidae | *Canthigaster valentini* | H | No Group |
| Pomacanthidae | *Centropyge shepardi* | H | No Group |
| Pomacentridae | *Chrysiptera brownriggii* | H | No Group |
| Monacanthidae | *Oxymonacanthus longirostris* | Cor | No Group |

| | | | |
|---|---|---|---|
| Cirrhitidae | *Amblycirrhitus bimacula* | MI | No Group |
| Cirrhitidae | *Cirrhitichthys falco* | MI | No Group |
| Labridae | *Labroides rubrolabiatus* | MI | No Group |
| Cirrhitidae | *Neocirrhites armatus* | MI | No Group |
| Labridae | *Pseudojuloides splendens* | MI | No Group |
| Apogonidae | *Ostorhinchus novemfasciatus* | Pk | No Group |
| Labridae | *Pteragogus cryptus* | MI | No Group |
| Scorpaenidae | *Sebastapistes* sp. | Pisc | No Group |
| Scorpaenidae | *Taenianotus triacanthus* | Pisc | No Group |
| Pomacentridae | *Amphiprion perideraion* | Pk | No Group |
| Pomacentridae | *Chromis fumea* | Pk | No Group |
| Labridae | *Cirrhilabrus jordani* | Pk | No Group |
| Blenniidae | *Ecsenius bicolor* | Pk | No Group |
| Blenniidae | *Ecsenius midas* | Pk | No Group |
| Blenniidae | *Ecsenius opsifrontalis* | Pk | No Group |
| Pomacentridae | *Lepidozygus tapeinosoma* | Pk | No Group |
| Blenniidae | *Meiacanthus atrodorsalis* | Pk | No Group |
| Apogonidae | *Ostorhinchus apogonoides* | Pk | No Group |
| Pomacentridae | *Plectroglyphidodon lacrymatus* | Pk | No Group |
| Pomacentridae | *Pomacentrus brachialis* | Pk | No Group |
| Pomacentridae | *Pomacentrus nigriradiatus* | Pk | No Group |
| Pomacentridae | *Pomacentrus philippinus* | Pk | No Group |
| Pomacentridae | *Pomacentrus vaiuli* | Pk | No Group |
| Serranidae | *Pseudanthias dispar* | Pk | No Group |
| Serranidae | *Pseudanthias hawaiiensis* | Pk | No Group |
| Tetraodontidae | *Canthigaster bennetti* | H | No Group |
| Pomacanthidae | *Centropyge bispinosa* | H | No Group |
| Pomacanthidae | *Centropyge heraldi* | H | No Group |
| Pomacanthidae | *Centropyge loricula* | H | No Group |
| Blenniidae | *Cirripectes obscurus* | H | No Group |
| Blenniidae | *Cirripectes polyzona* | H | No Group |
| Blenniidae | *Cirripectes* sp. | H | No Group |
| Blenniidae | *Cirripectes springeri* | H | No Group |
| Blenniidae | *Cirripectes stigmaticus* | H | No Group |
| Blenniidae | *Cirripectes variolosus* | H | No Group |
| Callionymidae | *Callionymidae* | MI | No Group |
| Labridae | *Labroides phthirophagus* | MI | No Group |

| | | | |
|---|---|---|---|
| Pomacanthidae | *Paracentropyge multifasciata* | MI | No Group |
| Blenniidae | *Plagiotremus ewaensis* | MI | No Group |
| Blenniidae | *Plagiotremus goslinei* | MI | No Group |
| Scorpaenidae | *Sebastapistes coniorta* | MI | No Group |
| Monacanthidae | *Pervagor melanocephalus* | Om | No Group |
| Blenniidae | *Plagiotremus laudandus* | Par | No Group |
| Blenniidae | *Plagiotremus rhinorhynchos* | Par | No Group |
| Blenniidae | *Plagiotremus tapeinosoma* | Par | No Group |
| Labridae | *Pseudocheilinus ocellatus* | MI | No Group |
| Pomacanthidae | *Centropyge flavissima* & *vroliki* | H | No Group |
| Pomacentridae | *Amblyglyphidodon curacao* | Om | No Group |
| Pomacentridae | *Amphiprion melanopus* | Pk | No Group |
| Pomacentridae | *Chromis agilis* | Pk | No Group |
| Gobiidae | *Istigobius* sp. | Pk | No Group |
| Pomacentridae | *Pomacentrus pavo* | Pk | No Group |
| Apogonidae | *Pristiapogon fraenatus* | Pk | No Group |
| Tetraodontidae | *Canthigaster epilampra* | H | No Group |
| Tetraodontidae | *Canthigaster solandri* | H | No Group |
| Blenniidae | *Cirripectes vanderbilti* | H | No Group |
| Pomacentridae | *Stegastes albifasciatus* | H | No Group |
| Pomacentridae | *Stegastes aureus* | H | No Group |
| Pomacentridae | *Stegastes marginatus* | H | No Group |
| Pomacentridae | *Plectroglyphidodon dickii* | Cor | No Group |
| Cirrhitidae | *Paracirrhites xanthus* | MI | No Group |
| Monacanthidae | *Paraluteres prionurus* | MI | No Group |
| Microdesmidae | *Microdesmidae* | Pk | No Group |
| Scorpaenidae | *Sebastapistes ballieui* | MI | No Group |
| Apogonidae | *Apogon kallopterus* | Pk | No Group |
| Pomacentridae | *Chromis weberi* | Pk | No Group |
| Labridae | *Cirrhilabrus exquisitus* | Pk | No Group |
| Syngnathidae | *Corythoichthys flavofasciatus* | Pk | No Group |
| Pomacentridae | *Dascyllus albisella* | Pk | No Group |
| Microdesmidae | *Gunnellichthys curiosus* | Pk | No Group |
| Apogonidae | *Pristiapogon kallopterus* | Pk | No Group |
| Serranidae | *Pseudanthias olivaceus* | Pk | No Group |
| Ptereleotridae | *Ptereleotris heteroptera* | Pk | No Group |
| Ptereleotridae | *Ptereleotris zebra* | Pk | No Group |

