

ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT: AMERICAN SAMOA ARCHIPELAGO FISHERY ECOSYSTEM PLAN 2023



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 2023 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 indicators, and human dimensions. Information like marine spatial planning and the 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 and implemented by NMFS.

Cover Image: *Alia* floating in Ta‘ū harbor. Photo by WPRFMC.

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

Edited by Thomas Remington (Lynker); Joshua DeMello and Asuka Ishizaki, (WPRFMC).

© Western Pacific Regional Fishery Management Council 2024.
All rights reserved.

Published in the United States by the Western Pacific Regional Fishery Management Council
under NOAA Award #NA20NMF4410013.

ISBN 978-1-950193-41-7

This document can be cited as follows:

WPRFMC. 2024. Annual Stock Assessment and Fishery Evaluation Report for the American Samoa Archipelago Fishery Ecosystem Plan 2023. T Remington, J DeMello, A Ishizaki (Eds.). Honolulu: Western Pacific Regional Fishery Management Council.

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

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

NMFS Pacific Islands Fisheries Science Center: Marc Nadon, Felipe Carvalho, Jenny Suter, 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.

NMFS Pacific Islands Regional Office: David O’Brien, Sean Hanser, Irene Kelly, Heather Cronin, Savannah Lewis, and Keith Kamikawa.

The Council also acknowledges the staff of the **NMFS PIFSC Fisheries Research and Monitoring Division data programs** for providing the technical support to generate the data summaries.

This page was intentionally left blank.

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) and remained effective through 2023.

In 2023, NMFS developed a new benchmark stock assessment for American Samoa BMUS (Nadon et al. 2023) that is a single-species assessment covering nine of the eleven MUS. The assessment used an age-structured model within the modeling framework Stock Synthesis 3.30, which integrated catch-at-age fitting a population model to relative abundance and size composition data. The American Samoa BMUS were determined to be not overfished and not subject to overfishing for all nine species assessed, but the rebuilding plan remained in effect through 2023 as NMFS and the Council worked to discontinue it.

Total estimated catch for American Samoa BMUS in 2023 (4,689 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 was mostly positive 2023 relative to 2022 but still represented declines from historical averages. Total estimated BMUS catch from creel survey data expansion was 4,689 lb, with a large portion derived from the shore-based creel surveys (921 lb) that had the third highest catch estimate over the course of the time series. The total estimated catch value for 2023 represents an 58% reduction from the short-term (10-year) average and 63% reduction from the long-term (20-year) average. Similar to 2021 and 2022, commercial BMUS catch from commercial purchase data were confidential in 2023 due to fewer than three dealers and/or vendors reporting fish sales. Catch-per-unit-effort (CPUE) for BMUS in 2023, measured in both pounds per trip and pounds per gear hour, was less than last year and lower than the 10- and 20-year averages for both metrics. There were 21 lb/trip of BMUS harvested by bottomfish fishing, which was a 40% reduction from the short-term trend and 59% reduction from the long-term trend. The estimated 0.67 lb/gear hour of BMUS harvested by bottomfish fishing was 33% less than the 10-year average and represented a 51% decrease from the 20-year average. Effort in the fishery also continued to decline; there were just 23 tallied fishing trips that harvested BMUS with bottomfish fishing gear in 2023, which was a 58% decrease from the 10-year trend and a 62% decrease from the 20-year trend. Tallied gear hours bottomfish fishing for BMUS were 664, a 75% reduction from both the short- and long-term trends. Participation in the bottomfish fishery also represented a decrease from historical trends in 2023, with just six unique vessels recorded as harvesting BMUS with bottomfish fishing (a decrease of 33% and 45% from the 10- and 20-year averages, respectively). There was no recorded bycatch in American Samoa boat-based bottomfish fisheries in 2023.

The ECS harvested the most in American Samoa in 2023 was the humpback snapper (*Lutjanus gibbus*) at 2,556 lb according to creel survey data. The redlip parrotfish (*Scarus rubroviolaceus*) had the second most catch in the creel survey data (1,363 lb), and consistent with data from 2022, the blue-banded surgeonfish (*Acanthurus lineatus*) had the most catch in commercial invoice data (6,278 lb). 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 2023 for two of the six species were zero. The four species with catch estimates for the year were *Panulirus penicillatus* (776 lb), *Sargocentron tiere* (28 lb), *Crenimugil crenilabis* (47 lb) and *Epinephelus melanostigma* (112 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, four of the six species had zero recorded catch. The only species with commercial catch data in 2023 were *P. penicillatus* (37 lb) and *C. crenilabis* (22 lb).

There were no federal permits issued for American Samoa lobster or deepwater shrimp fisheries in 2023, 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, socioeconomic, 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 2023 included poor market conditions and a lack of ice resulting in difficulties selling bottomfish. El Niño impacted coral bleaching due to warmer water temperatures that caused target fishery species to move from their normal areas. Fishers noted some impacts they are experiencing as a result of climate change, such as sea level rise, coral bleaching, and the prevalence brown algae

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, and surveys in 2023 were conducted around American Samoa and Baker Island. Coral coverage as determined by the most recent surveys increased in each island area of the archipelago relative to previous surveys from 2016-2018. Total estimated fish biomass in American Samoa increased around Swains Island, Ofu-Olosega, and Tau, while biomass decreased around Tutuila and Rose Atoll.

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 2023, but the PIFSC Life History Program is working with the American Samoa DMWR and fishers to support biosampling.

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 165th Council meeting; specifically, it identifies the various social and economic groups within the region’s fishing communities and their interconnections. The section begins with an overview of the socioeconomic context for the region, provides a summary of relevant studies and data for American Samoa, gives summaries of relevant data and studies for 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 from 2021 through 2023 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 2023, there were updates to the section noting a review of 2023 data for possible catches of oceanic whitetip sharks while bottomfishing associated with incidental take statement monitoring specified under the most recent biological opinion authorizing continued operation of the fishery. The Council's Plan Team is working to draft methods to report interactions with this species in regional bottomfish fisheries.

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 (CO₂) is increasing exponentially with a time series maximum at 421 ppm in 2023. Since 1989, the oceanic pH at Station ALOHA in Hawaii has shown a significant linear decrease of 0.047 pH units, or roughly a 11.3% increase in acidity ([H⁺]) and was 8.05 in 2022. The Oceanic Niño Index, which is a measure of the El Niño – Southern Oscillation (ENSO) phase, indicated a transition from La Niña to El Niño conditions in 2023. The Pacific Decadal Oscillation (PDO) was negative in 2023. The Accumulated Cyclone Energy (ACE) Index ($\times 10^4$ kt²) was above average in the Eastern and Central North Pacific, and below average in the Western North and South Pacific; there were six named storms in the South Pacific in 2023, three of which became cyclones and two major cyclones. Annual mean sea surface temperature (SST) was 28.9 °C in 2023, and over the period of record, annual SST has increased at a rate of 0.020 °C/year. The annual anomaly was 0.47 °C warmer than average with areas of stronger warming in the southwest part of the region. American Samoa experienced another coral heat stress at the end of 2023 with mass bleaching expected after a series of stress events from 2014 to 2017 and 2019 to 2020. Annual mean chlorophyll-*a* was 0.06 mg/m³ in 2023, and the annual anomaly was 0.0033 mg/m³ higher than average. Precipitation anomalies were relatively negative over the course of the year, with more rainfall observed later in the year. The local trend in sea level rise is 17.52 millimeters/year, equivalent to a change of 6.32 feet in 100 years; however, this trend is likely heavily influenced by local subsidence.

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 annual SAFE report addresses these requirements. The National Standard guidelines require a report on

the condition of the habitat. In the 2023 report, descriptions of projects relevant to EFH in American Samoa not otherwise represented in this report are presented alongside information on levels of EFH. 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 2023.

The marine planning section of the annual report tracks activities with multi-year planning horizons and begins to monitor the impact of established facilities. No ocean activities with multi-year planning horizons were identified for American Samoa in 2023. 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.

At its May 2024 meeting, the Plan Team developed the following recommendation relevant to the American Samoa annual SAFE report:

Regarding Federal Fishing Permits, the Archipelagic Plan Team:

- Reviewed the Federal Permit and Logbook Data module of the annual SAFE reports and noted the lack of federal permits and related reporting for many fisheries (e.g., MHI non-commercial bottomfish). Therefore, the Archipelagic Plan Team recommends the Council include a review of the efficacy of its federal permits as part of its regulatory review project funded by forthcoming Inflation Reduction Act (IRA) funds.

Regarding Territorial Non-Commercial Module, the Archipelagic Plan Team:

- Recommends the Council approve the inclusion of the territorial non-commercial fishery data modules that utilize a new approach of estimating species level commercial landings in the American Samoa and Mariana Archipelago annual SAFE reports as presented. The APT notes the substantial effort required to develop these modules but also their importance in ensuring consistency between data presented in stock assessments and the annual SAFE reports.

TABLE OF CONTENTS

Executive Summary	v
1 Fishery Performance	1
1.1 Fishery Descriptions	1
1.1.1 Bottomfish Fishery	2
1.1.2 Ecosystem Component Fishery	2
1.2 Fishery Data Collection System	3
1.2.1 Boat-Based Creel Survey	3
1.2.2 Shore-Based Creel Survey	4
1.2.3 Commercial Receipt Book System	4
1.2.4 Boat Inventory	4
1.3 Meta-Data Dashboard Statistics	5
1.3.1 Creel Survey Meta-Data Statistics	5
1.3.2 Commercial Receipt Book Statistics	6
1.4 Fishery Summary Dashboard Statistics	8
1.5 Catch Statistics	10
1.5.1 Catch by Data Stream	10
1.5.2 Expanded Catch Estimates by Fishing Method	12
1.5.3 Top and Prioritized Species in Boat-Based Fishery Catch	14
1.6 Catch-per-Unit-Effort (CPUE) Statistics	17
1.7 Effort Statistics	21
1.8 Participants	24
1.9 Bycatch Estimates	27
1.10 Non-Commercial Fishery Catch Statistics	28
1.10.1 Catch Estimates	28
1.10.2 Caveats for Non-Commercial Catch Estimates	31
1.11 Federal Logbook Data	32
1.11.1 Number of Federal Permit Holders	32
1.11.2 Summary of Catch and Effort for FEP Fisheries	32
1.12 Status Determination Criteria	34
1.12.1 Bottomfish Fishery	34
1.12.2 Current Stock Status	36
1.13 Overfishing Limit, Acceptable Biological Catch, and Annual Catch Limits	37
1.13.1 Brief Description of the ACL Process	37
1.13.2 Current OFL, ABC, ACL, and Recent Catch	38
1.14 Best Scientific Information Available	38
1.14.1 Bottomfish fishery	38
1.15 Harvest Capacity and Extent	39
1.16 Administrative and Regulatory Actions	40
2 Ecosystem Considerations	41
2.1 Fisher Observations	41
2.1.1 Information from Advisory Panel Meetings	41
2.1.2 Information from the Annual Summit	42
2.2 Coral Reef Fish Ecosystem Parameters	43
2.2.1 Regional Reef Fish Biomass and Habitat Condition	43

2.2.2	Archipelagic Reef Fish Biomass and Habitat Condition	46
2.3	Life History Information and Length-Derived Variables	48
2.3.1	American Samoa Coral Reef Ecosystem – Life History	48
2.3.2	American Samoa – Management Unit Species Life History	53
2.4	Socioeconomics.....	58
2.4.1	Response to Previous Council Recommendations.....	59
2.4.2	Introduction.....	60
2.4.3	Equity and Environmental Justice	64
2.4.4	People Who Fish.....	65
2.4.5	Fishery Economic Performance.....	69
2.4.6	Ongoing Research and Information Collection	74
2.4.7	Relevant PIFSC Economics and Human Dimensions Publications: 2023	76
2.5	Protected Species.....	78
2.5.1	Indicators for Monitoring Protected Species Interactions in the American Samoa FEP Fisheries	78
2.5.2	Status of Protected Species Interactions in the American Samoa FEP Fisheries ..	81
2.5.3	Identification of Emerging Issues	81
2.5.4	Identification of Research, Data, and Assessment Needs.....	83
2.6	Climate and Oceanic Indicators	84
2.6.1	Introduction.....	84
2.6.2	Response to Previous Plan Team and Council Recommendations.....	85
2.6.3	Conceptual Model.....	85
2.6.4	Selected Indicators	86
2.7	Essential Fish Habitat.....	105
2.7.1	Introduction.....	105
2.7.2	Habitat Use by MUS and Trends in Habitat Condition	107
2.7.3	Report on Review of EFH Information	109
2.7.4	EFH Levels	109
2.7.5	Project Updates	111
2.7.6	Research and Information Needs	111
2.8	Marine Planning	112
2.8.1	Introduction.....	112
2.8.2	Response to Previous Council Recommendations.....	112
2.8.3	Marine Managed Areas established under the FEPs.....	114
2.8.4	Fishing Activities and Facilities.....	116
2.8.5	Non-Fishing Activities and Facilities	117
2.8.6	American Samoa Spatial Planning Tools	117
3	Data Integration	118
3.1	Introduction	118
3.1.1	Potential Indicators for Insular Fisheries	118
3.1.2	2018 Recommendations and Direction for Chapter Development	119
3.2	Past Work	120
3.3	Sea Surface Temperature	121
3.3.1	Evaluating relationship for entire coral reef fishery	122
3.3.2	Evaluating relationships for dominant taxa	124
3.4	Primary Productivity	126

3.4.1	Evaluating relationship for entire coral reef fishery	127
3.4.2	Evaluating relationships with dominant taxa.....	129
3.5	Multivariate Assessments of Additional Environmental Variables	131
3.5.1	Non-Metric Multidimensional Scaling	131
4	References.....	134
Appendix A: List of Species		A-1
Appendix B: List of Protected Species and Designated Critical Habitat.....		B-1

TABLE OF TABLES

Table 1. Summary of American Samoa boat-based creel survey meta-data	5
Table 2. Summary of American Samoa commercial receipt book meta-data	7
Table 3. Annual indicators for the American Samoa BMUS fishery describing performance and comparing 2023 estimates with short- (10-year) and long-term (20-year) averages	8
Table 4. Annual indicators for American Samoa ECS fisheries describing performance and comparing 2023 estimates with short- (10-year) and long-term (20-year) averages	9
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	11
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	12
Table 7a. Top ten landed ECS in American Samoa from boat-based creel survey data in 2023 .	14
Table 8a. Catch (lb) from boat-based creel survey expansion data for prioritized species in American Samoan ECS fisheries	15
Table 9. Non-expanded CPUE (lb/trip and lb/gear hour) for bottomfish fishing gears in the American Samoa boat-based fishery for all species and BMUS only	19
Table 10. Non-expanded effort (trips and gear hours) for bottomfish fishing gears in the American Samoa boat-based fishery for all species and BMUS only	22
Table 11a. Non-expanded number of unique vessels for bottomfish fishing gears in the American Samoa boat-based fishery for all species and BMUS only	24
Table 12. Non-expanded catch and bycatch in the American Samoa boat-based fisheries	27
Table 13. Summary of American Samoa BMUS non-commercial catch estimates (lb) derived from commercial purchase system data and creel survey program data for all gear types	30
Table 14. Number of federal permit holders in American Samoa crustacean fisheries	32
Table 14. Summary of available federal logbook data for lobster fisheries in American Samoa	33
Table 15. Summary of available federal logbook data for deepwater shrimp fisheries in American Samoa	34
Table 16. Overfishing threshold specifications for BMUS	35
Table 17. Recruitment overfishing control rule specifications for BMUS	35
Table 18. Stock assessment parameters for the BMUS complex (from Nadon et al. 2023)	37
Table 19. American Samoa ACL table with 2023 total estimated catch (lb)	38
Table 20. American Samoa ACL proportion of harvest capacity and extent in 2023	40
Table 21. Available age, growth, and reproductive maturity information for prioritized coral reef ecosystem component species in American Samoa	51
Table 22. Available length-derived information for prioritized coral reef ecosystem component species in American Samoa	52
Table 23. Available age, growth, and reproductive maturity information for BMUS targeted for otoliths and gonads sampling in American Samoa	55
Table 24. Available length-derived information for BMUS in American Samoa	56
Table 25. Commercial landings and revenue for the American Samoa bottomfish fishery	71
Table 26. Average and itemized costs for American Samoa bottomfish trips (adjusted to 2023 dollars)	72
Table 27. Top 10 ECS commercial landings, revenue, and price	74
Table 28. Priority ECS commercial landings, revenue, and price	74
Table 29. Pacific Islands Region 2023 Commercial Fishing Economic Assessment Index	75

Table 30. Pacific Islands Region 2024 Commercial Fishing Economic Assessment Index	75
Table 31. Summary of ESA consultations for American Samoa FEP Fisheries	79
Table 32. Status of candidate ESA species, recent ESA listing processes, and post-listing activities	82
Table 33. Level of EFH information available for American Samoa BMUS	110
Table 34. EFH and HAPC for American Samoa BMUS.....	110
Table 35. MMAs established under FEPs from 50 CFR § 665	116
Table 36. Families recorded in creel survey data in the U.S. Western Pacific evaluated in these analyses	123
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 ($\alpha=0.05$).....	123
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	128

TABLE OF FIGURES

Figure 1. Data sources (gray boxes) and scripts (orange boxes) used to generate commercial and total catch estimates in the territories, from which non-commercial catch can be calculated.....	30
Figure 1. Mean coral cover (%± standard error of the mean, or SEM) per U.S. Pacific Island averaged from 2010-2023 by latitude	44
Figure 2. Mean fish biomass (g/m ² ± SEM) per U.S. Pacific Island of functional, taxonomic, and trophic groups from 2010-2023 by latitude	45
Figure 3. Mean coral cover (%± SEM) per island from 2010-2023 by latitude	46
Figure 4. Mean fish biomass (g/m ² ± standard error) of American Samoa functional, taxonomic, and trophic groups from 2010-2023 by island	47
Figure 5. Settlement of the Pacific Islands, courtesy Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Polynesian_Migration.svg	58
Figure 6. American Samoa Employment Estimates from 2012-2022; sourced from American Samoa Government (2023)	63
Figure 7. Pounds sold and revenue for the American Samoa bottomfish fishery*.....	70
Figure 8. Price BMUS in the American Samoa bottomfish fishery	70
Figure 9. Average costs for American Samoa bottomfish trips (adjusted to 2023 dollars).....	72
Figure 10. Indicators of change of archipelagic coastal and marine systems; conceptual model	86
Figure 11. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability	87
Figure 12 Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of anthropogenic climate change	88
Figure 13. Regional spatial grids representing the scale of the climate change indicators being monitored	88
Figure 14. Monthly mean (black) and seasonally corrected (blue) atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii	90
Figure 15. Time series and long-term trend of oceanic pH measured at Station ALOHA.....	91
Figure 16. Oceanic Niño Index from 1950–2023 El Niño periods in red, La Niña periods in blue, and neutral periods in grey	92
Figure 17. Pacific Decadal Oscillation from 1854–2023 with positive warm periods in red and negative cool periods in blue.....	93
Figure 18. 2023 Pacific basin tropical cyclone tracks	95
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.....	96
Figure 20. Sea surface temperature climatology and anomalies from 1985–2023.....	97
Figure 21. Coral Thermal Stress Exposure measured at Samoa Virtual Station 2014–2023 (Coral Reef Watch Degree Heating Weeks)	98
Figure 22. Chlorophyll- <i>a</i> and Chlorophyll- <i>a</i> Anomaly from 1998–2023	99
Figure 23. CMAP precipitation (top) and anomaly (bottom) across the American Samoa Longline Grid with 2023 values in blue.....	101
Figure 24a. Sea surface height and anomaly	102
Figure 25. Monthly mean sea level without regular seasonal variability due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents.....	104

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)	108
Figure 27. Regulated fishing areas of American Samoa.....	115
Figure 28. Average annual SST (°C) in American Samoa from 1985-2016 (CV = 1.15).....	121
Figure 29. Total annual catch (lb; blue) for the American Samoa coral reef fishery plotted with average annual SST (°C; black) from 1989-2016.....	122
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	124
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.....	125
Figure 32. Fluorometric chlorophyll- <i>a</i> concentrations (mg/m ³) from 1998–2016 (CV = 4.90). 127	
Figure 33. Comparison of American Samoa reef fish catch (lb; black) and chlorophyll- <i>a</i> concentrations (mg/m ³ ; blue) from 1998 – 2014 and two years of time lag.....	128
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- <i>a</i> concentrations (mg/m ³) from 1998-2014.....	129
Figure 35. Linear regressions showing three correlations between total annual catch (lb) for the American Samoa coral reef fishery and fluorometric chlorophyll- <i>a</i> concentrations (mg/m ³) for (a) Lutjanids, (b) Holocentrids, and (c) Acanthurids from 1998–2014 with phase lag (t+2 years)	130
Figure 36. NMS scree plot showing the stress test to determine dimensionality for the final solution for the American Samoa multivariate analysis	132
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	133

ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
A ₅₀	Age at 50% Maturity
AΔ 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 Δ ₅₀	Length at 50% Sex Reversal
L _∞	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 km²) 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 km² 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 km²) with a more steeply sloping bathymetry.

The Samoa archipelago was formed by a series of volcanic eruptions from the “Samoa 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 2.2).

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 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 Lau’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
2023	189	84	8
10-year avg.	214	163	17
10-year SD	20	83	14
20-year avg.	223	231	11
20-year SD	27	118	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. It seems that this decline reflects changes in the survey frequency with more recent years having 3 sampling days a week. The decline in creel survey effort in 2022 can be attributed COVID-19 restrictions that lasted approximately four months of that year. The decline of the bottomfish fishery since 2019 likely also contributes to the decline of creel survey interviews. A notable development is the increase of catch interviews in 2023 which may reflect increased fishing activities. This suggests that the boat-based fishery is recovering from the COVID-19 impacts.

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	12	349	6	8
1991	15	526	10	35
1992	11	243	6	29
1993	16	523	9	64
1994	14	901	10	60
1995	17	1,724	11	103
1996	13	1,572	7	46
1997	17	1,638	n.d.	n.d.
1998	19	1,633	3	10
1999	18	1,412	5	29
2000	18	1,084	6	54
2001	31	1,054	10	57
2002	24	914	6	39
2003	28	1,041	7	40
2004	25	809	12	50
2005	53	751	13	42
2006	48	827	6	27
2007	50	901	7	59
2008	38	683	10	59
2009	36	569	13	64
2010	28	486	8	21
2011	25	648	3	12
2012	26	698	8	20
2013	32	576	4	10
2014	34	844	8	32
2015	42	1,259	6	45
2016	40	850	5	17
2017	38	748	6	21
2018	42	648	4	16
2019	40	787	6	41
2020	39	297	4	8
2021	29	223	n.d.	n.d.
2022	18	89	n.d.	n.d.
2023	25	334	n.d.	n.d.
10-year avg.	35	608	4	20

Year	# Vendors	# Invoices Collected	# BMUS Vendors	# BMUS Invoices Collected
10-year SD	8	344	2	14
20-year avg.	35	651	6	28
20-year SD	9	262	4	19

‘n.d.’ indicates data are not disclosed due to confidentiality rules.

In summary, there has been a decline in the number of engaged vendors, invoices collected, and vendors selling BMUS in the last 8 years until 2023. 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 since 2020. There were fewer than three vendors that sold BMUS in 2021 and 2022, and thus, the data are not disclosed due to confidentiality rules. The number of vendors engaged and invoices collected increased in 2023 which may reflect increased fishing activities. However, the number of vendors selling BMUS has not recovered.

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



- above 1 standard deviation



- decreasing trend in the time series



- below 1 standard deviation



- no trend in the time series



- 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 2023 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)		

Fishery	Fishery statistics	Short-term (10 years)	Long-term (20 years)
All gears (BMUS only)	All BMUS from creel survey data	4,689[▼ 58%]  	4,689[▼ 63%]  
	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	21[▼ 40%]  	21[▼ 59%]  
	Bottomfish lb/gr-hr	0.67[▼ 33%]  	0.67[▼ 51%]  
Fishing effort (from boat-based creel surveys)			
Bottomfish fishing (BMUS only)	Tallied bottomfish trips	23[▼ 58%]  	23[▼ 62%]  
	Tallied bottomfish gear hours	664[▼ 75%]  	664[▼ 75%]  
Fishing participation (from boat-based creel surveys)			
Bottomfish fishing (BMUS only)	Tallied number of bottomfish vessels	6[▼ 33%]  	6[▼ 45%]  
	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	308[▼ 72%]  	308[▼ 86%]  
	# 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 2023 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	<i>Sargocentron tiere</i> from creel survey data	28[▲ 8%]  	28[▲ 75%]  
	<i>Sargocentron tiere</i> from commercial purchase data	0[no change]  	0[no change]  
	<i>Crenimugil crenilabis</i> from creel survey data	47[▼ 19%]  	47[▲ 68%]  
	<i>Crenimugil crenilabis</i> from commercial purchase data	22[▲ 633%]  	22[▲ 2100%]  

	<i>Panulirus penicillatus</i> from creel survey data	776[▲104%]  	776[▼33%]  
	<i>Panulirus penicillatus</i> from commercial purchase data	37[▼95%]  	37[▼97%]  
	Clams from creel survey data	0[no change]  	0[no change]  
	Clams from commercial purchase data	0[no change]  	0[no change]  
	<i>Octopus cyanea</i> from creel survey data	0[no change]  	0[no change]  
	<i>Octopus cyanea</i> from commercial purchase data	0[no change]  	0[no change]  
	<i>Epinephelus malanostigma</i> from creel survey data	112[▲3%]  	112[▲115%]  
	<i>Epinephelus malanostigma</i> from commercial purchase data	0[no change]  	0[no change]  

‘n.d.’ indicates data are 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 tere*), 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	1,777	11,542	1,304
1991	11,199	327	11,526	2,116
1992	8,361	855	9,216	1,895
1993	9,368	342	9,710	3,464
1994	21,616	509	22,125	2,375
1995	22,228	255	22,483	4,855
1996	20,831	1,023	21,854	1,082
1997	27,380	-	27,380	n.d.
1998	7,661	-	7,661	492
1999	9,925	-	9,925	1,701
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	-	10,760	3,233
2005	9,580	-	9,580	2,490
2006	3,029	277	3,306	2,203
2007	10,499	183	10,682	4,001
2008	23,170	238	23,408	3,171
2009	48,229	201	48,430	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	-	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	311	11,830	838
2019	10,848	574	11,422	1,749
2020	7,408	312	7,720	336

Year	Boat-Based Creel Survey Estimates	Shore-Based Creel Survey Estimates	Total Creel Survey Estimates	Commercial Landings
2021	1,361	439	1,800	n.d.
2022	1,022	474	1,496	n.d.
2023	3,768	921	4,689	n.d.
10-year avg.	10,967	359	11,290	1,092
10-year SD	7,173	271	6,957	908
20-year avg.	12,432	244	12,640	1,645
20-year SD	10,493	245	10,431	1,155

‘-’ indicates no data are available. ‘n.d.’ indicates data are not disclosed due to confidentiality rules.