| | | | |
|---|---|---|---|
| Pomacanthidae | *Centropyge vrolikii* | H | No Group |
| Pomacentridae | *Plectroglyphidodon leucozonus* | H | No Group |
| Pomacentridae | *Plectroglyphidodon johnstonianus* | Cor | No Group |
| Labridae | *Anampses melanurus* | MI | No Group |
| Apogonidae | *Cheilodipterus quinquelineatus* | MI | No Group |
| Cirrhitidae | *Cirrhitichthys oxycephalus* | MI | No Group |
| Cirrhitidae | *Cirrhitops fasciatus* | MI | No Group |
| Labridae | *Halichoeres biocellatus* | MI | No Group |
| Labridae | *Labroides dimidiatus* | MI | No Group |
| Labridae | *Labropsis micronesica* | MI | No Group |
| Labridae | *Macropharyngodon negrosensis* | MI | No Group |
| Labridae | *Pseudojuloides cerasinus* | MI | No Group |
| Labridae | *Pseudojuloides polynesica* | MI | No Group |
| Blenniidae | *Aspidontus taeniatus* | Par | No Group |
| Tetraodontidae | *Torquigener randalli* | MI | No Group |
| Pomacentridae | *Plectroglyphidodon sindonis* | H | No Group |
| Pomacanthidae | *Centropyge potteri* | H | No Group |
| Cirrhitidae | *Oxycirrhites typus* | Pk | No Group |
| Serranidae | *Pseudanthias bicolor* | Pk | No Group |
| Ptereleotridae | *Ptereleotris microlepis* | Pk | No Group |
| Pomacentridae | *Stegastes lividus* | H | No Group |
| Labridae | *Cirrhilabrus punctatus* | MI | No Group |
| Labridae | *Halichoeres margaritaceus* | MI | No Group |
| Labridae | *Pseudojuloides atavai* | MI | No Group |
| Holocentridae | *Sargocentron punctatissimum* | MI | No Group |
| Monacanthidae | *Pervagor janthinosoma* | Om | No Group |
| Pomacentridae | *Amphiprion clarkii* | Pk | No Group |
| Serranidae | *Anthias* sp. | Pk | No Group |
| Blenniidae | *Blenniella chrysospilos* | Pk | No Group |
| Chaetodontidae | *Chaetodon kleinii* | Pk | No Group |
| Pomacentridae | *Dascyllus trimaculatus* | Pk | No Group |
| Apogonidae | *Ostorhinchus maculiferus* | Pk | No Group |
| Serranidae | *Pseudanthias cooperi* | Pk | No Group |
| Gobiidae | *Amblygobius phalaena* | H | No Group |
| Tetraodontidae | *Canthigaster amboinensis* | H | No Group |
| Tetraodontidae | *Canthigaster coronata* | H | No Group |

| | | | |
|---|---|---|---|
| Pomacanthidae | *Centropyge flavissima* | H | No Group |
| Pomacentridae | *Stegastes nigricans* | H | No Group |
| Labridae | *Halichoeres melanurus* | MI | No Group |
| Labridae | *Halichoeres melasmapomus* | MI | No Group |
| Labridae | *Labroides bicolor* | MI | No Group |
| Labridae | *Labropsis xanthonota* | MI | No Group |
| Cirrhitidae | *Paracirrhites arcatus* | MI | No Group |
| Labridae | *Pseudocheilinus evanidus* | MI | No Group |
| Labridae | *Pseudocheilinus octotaenia* | MI | No Group |
| Monacanthidae | *Pervagor aspricaudus* | Om | No Group |
| Ostraciidae | *Lactoria fornasini* | SI | No Group |
| Labridae | *Pseudojuloides* sp. | MI | No Group |
| Pomacentridae | *Abudefduf sexfasciatus* | Pk | No Group |
| Pomacentridae | *Chromis vanderbilti* | Pk | No Group |
| Pomacentridae | *Chromis xanthura* | Pk | No Group |
| Labridae | *Cirrhilabrus* sp. | Pk | No Group |
| Pomacanthidae | *Genicanthus watanabei* | Pk | No Group |
| Labridae | *Thalassoma amblycephalum* | Pk | No Group |
| Pomacanthidae | *Centropyge bicolor* | H | No Group |
| Serranidae | *Belonoperca chabanaudi* | MI | No Group |
| Labridae | *Coris centralis* | MI | No Group |
| Labridae | *Halichoeres ornatissimus* | MI | No Group |
| Malacanthidae | *Hoplolatilus starcki* | MI | No Group |
| Labridae | *Macropharyngodon meleagris* | MI | No Group |
| Labridae | *Oxycheilinus bimaculatus* | MI | No Group |
| Labridae | *Pteragogus enneacanthus* | MI | No Group |
| Labridae | *Stethojulis balteata* | MI | No Group |
| Labridae | *Stethojulis strigiventer* | MI | No Group |
| Labridae | *Stethojulis trilineata* | MI | No Group |
| Pomacentridae | *Stegastes* sp. | H | No Group |
| Apogonidae | *Apogon* sp. | Pk | No Group |
| Apogonidae | *Apogonidae* | Pk | No Group |
| Chaetodontidae | *Chaetodon miliaris* | Pk | No Group |
| Pomacentridae | *Dascyllus auripinnis* | Pk | No Group |
| Labridae | *Pseudocoris yamashiroi* | Pk | No Group |
| Labridae | *Stethojulis bandanensis* | Pk | No Group |
| Monacanthidae | *Cantherhines verecundus* | H | No Group |
| Pomacanthidae | *Centropyge interrupta* | H | No Group |
| Pomacentridae | *Stegastes fasciolatus* | H | No Group |

| | | | |
|---|---|---|---|
| Blenniidae | *Exallias brevis* | Cor | No Group |
| Labridae | *Labrichthys unilineatus* | Cor | No Group |
| Labridae | *Halichoeres prosopeion* | MI | No Group |
| Labridae | *Macropharyngodon geoffroy* | MI | No Group |
| Gobiidae | *Valenciennea strigata* | MI | No Group |
| Ostraciidae | *Ostracion whitleyi* | SI | No Group |
| Scorpaenidae | *Dendrochirus barberi* | MI | No Group |
| Blenniidae | *Blenniidae* | Pk | No Group |
| Synodontidae | *Synodus binotatus* | Pisc | No Group |
| Pomacentridae | *Amphiprion chrysopterus* | Pk | No Group |
| Serranidae | *Pseudanthias pascalus* | Pk | No Group |
| Acanthuridae | *Ctenochaetus flavicauda* | H | No Group |
| Labridae | *Cheilinus oxycephalus* | MI | No Group |
| Holocentridae | *Sargocentron diadema* | MI | No Group |
| Holocentridae | *Sargocentron xantherythrum* | MI | No Group |
| Labridae | *Thalassoma quinquevittatum* | MI | No Group |
| Labridae | *Iniistius umbrilatus* | MI | No Group |
| Labridae | *Thalassoma* sp. | MI | No Group |
| Pomacentridae | *Pomacentridae* | Om | No Group |
| Pomacentridae | *Abudefduf notatus* | Pk | No Group |
| Chaetodontidae | *Hemitaurichthys polylepis* | Pk | No Group |
| Ptereleotridae | *Ptereleotris evides* | Pk | No Group |
| Labridae | *Anampses twistii* | MI | No Group |
| Apogonidae | *Cheilodipterus* sp. | MI | No Group |
| Labridae | *Cymolutes lecluse* | MI | No Group |
| Labridae | *Halichoeres hartzfeldii* | MI | No Group |
| Labridae | *Halichoeres marginatus* | MI | No Group |
| Pinguipedidae | *Parapercis clathrata* | MI | No Group |
| Pinguipedidae | *Parapercis schauinslandii* | MI | No Group |
| Labridae | *Choerodon jordani* | Om | No Group |
| Monacanthidae | *Pervagor* sp. | Om | No Group |
| Monacanthidae | *Pervagor spilosoma* | Om | No Group |
| Pomacanthidae | *Apolemichthys arcuatus* | SI | No Group |
| Holocentridae | *Neoniphon argenteus* | MI | No Group |
| Apogonidae | *Cheilodipterus artus* | MI | No Group |
| Pomacentridae | *Chromis ovalis* | Pk | No Group |
| Labridae | *Bodianus mesothorax* | MI | No Group |
| Pinguipedidae | *Parapercis millepunctata* | MI | No Group |
| Labridae | *Halichoeres* sp. | MI | No Group |