In summary, bottomfish and BMUS landings have steadily declined in the last 10-20 years, 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. The BMUS landings seemed to have increased in 2023 but the uptick has not significantly changed the declining trend.

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	-	-
1992	15,552	8,361	-	-	-	-
1993	18,273	7,852	4,876	1,471	-	-
1994	46,341	20,010	7,936	1,492	26,279	0
1995	20,895	11,282	37,376	10,850	-	-
1996	37,774	16,941	12,829	3,890	-	-
1997	38,373	22,029	10,411	4,957	59,724	394
1998	10,717	7,248	723	338	48,762	75

Year	Bottomfish Fishing		Bottom-Troll Mixed		Spearfishing	
	All	BMUS	All	BMUS	All	BMUS
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	-	-	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
2022	1,509	807	84	66	9,324	120
2023	5,286	1,967	8,949	1,696	10,727	105
10-year avg.	21,938	9,427	6,253	1,402	10,514	112
10-year SD	15,382	6,624	4,290	1,194	3,609	73
20-year avg.	29,116	11,303	4,296	1,048	13,830	69
20-year SD	24,022	10,337	3,866	985	11,888	70

‘-’ indicates no data are available.

In summary, BMUS landings have closely tracked landings for all bottomfish and account for 40% of the total bottomfish landings. In addition, Bottomfishing has declined in the last 10 to 20 years with steep decline in 2020 and 2021 due to the impact of COVID-19. However, the mixed bottomfish-trolling displays a different trend, with landings from bottomfish-trolling increased in 2020 and a not so steep decline in 2021. There was a slight increase in bottomfishing, including BMUS fishing in 2022. There was a notable catch decline in mixed bottomfishing-trolling in 2022 as part of a continuous decline since 2020. However, the years from 2020 to 2022 are characterized by low fishing effort especially for mixed bottomfishing-trolling. There was a

recommendation in the previous Plan Team meeting for PIFSC to analyze the influence of low fishing effort on expanded catch estimates.

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 2023

Common Name	Scientific Name	Catch (lb)
Humpback snapper	<i>Lutjanus gibbus</i>	2,556
Redlip parrotfish	<i>Scarus rubroviolaceus</i>	1,363
Blue-banded surgeonfish	<i>Acanthurus lineatus</i>	1,068
Bluespine unicornfish	<i>Naso unicornis</i>	1,067
Redtail parrotfish	<i>Chlorurus japanensis</i>	967
Steephead parrotfish	<i>Chlorurus microrhinos</i>	833
Spiny lobster	<i>Panulirus pencillatus</i>	776
Twinspot/red snapper	<i>Lutjanus bohar</i>	654
Orangespot emperor	<i>Lethrinus erythracanthus</i>	521
Dark-capped parrotfish	<i>Scarus oviceps</i>	509

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 commercial landings data in 2023

Common Name	Scientific Name	Catch (lb)
Blue-banded surgeonfish	<i>Acanthurus lineatus</i>	6,278
Unicornfishes	<i>Naso</i> spp.	2,608
Parrotfishes	<i>Scarus</i> spp.	2,563
Groupers	<i>Epinephelus</i> spp.	782
Squirrelfishes	<i>Sargocentron</i> spp.	644
Striped bristletooth	<i>Ctenochaetus striatus</i>	567
Emperors	Multi-genera, multi-species	463
Inshore groupers	Multi-genera, multi-species	285
Bigeye scad	<i>Selar crumenophthalmus</i>	276
Mullet	<i>Mugil cephalus</i>	245

In summary, species groupings and catch are usually different for ECS between the creel survey and commercial invoice data. The differences reflect fish species consumer preferences and

fishermen's preferences for which species to keep or sell. *Acanthurus lineatus* was the top ECS from commercial invoices and a top species in the creel. On the other hand, *Lutjanus gibbus* was the most dominant species in the creel surveys but recorded in the invoices. 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., groupers "*Epinephelus* spp.", emperors and inshore groupers. Inshore groupers actually include *Epinephelus* groupers. These general groupings covered the species level catch in the creel surveys. Lobsters had high catches in the creel survey data but were notably absent in the commercial invoices. Lobsters are usually in-demand although relatively more expensive. Based on figures below, there was relatively few lobsters sold in 2023.

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	<i>Sargocentron tiere</i>	<i>Crenimugil crenilabis</i>	<i>Panulirus penicillatus</i>	Clams (multi- species)	<i>Octopus cyanea</i>	<i>Epinephelus melanostigma</i>
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
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	0	0	0	0
2005	0	0	65	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

Year	<i>Sargocentron tiere</i>	<i>Crenimugil crenilabis</i>	<i>Panulirus penicillatus</i>	Clams (multi- species)	<i>Octopus cyanea</i>	<i>Epinephelus melanostigma</i>
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	46	23	551	0	0	90
2023	28	47	776	0	0	112
10-yr avg.	26	58	381	0	0	109
10-yr SD	19	58	341	0	0	59
20-yr avg.	16	28	1,159	0	0	52
20-yr SD	22	49	1,935	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	<i>Sargocentron tiere</i>	<i>Crenimugil crenilabis</i>	<i>Panulirus penicillatus</i>	Clams (multi- species)	<i>Octopus cyanea</i>	<i>Epinephelus melanostigma</i>
1990	0	0	1,307	0	0	0
1991	0	0	1,389	0	0	0
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	4,262	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

Year	<i>Sargocentron tiere</i>	<i>Crenimugil crenilabis</i>	<i>Panulirus penicillatus</i>	Clams (multi- species)	<i>Octopus cyanea</i>	<i>Epinephelus melanostigma</i>
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	379	0	0	0
2022	0	0	58	0	0	0
2023	0	22	37	0	0	0
10-yr avg.	0	3	685	0	0	0
10-yr SD	0	7	481	0	0	0
20-yr avg.	0	1	1,184	0	0	0
20-yr SD	0	5	1,212	0	0	0

In summary, 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 $\sum \text{catch} / \sum (\text{number of gears used} * \text{number of hours fished})$ or $\sum \text{catch} / \sum \text{trips}$ 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 with an uptick in 2022. The uptick can be an artifact of low fishing effort. The general decline is also reflected when comparing 10- and 20-year averages. There were variabilities in CPUE for mixed-bottomfishing trolling and spearfishing and their respective BMUS over time, and there has been no robust analysis of potential variables that could account for this interannual variabilities.

Table 9. Non-expanded 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	-	-
1987	138	4.83	13	0.58	210	5.12	61	1.20	191	5.24	-	-
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	-	-
1991	121	2.99	69	1.58	219	5.69	81	1.99	358	6.28	-	-
1992	139	4.00	80	2.29	-	-	-	-	-	-	-	-
1993	124	2.75	62	1.39	255	4.90	100	1.93	70	-	-	-
1994	125	2.62	53	1.10	193	3.37	30	0.53	247	2.40	-	-
1995	121	3.11	67	1.50	160	3.42	49	1.00	-	-	-	-
1996	143	5.58	61	2.27	283	6.69	72	1.67	-	-	-	-
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	-	-	393	10.90	-	-
1999	151	5.12	103	3.44	103	8.58	-	-	186	7.16	-	-
2000	122	4.11	61	2.08	36	3.00	5	0.42	-	-	-	-
2001	140	5.58	76	2.94	-	-	-	-	164	6.24	-	-
2002	81	2.62	40	1.27	-	-	-	-	177	3.75	-	-
2003	105	5.26	50	2.53	157	6.57	61	2.01	179	5.00	-	-
2004	77	1.54	32	1.06	151	6.24	73	2.88	154	6.91	-	-
2005	97	4.72	53	2.82	138	7.64	53	2.93	30	3.00	-	-
2006	81	3.47	32	1.03	97	4.30	41	1.82	86	2.11	4	-
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	-	-
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	-	-
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	-
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
2023	56	1.85	21	0.67	119	4.46	23	0.84	73	1.80	6	0.16
10-year avg.	74	2.14	35	1.00	126	3.28	32	0.77	67	1.52	5	0.10
10-year SD	25	0.84	11	0.40	34	1.68	11	0.33	37	0.94	4	0.09
20-year avg.	109	3.02	51	1.37	165	4.22	55	1.45	121	3.85	5	0.13
20-year SD	67	1.38	28	0.68	98	2.06	60	1.05	92	3.25	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 vessels, trips, and gear-hours have continued their decreasing trends relative to 10- and 20-year averages.

Table 10. Non-expanded 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
2023	23	664	23	664	11	293	10	278	47	1,755	10	398
10-year avg.	58	2,736	55	2,697	17	1,678	16	1,303	40	2,474	7	982
10-year SD	39	2,529	35	2,517	12	2,481	12	1,774	11	2,614	3	2,051
20-year avg.	72	2,893	61	2,647	15	1,027	14	817	41	1,879	5	538
20-year SD	36	2,146	35	2,137	10	1,874	10	1,351	23	2,101	4	1,519

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. Non-expanded 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
2023	6	6	6	6	7	6
10-year avg.	9	9	6	6	4	3
10-year SD	4	4	3	3	1	1
20-year avg.	12	11	5	5	4	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 with a slight increase for the former and a significant increase for the latter in 2023.

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 $\sum \text{fishers} / \sum \text{trips}$. 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. Non-expanded average number of fishers 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

Year	Bottomfish Fishing		Bottom-Troll Mixed		Spear	
	All	BMUS	All	BMUS	All	BMUS
1992	2	2	0	0	0	0
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
2023	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. Non-expanded catch and bycatch in the American Samoa boat-based 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

Year	BMUS			Non-BMUS			BMUS + Non-BMUS		
	# Caught	# Discard or Release	% Bycatch	# Caught	# Discard or Release	% Bycatch	# Caught	# Discard or Release	% Bycatch
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
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
2023	308	0	0	451	0	0	759	0	0
10-yr avg.	1,087	0	0	1,267	0	0	2,354	0	0
10-yr SD	1,176	0	0	1,227	0	0	2,398	0	0
20-yr avg.	2,230	0	0	2,614	0	0	4,844	0	0
20-yr SD	2,453	0	0	2,005	0	0	4,277	0	0

1.10 NON-COMMERCIAL FISHERY CATCH STATISTICS

In the Pacific Islands, small boat fisheries are known to comprise a mix of commercial and non-commercial fishing. While over anywhere from 78% to 100% of fish catches in American Samoa are typically intended for sale, non-commercial catch supports fishing communities in many important ways, from contributing to food security to social cohesion and upholding cultural traditions (Chan and Pan 2019; Leong et al. 2020). These benefits, including those from informal and non-market economies, are especially important for community resilience during times of stress, such as during COVID-19 (Smith et al. 2022). While limited data are collected on non-commercial fishing, calculating non-commercial catch estimates is an important first step in demonstrating the potential scope of these additional under-documented benefits from fishing.

1.10.1 Catch Estimates

The general approach agreed upon by the Archipelagic Plan Team for the estimation of non-commercial BMUS catches in the territories is to subtract the dealer-reported (i.e. commercial) catches from the total estimated catches from creel surveys. Three sources of catch data are needed from each territory: the boat-based creel survey data, the shore-based creel survey data, and the dealer-reported catches. This report is preliminary, as continual improvement of the

process and integration into the central WPacFIN data warehouse are underway. The estimates of total BMUS catch and effort may differ from those in other sections of this annual SAFE report.

The boat- and shore-based creel surveys consist of fisher interviews and effort surveys conducted by the American Samoa DMWR. During an interview, species-specific catch and fishing effort information are recorded to obtain catch rate estimates. Effort data are collected through a participation survey and a boating-log survey for shore- and boat-based fishing, respectively, to estimate the total annual fishing effort. The data are uploaded into the WPacFIN data warehouse and quality control and processing scripts (via SQL and R) are used to generate the expanded catch by year. These scripts are stored and maintained in the WPacFIN Github repository (see top box in Figure 1). Further details regarding these data collection programs and the expansion algorithms designed to estimate total catch and effort can be found in Langseth et al. (2019) and Ma et al. (2022).

For each territory, the standard estimates of total annual catch and effort are obtained by first multiplying the catch rate by the total annual effort. The species composition from the creel interviews is then applied to obtain total species-specific catches for each territory. For the dealer-reported catch, the local resource management agencies collect data from first-level purchasers of local fresh fish by species or species groups (e.g. genus, family, and non-taxonomic groups such as “grouper”, “deep snapper”, or “bottomfish”).

The commercial receipt and creel data are checked for errors and inconsistencies before estimating the species-level catches. The PIFSC Stock Assessment and WPacFIN programs continue to work with staff in the jurisdictions to capture and fix the errors in the raw data, when possible. However, some of these errors are identified during the latest stock assessments and are fixed using temporary R scripts that are not yet integrated into the WPacFIN system (Figure 1), resulting in the different estimates of catch presented here. This process will be further reviewed and incorporated into the WPacFIN system in the next improvement phase.

The key difference resulting from this new method is improved estimates of total catch by species from the species groups (e.g. “grouper”, “deep snapper”, “bottomfish”) reported by the dealers using the proportions calculated from the creel surveys.

This methodology for splitting catches by species for the new approach to estimating catch consists of:

1. Calculate the average catch by species in 10-year periods from the creel data, then calculate the proportions of species in each taxonomic group (e.g. deep snapper, grouper). The period averaging controls for temporal changes in species composition (see Section 1.1.2 in Nadon et al. (2023) for further details)
2. Apply the species proportions to the total catch by year in each taxonomic group to split this catch into its individual species.
3. Sum all species-level catches into the BMUS group to obtain a final, corrected catch
4. Subtract the dealer-reported catch from the total catch to obtain the non-commercial catch.

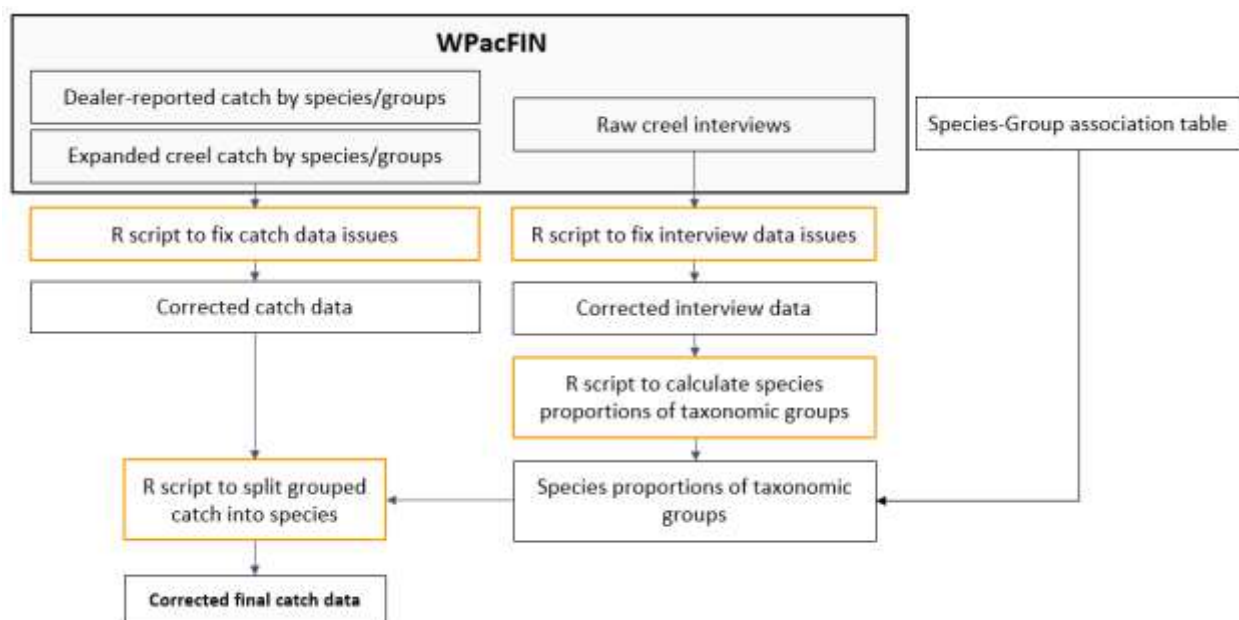


Figure 1. Data sources (gray boxes) and scripts (orange boxes) used to generate commercial and total catch estimates in the territories, from which non-commercial catch can be calculated

Table 13. Summary of American Samoa BMUS non-commercial catch estimates (lb) derived from commercial purchase system data and creel survey program data for all gear types

Year	Total Corrected Creel Survey Catch Estimates	Total Corrected Commercial Landings	Total Estimated Non-Commercial Catch	Proportion of Non-Commercial Catch
1990	11,128	1,615	9,513	0.85
1991	17,834	4,163	13,671	0.77
1992	11,455	4,333	7,123	0.62
1993	11,386	6,572	4,814	0.42
1994	26,150	7,997	18,153	0.69
1995	25,166	23,589	1,577	0.06
1996	25,204	20,914	4,290	0.17
1997	30,470	13,891	16,579	0.54
1998	8,508	15,709	-	0.00
1999	11,002	10,765	237	0.02
2000	16,078	19,435	-	0.00
2001	33,310	21,279	12,031	0.36
2002	29,123	21,848	7,275	0.25
2003	11,614	17,840	-	0.00
2004	14,729	13,328	1,401	0.10
2005	12,678	11,575	1,104	0.09
2006	5,247	16,814	-	0.00

Year	Total Corrected Creel Survey Catch Estimates	Total Corrected Commercial Landings	Total Estimated Non-Commercial Catch	Proportion of Non-Commercial Catch
2007	20,126	15,866	4,260	0.21
2008	32,387	13,820	18,566	0.57
2009	62,148	12,131	50,017	0.80
2010	12,102	4,415	7,687	0.64
2011	24,722	2,888	21,834	0.88
2012	7,588	3,474	4,115	0.54
2013	21,578	5,575	16,003	0.74
2014	23,354	6,256	17,098	0.73
2015	30,712	5,601	25,111	0.82
2016	23,168	5,401	17,766	0.77
2017	17,635	5,492	12,143	0.69
2018	13,853	2,218	11,635	0.84
2019	12,943	3,881	9,062	0.70
2020	8,889	589	8,299	0.93
2021	2,338	705	1,634	0.70
2022	3,443	475	2,968	0.86
10-year avg.	15,791	3,620	12,172	0.78
10-year SD	8,741	2,258	6,770	0.08
20-year avg.	18,063	7,417	11,535	0.58
20-year SD	13,046	5,586	11,617	0.31

1.10.2 Caveats for Non-Commercial Catch Estimates

There are several important concerns and caveats that must be taken into account when estimating non-commercial catch values and using those data for monitoring and management purposes. With respect to available data, catch estimates are based on the best available existing data collected via creel surveys. As noted by Chan and Pan (2019), the actual populations of fishing participants in American Samoa are difficult to gauge. Without accurate knowledge of the population, the representativeness of the sample cannot be meaningfully calculated. While quantitative evaluations of the survey methods have shown that they are conceptually sound (Pawluk et al. 2023), fishers and members of the fishing community have voiced concerns about the representativeness of expanded data derived from creel interviews. In addition, the estimates of total catch and fish sales come from different reporting systems. The quality of commercial landings data collected through commercial sales receipt books are also variable across years and geographic areas (Chan and Pan 2019). Further, additional commercial activity via channels such as roadside markets or direct-to-consumer sales may not be captured through the commercial purchase system methodology. However, those channels are also more reflective of the broader informal and non-market economies supported by non-commercial fishing.

1.11 FEDERAL LOGBOOK DATA

1.11.1 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.

1.11.1.1 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.

1.11.1.2 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 Region.

1.11.1.3 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 14. Table 14 provides the number of permits issued to American Samoa FEP fisheries between 2014 and 2023. Data are from the Pacific Islands Regional Office (PIRO) Sustainable Fisheries Division (SFD) permits program.

Table 14. Number of federal permit holders in American Samoa crustacean fisheries

Crustacean Fishery¹	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Lobster	1	0	0	0	0	0	0	0	0	0
Shrimp	1	0	0	0	0	0	0	0	0	0

¹ Source: PIRO SFD unpublished data.

1.11.2 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.

1.11.2.1 Spiny and Slipper Lobster

Table 15. 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 (#)	
				<i>Spiny lobster ECS²</i>	<i>Slipper lobster ECS²</i>	<i>Spiny lobster ECS²</i>	<i>Slipper lobster ECS²</i>
2004	0	-					
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	-					
2023	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.

1.11.2.2 Deepwater Shrimp

Table 16. 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	-			
2018	0	-			
2019	0	-			
2020	0	-			
2021	0	-			
2022	0	-			
2023	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).

1.12 STATUS DETERMINATION CRITERIA

1.12.1 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 17.

Table 17. Overfishing threshold specifications for BMUS

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

Standardized values of fishing effort (E) and 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 18. Again, E_{MSY} is used as a proxy for F_{MSY} .

Table 18. Recruitment overfishing control rule specifications for BMUS

$F_{RO-REBUILD}$	$SSBPR_{MIN}$	$SSBPR_{TARGET}$
------------------	---------------	------------------

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

1.12.2 Current Stock Status

1.12.2.1 Bottomfish

Biological and other fishery data are poor for all bottomfish species in the American Samoa Archipelago. In previous assessments, data are only available on commercial landings by species and CPUE for the multi-species complexes as a whole. It is not possible to partition these effort measures among the various BMUS. The most recent stock assessment (Nadon et al. 2023) for the American Samoa bottomfish MUS (comprised of 11 species of shallow and deep species of snapper, grouper, jacks, and emperors) was based on estimates of total catch, an abundance index, and length composition derived from four data sources: historical catches from old reports, recent catches from the boat and shore-based creel surveys, length composition from boat-based creel and the biosampling program, and an abundance index from boat-based creel interviews. The assessment is a single-species assessment covering nine of the eleven MUS. The assessment used an age-structured model within the modeling framework Stock Synthesis 3.30, which integrated catch-at-age fitting a population model to relative abundance and size composition data. Determinations of overfishing and overfished status can then be made by comparing current biomass and harvest rates to MSY-level reference points. The American Samoa BMUS were determined to be not overfished and not subject to overfishing for all nine species assessed (Table 19).

Table 19. Stock assessment parameters for the BMUS complex (from Nadon et al. 2023)

Species	Samoan name	F / F _{MSY2021}	SSB / SSB _{MSST} 2021	SSB ₂₀₂₁	Status in 2021
<i>Aphareus rutilans</i>	Palu-gutusaliva	<0.01	3.1	14.2	No overfishing, not overfished
<i>Aprion virescens</i>	Asoama	0.05	1.7	5.0	No overfishing, not overfished
<i>Caranx lugubris</i>	Tafaui	0.02	4.4	2.1	No overfishing, not overfished
<i>Etelis carbunculus</i>	Palu-malau	-	-	-	Unknown
<i>Etelis coruscans</i>	Palu-loa	0.05	1.7	12.9	No overfishing, not overfished
<i>Lethrinus rubrioperculatus</i>	Filoa-paomumu	0.02	2.8	9.6	No overfishing, not overfished
<i>Lutjanus kasmira</i>	Savane	<0.01	7.6	12.5	No overfishing, not overfished
<i>Pristipomoides filamentosus</i>	Palu-‘ena-‘ena	-	-	-	Unknown
<i>Pristipomoides flavipinnis</i>	Palu-sina	<0.01	3.2	3.2	No overfishing, not overfished
<i>Pristipomoides zonatus</i>	Palu-ula	<0.01	3.3	2.0	No overfishing, not overfished
<i>Variola louti</i>	Velo	<0.01	4.1	2.1	No overfishing, not overfished

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

1.13.1 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.

1.13.2 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). At the time of publication of this report, the rebuilding plan remained active despite the results of the most recent stock assessment (Nadon et al. 2023). The Council anticipates taking action to discontinue the rebuilding plan and implement species specific ACLs for the American Samoa BMUS complex in 2024.

The catch shown in Table 20 presents the 2023 catch estimate against the rebuilding ACL.

Table 20. American Samoa ACL table with 2023 total estimated catch (lb)

Fishery	MUS	OFL*	ABC	ACL**	Catch
Bottomfish	Bottomfish multi-species complex	8,000	N/A	5,000	4,689

* OFL derived from the stock assessment (Langseth et al. 2019) with 2025 as the terminal year.

** The catch limit for 2023 was a rebuilding ACL implemented by NMFS as part of the rebuilding plan for American Samoa BMUS (87 FR 25590, May 2, 2022).

1.14 BEST SCIENTIFIC INFORMATION AVAILABLE

1.14.1 Bottomfish fishery

1.14.1.1 Stock Assessment Benchmark

The benchmark stock assessment for the American Samoa BMUS, was developed and finalized by Nadon et al. (2023). The assessments used an integrated age-structured within the Stock Synthesis 3.30 modeling framework. Estimates of fishing mortality (F), spawning stock biomass (SSB), the fishing mortality at maximum sustainable yield (F_{MSY}), and the spawning stock biomass at the minimum stock size threshold (SSB_{MSS}) allowed for determination of stock status relative to reference points determining overfishing ($F/F_{MSY} > 1$) and overfished ($SSB/SSB_{MSS} < 1$) status. Stock projections were conducted for 2024-2028 for a range of hypothetical five-year catches, and the corresponding risk of overfishing was calculated.

1.14.1.2 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. There was no stock assessment update developed after the Langseth et al. 2019 benchmark assessment. The PIFSC-SAP developed another benchmark assessment as described in previous sections. The next stock assessment update is scheduled to be completed in 2026.

1.14.1.3 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.

1.15 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 21 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). At the time of publication of this report, the rebuilding plan remained active despite the results of the most recent stock assessment (Nadon et al. 2023). The Council anticipates taking action to discontinue the rebuilding plan and implement species specific ACLs for the American Samoa BMUS complex in 2024.

Table 21. American Samoa ACL proportion of harvest capacity and extent in 2023

Fishery	MUS	ACL*	Catch	Harvest extent (%)	Harvest capacity (%)
Bottomfish	Bottomfish multi-species complex	5,000	4,689	93.8	6.2

* The catch limit for 2023 was a rebuilding ACL implemented by NMFS as part of the rebuilding plan for American Samoa BMUS (87 FR 25590, May 2, 2022).