| | | | |
|---|---|---|---|
| Serranidae | *Cephalopholis leopardus* | Pisc | No Group |
| Apogonidae | *Cheilodipterus macrodon* | Pisc | No Group |
| Pomacentridae | *Abudefduf vaigiensis* | Pk | No Group |
| Chaetodontidae | *Heniochus diphreutes* | Pk | No Group |
| Holocentridae | *Myripristis vittata* | Pk | No Group |
| Caesionidae | *Pterocaesio trilineata* | Pk | No Group |
| Labridae | *Thalassoma hardwicke* | Pk | No Group |
| Monacanthidae | *Cantherhines sandwichiensis* | H | No Group |
| Tetraodontidae | *Canthigaster rivulata* | H | No Group |
| Acanthuridae | *Zebrasoma flavescens* | H | No Group |
| Acanthuridae | *Zebrasoma scopas* | H | No Group |
| Monacanthidae | *Amanses scopas* | Cor | No Group |
| Labridae | *Anampses chrysocephalus* | MI | No Group |
| Labridae | *Anampses* sp. | MI | No Group |
| Labridae | *Bodianus axillaris* | MI | No Group |
| Labridae | *Bodianus prognathus* | MI | No Group |
| Labridae | *Coris dorsomacula* | MI | No Group |
| Labridae | *Coris venusta* | MI | No Group |
| Labridae | *Cymolutes praetextatus* | MI | No Group |
| Labridae | *Pseudocoris aurantiofasciata* | MI | No Group |
| Labridae | *Pseudocoris heteroptera* | MI | No Group |
| Scorpaenidae | *Pterois antennata* | MI | No Group |
| Holocentridae | *Sargocentron microstoma* | MI | No Group |
| Labridae | *Thalassoma jansenii* | MI | No Group |
| Nemipteridae | *Scolopsis lineata* | Om | No Group |
| Zanclidae | *Zanclus cornutus* | SI | No Group |
| Labridae | *Bodianus anthioides* | Pk | No Group |
| Chaetodontidae | *Hemitaurichthys thompsoni* | Pk | No Group |
| Acanthuridae | *Zebrasoma rostratum* | H | No Group |
| Kuhliidae | *Kuhlia sandvicensis* | Pk | No Group |
| Scorpaenidae | *Pterois sphex* | Pisc | No Group |
| Synodontidae | *Synodontidae* | Pisc | No Group |
| Pomacentridae | *Chromis verater* | Pk | No Group |
| Pempheridae | *Pempheridae* | Pk | No Group |
| Serranidae | *Pseudanthias thompsoni* | Pk | No Group |
| Balistidae | *Xanthichthys auromarginatus* | Pk | No Group |
| Acanthuridae | *Ctenochaetus binotatus* | H | No Group |
| Labridae | *Anampses meleagrides* | MI | No Group |

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

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

| | | | |
|---|---|---|---|
| Mullidae | *Mulloidichthys mimicus* | MI | No Group |
| Holocentridae | *Myripristis violacea* | MI | No Group |
| Labridae | *Novaculichthys taeniourus* | MI | No Group |
| Balistidae | *Rhinecanthus aculeatus* | MI | No Group |
| Synodontidae | *Saurida flamma* | Pisc | No Group |
| Acanthuridae | *Paracanthurus hepatus* | Pk | No Group |
| Caesionidae | *Caesionidae* | Pk | No Group |
| Holocentridae | *Holocentridae* | MI | No Group |
| Priacanthidae | *Heteropriacanthus carolinus* | Pk | No Group |
| Holocentridae | *Myripristis adusta* | Pk | No Group |
| Holocentridae | *Myripristis amaena* | Pk | No Group |
| Labridae | *Cheilinus chlorourus* | MI | No Group |
| Labridae | *Gomphosus varius* | MI | No Group |
| Lethrinidae | *Lethrinus harak* | MI | No Group |
| Holocentridae | *Neoniphon sammara* | MI | No Group |
| Serranidae | *Epinephelus melanostigma* | Pisc | No Group |
| Serranidae | *Epinephelus merra* | Pisc | No Group |
| Holocentridae | *Myripristis berndti* | Pk | No Group |
| Priacanthidae | *Priacanthus hamrur* | Pk | No Group |
| Priacanthidae | *Priacanthus meeki* | Pk | No Group |
| Acanthuridae | *Acanthurus albipectoralis* | H | No Group |
| Tetraodontidae | *Arothron nigropunctatus* | Cor | No Group |
| Mullidae | *Parupeneus insularis* | MI | No Group |
| Mullidae | *Parupeneus pleurostigma* | MI | No Group |
| Holocentridae | *Sargocentron tiere* | MI | No Group |
| Labridae | *Thalassoma trilobatum* | MI | No Group |
| Mullidae | *Upeneus taeniopterus* | MI | No Group |
| Balistidae | *Melichthys vidua* | H | No Group |
| Serranidae | *Epinephelus spilotoceps* | Pisc | No Group |
| Lutjanidae | *Lutjanus semicinctus* | Pisc | No Group |
| Serranidae | *Pogonoperca punctata* | Pisc | No Group |
| Caesionidae | *Caesio caerulaurea* | Pk | No Group |
| Carangidae | *Decapterus macarellus* | Pk | No Group |
| Holocentridae | *Myripristinae* | Pk | No Group |
| Caesionidae | *Pterocaesio marri* | Pk | No Group |
| Balistidae | *Xanthichthys caeruleolineatus* | Pk | No Group |
| Labridae | *Iniistius pavo* | MI | No Group |
| Holocentridae | *Neoniphon opercularis* | MI | No Group |
| Holocentridae | *Neoniphon* sp. | MI | No Group |