1.16 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions NMFS implemented for insular fisheries in American Samoa during calendar year 2023.

On December 26, 2023, NMFS published the final rule to extend the region-wide moratorium on the harvest of gold corals in the U.S. Pacific Islands through June 30, 2028 (88 FR 88835). NMFS intends this rule to prevent overfishing and to stimulate research on gold corals.

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 2020 can be found in the pelagic and the respective archipelagic reports (WPFMC 2021a, 2021b, 2021c, 2021d). Fisher observations from 2021 can be accessed in the 2021 pelagic (WPFMC 2022d) and archipelagic SAFE reports (WPFMC 2022a, 2022b, 2022c). Fisher observations from 2022 were also collected during Advisory Panel meetings and were summarized in 2022 pelagic (WPFMC 2023d) and archipelagic SAFE reports (WPFMC 2023a, 2023b, 2023c).

In 2023, the Council collected archipelagic fisher observations during 3 quarterly advisory panel meetings for American Samoa. Input collected by fishers during these meetings was limited to American Samoa Advisory Panel members followed with an annual review meeting open to Advisory Panel members and members of the American Samoa fishing community. Data gathered from these meetings is reported below.

2.1.1 Information from Advisory Panel Meetings

First Quarter (January-March)

During the first quarter, American Samoa Advisory Panel members noted a lot of squid nearshore but could not fish in several areas due to funeral-related closures. They reported that there have been a lot of funerals and often as a result, closures to fishing. The fish market business is consistent, selling out of fish everyday by 2pm. Akule has been around since the end of April, mostly in deeper waters, but sometimes they will come in on top of the coral and local fishers will catch what they need. Fishers are still waiting for updates on the Super Alia program. One AP member reported meeting with the Department of Education about a training program for kids to learn technical skills so that they can learn about fishing jobs and participate in the fishery. Fishers questioned whether the AP might have a budget to help fund training opportunities. Not many kids are getting into fishing unless they live in Manu‘a.

Second Quarter (April-June)

In the second quarter, AP members reported that local areas remained closed to fishing due to funeral-related closures. Only kids under the age of 16 are allowed to fish. They also reported not a lot of boats fishing, at least not the small alias. The AP also provided an update on the Super Alia program. The first vessel is ready for sea trials and inspection, with the intention for it to be shipped down in September. The hope is for all the vessels to be down in American Samoa within 2 years. They received an incubator grant from the U.S. Department of the Interior to train people to fish the boats, including education, economics, and navigation, with U.S. Coast Guard partners. The super alia vessel will have a 12 mile hydraulically operated longline drum, electric bottomfish reels, and dual Yanmar diesel engines. They will be able to carry 4,000 pounds of fish and can carry ice.

Third Quarter (July-September)

DMWR in American Samoa is in the process of introducing around 650 species of Giant Clams in an attempt to enhance the local population. They also reported that DMWR was able to change a shark statute whereby local fishers could not buy/sell/trade/transfer sharks or shark parts outside American Samoa, but they were allowed to use them for cultural purposes.

2.1.2 Information from the Annual Summit

2.1.2.1 Social

American Samoa fishers discussed fishing infrastructure issues including improvements to boat ramps made with WPFMC Sustainable Fisheries funds. During the meeting, fishers expressed their gratitude to be able to go fishing and share their catch with the community.

2.1.2.2 Economic

Issues related to the economics of fishing occupied much of the discussion. Fishers decried market conditions, including a lack of ice (flake ice) needed to preserve the quality of fish necessary to fetch good prices at markets. Due to the lack of good ice, some market vendors will not purchase bottomfish caught by alia vessels. Fishers described past attempts to address the issue, but how each of them were appreciated, but ultimately did not solve the problem. Fishers noted a lack of fresh fish, particularly bottomfish caught by alia boats in local markets. They explained that local markets primarily sell frozen fish caught elsewhere. Fishers also described how decentralized roadside markets make it challenging to secure consistent prices, which they felt highlight the need for a centralized market hub with price floors for local fishers. Some felt that outer island fisheries should be further developed to bring to markets on more populated islands, but at least on outer island fisher objected to this idea. Manu'a and Aunu'u fishers described selective targeting behavior, but also noted that some fishers take some undersized fish. Despite this, they felt that the lower population on those islands results in less pressure on their local fisheries.

2.1.2.3 Biological

Archipelagic issues included the abundance of coral reef fish around Manu'a and the potential for overfishing of ecosystem component species around Aunu'u, which may be causing fish to scatter or dive deeper for safety.

2.1.2.4 Physical/Oceanographic

Fishers noted that El Niño impacted coral bleaching from warmer water temperatures. These warmer water temperatures also forced them to search around more to catch bottomfish. A few fishers reported that hurricane season is their favorite time to fish as it often coincides with light or calm wind days. Aunu'u fishers described some impacts they are experiencing as a result of climate change, such as sea level rise, coral bleaching, and brown algae. The brown algae used to be more prevalent but is not seen growing much anymore. Fishers also referenced favorable currents that caused good fishing conditions.

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 2023. ‘Hard Coral Cover’ is mean cover derived from benthic imagery (photoquadrats) collected by divers across the survey domain, including most sites where reef fish surveys occurred. In previous reports, this parameter stemmed from diver visual rapid assessments of coral cover. Note that no surveys were conducted in 2020 or 2021 in any region due to COVID-19.

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 Area (PRIA)

Spatial Scale: Regional

Data Source: Data used to generate cover and biomass estimates come from 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](#)). Fish 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. Cover estimates are derived from photoquadrats collected by divers within the same survey domain, including at all the fish survey sites. Post-hoc annotation methods are described in detail in Lamirand et al. (2022).

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.

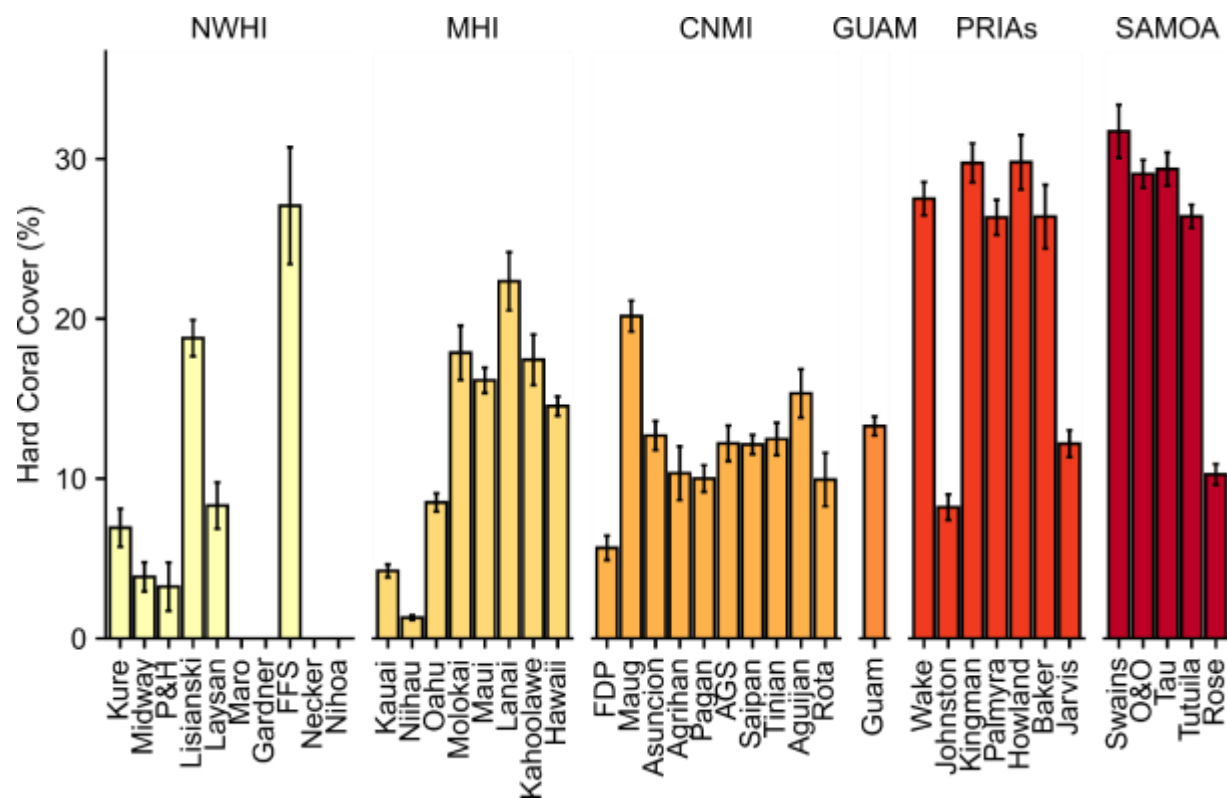


Figure 2. Mean coral cover (% ± standard error of the mean, or SEM) per U.S. Pacific Island averaged from 2010-2023 by latitude

Note: Coverage data presented here is derived from benthic imagery (photoquadrats) collected by divers across the survey domain. In previous reports, hard coral cover stemmed from diver visual assessments, which is a less rigorous method for estimating this parameter.

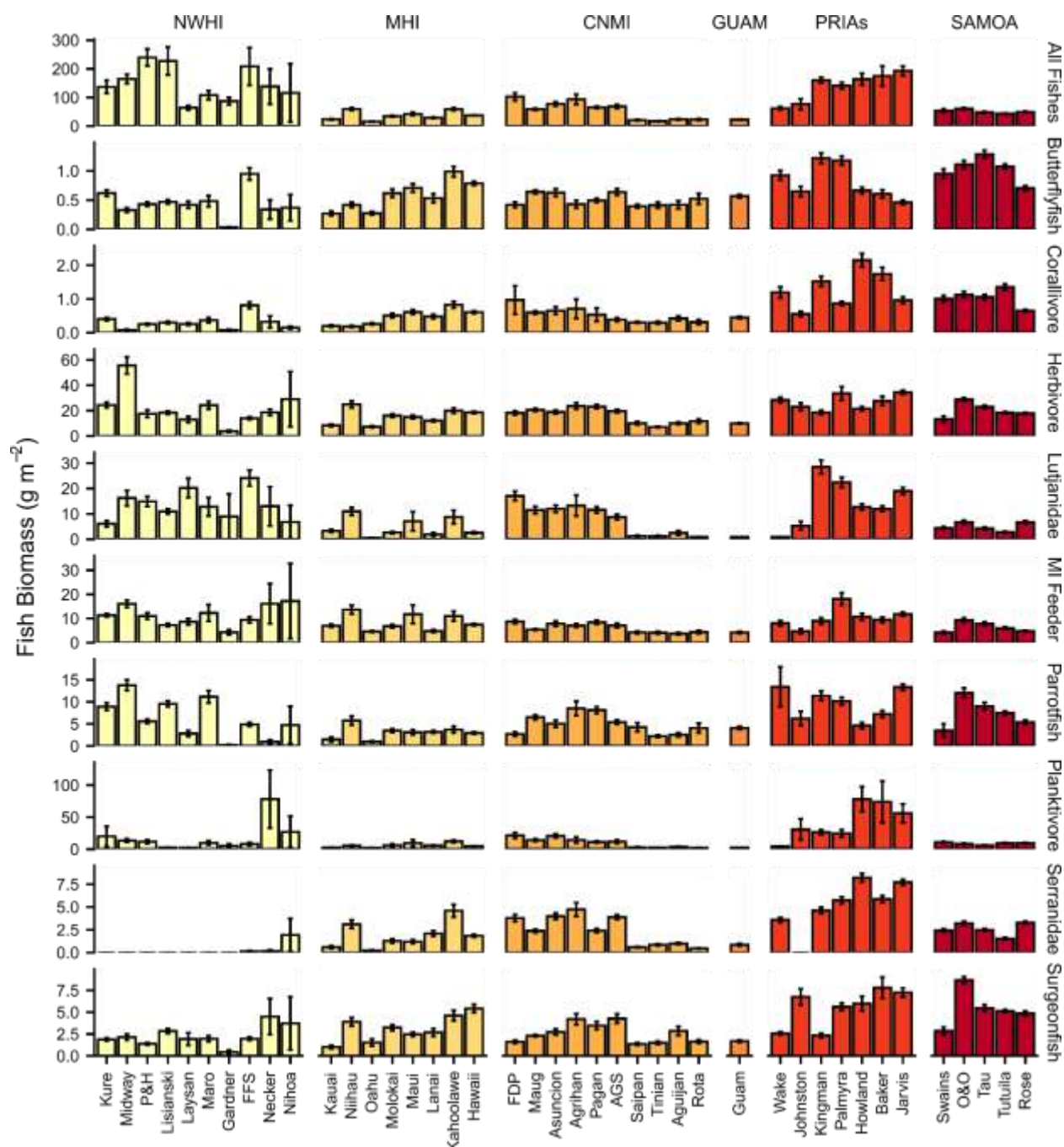


Figure 3. Mean fish biomass ($\text{g/m}^2 \pm \text{SEM}$) per U.S. Pacific Island of functional, taxonomic, and trophic groups from 2010-2023 by latitude

Note: The group ‘Serranidae’ excludes planktivorous members of that family (i.e., anthias), which can be 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 targeted 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 2023. ‘Hard Coral Cover’ is mean cover derived from benthic imagery (photoquadrats) collected by divers across the survey domain, including most sites where reef fish surveys occurred. In previous reports, this parameter stemmed from diver visual rapid assessments of coral cover. Note that no surveys were conducted in 2020 or 2021 in any region due to COVID-19.

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 are sourced from surveys conducted by NMFS PIFSC ESD and partners as part of the Pacific NCRMP. Survey methods and sampling design, and methods to generate biomass and cover parameters are described in Section 2.2.1.

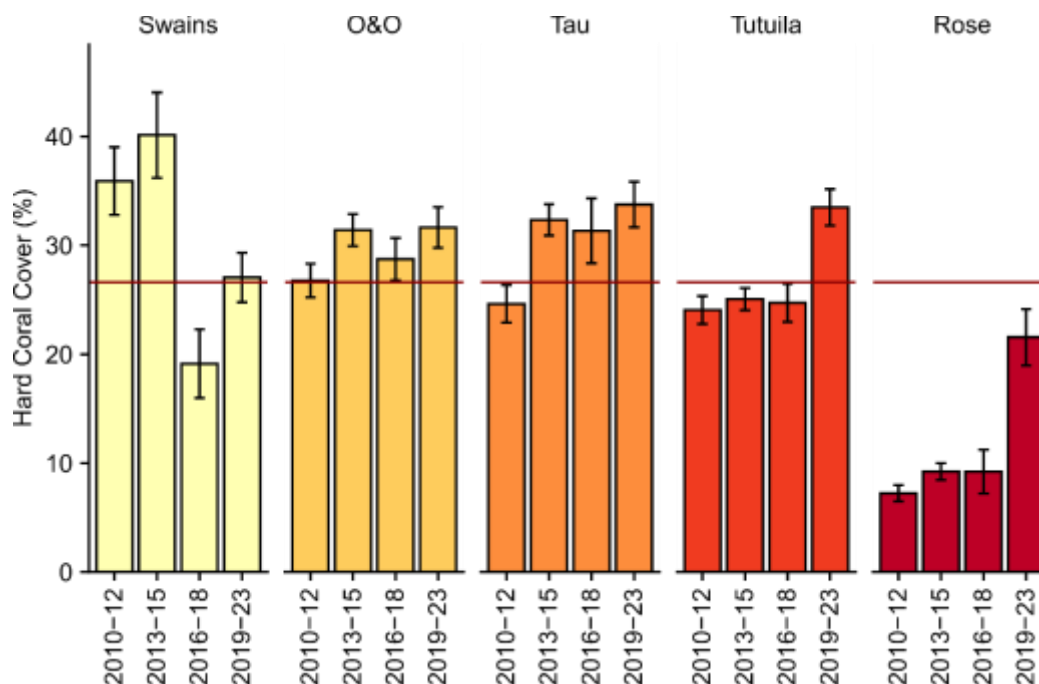


Figure 4. Mean coral cover (% ± SEM) per island from 2010-2023 by latitude

Note: The red horizontal line is the region-wide mean estimate for the entire time period. Coverage data presented here is derived from benthic imagery (photoquadrats) collected by divers across the survey domain. In previous reports, hard coral cover stemmed from diver visual assessments, which is a less rigorous method for estimating this parameter.

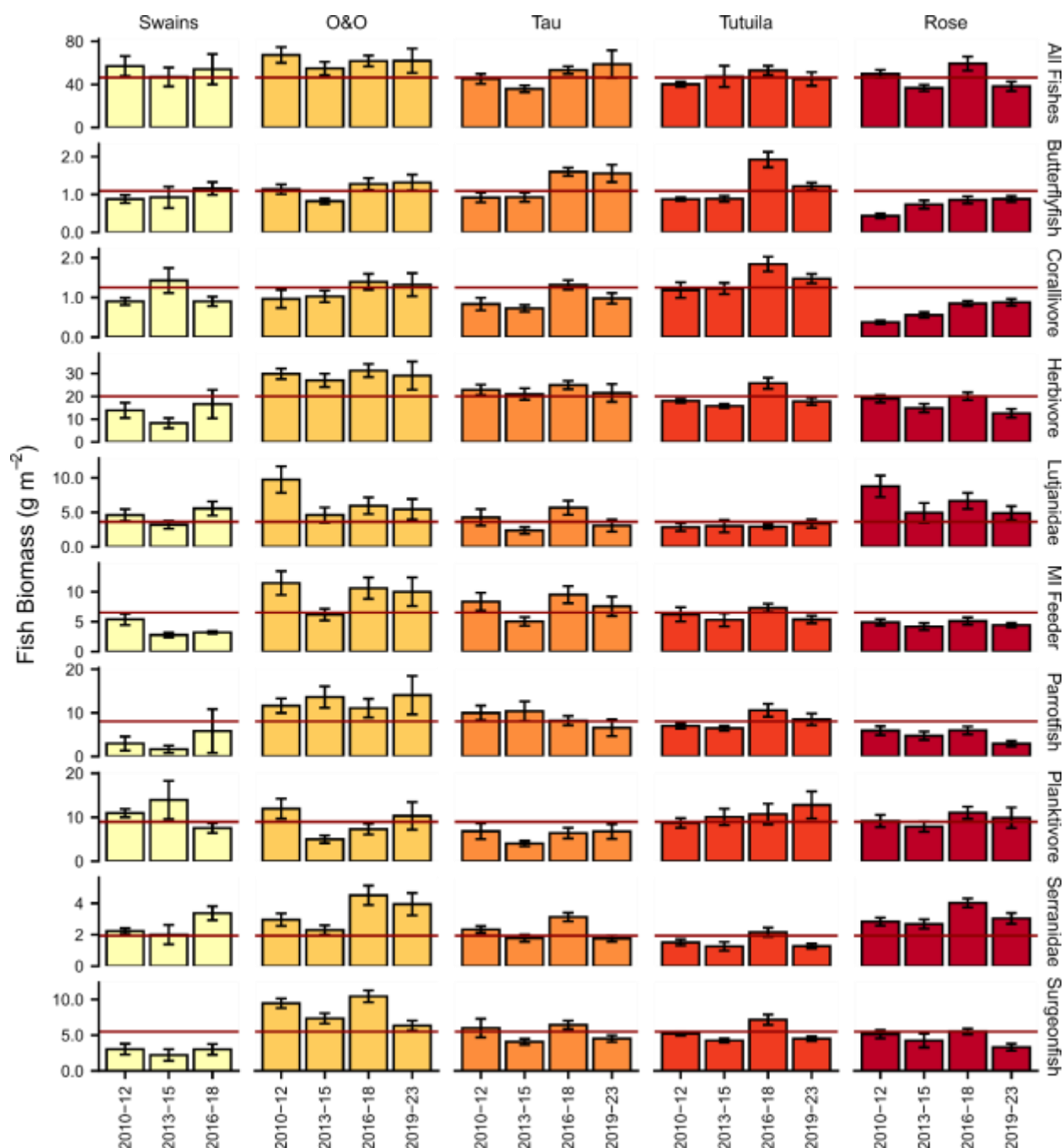


Figure 5. Mean fish biomass (g/m² ± standard error) of American Samoa functional, taxonomic, and trophic groups from 2010-2023 by island

Note: The group ‘Serranidae’ excludes planktivorous members of that family (i.e., anthias), which can be 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 targeted surgeonfish species. Red horizontal lines are the region-wide mean estimates for the entire time period.

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 Biosampling 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 growth function, typically the von Bertalanffy growth function (VBGF). This function typically uses three coefficients (L_{∞} , k , and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and

sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex, and these data are fitted to a three- or four-parameter logistic function to determine the best fit 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 ($A\Delta_{50}$) can be 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 22 for specific details on data sources by species.

Parameter Definitions:

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

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

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

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

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

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

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

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

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

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. 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 22. 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_{∞}	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
<i>Crenimugil crenilabis</i>										
<i>Epinephelus melanostigma</i>										
<i>Octopus cyanea</i>										
<i>Panulirus penicillatus</i>										
<i>Sargocentron tere</i>										
<i>Tridacna maxima</i>										

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

2.3.1.2 Fish Length Derived Parameters

Description: The NMFS Commercial Fishery Biosampling 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. The goals of the Field/Market Sampling Program were to allow:

- Broad scale observations of 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
- Development of accurate local length-weight curves.

In American Samoa, the Biosampling Program focused on the commercial coral reef spear fishery with occasional sampling of the bottomfish fishery occurring locally and less frequently at the outer 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 Biosampling Program

Parameter Definitions:

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

L_{max} – maximum fish length is the largest individual per species recorded in the Biosampling 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-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 23. Available length-derived information for prioritized coral reef ecosystem component species in American Samoa

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

2.3.2 American Samoa – 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 growth curve, typically a VBGF. This function typically uses three coefficients (L_{∞} , k , and t_0), which together characterize the shape of the length-at-age growth relationship.

Length-at-reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved, cut into five-micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex, and these data are fitted to a three- or four-parameter logistic function to determine the best fit 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 ($A\Delta_{50}$) can be 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 24 for specific details on data sources by species.

Parameter definitions: Identical to Section 2.3.1.1.

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_{∞} , 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 24. 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_{∞}	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
<i>Aphareus rutilans</i>							NA		NA	
<i>Aprion virescens</i>							NA		NA	
<i>Caranx lugubris</i>							NA		NA	
<i>Etelis carbunculus</i> ¹							NA		NA	
<i>Etelis coruscans</i>							NA		NA	
<i>Lethrinus rubrioperculatus</i>	f=10 ^d m=10 ^d	f=27.3 ^d m=29.1 ^d	f=0.74 ^d m=0.71 ^d	f=-0.16 ^d m=-0.15 ^d				f=21.2 ^{d,e}		Pardee et al. (2020)
<i>Lutjanus kasmira</i>							NA		NA	
<i>Pristipomoides filamentosus</i>							NA		NA	
<i>Pristipomoides flavipinnis</i>	28 ^d	41.15 ^d	0.47 ^d		0.22 ^d		NA		NA	O'Malley et al. (2019)
<i>Pristipomoides zonatus</i>							NA		NA	
<i>Variola louti</i>										

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_{∞} and L_{50}

2.3.2.2 Fish Length Derived Parameters

Description: The NMFS Commercial Fishery Biosampling 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 2.3.1.2

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 25. Available length-derived information for BMUS in American Samoa

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

Species	Length derived parameters					Reference
	<i>n</i>	<i>L_{max}</i>	<i>N_{L-W}</i>	<i>a</i>	<i>b</i>	
<i>Pristipomoides flavipinnis</i>	262	56.5	262	0.0249	2.90	Matthews et al. (2019)
<i>Pristipomoides zonatus</i>						
<i>Pristipomoides filamentosus</i>						
<i>Variola louti</i>		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 need 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 6).



Figure 6. 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 194th meeting held via web conference and in Saipan, CNMI and Tumon Bay, Guam in March 2023, the Council directed staff to request NMFS include territorial representatives on the Equity and Environmental Justice (EEJ) Working Group to provide expertise needed to identify, effectively engage with and address the needs of Pacific Island communities. Membership on the Pacific Islands Region (PIR) EEJ Working Group from NMFS staff in the territories was specifically sought and included. The Council also established a working group to work on the national review of National Standards 4, 8, and 9. PIFSC SEES staff contributed to the national review.

At its 195th meeting held via web conference and in Pago Pago, American Samoa in June 2023, the Council directed staff to convene the P* and SEEM working groups to quantify the scientific uncertainties in the 2023 benchmark stock assessment for American Samoa BMUS. PIFSC SEES staff participated in the American Samoa SEEM working group meeting.

The Council also directed staff to proceed with developing program area priorities linked with management objectives for the 2025-2029 MSA Research Priorities. PIFSC SEES contributed to updates of the MSA Research Priorities.

Additionally, the Council requested NMFS PIFSC continue its effort to develop the territorial non-commercial fishery performance modules for inclusion in the annual SAFE reports. PIFSC SEES staff participated in the development of the non-commercial modules for both archipelagic and pelagic fisheries. This included development of the analysis process and drafting the new section of the reports.

In addition, the Council directed the Plan team to include in future EEJ modules a focus on impacts of regulations. Equitable distribution of benefits will be included in the PIR EEJ Implementation Plan.

Further, the Council endorsed the recommendations by its Social Science Planning Committee (SSPC) regarding fishers observations, and directed staff and the SSPC to coordinate broader engagement and outreach. In 2023, PIFSC SEES staff continued to provide support and analysis for the fisher observation sections of the annual SAFE reports, which have now broadened from an annual summit to include regular updates during each scheduled Advisory Panel meeting. In

addition to the annual SAFE reports, full data reports are generated and archived in the PIFSC library repository.

The Council also requested that NOAA evaluate the holistic impacts of the proposed Pacific Remote Islands (PRI) sanctuary on fishing fleets that have historically fished the PRIA EEZ. PIFSC SEES staff contributed to analysis and preparation of a report on "Fishery Management Scenarios for the Monument Adjacent Area within the Proposed Pacific Remote Islands Sanctuary" (Sabater et al. 2023). The Council also requested NOAA conduct an economic study that considers effects to American Samoa-based fishery on the proposed Effort Limit Area for Purse Seine (ELAPS) rulemaking. PIFSC SEES staff conducted analysis and prepared the report "Economic Contributions of U.S. Commercial Fisheries in American Samoa" (Chan 2023).