| | | | |
|---|---|---|---|
| Mullidae | *Parupeneus crassilabris* | MI | No Group |
| Labridae | *Anampses cuvier* | MI | No Group |
| Labridae | *Cheilinus fasciatus* | MI | No Group |
| Siganidae | *Siganus punctatus* | H | No Group |
| Gobiidae | *Gobiidae* | MI | No Group |
| Scorpaenidae | *Pterois volitans* | Pisc | No Group |
| Balistidae | *Melichthys niger* | Pk | No Group |
| Priacanthidae | *Priacanthus* sp. | Pk | No Group |
| Monacanthidae | *Monacanthidae* | H | No Group |
| Siganidae | *Siganidae* | H | No Group |
| Diodontidae | *Diodon holocanthus* | MI | No Group |
| Mullidae | *Mulloidichthys vanicolensis* | MI | No Group |
| Mullidae | *Parupeneus multifasciatus* | MI | No Group |
| Balistidae | *Sufflamen fraenatum* | MI | No Group |
| Monacanthidae | *Cantherhines dumerilii* | Om | No Group |
| Pomacanthidae | *Pomacanthus imperator* | SI | No Group |
| Lethrinidae | *Lethrinus rubrioperculatus* | MI | No Group |
| Caesionidae | *Caesio teres* | Pk | No Group |
| Balistidae | *Odonus niger* | Pk | No Group |
| Acanthuridae | *Acanthurus nigricauda* | H | No Group |
| Acanthuridae | *Acanthurus olivaceus* | H | No Group |
| Acanthuridae | *Zebrasoma veliferum* | H | No Group |
| Labridae | *Bodianus loxozonus* | MI | No Group |
| Labridae | *Coris gaimard* | MI | No Group |
| Labridae | *Hologymnosus annulatus* | MI | No Group |
| Labridae | *Hologymnosus doliatus* | MI | No Group |
| Mullidae | *Mulloidichthys flavolineatus* | MI | No Group |
| Acanthuridae | *Acanthurus maculiceps* | H | No Group |
| Kyphosidae | *Kyphosus hawaiiensis* | H | No Group |
| Cheilodactylidae | *Cheilodactylus vittatus* | SI | No Group |
| Ostraciidae | *Ostraciidae* | SI | No Group |
| Siganidae | *Siganus argenteus* | H | No Group |
| Labridae | *Anampses caeruleopunctatus* | MI | No Group |
| Serranidae | *Epinephelus fasciatus* | Pisc | No Group |
| Labridae | *Thalassoma ballieui* | MI | No Group |
| Labridae | *Thalassoma purpureum* | MI | No Group |
| Serranidae | *Cephalopholis miniata* | Pisc | No Group |
| Hemiramphidae | *Hemiramphidae* | Pk | No Group |
| Acanthuridae | *Acanthurus leucocheilus* | H | No Group |

| | | | |
|---|---|---|---|
| Ostraciidae | *Ostracion cubicus* | H | No Group |
| Bothidae | *Bothus mancus* | MI | No Group |
| Labridae | *Cheilinus* sp. | MI | No Group |
| Labridae | *Cheilinus trilobatus* | MI | No Group |
| Malacanthidae | *Malacanthus latovittatus* | MI | No Group |
| Labridae | *Oxycheilinus unifasciatus* | Pisc | No Group |
| Labridae | *Oxycheilinus* sp. | MI | No Group |
| Serranidae | *Epinephelus retouti* | Pisc | No Group |
| Mullidae | *Mulloidichthys pfluegeri* | MI | No Group |
| Serranidae | *Cephalopholis sexmaculata* | Pisc | No Group |
| Serranidae | *Cephalopholis sonnerati* | Pisc | No Group |
| Serranidae | *Gracila albomarginata* | Pisc | No Group |
| Mullidae | *Parupeneus cyclostomus* | Pisc | No Group |
| Belonidae | *Platybelone argalus* | Pisc | No Group |
| Acanthuridae | *Acanthurus mata* | Pk | No Group |
| Tetraodontidae | *Arothron meleagris* | Cor | No Group |
| Balistidae | *Balistoides conspicillum* | MI | No Group |
| Labridae | *Hemigymnus fasciatus* | MI | No Group |
| Lethrinidae | *Lethrinus obsoletus* | MI | No Group |
| Mullidae | *Mullidae* | MI | No Group |
| Mullidae | *Parupeneus barberinus* | MI | No Group |
| Holocentridae | *Sargocentron* sp. | MI | No Group |
| Ephippidae | *Platax orbicularis* | Om | No Group |
| Serranidae | *Epinephelus macrospilos* | Pisc | No Group |
| Scorpaenidae | *Scorpaenopsis cacopsis* | Pisc | No Group |
| Kyphosidae | *Kyphosus cinerascens* | H | No Group |
| Labridae | *Cheilio inermis* | MI | No Group |
| Mullidae | *Parupeneus porphyreus* | MI | No Group |
| Serranidae | *Epinephelus socialis* | Pisc | No Group |
| Tetraodontidae | *Arothron hispidus* | MI | No Group |
| Holocentridae | *Sargocentron spiniferum* | MI | No Group |
| Carangidae | *Trachinotus baillonii* | Pisc | No Group |
| Labridae | *Epibulus insidiator* | MI | No Group |
| Serranidae | *Epinephelus howlandi* | Pisc | No Group |
| Labridae | *Bodianus albotaeniatus* | MI | No Group |
| Labridae | *Bodianus bilunulatus* | MI | No Group |
| Acanthuridae | *Acanthurus* sp. | H | No Group |
| Serranidae | *Aethaloperca rogaa* | Pisc | No Group |
| Serranidae | *Anyperodon leucogrammicus* | Pisc | No Group |