At its 196th meeting held in Honolulu, Hawaii in September 2023, the Council requested the PIFSC SEES Program's small-boat fishing survey be replicated in other jurisdictions including Guam and the CNMI. The next iteration of the small-boat fishing survey is planned for implementation in the Mariana Archipelago in 2025, with outreach beginning in Fiscal Year 2024. American Samoa will be included in future iterations.

At its 197th meeting held via web conference in December 2023 the Council directed staff to coordinate with advisory group representatives, PIRO, PIFSC and other relevant entities as appropriate to finalize the Inflation Reduction Act (IRA) project proposal by January 31, 2024. PIFSC SEES staff provided background on federal needs and priorities and provided feedback as subject matter experts on topics considered for IRA project proposals developed by Council staff.

In addition, the Council directed staff to convene a workshop of Council staff, PIFSC, PIRO and SSC members to finalize and prioritize the MSA 2025-2029 research priorities. PIFSC SEES staff prepared updates on SEES work support of MSA 2020-2024 Research Priorities, in preparation for development of the next five-year research priorities.

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). Since the early 2000s, 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. Women and fa'afafine (a third gender within traditional Samoan culture) engaged in fishing have emphasized the important role of fishing in intergenerational relationships and cultural subsistence with respect to elder care, and domestic labour, art, and design (Fisk et al. 2023).

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 km² 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 2023). Exports are primarily canned tuna and associated products. In 2022, domestic exports from American Samoa were valued at \$376,899, of which \$370,824,000 (over 98%) came from canned tuna sale (American Samoa Government 2023). 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 2022, the ASG employed 7,224 people accounting for 43% of the total workforce in the Territory (American Samoa Government 2023), and the private sector employed 7,426 people (Figure 7). The canneries employed 2,275 people, accounting for 13% 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.

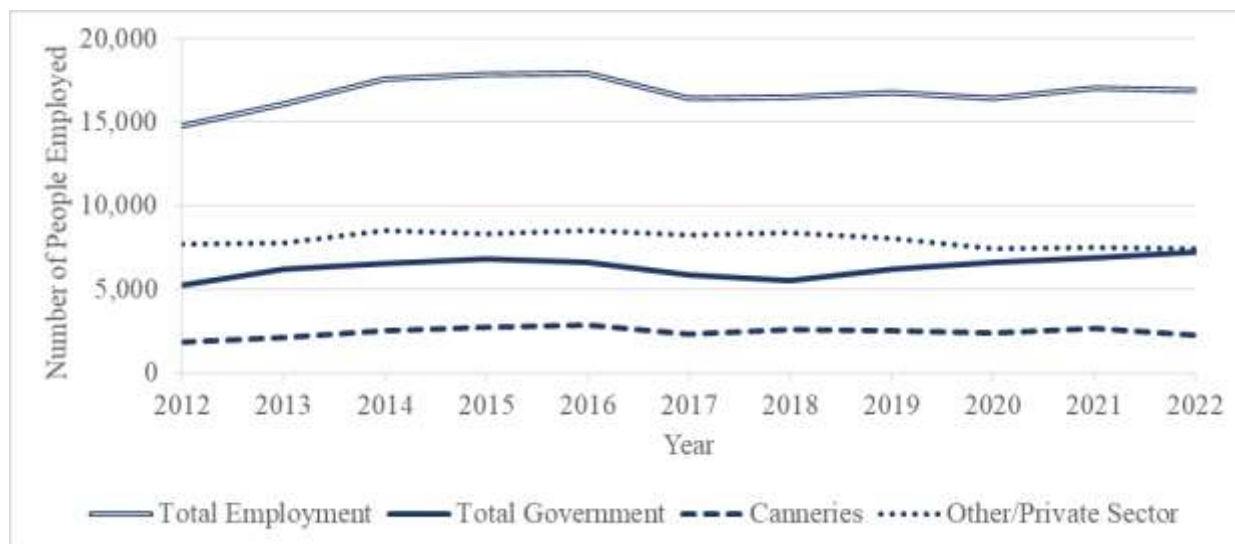


Figure 7. American Samoa Employment Estimates from 2012-2022; sourced from American Samoa Government (2023)

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 took 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.

The proposed Pacific Remote Islands National Marine Sanctuary raised concerns about potential impacts to the American Samoa economy related to potential reduction in fish offloaded at the cannery. A study using an IMPLAN model to examine economic contributions of U.S. commercial fisheries in American Samoa found that indirect, induced, and value-added effects of purse seine, longline, and small boat fisheries contributed the equivalent of 20% of total employment, 18% of total labor income, more than a quarter of the total economic output, and more than one-fifth of the 2019 GDP in American Samoa (Chan 2023). Hypothetical scenarios of reduced fish landings of 10%, 30%, and 50% showed large ripple effects on the local economy, leading to a potential 2-10% reduction in employment, 2-9% reduction in labor income, 2-11% reduction in GDP, and 3-14% reduction in output (Chan 2023).

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.

2.4.3.1 Underserved Communities

In defining underserved communities, the national EEJ strategy includes groups that are relevant to American Samoa. This includes, but is not limited to Pacific Islanders, persons who live in rural areas, processing plant workers, subsistence fishers and their dependents, and territorial and commonwealth communities. More nuanced and detailed understanding of which communities are underserved in which contexts and why has been identified as an action in the PIR EEJ implementation plan (to be published July, 2024).

2.4.3.1.1 Index of Disadvantage

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

2.4.3.2 Next Steps

The EEJ subgroup of the APT/PT identified the following priority areas for future work:

- Demographics: have a better understanding of the demographics of the people participating in fisheries, and how those may shift over time.
- Defining communities and fisheries: including underserved communities, as well commercial and non-commercial fisheries.
- Management impacts: understand how different communities, demographic, or fisheries groups are impacted by fisheries management
- EEJ implementation: identify key EEJ issues and update yearly
- Fish flow: track what happens to fish after it has been caught

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. A total of 33 fishers responded to a cost-earnings survey of the American Samoa small boat fishery conducted in 2021, of an estimated 60 potential active participants (Dombrow and Hospital 2023). Approximately 90% engaged in nearshore or shallow bottomfish fishing, 81% engaged in deep-water bottomfish fishing, and 75% went trolling. The largest percentage of respondents (27%) identified part-time commercial fishing as their primary motivation, followed by full-time commercial (21%) and cultural fishing (18%). While fishers sold approximately 46% of their catch, they gave away 26% and kept about 21% for personal or family consumption; nearly all fishers (94%) gave away a portion of their catch and 97% kept some catch for personal and family consumption (Dombrow and Hospital, 2023).

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). In 2023, fishers were still concerned about the slow rollout of COVID relief and CARES Act funds (Ayers et al. 2023).

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. Alia 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. A 2021 survey of small-boat fishers indicated that bottomfish was the primary species group targeted to sell (39%), although nearly half (41%) of respondents also indicated that bottomfish was their primary target species to keep for personal and family consumption; however, respondents from the Manu'a Islands reported bottomfish as their primary target species group (56%) to give away (Dombrow and Hospital 2023).

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, Revenue, Prices

This section describes trends in commercial pounds sold, revenue, and price for the American Samoa bottomfish fishery. Figure 8 presents the trends for commercial pounds sold and revenue for the bottomfish fishery (i.e., BMUS only) from 2004 to 2023, and Figure 9 presents the trends in fish price for bottomfish sold from 2004 to 2023. Supporting data for Figure 8 and Figure 9 are shown in Table 26. 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 from 2021 through 2023 are confidential due to fewer than three participating vendors, so no detailed figures are presented. The 17-year average (i.e., 2003-2020) 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. Thus, the commercial landings presented here, collected through “Commercial Sales Receipt Books” Program that might not be able to capture all the commercial activities of the bottomfish landed, could only represent the lower bound of total commercial landings.

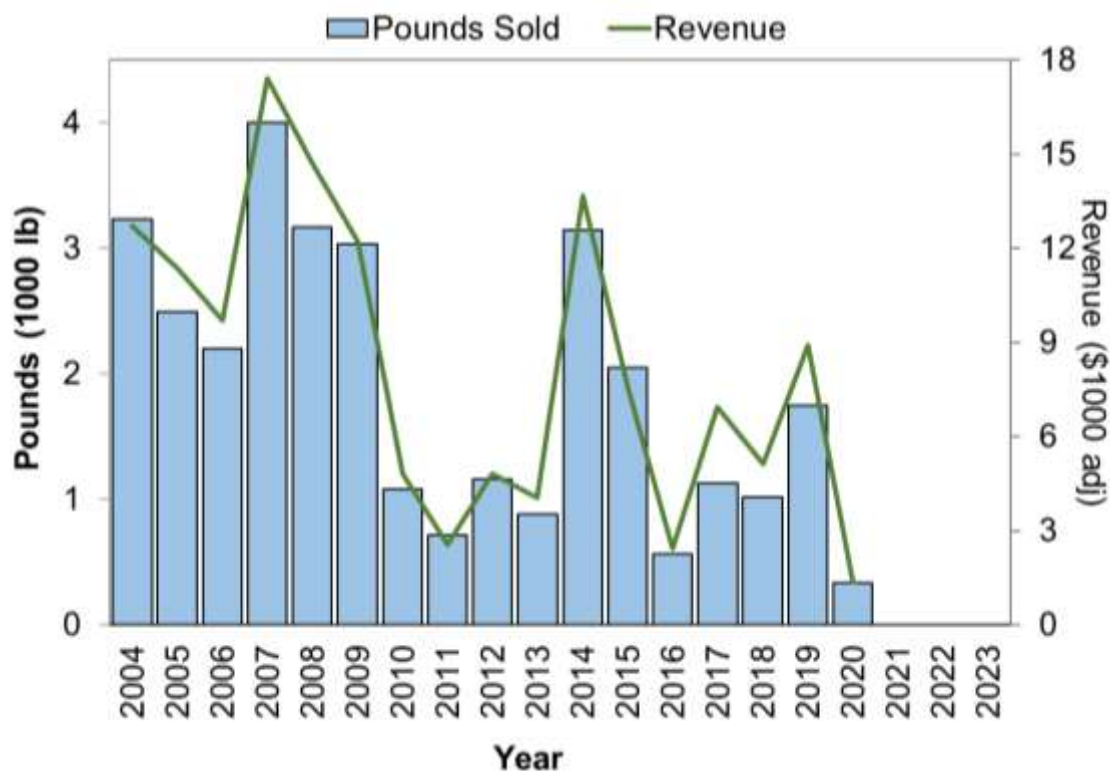


Figure 8. Pounds sold and revenue for the American Samoa bottomfish fishery*

* Data were confidential in 2021, 2022, and 2023 due to fewer than three participating vendors.

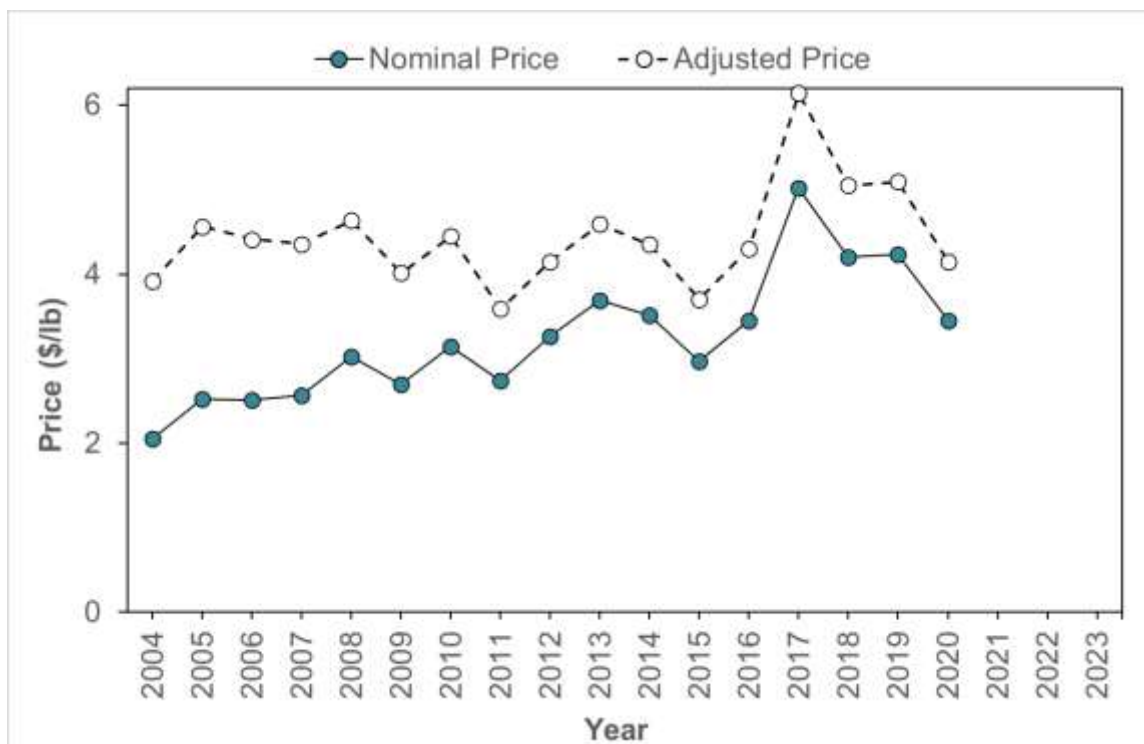


Figure 9. Price BMUS in the American Samoa bottomfish fishery

* Data were confidential in 2021, 2022, and 2023 due to fewer than three participating vendors.

Table 26. 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
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	1,016	9%	4,270	5,137	4.20	5.05	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	1,022	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1
2023	3,768	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 10 shows the average trip costs for American Samoa bottomfish trips from 2009-2023. Trip cost data are not available prior to 2009 when the trip data collection program began.

In 2023, the average cost for a bottomfish trip was \$76 (i.e., lower than \$123 in nominal trip costs in 2022). Fuel price decreased in 2023, and trip cost went down due to reduced fuel usage and price. Supporting data for Figure 10 are presented in Table 27. The cost data summaries were generated by excluding outliers (i.e., cases with >10 gallons/hour fished).

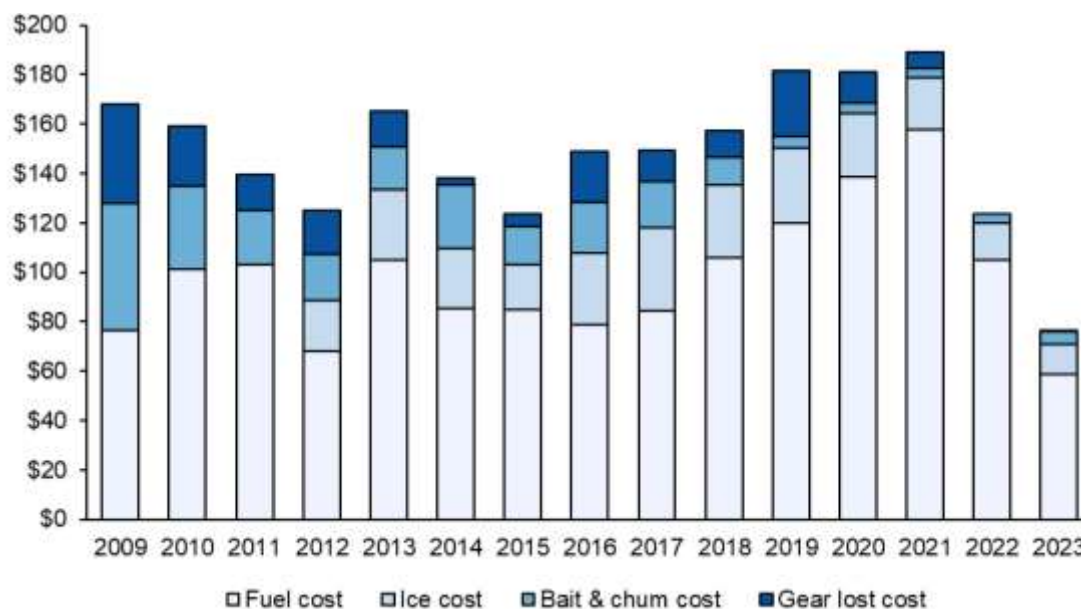


Figure 10. Average costs for American Samoa bottomfish trips (adjusted to 2023 dollars)

Data source: PIFSC Continuous Cost Data Collection Program <https://repository.library.noaa.gov/view/noaa/19758> (Chan and Pan 2019). Trip cost data are not available prior to 2009 when the trip data collection program began. CPI 2023 was not available when the reported was generated.

Table 27. Average and itemized costs for American Samoa bottomfish trips (adjusted to 2023 dollars)

Year	Total trip costs (\$)	Total trip cost adj. (\$)	Fuel cost adj. (\$)	Ice cost adj. (\$)	Bait cost adj. (\$)	Gear lost 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
2023	76	76	59	12	5	0	4.54	1

Data source: PIFSC Continuous Cost Data Collection Program <https://repository.library.noaa.gov/view/noaa/19758> (Chan and Pan 2019). CPI 2023 was not available when the reported was generated.

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 socioeconomic 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 28 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 15,527 pounds (valued at \$63,005) in 2023. The data from 2022 are also presented in the table for comparison. The commercial landings and revenue in 2023 were lower than in 2022. 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 29 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 28. 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)
Humpback snapper	2,556	Blue-banded surgeonfish	6,278	25,498	4.06
Redlip parrotfish	1,363	Parrotfishes	2,563	11,859	4.63
Blue-banded surgeonfish	1,068	Unicornfishes	2,608	10,483	4.02
Bluespine unicornfish	1,067	Groupers	782	3,137	4.01
Redtail parrotfish	967	Snubnose pompano	740	2,660	3.59
Steephead parrotfish	833	Squirrelfishes	644	2,599	4.04
Spiny lobster	776	Striped bristletooth	567	2,335	4.12
Twinspot/red snapper 2	654	Emperors	463	1,852	4.00
Orangespot emperor	521	Tilapia	597	1,428	2.39
Dark-capped parrotfish	509	Inshore groupers	285	1,154	4.05
Sum 2023	10,314		15,527	63,005	4.06
Sum 2022	7,006		2,035	8,078	3.97

Data source: WPacFIN, creel survey data and commercial receipt books.

Table 29. Priority ECS commercial landings, revenue, and price

Year	Common Name	Landings Boat Based Estimated (lbs)	Estimated com. landings (lbs)	% sold	Estimated revenue	Price (\$/lb)
2023	Green spiny lobster	776	37	5%	206	5.57
2023	One-blotch grouper	112				
2023	Fringelip mullet	47				
2023	Bluelined squirrelfish	28				
2022	Green spiny lobster	551	58	11%	232	4.00
2022	One-blotch grouper	90				
2022	Bluelined squirrelfish	46				
2022	Fringelip mullet	23				

Data source: WPacFIN, creel survey data and commercial receipt books.

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/>.

The table below represents the most recent data available for CFEAI metrics for select regional commercial fisheries for 2023. 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 30. Pacific Islands Region 2023 Commercial Fishing Economic Assessment Index

	2023 CFEAI (Current)				
	2023 Reporting Year (e.g. 1/2023-12/2023)				
	Data			Assessment	
Pacific Islands Fisheries	Anticipated Fishing Revenue Most Recent Year	Anticipated Operating Cost Most Recent Year	Anticipated Fixed Cost Most Recent Year	Anticipated Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year	Anticipated Profit Assessment Most Recent Year
HI Longline	2023	2023	2023	2023	2016
ASam Longline	2023	2023	2016	2023	2019
HI Offshore Handline	2023	2021	2021	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	2023	

PIFSC maintained the ongoing economic data collection in American Samoa for small boat fisheries (Chan and Pan 2019) during 2023. 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 completed survey data analysis and results were published in 2023.

PIFSC also generates projections for upcoming fiscal years, and the table below provides the projected CFEAI report for 2024 (*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 2024.

Table 31. Pacific Islands Region 2024 Commercial Fishing Economic Assessment Index

	2024 Projected CFEAI				
	2024 Reporting Year (e.g. 1/2024-12/2024)				
	Data			Assessment	
Pacific Islands Fisheries	Anticipated Fishing Revenue Most Recent Year	Anticipated Operating Cost Most Recent Year	Anticipated Fixed Cost Most Recent Year	Anticipated Returns Above Operating Costs (Quasi Rent) Assessment Most Recent Year	Anticipated Profit Assessment Most Recent Year
HI Longline	2024	2024	2023	2024	2024
ASam Longline	2024	2024	2016	2024	2019
HI Offshore Handline	2024	2021	2021	2019	2019
HI Small Boat (pelagic)	2024	2021	2021	2023	2023
HI Small Boat (bottomfish)	2024	2021	2021	2023	2023
HI Small Boat (reef)	2024	2021	2021	2023	2023
Guam Small boat	2024	2024	2019	2024	
CNMI Small boat	2024	2024	2019	2024	
ASam Small boat	2024	2024	2021	2023	

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 2024.

2.4.7 Relevant PIFSC Economics and Human Dimensions Publications: 2023

Publication	MSRA priority
Ayers A, Leong K, Hospital J, Tam C, Morioka C. 2023. 2022 American Samoa Fisher Observations Data Summary and Analysis. Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-23-14, 14 p. https://doi.org/10.25923/vwj1-3z88	HC3.1.1 HC3.1.3 HC1.1.7
Cai, J, Chan HL, Yan X, Leung PS. 2023 A global assessment of species diversification in aquaculture. <i>Aquaculture</i> 576: 739837. https://doi.org/10.1016/j.aquaculture.2023.739837	HC1.1.6 HC1.1.3
Chan, HL. 2023. Economic Contributions of U.S. Commercial Fisheries in American Samoa. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-151, 35 p. https://doi.org/10.25923/x904-a830	HC1.1.6
Dombrow C, Hospital J. 2023. Economic and Social Characteristics of the American Samoa Small Boat Fishery 2021. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-23-05, 92 p. https://doi.org/10.25923/hqca-xs29 .	HC1.1.1 HC1.1.2 HC1.1.3 HC1.1.8
Dombrow C, Hospital J. 2023. Economic and Social Characteristics of the American Samoa Small Boat Fishery 2021. Pacific Islands Fisheries Science Center, Results Brochure: https://drive.google.com/file/d/1X_Psn3poHbOeO-cJCpTHbdfUmJrgMIY/view?usp=sharing	HC1.1.1 HC1.1.2 HC1.1.3 HC1.1.8
Fisk JJ, Matagi N, Kleiber D. 2023. Gleaning the expanse: Gender and invisibilised dimensions of fisheries in American Samoa. <i>Women in Fisheries Information Bulletin</i> 37, p. 7-10. https://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/WIF/37/WIF37_07_Fisk.pdf	HC1.2.3 HC3.1.3
Nakachi A, Leong K, Mastitski A, Norman K, Weng C, Wise S 2023. Compilation of fishing definitions in NOAA Fisheries law and policy Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-23-16, 43 p. https://doi.org/10.25923/tkqr-bq21	HC1.2.1
Parke M, Lumsden B, Beidron I, Rykaczewski R, Woodworth-Jefcoats P, Wren J, Tanaka K, Ahrens R, Ruzicka J, O'Malley J, Trianni M, Oleson E, Barbeiri M, Allen C, Bradford A, Robinson S, Gaos A, Leong K, Fisk J, Gove J, Whitney J. 2023. Ecosystem-based Fisheries Science in a Data-limited Region. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-141, 37 p. https://doi.org/10.25923/2aec-eb81	IF8.1.1 IF8.1.8 HC2.1.2
Perng LY, Walden J, Leong KM, DePiper GS, Speir C, Blake S, Norman K, Kasperski S, Weijerman M, Oleson KLL. 2023. Identifying social thresholds and measuring social achievement in social-ecological systems: A cross-regional	HC2.1.2 HC2.1.4

comparison of fisheries in the United States. Marine Policy (152): 105595. https://doi.org/10.1016/j.marpol.2023.105595	
Thunberg, E., A. Kitts, G. Ardini, HL Chan. A. Chen, B. Garber-Yonts, J. Hilger, C. Hutt, C. Liese, S. Lovell, M. McGregor, M. Pan, D. Records, G. Silva, E. Steiner, S. Stohs, M. Travis, S. Werner, and S. Warpinski. 2023. A Snapshot Update of NOAA Fisheries Data Collection of Commercial and For-Hire Fishery Costs and Earnings. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-F/SPO-245, 71 p. https://spo.nmfs.noaa.gov/content/tech-memo/snapshot-update-noaa-fisheries-data-collection-commercial-and-hire-fishery-cost	HC1.1.1
White House Subcommittee on Ocean Science and Technology (SOST) - Interagency Working Group on Ocean Acidification (IWG-OA). 2023. Ocean Chemistry Coastal Community Vulnerability Assessment. Pacific Islands Chapter. https://oceanacidification.noaa.gov/wp-content/uploads/2023/08/IWGOA_Vulnerability_Assessment_2023.pdf	HC1.1.5 HC2.2.1
Woodworth-Jefcoats P, Jacobs A, Ahrens R, Barkley H, Barlow A, Bolen L, Carvalho F, Chung A, Crigler E, DeMello J, Fitchett M, Fox M, Asuka I, Larin P, Lumsden B, Makaiau J, McGregor M, Oliver T, O'Malley J, Richards B, Robinson S, Sabater M, Sculley M, Seeley M, Sweeney J, Tanaka K, Taylor K, Yamada Z 2023. Pacific Islands Regional Action Plan to implement the NOAA Fisheries Climate Science Strategy Through 2024 U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-142, 35 p. https://doi.org/10.25923/2jjs-tx42	HC2.2.1 HC2.2.2 HC3.1.2

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 32.

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 32. 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 2024 LOF (89 FR 12257, February 16, 2024) 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 2.5.1.2, 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 33 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 33. 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/Other	Recovery Plan
Oceanic whitetip shark	<i>Carcharhinus longimanus</i>	Positive (81 FR 1376, 1/12/2016)	Positive, threatened (81 FR 96304, 12/29/2016)	Listed as threatened (83 FR 4153, 1/30/2018)	<u>Critical habitat:</u> Designation not prudent; no areas within U.S. jurisdiction that meet definition of critical habitat (85 FR 12898, 3/5/2020) <u>Other:</u> Protective regulations under ESA 4(d) proposed (89 FR 41917, 5/14/2024)	Draft Recovery Plan published January 25, 2023 (88 FR 4817)
Chambered nautilus	<i>Nautilus pompilius</i>	Positive (81 FR 58895, 8/26/2016)	Positive, threatened (82 FR 48948, 10/23/2017)	Listed as threatened (83 FR 48876, 9/28/2018)	<u>Critical habitat:</u> 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	<i>Manta birostris</i>	Positive (81 FR 8874, 2/23/2016)	Positive, threatened (82 FR 3694, 1/12/2017)	Listed as threatened (83 FR 2916, 1/22/2018)	<u>Critical habitat:</u> 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.

Species		Listing Process			Post-Listing Activity	
Common Name	Scientific Name	90-Day Finding	12-Month Finding / Proposed Rule	Final Rule	Critical Habitat/Other	Recovery Plan
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, withdrawn), Critical habitat proposed (88 FR 83644, November 30, 2023)comment period extended through 5/26/2021 (86 FR 16325)	In development, interim recovery outline in place; recovery workshops convened in May 2021.
Giant clams	<i>Hippopus</i> , <i>H. porcellanus</i> , <i>Tridacna costata</i> , <i>T. derasa</i> , <i>T. gigas</i> , <i>T. Squamosa</i> , and <i>T. tevoroa</i>	Positive (82 FR 28946, 06/26/2017)	TBA (status review ongoing)	TBA	N/A	N/A
Green sea turtle	<i>Chelonia mydas</i>	Positive (77 FR 45571, 8/1/2012)	Identification of 11 DPSs, endangered and threatened (80 FR 15271, 3/23/2015)	11 DPSs listed as endangered and threatened (81 FR 20057, 4/6/2016)	Critical habitat proposed (88 FR 46572, 07/19/2023)	TBA

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

2.5.4 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

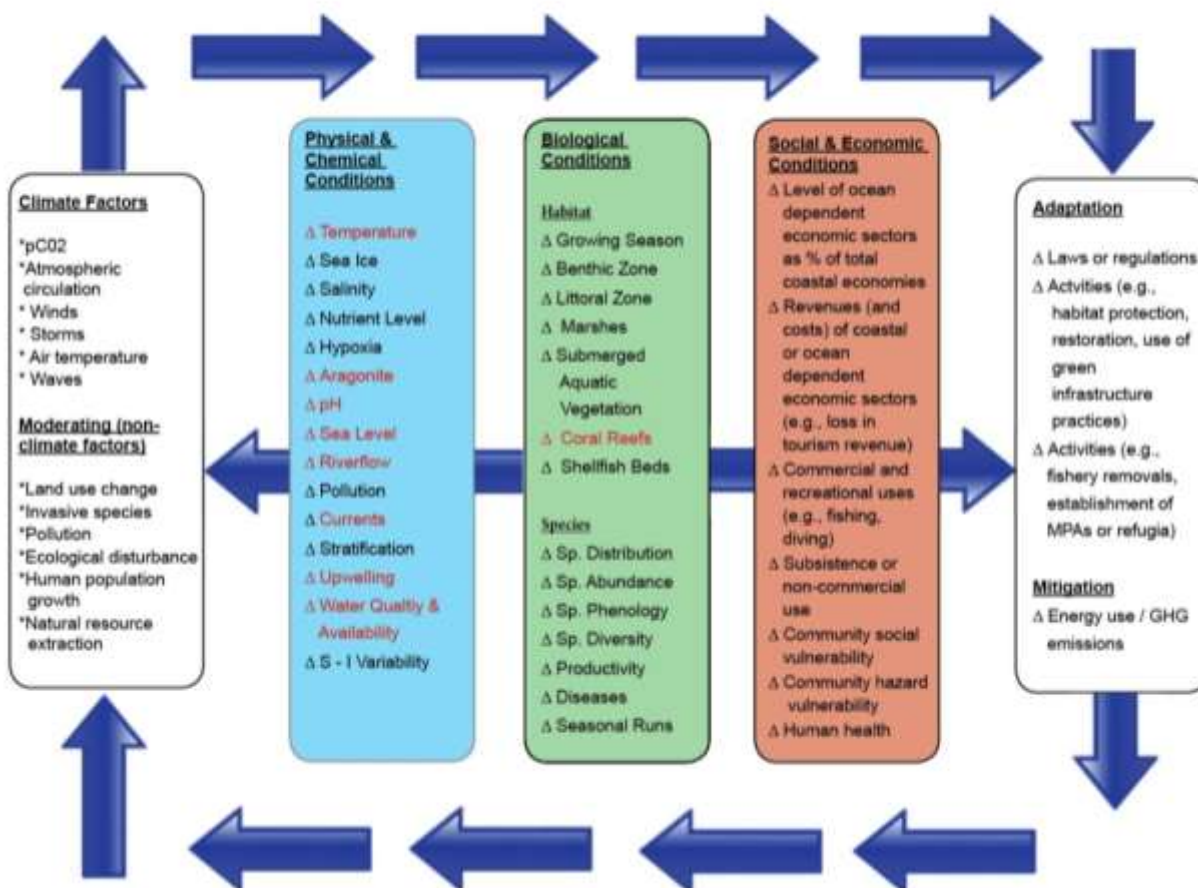
In developing this chapter, the Council relied on a number of recent reports conducted in the context of the U.S. National Climate Assessment including, most notably, the 2012 Pacific Islands Regional Climate Assessment (PIRCA) and the Ocean and Coasts chapter of the 2014 report on a Pilot Indicator 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 11).

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

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

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



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

Figure 11. 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 (CO₂)
- 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 12 and Figure 13 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.

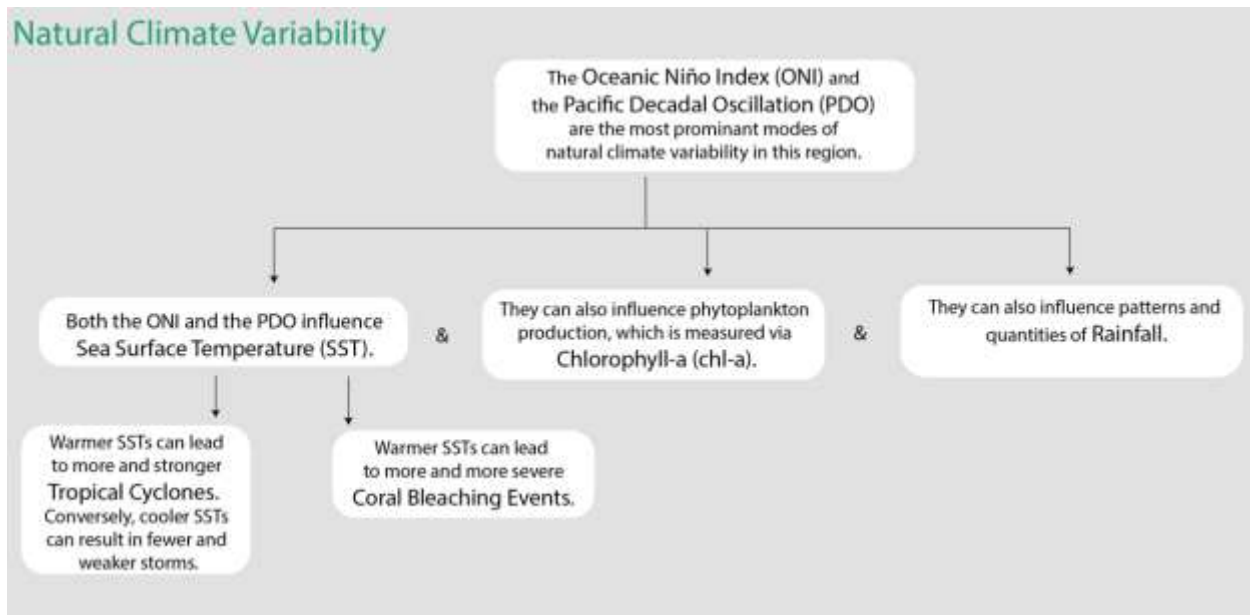


Figure 12. Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of natural climate variability

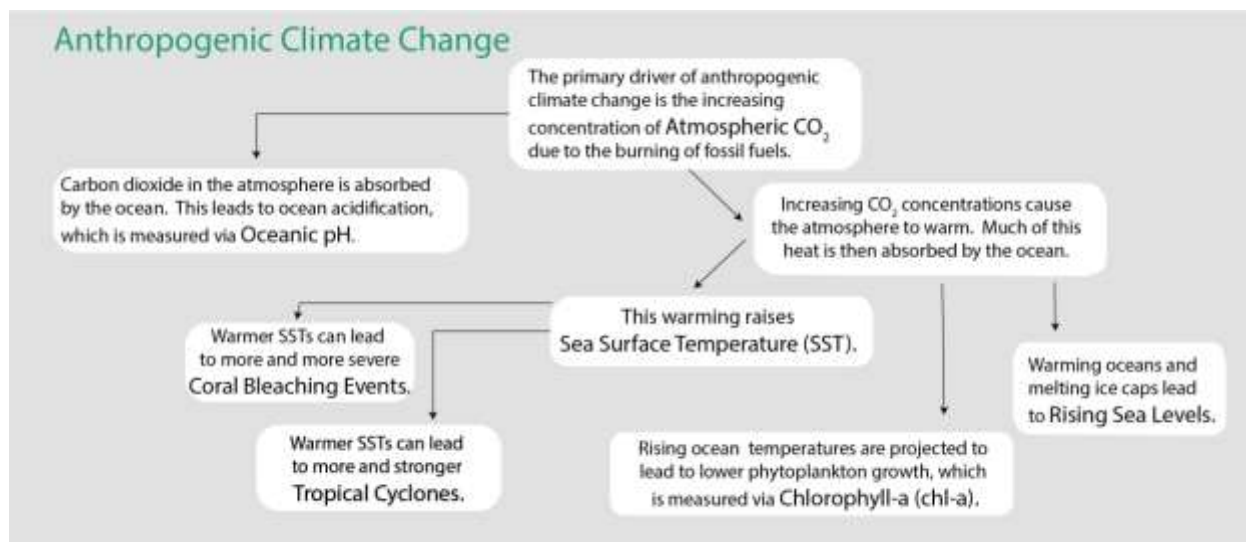


Figure 13 Schematic diagram illustrating how indicators are connected to one another and how they vary as a result of anthropogenic climate change

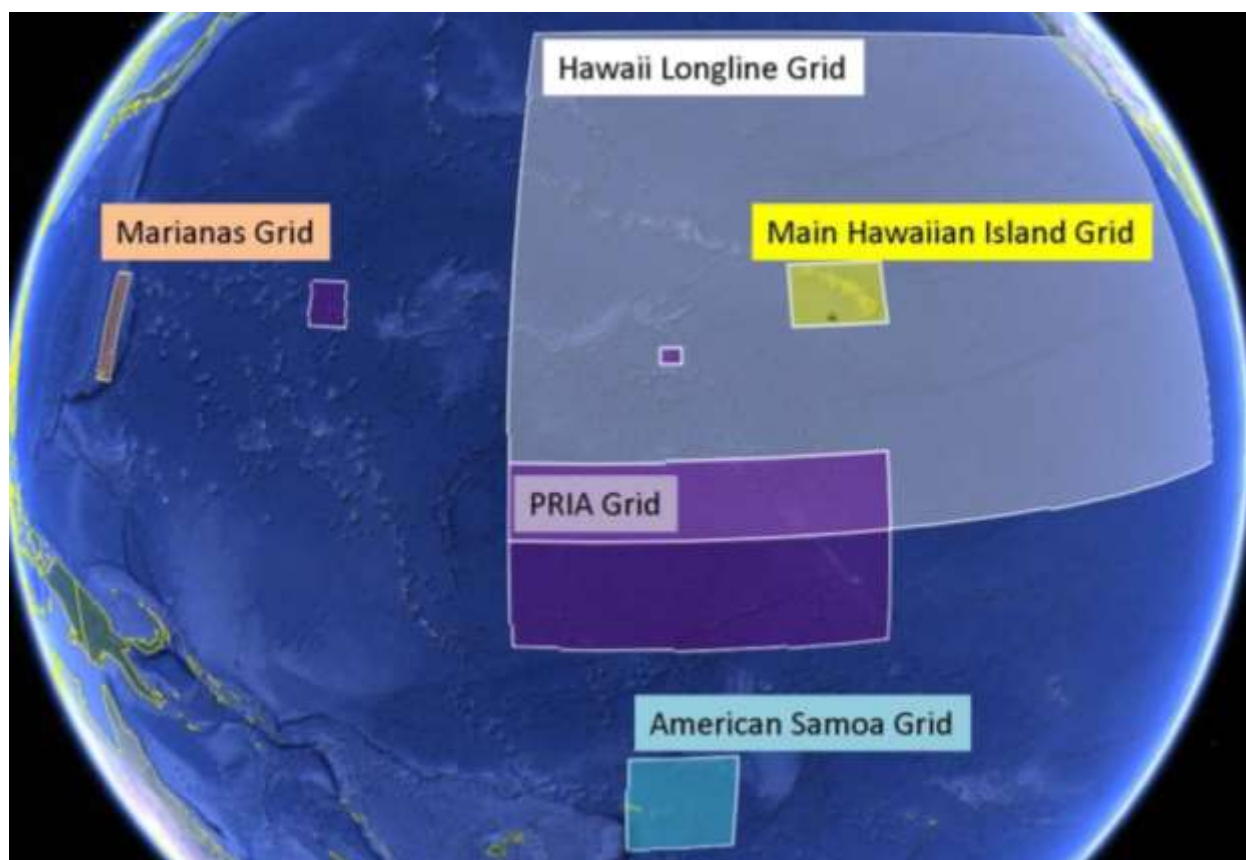


Figure 14. Regional spatial grids representing the scale of the climate change indicators being monitored

2.6.4.1 Atmospheric Concentration of Carbon Dioxide at Mauna Loa

Rationale: Atmospheric carbon dioxide (CO₂) 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 CO₂ is increasing exponentially. This means that atmospheric CO₂ is increasing more quickly over time. In 2023, the annual mean concentration of CO₂ was 421.08 ppm. This is the highest annual value recorded. This year also saw the highest monthly value, which was 424 ppm. In 1959, the first year full of the time series, the atmospheric concentration of CO₂ was 316 ppm. The annual mean passed 350 ppm in 1988, and 400 ppm in 2015.

Description: Monthly mean atmospheric CO₂ 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 CO₂ 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 CO₂ is removed from the atmosphere. In the winter (outside the growing season), respiration exceeds photosynthesis, and CO₂ 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, Hawai‘i, but representative of global atmospheric carbon dioxide concentration. Note that due to the eruption of the Mauna Loa Volcano, measurements from Mauna Loa Observatory were suspended as of 29 November 2022. Observations from December 2022 to 4 July 2023 are from a site at the Maunakea Observatories, approximately 21 miles north of the Mauna Loa Observatory. Mauna Loa observations resumed in July 2023.

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 (2023).

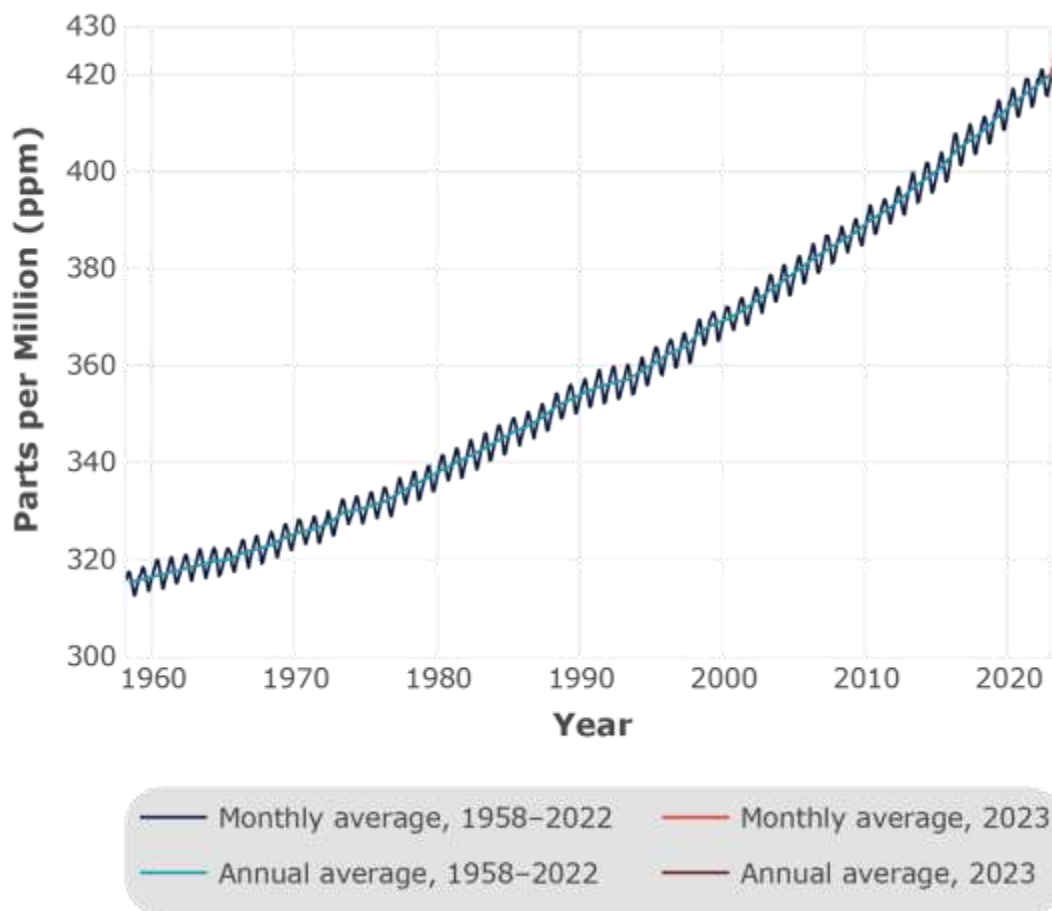


Figure 15. Monthly mean (black) and seasonally corrected (blue) atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii

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 11.3% more acidic than it was 30 years ago at the start of this time series. Over this time, pH has declined by 0.047 at a constant rate. In 2022, the most recent year for which data are available, the average pH was 8.05. Additionally, for the 7th 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 (8.058) is lower than the lowest pH value reported in the first year of the time series (8.083).

Description: Trends in surface (5 m) pH at Station ALOHA, north of Oahu (22.75°N, 158°W), collected by the Hawai'i Ocean Time-Series (HOT) from October 1988 to 2022 (2023 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 CO₂ and the amount of CO₂ 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 2024) using the methodology provided by Zeebe and Wolf-Gladrow (2001). Graphics produced in part using Stawitz (2023).

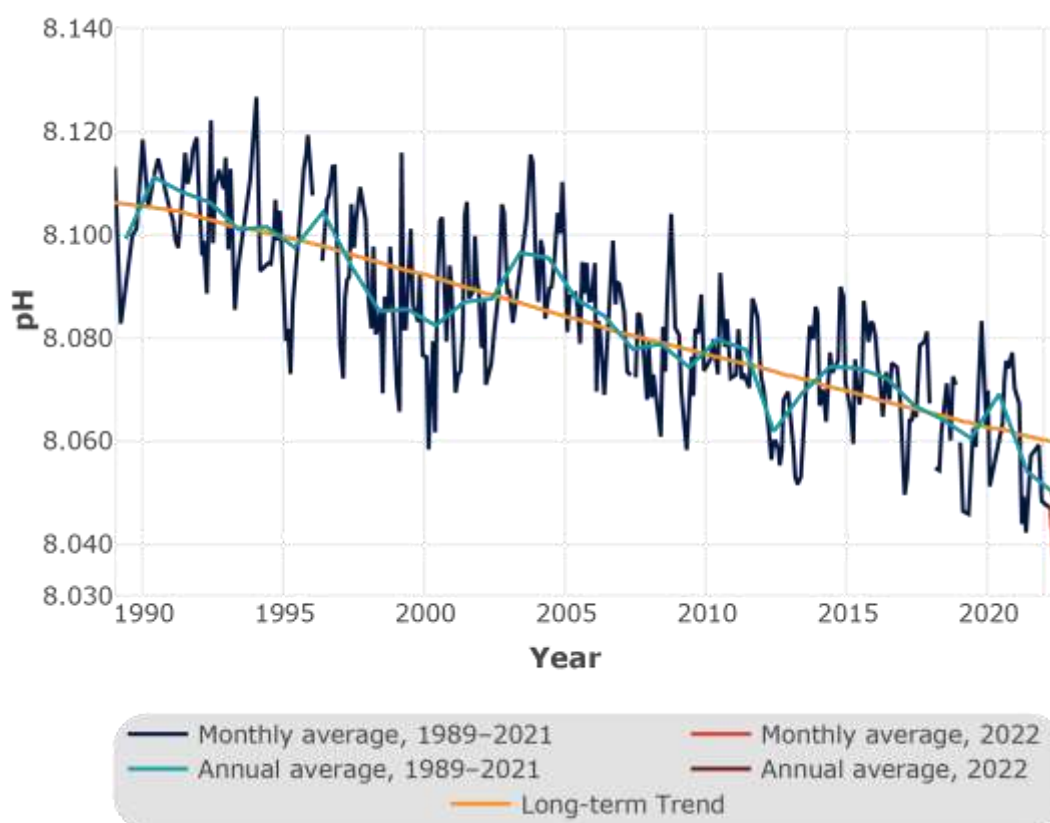


Figure 16. Time series and long-term trend of oceanic pH measured at Station ALOHA

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 a transition from La Niña to El Niño conditions in 2023. In 2023, the ONI ranged from -0.68 to 1.95. 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 (2024). Graphics produced in part using Stawitz (2023).

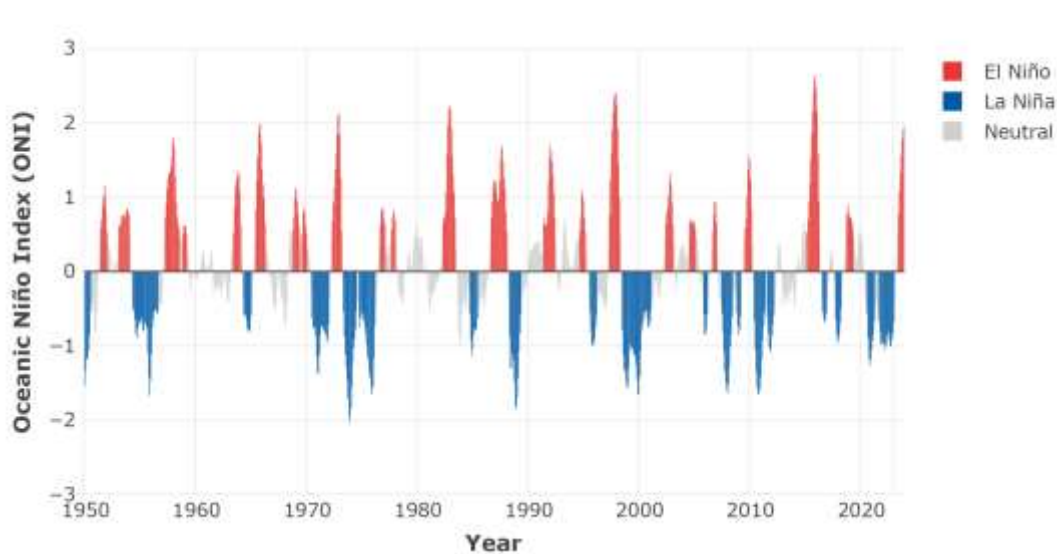


Figure 17. Oceanic Niño Index from 1950–2023 El Niño periods in red, La Niña periods in blue, and neutral periods in grey

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 2023. The index ranged from -2.47 to -0.949 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 (2024b).

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 (2024b), Mantua (1997), and Newman (2016). Graphics produced in part using Stawitz (2023).

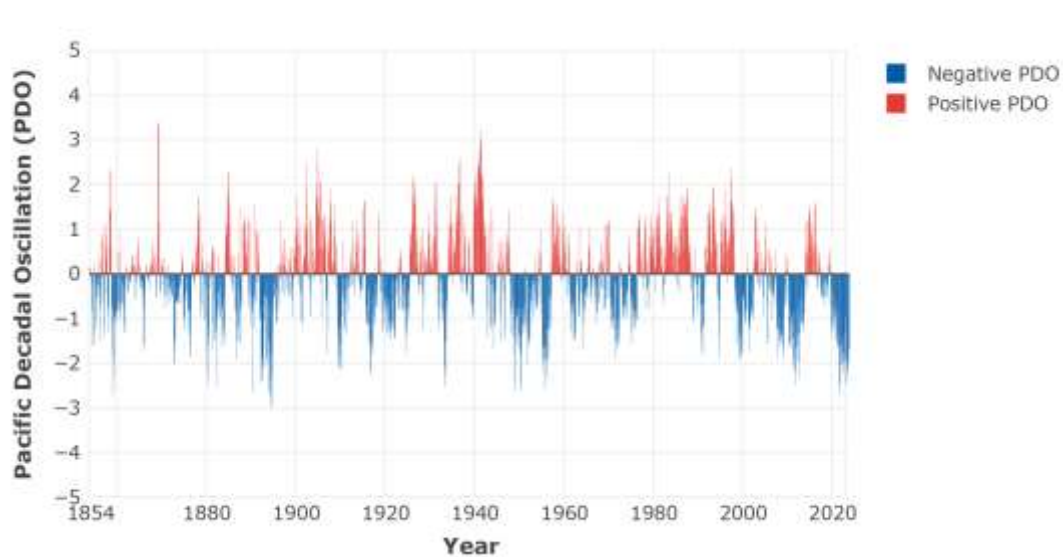


Figure 18. Pacific Decadal Oscillation from 1854–2023 with positive warm periods in red and negative cool periods in blue

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

Status:

Eastern North Pacific. Tropical cyclone activity was slightly above average in the Eastern Pacific in 2023. There were 17 named storms, 10 of which were hurricanes. There were 8 major hurricanes (category 3 or higher). The number of named and major storms, as well as Accumulated Cyclone Energy (ACE), were slightly the above 1991–2020 average.

Central North Pacific. In July, Hurricane Calvin became a major hurricane as it moved from Mexico towards Hawai‘i. Calvin led to tropical storm warnings in Hawai‘i but caused minimal damage. Of note in 2023 was Hurricane Dora, which formed in the Eastern Pacific on 31 July 2023, crossed into the Central Pacific on 6 August 2023, and carried on westward into the Western Pacific on 12 August 2023. Overall, Central Pacific tropical cyclone activity was below the 1991–2020 average in 2023. There were 2 named storms, one of which—Dora—reached hurricane status and became a major hurricane. On average (1991–2020), the central Pacific sees four named storms, two hurricanes, and one major hurricane each year. The 2023 ACE index was slightly above the 1991–2020 average. Portions of this summary inserted from <https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202307>.