| | | | |
|---|---|---|---|
| Serranidae | *Cephalopholis argus* | Pisc | No Group |
| Serranidae | *Cephalopholis* sp. | Pisc | No Group |
| Serranidae | *Epinephelus maculatus* | Pisc | No Group |
| Holocentridae | *Myripristis murdjan* | Pk | No Group |
| Acanthuridae | *Naso brevirostris* | Pk | No Group |
| Acanthuridae | *Naso maculatus* | Pk | No Group |
| Acanthuridae | *Naso vlamingii* | Pk | No Group |
| Kyphosidae | *Kyphosus vaigiensis* | H | No Group |
| Muraenidae | *Gymnothorax eurostus* | MI | No Group |
| Labridae | *Hemigymnus melapterus* | MI | No Group |
| Balistidae | *Pseudobalistes flavimarginatus* | MI | No Group |
| Lethrinidae | *Lethrinus xanthochilus* | Pisc | No Group |
| Acanthuridae | *Naso caesius* | Pk | No Group |
| Lethrinidae | *Monotaxis grandoculis* | MI | No Group |
| Serranidae | *Variola albimarginata* | Pisc | No Group |
| Labridae | *Coris flavovittata* | MI | No Group |
| Tetraodontidae | *Arothron mappa* | Om | No Group |
| Carangidae | *Carangoides ferdau* | Pisc | No Group |
| Carangidae | *Carangoides orthogrammus* | Pisc | No Group |
| Carangidae | *Scomberoides lysan* | Pisc | No Group |
| Acanthuridae | *Acanthuridae* | H | No Group |
| Lethrinidae | *Lethrinus amboinensis* | MI | No Group |
| Lethrinidae | *Lethrinus erythracanthus* | MI | No Group |
| Ephippidae | *Platax teira* | Om | No Group |
| Serranidae | *Plectropomus areolatus* | Pisc | No Group |
| Carangidae | *Gnathanodon speciosus* | Pisc | No Group |
| Serranidae | *Epinephelus polyphekadion* | Pisc | No Group |
| Serranidae | *Epinephelus tauvina* | Pisc | No Group |
| Muraenidae | *Gymnothorax breedeni* | Pisc | No Group |
| Acanthuridae | *Naso hexacanthus* | Pk | No Group |
| Acanthuridae | *Naso* sp. | Pk | No Group |
| Kyphosidae | *Kyphosus sandwicensis* | H | No Group |
| Kyphosidae | *Kyphosus* sp. | H | No Group |
| Balistidae | *Balistidae* | MI | No Group |
| Balistidae | *Balistoides viridescens* | MI | No Group |
| Muraenidae | *Echidna nebulosa* | MI | No Group |
| Haemulidae | *Plectorhinchus gibbosus* | MI | No Group |
| Balistidae | *Balistes polylepis* | MI | No Group |
| Tetraodontidae | *Tetraodontidae* | MI | No Group |