Western North Pacific. Typhoon Mawar, which formed in May, was just the third category 4 (winds ≥ 130 mph) typhoon to pass within 100 miles of Guam in the Western Pacific. It was the first major typhoon in that area since Mangkut in 2018. Mawar resulted in heavy rainfall and widespread power outages on the island. Despite Typhoon Mawar, tropical cyclone activity in the Western Pacific was below average. The Western Pacific saw the second-fewest named storms since 1951, with only 17 forming in 2023. Of these storms, 12 were typhoons and 8 became major typhoons. These counts were all below average (1991–2020), as was the ACE. Since 1980, the number of named storms and typhoons to form each year has decreased slightly at a rate of about 1 storm per decade. Portions of the summary inserted from <https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202305>, and <https://www.ncei.noaa.gov/access/monitoring/monthly-report/tropical-cyclones/202313>.

South Pacific. South Pacific tropical cyclone activity was below average in 2023. There were 6 named storms, 3 of which became cyclones and 2 major cyclones. The 2023 ACE was less than the 1991–2020 average.

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 19 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 20 shows the ACE values for each hurricane/typhoon season and has a horizontal line representing the average annual ACE value.

Timeframe: Annual.

Region/Location:

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

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

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

South Pacific: south of the equator.

Measurement Platform: Satellite.

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

Sourced from: Knapp et al. (2010), Knapp et al. (2018), and NOAA (2024c).

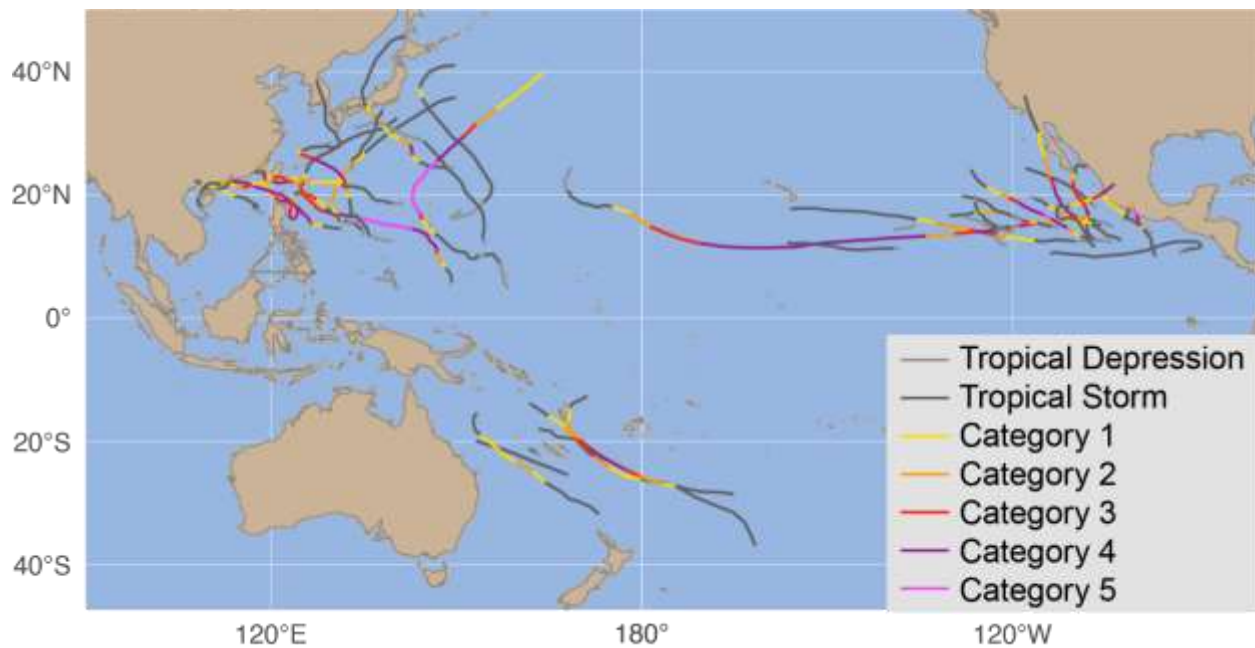


Figure 19. 2023 Pacific basin tropical cyclone tracks

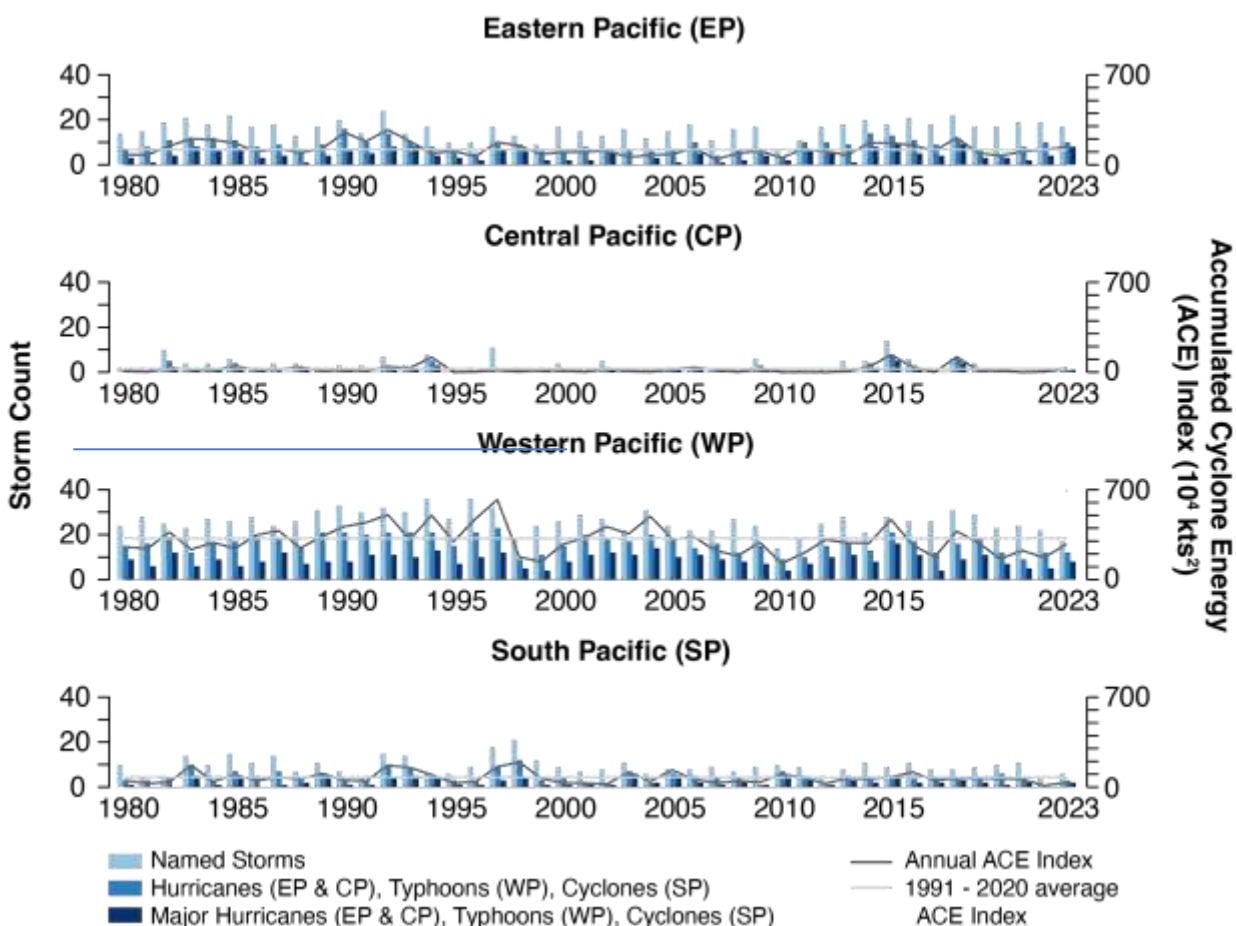


Figure 20. Storm counts (bars) and Accumulated Cyclone Energy (ACE) index values (lines) in each region of the Pacific. Both annual ACE index (black lines) and 1991–2020 average ACE index (grey lines) are shown

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 28.90 °C in 2023. Over the period of record, annual SST has increased at a rate of 0.020 °C/yr. Monthly SST values in 2023 ranged from 28.29–29.57 °C, within the range of temperatures seen (26.55–29.96 °C) over the previous years of the time series (1985–2022). The annual anomaly was 0.47 °C warmer than the reference (1985–2009) climatology, with areas of stronger warming in the southwest part of the region.

Note that from the top to bottom in Figure 21, panels show climatological SST (1985–2009), 2023 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 2024c).

Timeframe: Monthly.

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

Measurement Platform: Satellite.

Sourced from: NOAA OceanWatch (2024a).

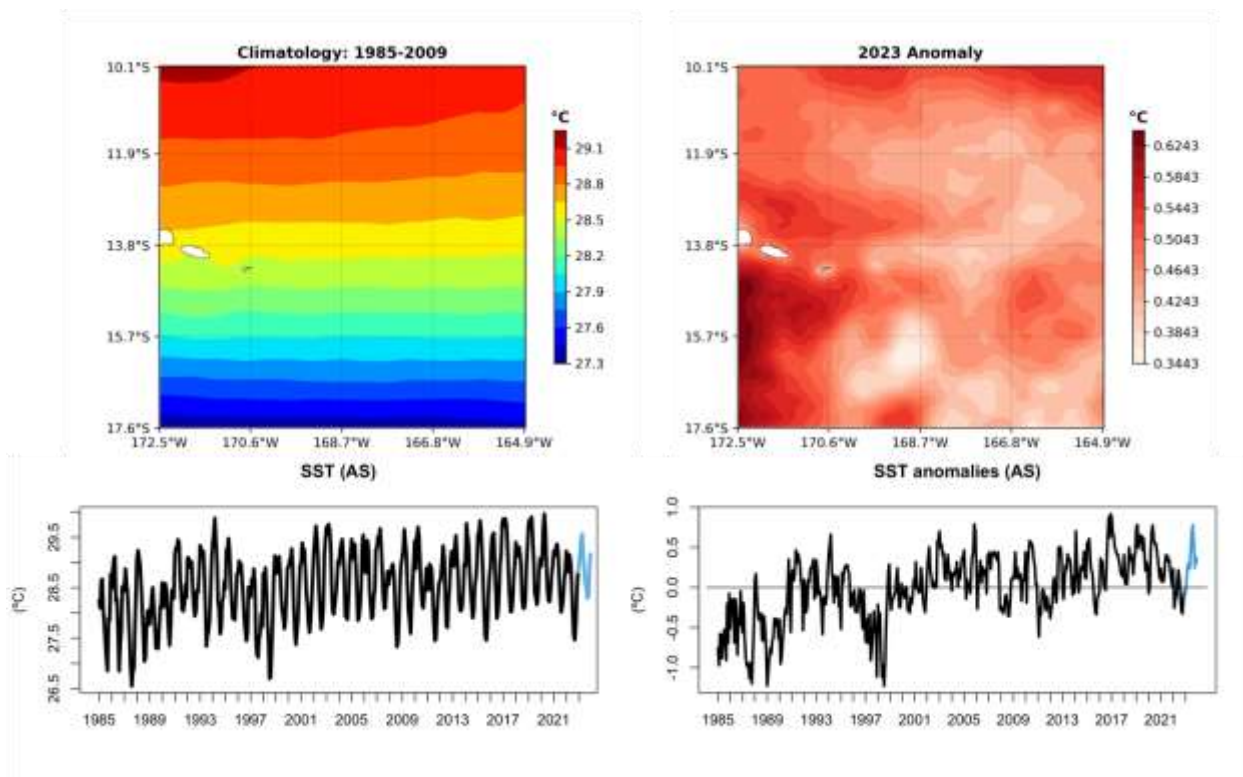


Figure 21. Sea surface temperature climatology and anomalies from 1985–2023

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 another coral heat stress at the end of 2023 with mass bleaching expected.

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: 2014–2023, daily data.

Region/Location: Global.

Sourced from: NOAA Coral Reef Watch (2024).

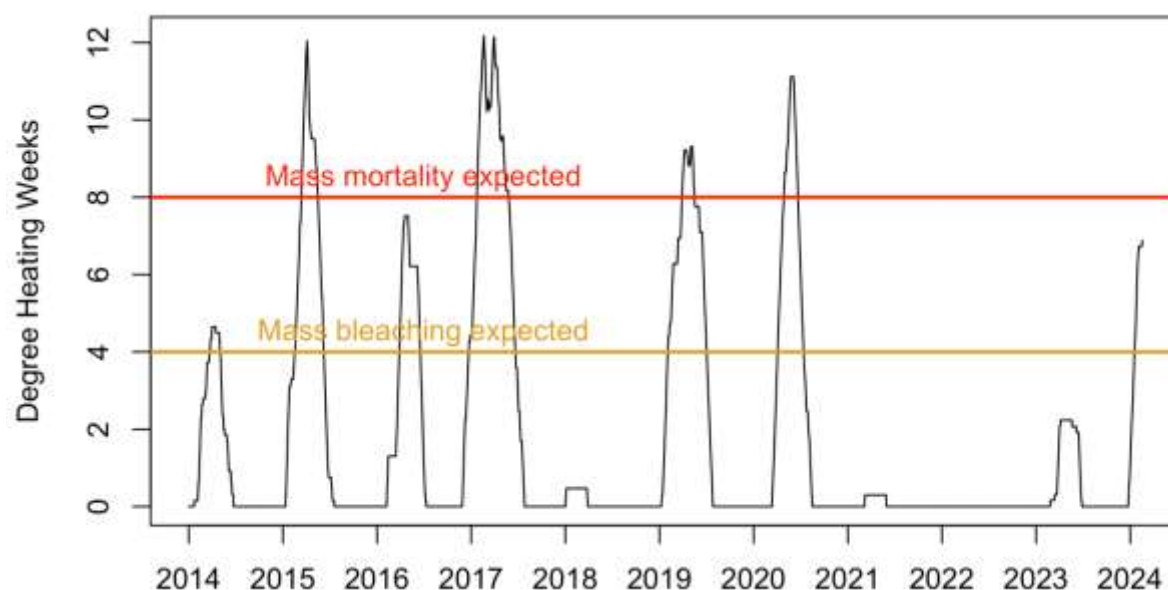


Figure 22. Coral Thermal Stress Exposure measured at Samoa Virtual Station 2014–2023 (Coral Reef Watch Degree Heating Weeks)

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 0.060 mg/m³ in 2023. Over the period of record, annual chlorophyll-*a* has shown no significant temporal trend. Monthly chlorophyll-*a* values in 2023 ranged from 0.054–0.067 mg/m³, within the range of Chl-A concentrations seen (0.037–0.088 mg/m³) over the previous years of the time series (1998–2022). The annual anomaly was 0.0033 mg/m³ higher than the reference (1998–2009) climatological values, with an area of below average chlorophyll concentration in the northwest and southern boundary of the region.

Description: Chlorophyll-*a* concentration from 1998–2023 were derived from the ESA Ocean Color Climate Change Initiative dataset, v6.0. A monthly climatology was generated across the entire period to provide an anomaly time series. An annual anomaly was generated in reference to the 1998–2009 climatology to provide a 2023 spatial anomaly.

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: 1998–2023, daily data available, monthly means shown.

Region/Location: Global.

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

Sourced from: NOAA OceanWatch (2024b).

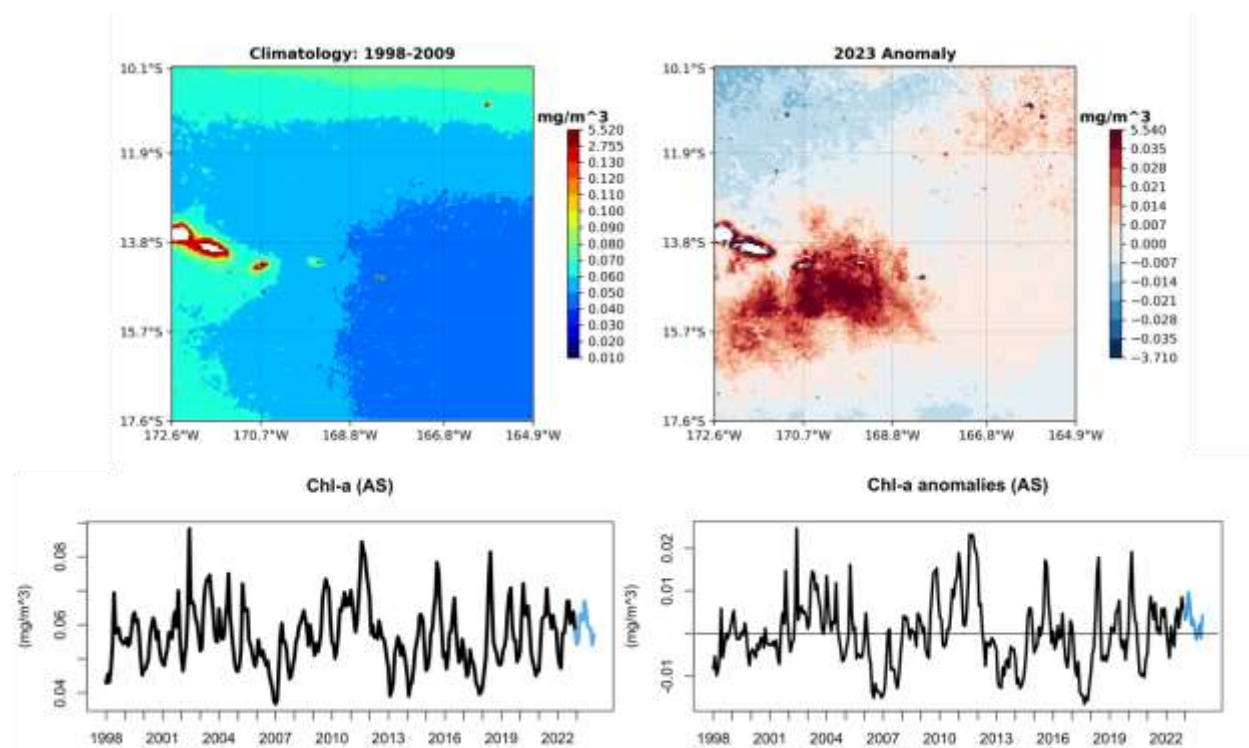


Figure 23. Chlorophyll-*a* and Chlorophyll-*a* Anomaly from 1998–2023

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 (2024).

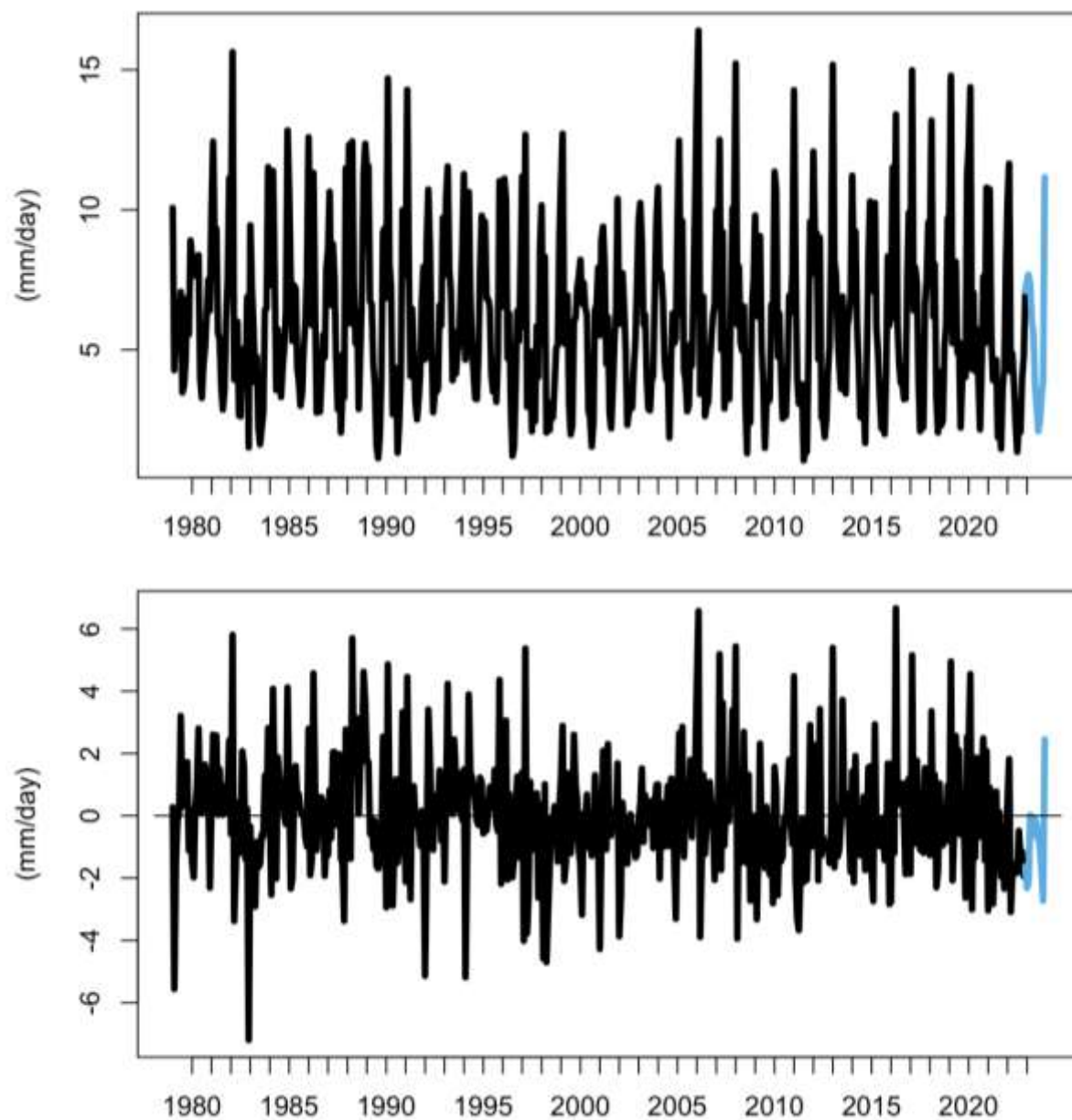


Figure 24. CMAP precipitation (top) and anomaly (bottom) across the American Samoa Longline Grid with 2023 values in blue

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 (2024), NOAA (2024d), and NOAA CoastWatch (2024).

2.7.4.10.1 Basin-Wide Perspective

- 3 This image of the mean sea level anomaly for May 2023 compared to 1993-2020 climatology from satellite altimetry shows the onset of the 2023 El Niño conditions across the Pacific Basin. The image captures the fact that sea level is higher in the Eastern and Central Pacific and lower in the Western Pacific (this basin-wide perspective provides a context for the location-specific sea level/sea surface height images that follow).

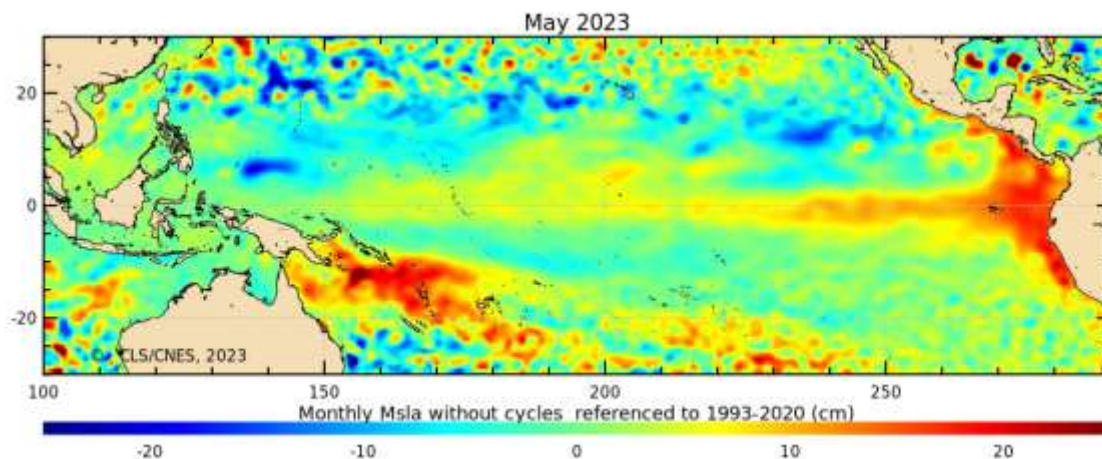


Figure 25a. Sea surface height and anomaly

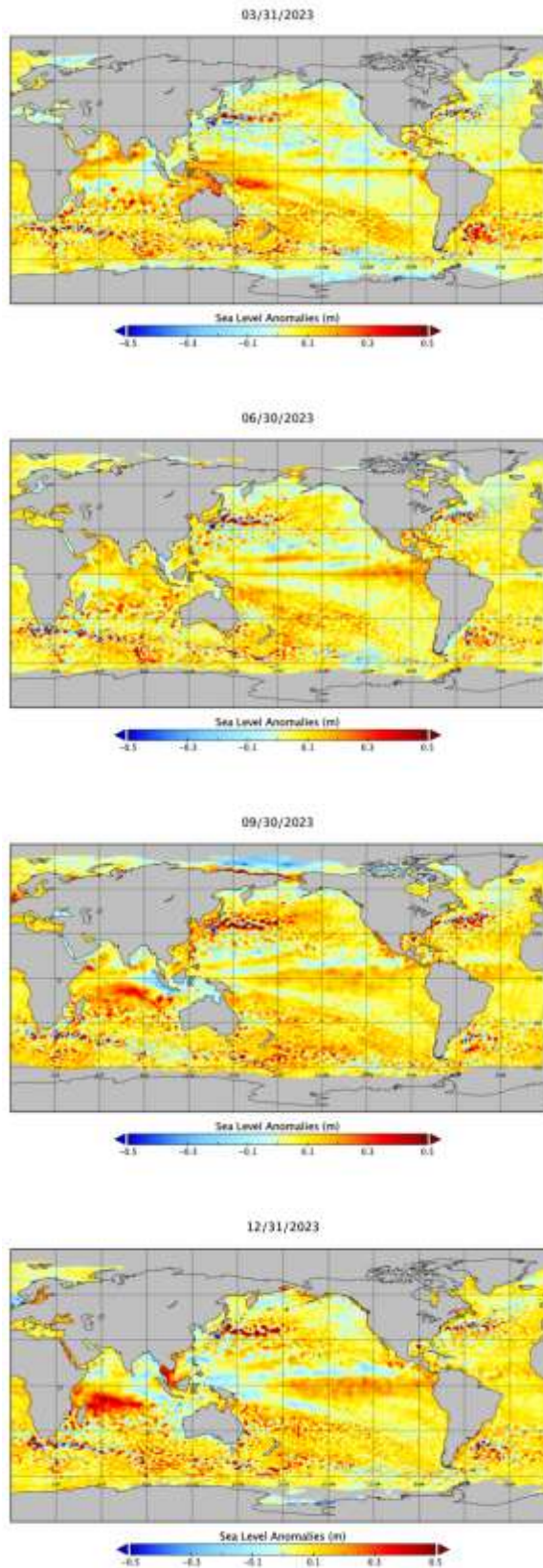


Figure 24b. Quarterly time series of mean sea level anomalies during 2023

Altimetry data are provided by the NOAA Laboratory for Satellite Altimetry, accessed from NOAA CoastWatch (2024).

3.5.3.9.1 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 26 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 17.52 millimeters/year with a 95% confidence interval of ± 6.32 mm/yr based on monthly mean sea level data from 2009 to 2023 which is equivalent to a change of 5.75 feet in 100 years. The trend is based only on data after 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 2024d).

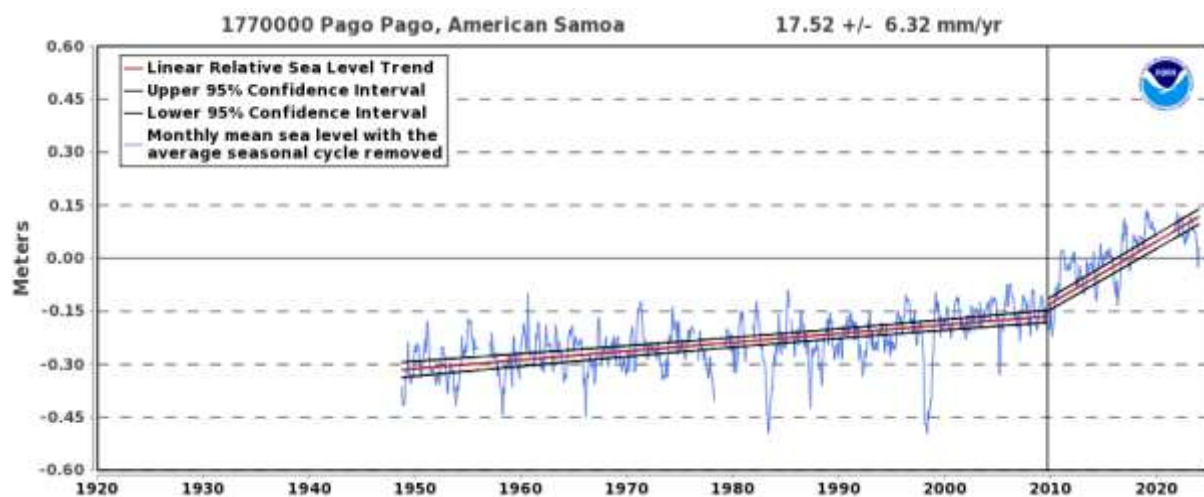


Figure 26. Monthly mean sea level without regular seasonal variability due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents

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 2.7.4;
- Updated research and information needs, which can be found in Section 2.7.6. 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.

At its 194th meeting, the Council heard a report on Archipelagic Plan Team (APT) discussion regarding changes to EFH related to the proposed revision of the American Samoa BMUS list. The APT noted that the proposed action to revise the BMUS would have little effect on the designation of EFH required to be specified in the American Samoa FEP. The APT recommended revising EFH definitions to reflect the proposed deep-water BMUS to be added to the lists, improving EFH definitions for all life stages of all BMUS where possible, and removing EFH definitions for shallow-water BMUS transitioning to ECS as a result of the proposed action.

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 km²) 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 27). 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.

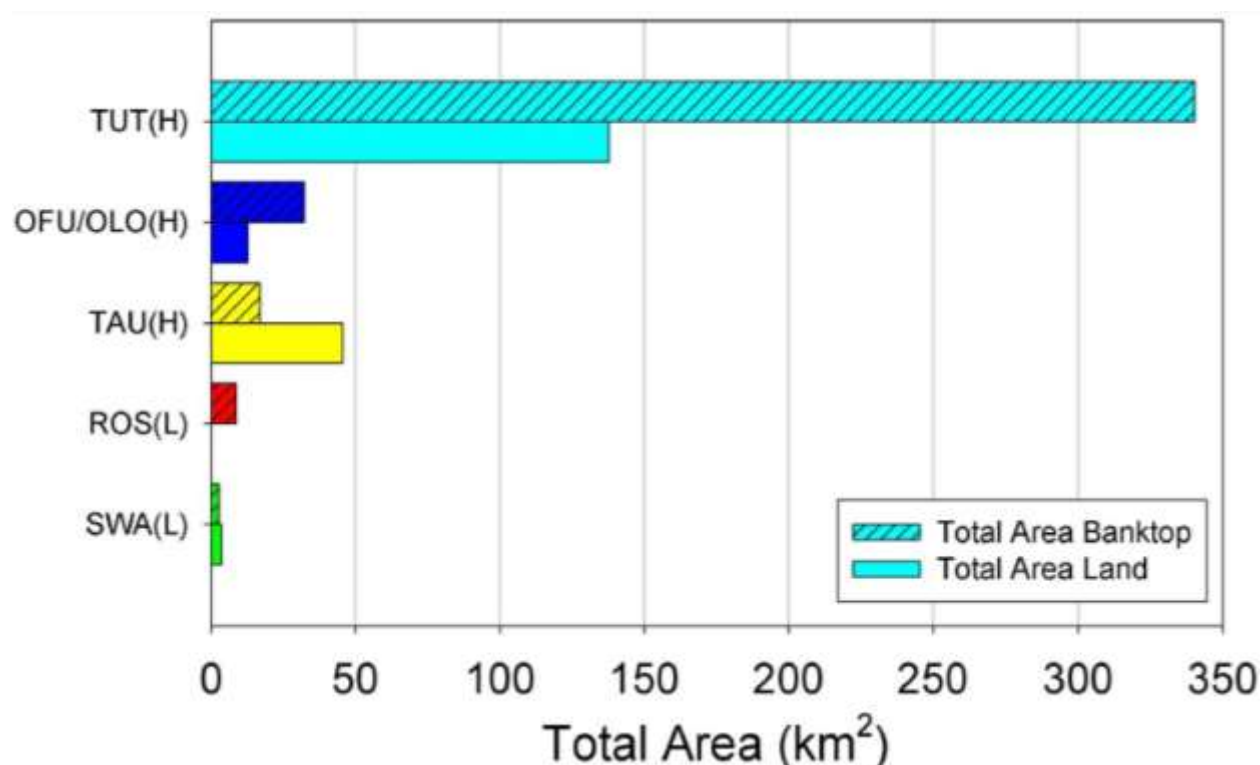


Figure 27. Bank top and terrestrial land area on high (H) or low (L) islands of Tutuila and Aunu'u (TUT), Ofu and Olosega (OFU/OLU), Ta'u (TAU), Rose (ROS), and Swains (SWA)

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 2023.

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 part of the National Coral Reef Monitoring Program (NCRMP) by the PIFSC ESD. The NOAA PIFSC ARP conducted an NCRMP survey in 2023, generating a new stream of EFH-relevant data for

the region (see Section 2.2). This survey is a randomized fishery-independent reef fish survey in shallow waters from 0-30 m depth.

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 2023 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 34. The designated areas of EFH and HAPC for American Samoa FEP bottomfish by life stage are summarized in Table 35. 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 2023.

Table 34. Level of EFH information available for American Samoa BMUS

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

Table 35. EFH and HAPC for American Samoa BMUS

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

American Samoa BMUS	EFH	HAPC
<i>P. zonatus</i> (snapper)		
<i>Variola louti</i> (lunartail grouper)		

2.7.5 Project Updates

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 American 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 36 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 28.

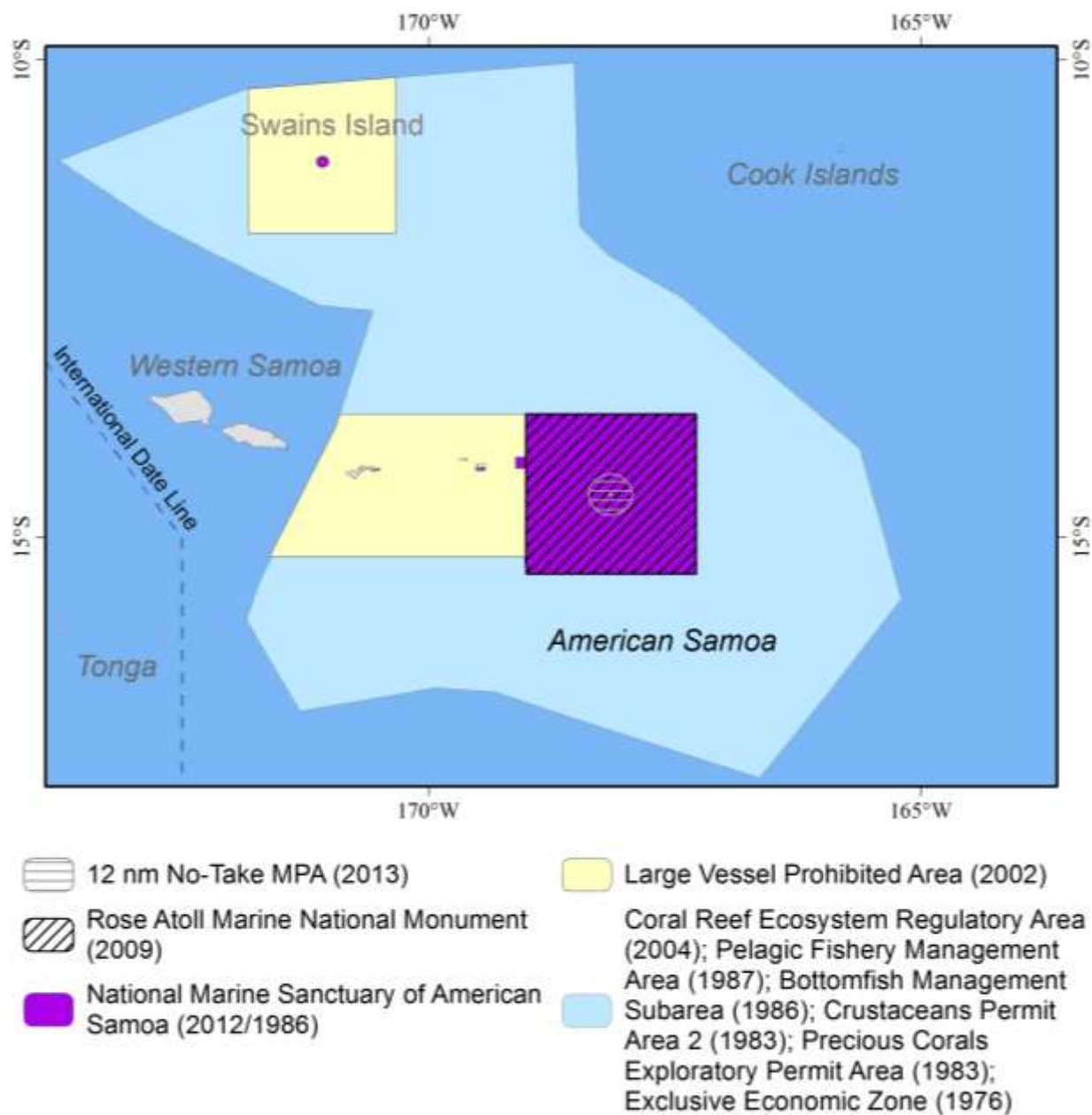


Figure 28. Regulated fishing areas of American Samoa

Table 36. 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.

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

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 discretely 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 2.6.4). 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 lowered 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 2.6.4). 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 2.6.4 in 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 29. 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.

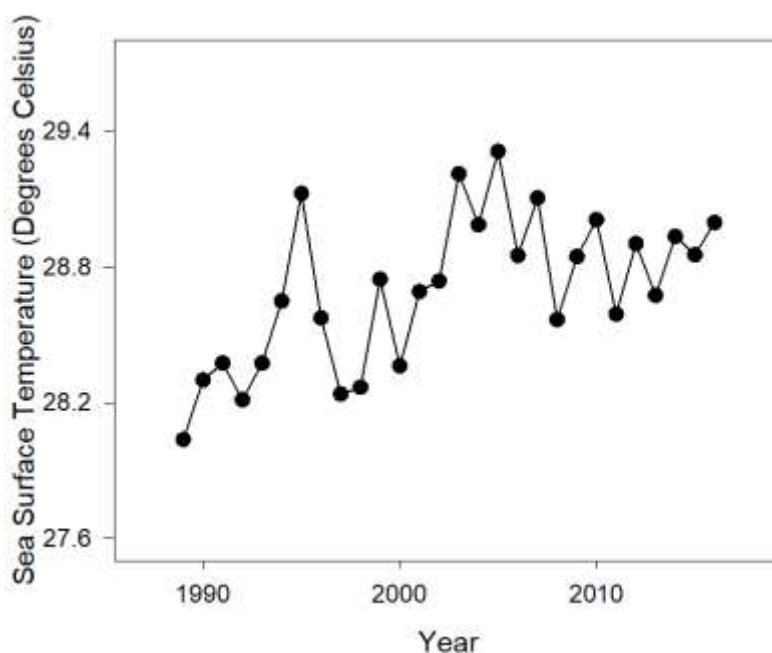


Figure 29. Average annual SST ($^{\circ}\text{C}$) in American Samoa from 1985-2016 ($CV = 1.15$)

3.3.1 Evaluating relationship for entire coral reef fishery

Figure 30 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 30).

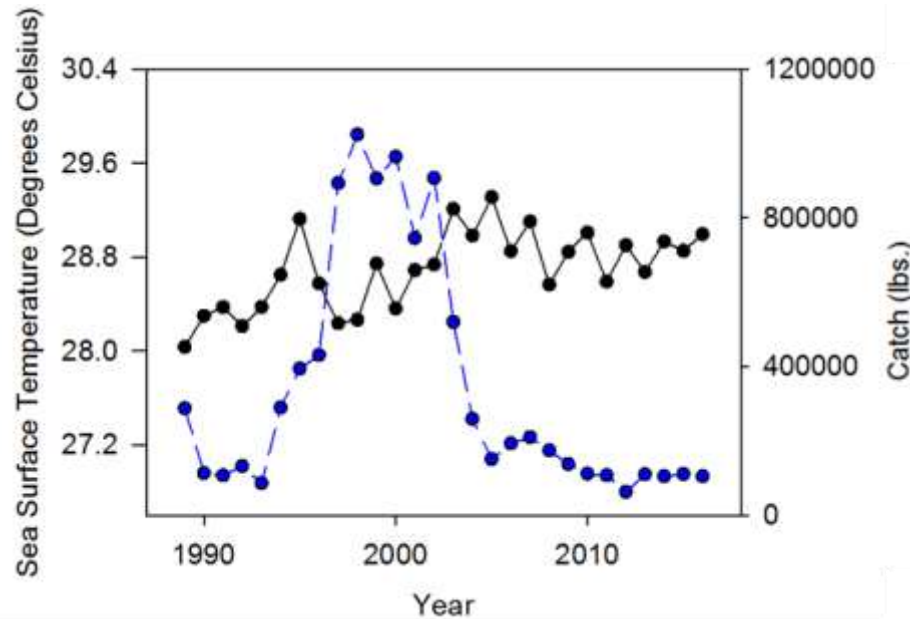


Figure 30. Total annual catch (lb; blue) for the American Samoa coral reef fishery plotted with average annual SST (°C; black) from 1989-2016

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 37 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 37. 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 38). 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 38; Figure 31). The observed association between the two parameters appeared to associate negatively over time despite the lack of a statistically significant trend (Figure 31).

Table 38. Correlation coefficients (r) between the coral reef fishery catch (lb) and SST ($^{\circ}\text{C}$) in American Samoa for 12 taxa harvested from 1989-2016; significant correlations are indicated in bold ($\alpha=0.05$)

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

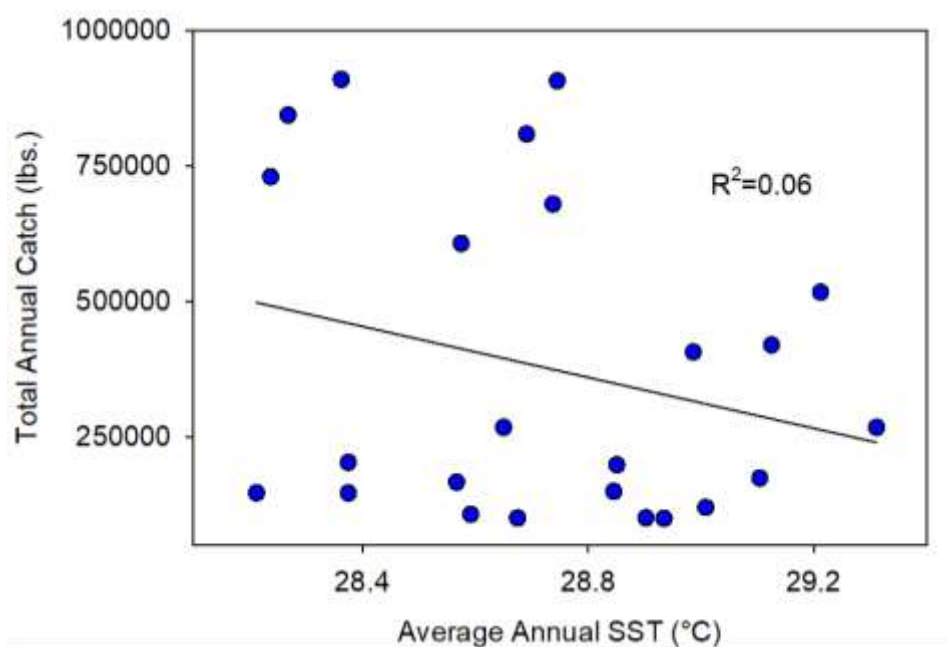


Figure 31. Linear regression showing the correlation between total annual catch (lb) for the coral reef fishery and average annual sea surface temperature (°C) in American Samoa from 1989-2016

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 38). 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 38; Figure 32a). 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 38; Figure 32b). 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 38; Figure 32c). 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.

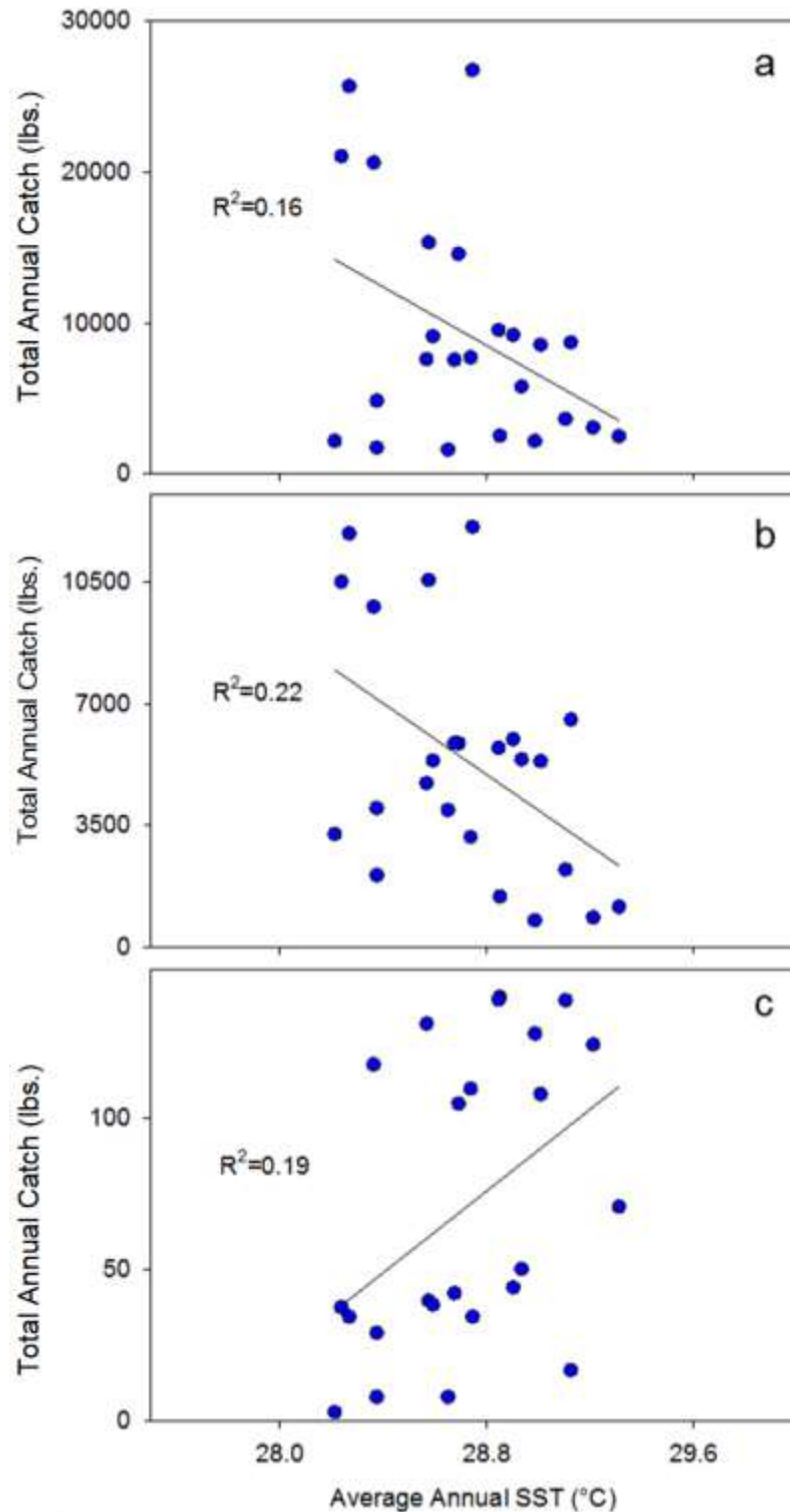


Figure 32. Linear regressions showing the three top correlations between total annual catch (lb) for the coral reef fishery and average annual SST (°C) in American Samoa for (a) Acanthurids, (b) Scarids, and (c) Mullids from 1989-2016

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 physiochemistry of nearshore reefs can especially be impacted by nutrient input accompanying precipitation and result in increased primary production (Ansell et al. 1996).

Long-term changes in regional primary productivity have the potential to change reef fish population abundance due to the susceptibility of these assemblages in shallow areas of coastal reefs to variations in water chemistry, especially when combined with the variability of other environmental parameters like sea surface temperature (Kitiona et al. 2016). For example, it has been suggested that warming ocean temperatures coupled with decreasing environmental productivity, likely due to a reduction in upwelling that isolated nutrients at depth, led to waning reef fish assemblages in the Southern California Bight (Roemmich and McGowan 1995). With recent progress in satellite and fluorometric measurements of oceanic surface waters, time series of global and regional primary production generated using chlorophyll-*a* concentration estimates have become increasingly available and are commonly used for evaluating the impact of environmental productivity on reef fish population abundance and the marine food web in general (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 Initiative 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 33. The chlorophyll levels had relatively low variability over the course of evaluated data ($\text{CV} = 4.90$; Figure 33). 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 $0.039 \text{ mg}/\text{m}^3$, and the lowest recorded level was seen at the inception of the time series in 2005 at $0.036 \text{ mg}/\text{m}^3$ (Figure 33).

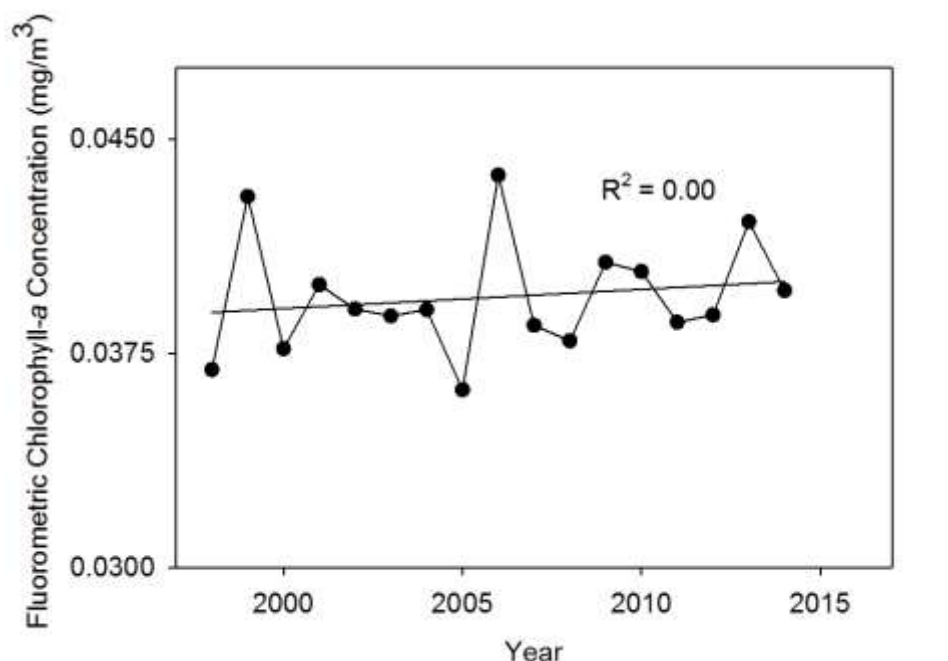


Figure 33. Fluorometric chlorophyll-a concentrations (mg/m³) from 1998–2016 (CV = 4.90)

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 34).