| | | | |
|---|---|---|---|
| Monacanthidae | *Aluterus scriptus* | Om | No Group |
| Ophichthidae | *Myrichthys magnificus* | MI | No Group |
| Aulostomidae | *Aulostomus chinensis* | Pisc | No Group |
| Muraenidae | *Enchelycore pardalis* | Pisc | No Group |
| Sphyraenidae | *Sphyraena helleri* | Pisc | No Group |
| Muraenidae | *Gymnothorax rueppelliae* | MI | No Group |
| Oplegnathidae | *Oplegnathus fasciatus* | MI | No Group |
| Serranidae | *Variola louti* | Pisc | No Group |
| Haemulidae | *Plectorhinchus picus* | MI | No Group |
| Haemulidae | *Plectorhinchus vittatus* | MI | No Group |
| Lethrinidae | *Lethrinidae* | MI | No Group |
| Lethrinidae | *Lethrinus* sp. | MI | No Group |
| Oplegnathidae | *Oplegnathus punctatus* | MI | No Group |
| Carangidae | *Caranx papuensis* | Pisc | No Group |
| Muraenidae | *Gymnothorax steindachneri* | Pisc | No Group |
| Diodontidae | *Diodon hystrix* | MI | No Group |
| Labridae | *Labridae* | MI | No Group |
| Belonidae | *Belonidae* | Pisc | No Group |
| Carangidae | *Caranx lugubris* | Pisc | No Group |
| Carangidae | *Caranx sexfasciatus* | Pisc | No Group |
| Scombridae | *Euthynnus affinis* | Pisc | No Group |
| Scombridae | *Grammatorcynus bilineatus* | Pisc | No Group |
| Lethrinidae | *Lethrinus olivaceus* | Pisc | No Group |
| Acanthuridae | *Naso annulatus* | Pk | No Group |
| Ophidiidae | *Brotula multibarbata* | MI | No Group |
| Dasyatidae | *Urogymnus granulatus* | MI | No Group |
| Scombridae | *Sarda orientalis* | Pisc | No Group |
| Congridae | *Congridae* | Pisc | No Group |
| Congridae | *Heterocongrinae* | Pisc | No Group |
| Scombridae | *Katsuwonus pelamis* | Pisc | No Group |
| Echeneidae | *Echeneis naucrates* | Pk | No Group |
| Carangidae | *Trachinotus blochii* | MI | No Group |
| Carangidae | *Caranx melampygus* | Pisc | No Group |
| Muraenidae | *Gymnothorax meleagris* | Pisc | No Group |
| Tetraodontidae | *Arothron stellatus* | Cor | No Group |
| Labridae | *Coris aygula* | MI | No Group |
| Carangidae | *Pseudocaranx dentex* | Pisc | No Group |
| Muraenidae | *Scuticaria tigrina* | Pisc | No Group |
| Serranidae | *Plectropomus laevis* | Pisc | No Group |

| | | | |
|---|---|---|---|
| Serranidae | *Epinephelus* sp. | Pisc | No Group |
| Serranidae | *Serranidae* | Pisc | No Group |
| Belonidae | *Tylosurus crocodilus* | Pisc | No Group |
| Carangidae | *Alectis ciliaris* | Pisc | No Group |
| Muraenidae | *Enchelynassa canina* | Pisc | No Group |
| Muraenidae | *Gymnothorax undulatus* | Pisc | No Group |
| Muraenidae | *Gymnomuraena zebra* | MI | No Group |
| Carangidae | *Carangidae* | Pisc | No Group |
| Fistulariidae | *Fistularia commersonii* | Pisc | No Group |
| Carangidae | *Caranx ignobilis* | Pisc | No Group |
| Carangidae | *Caranx* sp. | Pisc | No Group |
| Sphyraenidae | *Sphyraena qenie* | Pisc | No Group |
| Carangidae | *Elagatis bipinnulata* | Pisc | No Group |
| Chanidae | *Chanos chanos* | H | No Group |
| Dasyatidae | *Taeniurops meyeni* | MI | No Group |
| Dasyatidae | *Dasyatidae* | MI | No Group |
| Carangidae | *Seriola dumerili* | Pisc | No Group |
| Carcharhinidae | *Carcharhinus melanopterus* | Pisc | No Group |
| Sphyraenidae | *Sphyraena barracuda* | Pisc | No Group |
| Scombridae | *Thunnus albacares* | Pisc | No Group |
| Carcharhinidae | *Triaenodon obesus* | Pisc | No Group |
| Labridae | *Cheilinus undulatus* | MI | No Group |
| Carcharhinidae | *Carcharhinus amblyrhynchos* | Pisc | No Group |
| Muraenidae | *Gymnothorax flavimarginatus* | Pisc | No Group |
| Scombridae | *Scombridae* | Pisc | No Group |
| Scombridae | *Gymnosarda unicolor* | Pisc | No Group |
| Muraenidae | *Muraenidae* | Pisc | No Group |
| Carcharhinidae | *Carcharhinus limbatus* | Pisc | No Group |
| Muraenidae | *Gymnothorax javanicus* | Pisc | No Group |
| Muraenidae | *Gymnothorax* sp. | Pisc | No Group |
| Ginglymostomatidae | *Nebrius ferrugineus* | Pisc | No Group |
| Myliobatidae | *Aetobatus ocellatus* | MI | No Group |
| Carcharhinidae | *Carcharhinus galapagensis* | Pisc | No Group |
| Sphyrnidae | *Sphyrna lewini* | Pisc | No Group |
| Sphyrnidae | *Sphyrnidae* | Pisc | No Group |
| Myliobatidae | *Mobula* sp. | Pk | No Group |
| Scaridae | *Scarus fuscocaudalis* | H | Parrotfish |
| Scaridae | *Calotomus zonarchus* | H | Parrotfish |

| | | | |
|---|---|---|---|
| Scaridae | *Chlorurus japanensis* | H | Parrotfish |
| Scaridae | *Scarus globiceps* | H | Parrotfish |
| Scaridae | *Scarus spinus* | H | Parrotfish |
| Scaridae | *Scarus psittacus* | H | Parrotfish |
| Scaridae | *Scarus dubius* | H | Parrotfish |
| Scaridae | *Scarus oviceps* | H | Parrotfish |
| Scaridae | *Scarus schlegeli* | H | Parrotfish |
| Scaridae | *Chlorurus spilurus* | H | Parrotfish |
| Scaridae | *Scarus niger* | H | Parrotfish |
| Scaridae | *Scarus festivus* | H | Parrotfish |
| Scaridae | *Scarus frenatus* | H | Parrotfish |
| Scaridae | *Chlorurus frontalis* | H | Parrotfish |
| Scaridae | *Scarus dimidiatus* | H | Parrotfish |
| Scaridae | *Calotomus carolinus* | H | Parrotfish |
| Scaridae | *Scarus forsteni* | H | Parrotfish |
| Scaridae | *Scarus tricolor* | H | Parrotfish |
| Scaridae | *Scarus xanthopleura* | H | Parrotfish |
| Scaridae | *Hipposcarus longiceps* | H | Parrotfish |
| Scaridae | *Scarus altipinnis* | H | Parrotfish |
| Scaridae | *Chlorurus perspicillatus* | H | Parrotfish |
| Scaridae | *Scaridae* | H | Parrotfish |
| Scaridae | *Scarus rubroviolaceus* | H | Parrotfish |
| Scaridae | *Chlorurus microrhinos* | H | Parrotfish |
| Scaridae | *Cetoscarus ocellatus* | H | Parrotfish |
| Scaridae | *Scarus ghobban* | H | Parrotfish |
| Scaridae | *Chlorurus* sp. | H | Parrotfish |
| Scaridae | *Scarus* sp. | H | Parrotfish |
| Scaridae | *Bolbometopon muricatum* | Cor | Parrotfish |
| Lutjanidae | *Lutjanus fulvus* | MI | Snappers |
| Lutjanidae | *Lutjanus kasmira* | MI | Snappers |
| Lutjanidae | *Lutjanus gibbus* | MI | Snappers |
| Lutjanidae | *Lutjanus monostigma* | Pisc | Snappers |
| Lutjanidae | *Macolor macularis* | Pk | Snappers |
| Lutjanidae | *Aphareus furca* | Pisc | Snappers |
| Lutjanidae | *Macolor niger* | Pk | Snappers |
| Lutjanidae | *Macolor* sp. | Pk | Snappers |
| Lutjanidae | *Lutjanus bohar* | Pisc | Snappers |
| Lutjanidae | *Lutjanus argentimaculatus* | MI | Snappers |
| Lutjanidae | *Aprion virescens* | Pisc | Snappers |

# APPENDIX B: LIST OF PROTECTED SPECIES AND DESIGNATED CRITICAL HABITAT

Table B-1. Protected species found or reasonably believed to be found near or in American Samoa 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 |
| 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 |

| Common Name | Scientific Name | ESA Listing Status | MMPA Status | Occurrence | References |
|---|---|---|---|---|---|
| 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 |
| **Sea Turtles** | | | | | |
| Green Sea Turtle | *Chelonia mydas* | Endangered (Central South Pacific DPS) | N/A | Frequently seen. Nest at Rose Atoll in small numbers. | 43 FR 32800, 81 FR 20057, Balacz 1994 |
| Hawksbill Sea Turtle | *Eretmochelys imbricata* | Endangered[a] | N/A | Frequently seen. Nest at Rose Atoll, Swain's Island, and Tutuila. | 35 FR 8491, NMFS & USFWS 2013, Tuato'o-Bartley *et al.,* 1993 |
| Leatherback Sea Turtle | *Dermochelys coriacea* | Endangered[a] | N/A | Very rare. One juvenile recovered dead in experimental longline fishing. | 35 FR 8491, Grant, 1994 |
| Loggerhead Sea Turtle | *Caretta 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 breeding population on the Pacific coast of Mexico, which is listed as endangered) | 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 | Perrin *et al.,* 2009 |

| Common Name | Scientific Name | ESA Listing Status | MMPA Status | Occurrence | References |
|---|---|---|---|---|---|
| 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 US EEZ of A. Samoa | Bradford *et al.,* 2015 |
| Fin Whale | *Balaenoptera physalus* | Endangered | Strategic | No known sightings. 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 |
| 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 |
| Pantropical Spotted Dolphin | *Stenella attenuata* | Not Listed | Non-strategic | Found in tropical and subtropical waters worldwide. | Perrin *et al.,* 2009 |
| Pygmy Killer Whale | *Feresa attenuata* | Not Listed | Non-strategic | Found in tropical and subtropical waters worldwide. | Ross & Leatherwood, 1994 |
| Pygmy Sperm Whale | *Kogia breviceps* | Not Listed | Non-strategic | Found worldwide in tropical and warm-temperate waters. | Caldwell & Caldwell, 1989 |

| 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 | *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 |

| Common Name | Scientific Name | ESA Listing Status | MMPA Status | Occurrence | References |
|---|---|---|---|---|---|
| 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** | | | | | |
| 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 | Veron, 2014 |

| Common Name | Scientific Name | ESA Listing Status | MMPA Status | Occurrence | References |
|---|---|---|---|---|---|
| | | | | depths (less than 50 m depth). | |

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

Table B-2. ESA-listed species' critical habitat in the Pacific Ocean[a]

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