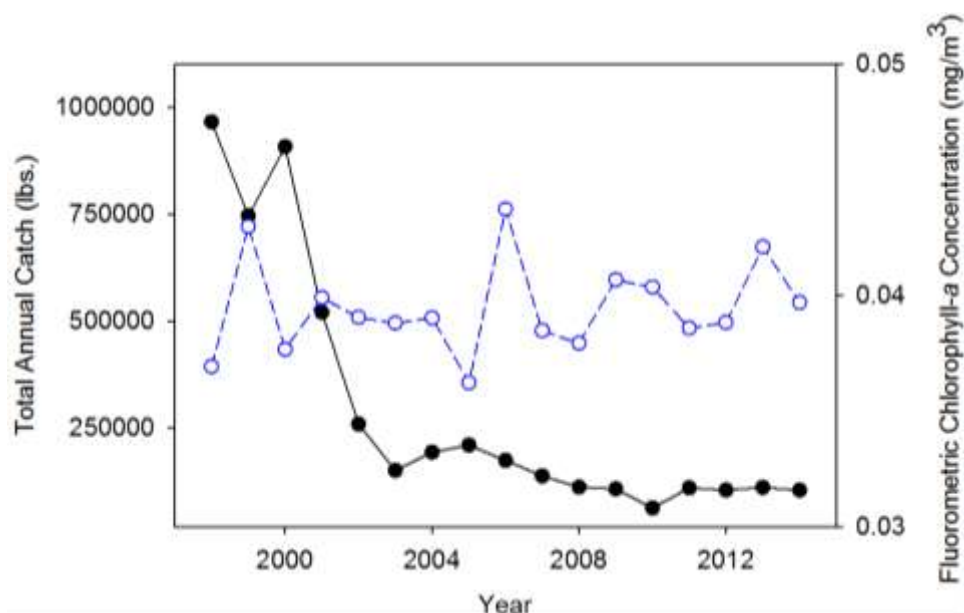


Figure 34. Comparison of American Samoa reef fish catch (lb; black) and chlorophyll-*a* concentrations (mg/m³; blue) from 1998 – 2014 and two years of time lag

The linear regressions performed between noncommercial reef catch in American Samoa and fluorometric chlorophyll-*a* concentrations (mg/m³) are shown in Figure 35. 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 39; Figure 35). 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 39. Correlation coefficients (r) from comparisons of time series of American Samoa coral reef fishery annual catch (lb) and fluorometric chlorophyll-*a* concentrations (mg/m³) 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

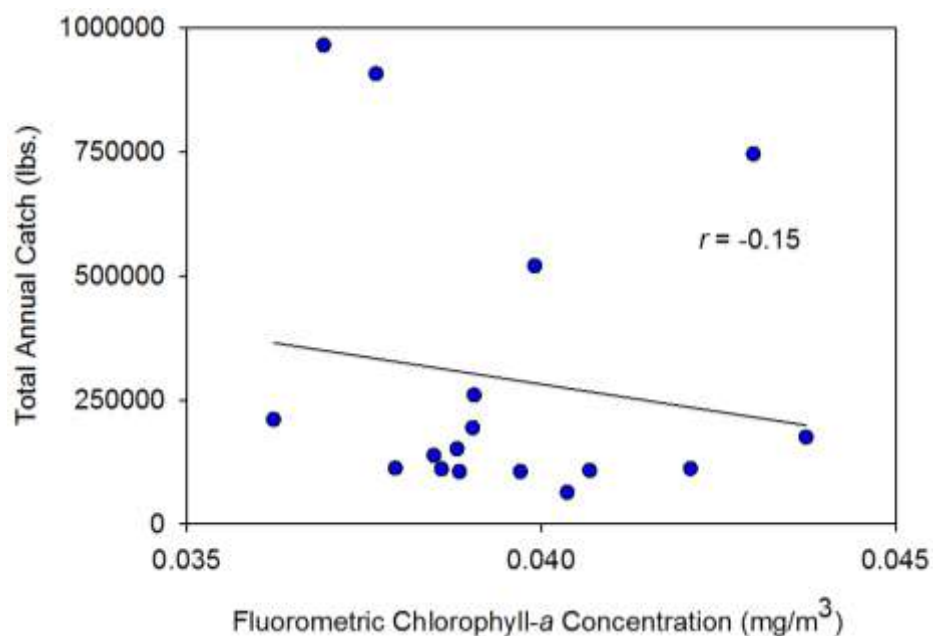


Figure 35. Linear regression showing between total annual catch (lb) for the American Samoa coral reef fishery with phase lag (t+2 years) and fluorometric chlorophyll-a concentrations (mg/m³) from 1998-2014

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 39). 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 39; Figure 36a-c).

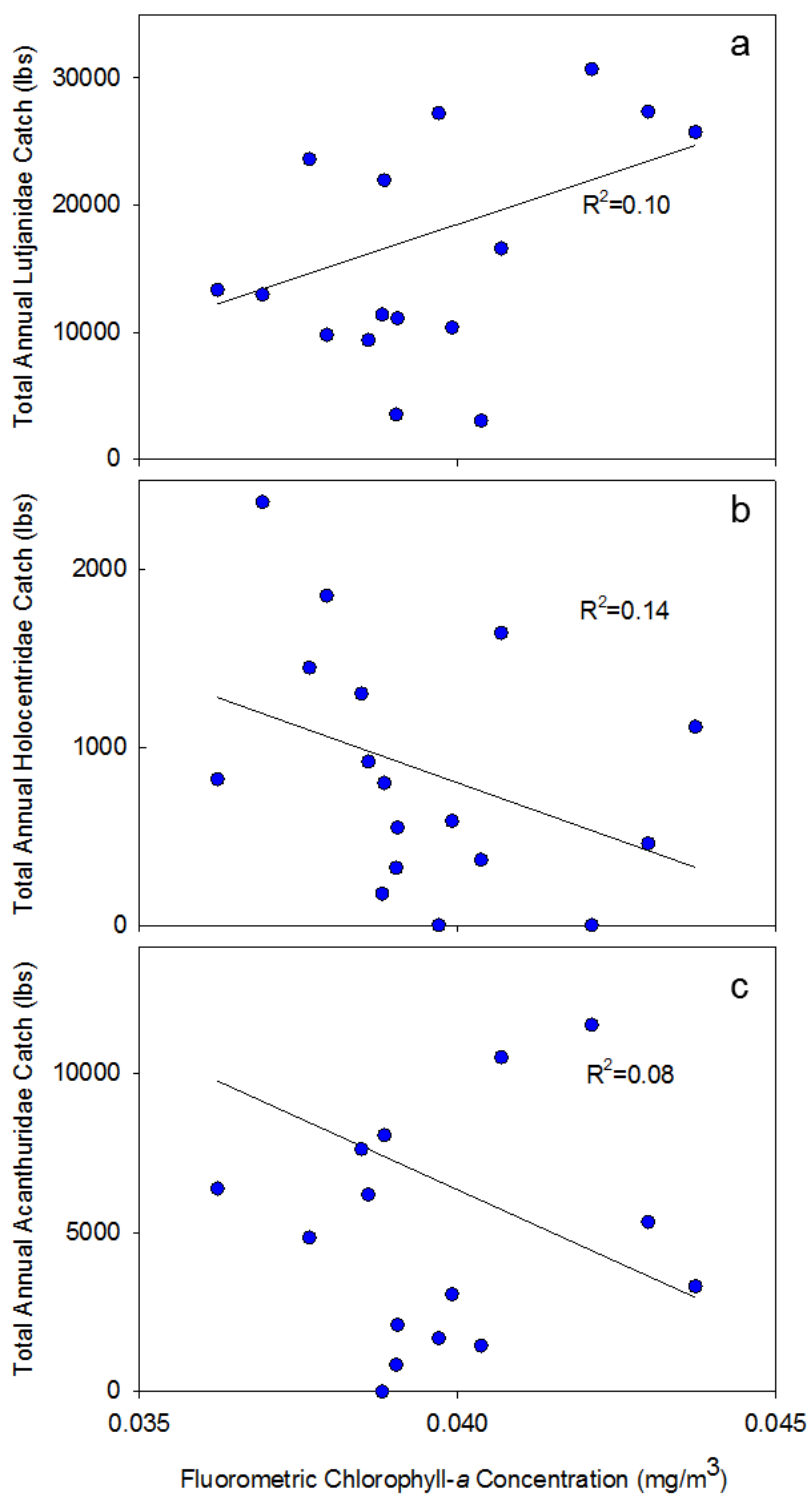


Figure 36. Linear regressions showing three correlations between total annual catch (lb) for the American Samoa coral reef fishery and fluorometric chlorophyll-*a* concentrations (mg/m³) for (a) Lutjanids, (b) Holocentrids, and (c) Acanthurids from 1998–2014 with phase lag (t+2 years)

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 2.6.4. 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 37). 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 37).

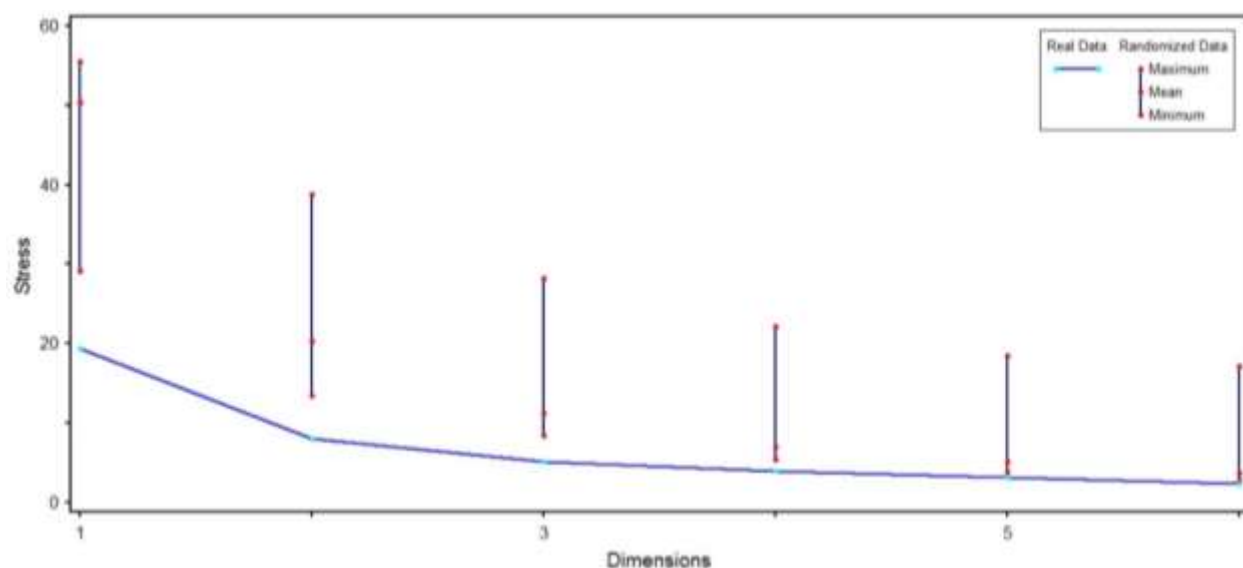


Figure 37. NMS scree plot showing the stress test to determine dimensionality for the final solution for the American Samoa multivariate analysis

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 38). 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 38). 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.

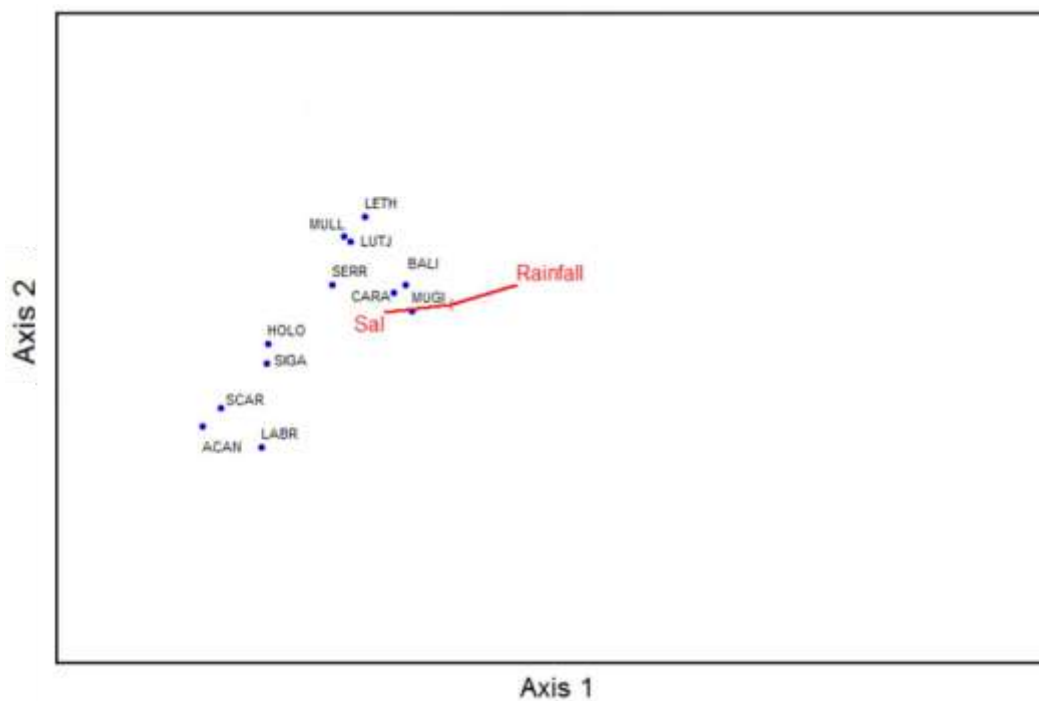


Figure 38. Two-dimensional scatterplot overlaid with a joint biplot depicting ordination scores resulting from an NMS analysis on creel survey expanded catch data and prominent environmental parameters in American Samoa from 1989-2014

4 REFERENCES

- American Samoa Government. 2023. American Samoa Statistical Yearbook 2022. American Samoa Department of Commerce, Statistics and Analysis Division.
- Andrews KR, Williams AJ, Fernandez-Silva I, Newman SJ, Copus JM, Wakefield CB, Randall JE, Bowen BW. 2016. Phylogeny of deepwater snappers (Genus *Etelis*) reveals a cryptic species pair in the Indo-Pacific and Pleistocene invasion of the Atlantic. *Molecular Phylogenetics and Evolution*, 100:361-371.
- Ansell AD, Gibson RN, Barnes M, Press UCL 1996. Coastal fisheries in the Pacific Islands. *Oceanography and Marine Biology: an annual review*, 34(395):531.
- APDRC. 2024. Monthly GODAS Potential temperature. Asia-Pacific Data Research Center, International Pacific Research Center at the University of Hawai'i at Mānoa. Accessed at http://apdrc.soest.hawaii.edu:80/dods/public_data/Reanalysis_Data/GODAS/monthly/potmp. Accessed 4 April 2024.
- Armstrong K, Herdrich DJ, Levine A. 2011. Historic fishing methods in American Samoa. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-24. Retrieved from https://www.pifsc.noaa.gov/library/pubs/tech/NOAA_Tech_Memo_PIFSC_24.pdf.
- Aviso. 2024. ENSO Maps. Ocean Bulletin, Centre National D'études Spatiales. Accessed from https://bulletin.aviso.altimetry.fr/html/produits/indic/enso/welcome_uk.php.
- Ayers A, Leong K, Hospital J, Tam C, Morioka C 2023. 2022 American Samoa Fisher Observations Data Summary and Analysis Pacific Islands Fisheries Science Center, PIFSC Data Report, DR-23-14, 14 p. <https://doi.org/10.25923/vwj1-3z88>.
- Ayotte P, McCoy K, Heenan A, Williams I, Zamzow J. 2015. Coral Reef Ecosystem Division standard operating procedures: data collection for Rapid Ecological Assessment fish surveys. PIFSC Administrative Report H-15-07. Retrieved from <https://repository.library.noaa.gov/view/noaa/9061>.
- Behrenfeld MJ, O'Malley RT, Siegel DA, McClain CR, Sarmiento JL, Feldman GC, Milligan AJ, Falkowski PG, Letelier RM, Boss ES. 2006. Climate-driven trends in contemporary ocean productivity. *Nature*, 444(7120):752-755.
- Brodziak J, O'Malley J, Richards B, DiNardo G. 2012. Stock assessment update of the status of the bottomfish resources of American Samoa, the Commonwealth of the Northern Mariana Islands and Guam, 2012. PIFSC Cent Admin Rep H-12-04.
- Carton JA, Giese BS. 2008. A Reanalysis of Ocean Climate Using Simple Ocean Data Assimilation (SODA), *Mon. Weather Rev.*, 136:2999-3017.
- Chan HL. 2023. Economic Contributions of U.S. Commercial Fisheries in American Samoa. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-151, 35 p. <https://doi.org/10.25923/x904-a830>.
- Chan HL, Pan M. 2019. Tracking economic performance indicators for small boat fisheries in America Samoa, Guam, and the Commonwealth of the Northern Mariana Islands. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-79. <https://doi.org/10.25923/8etp-x479>.

- Dombrow C, Hospital J. 2023. Economic and Social Characteristics of the American Samoa Small Boat Fishery 2021. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-23-05, 92 p. <https://doi.org/10.25923/hqca-xs29>.
- Fabry VJ, Seibel BA, Feely RA, Orr JC. 2008. Impacts of ocean acidification on marine fauna and ecosystem processes. *ICES Journal of Marine Science*, 65:414-432.
- Feely RA, Alin SR, Carter B, Bednarsek N, Hales B, Chan F, Hill TM, Gaylord B, Sanford E, Byrne RH, Sabine CL, Greeley D, Juranek L. 2016. Chemical and biological impacts of ocean acidification along the west coast of North America. *Estuarine, Coastal and Shelf Science*, 183:260-270. doi:10.1016/j.ecss.2016.08.043.
- Franklin E, Caloupka M, Kobayashi DR. 2015. WPSAR Tier 3 Panel Review of Stock Assessment Updates of the Bottomfish Management Unit Species of American Samoa, the Commonwealth of the Northern Mariana Islands, and Guam in 2015 Using Data through 2013. Honolulu: Western Pacific Regional Fishery Management Council.
- Fricke H, Meischner D. 1985. Depth limits of Bermudan scleractinian corals: a submersible survey. *Marine Biology*, 88(2):175-187.
- Grace-McCaskey CA. 2014. Examining the potential of using secondary data to better understand human-reef relationships across the Pacific. Pacific Islands Fisheries Science Center, PIFSC Administrative Report H-14-01. Accessed from https://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_14-01.pdf.
- Grace-McCaskey CA. 2015. American Samoa Fishing Community Profile: 2013 Update. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-15-04. Accessed from http://cynthiagracemccaskey.com/wp-content/uploads/2017/01/AmericanSamoaFishingCommunityProfile_PIFSC_Admin_Rep_15-04.pdf.
- Hart SR, Coetzee M, Workman RK, Blusztajn J, Johnson KTM, Sinton JM, Steinberger B, Hawkins JW. 2004. Genesis of the Western Samoa seamount province: age, geochemical fingerprint and tectonics. *Earth and Planetary Science Letters*, 227(1):37-56.
- Hart SR, Staudigel H, Koppers AAP, Blusztajn J, Baker ET, Workman R, Jackson M, Hauri E, Kurz M, Sims K, Fornari D, Saal A, Lyons, S. 2000. Vailulu'u undersea volcano: The New Samoa, *Geochem. Geophys. Geosyst.*, 1:1056 doi:10.1029/2000GC000108.
- Hawhee JM. 2007. Western Pacific Coral Reef Ecosystem Report. Honolulu: Western Pacific Regional Fishery Management Council.
- Honolulu Star Advertiser. 2016. Tuna cannery in American Samoa to halt production. October 13, 2016. Business Breaking Top News. <http://www.staradvertiser.com/2016/10/13/business/business-breaking/tuna-cannery-in-american-samoa-to-halt-production/>.
- HOT. 2024. Hawaii Ocean Time Series Data Organization & Graphical System (HOT-DOGS). School of Ocean and Earth Science and Technology, University of Hawaii Manoa. Accessed from <https://hahana.soest.hawaii.edu/hot/hot-dogs/bseries.html>. Accessed 18 March 2024.
- Huffman GJ, Adler RF, Arkin P, Chang A, Ferraro R, Gruber A, Janowiak J, McNab A, Rudolf B, Schneider U. 1997. The global precipitation climatology project (GPCP) combined precipitation dataset. *Bulletin of the American Meteorological Society*, 78(1):5-20.

- Islam MS, Tanaka M. 2004. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. *Marine Pollution Bulletin*, 48(7):624-649.
- Karl DM, Lukas R. 1996. The Hawaii Ocean Time-series program: Background, rationale and field implementation. *Deep-Sea Res II*, 43:129-156.
- Keeling CD, Bacastow RB, Bainbridge AE, Ekdahl CA, Guenther PR, Waterman LS. 1976. Atmospheric carbon dioxide variations at Mauna Loa Observatory, Hawaii. *Tellus*, 28:538-551.
- Kahng SE, Maragos JE 2006. The deepest, zooxanthellate scleractinian corals in the world? *Coral Reefs*, 25(2):254.
- Kitiona F, Spalding S, Sabater M. 2016. The impacts of climate change on coastal fisheries in American Samoa. Hilo: University of Hawaii.
- 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>.
- Kleiber D, Leong K. 2018. Cultural fishing in American Samoa. Pacific Islands Fisheries Science Center, PIFSC Administrative Report, H-18-03. doi:10.25923/fr4m-wm95.
- Knapp KR, Kruk MC, Levinson DH, Diamond HJ, Neumann CJ. 2010. The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying tropical cyclone best track data. *Bulletin of the American Meteorological Society*, 91:363-376. doi:10.1175/2009BAMS2755.1.
- Knapp KR, Diamond HJ, Kossin JP, Kruk MC, Schreck CJ. 2018. International Best Track Archive for Climate Stewardship (IBTrACS) Project, Version 4. NOAA National Centers for Environmental Information. <https://doi.org/10.25921/82ty-9e16>.
- Konter JG, Hanan BB, Blichert-Toft J, Koppers AA, Plank T, Staudigel H. 2008. One hundred million years of mantle geochemical history suggest the retiring of mantle plumes is premature. *Earth and Planetary Science Letters*. 275(3-4):285-95.
- Konter JG, Jackson MG. 2012. Large volumes of rejuvenated volcanism in Samoa: Evidence supporting a tectonic influence on late-stage volcanism. *Geochemistry, Geophysics, Geosystems*, 13(6):Q0AM04.
- Lang JC. 1974. Biological Zonation at the Base of a Reef: Observations from the submersible Nekton Gamma have led to surprising revelations about the deep fore-reef and island slope at Discovery Bay, Jamaica. *American Scientist*, 62(3):272-281.
- Langseth B, Syslo J, Yau A, Carvalho F. 2019. Stock assessments of the bottomfish management unit species of Guam, the Commonwealth of the Northern Mariana Islands, and American Samoa, 2019. NOAA Tech Memo. NMFS-PIFSC-86. doi:10.25923/bz8b-ng72.
- Leong KM, Torres A, Wise S, Hospital J. 2020. Beyond recreation: when fishing motivations are more than sport or pleasure. NOAA Admin Rep. H-20-05, 57 p. doi:10.25923/k5hk-x319. <https://repository.library.noaa.gov/view/noaa/23706>.

- Levine A, Allen S. 2009. American Samoa as a fishing community. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-19. Retrieved from https://www.pifsc.noaa.gov/library/pubs/tech/NOAA_Tech_Memo_PIFSC_19.pdf.
- Levine AS, Dillard MK, Loerzel J, Edwards PET. 2016. National Coral Reef Monitoring Program Socioeconomic Monitoring Component. Summary Findings for American Samoa, 2014. U.S. Dep. Commerce., NOAA Technical Memorandum CRCP 24.
- Ma H, Matthews T, Nadon M, Carvalho F. 2022. Shore-based and boat-based fishing surveys in Guam, the CNMI, and American Samoa: survey design, expansion algorithm, and a case study. NOAA PIFSC Tech. Memo. 126.
- Mantua NJ, Hare SR, Zhang, Y., Wallace, J.M., and R.C. Francis RC. 1997. A Pacific Interdecadal Climate Oscillation with Impacts on Salmon Production. Bull. Amer. Meteor. Soc., 78:1069-1079.
- Markrich M, Hawkins C. 2016. Fishing Fleets and Fishery Profiles: Management – Vessels – Gear – Economics. Pacific Islands Fishery Monographs. 5 September 2016. Honolulu: Western Pacific Regional Fishery Management Council.
- Matthews T, Ochavillo D, Felise S, Letalie T, Letuane M, Schuster E, Soonaolo A, Tofaeono S, Tua A, Tuilagi F. 2019. Length-weight relationships for 71 reef and bottomfish species from Tutuila and Aunu'u, American Samoa. . Pacific Islands Fisheries Science Center, PIFSC Administrative Report H-19-03.
- McClanahan TR, Graham NA, MacNeil MA, Muthiga NA, Cinner JE, Bruggemann JH, Wilson SK. 2011. Critical thresholds and tangible targets for ecosystem-based management of coral reef fisheries. Proceedings of the National Academy of Sciences, 108(41):17230-17233.
- Messié M, Radenac MH. 2006. Seasonal variability of the surface chlorophyll in the western tropical Pacific from SeaWiFS data. Deep Sea Research Part I: Oceanographic Research Papers, 53(10):1581-1600.
- Minton D. 2017. Non-fishing effects that may adversely affect essential fish habitat in the Pacific Islands region, Final Report. NOAA National Marine Fisheries Service, Contract AB-133F-15-CQ-0014.
- Nadon MO, Ault JS, Williams ID, Smith SG, DiNardo GT. 2015. Length-based assessment of coral reef fish populations in the main and northwestern Hawaiian Islands. PloS one, 10(8):e0133960.
- Nadon MO, Ault JS. 2016. A stepwise stochastic simulation approach to estimate life history parameters for data-poor fisheries. Canadian Journal of Fisheries and Aquatic Sciences, 73(12):1874-1884. <https://doi.org/10.1139/cjfas-2015-0303>.
- Nadon MO. 2019. Stock Assessment of Guam Coral Reef Fish, 2019. NOAA Technical Memorandum NMFS-PIFSC-82. doi: 10.25923/pyd6-7k49.
- Nadon MO, Oshima M, Bohaboy E, Carvalho F. 2023. Stock Assessment of American Samoa Bottomfishes, 2023. NOAA Technical Memorandum NMFS-PIFSC-143.

- Neall VE, Trewick SA. 2008. The age and origin of the Pacific islands: a geological overview. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363(1508):3293-3308.
- Newman M, Alexander MA, Ault TR, Cobb KM, Deser C, Di Lorenzo E, Mantua NJ, Miller AJ, Minobe S, Nakamura H, Schneider N, Vimont DJ, Phillips AS, Scott JD, Smith CA. 2016. The Pacific Decadal Oscillation, Revisited. *J. Clim.*, 29(12):4399-4427. doi: [10.1175/JCLI-D-15-0508.1](https://doi.org/10.1175/JCLI-D-15-0508.1).
- NOAA. 2002. CPC Merged Analysis of Precipitation. National Weather Service, National Centers for Environmental Prediction, Climate Prediction Center. Available at https://www.cpc.ncep.noaa.gov/products/global_precip/html/wpage.cmap.html. Updated 25 September 2002.
- NOAA. 2016. Pacific Island Pelagic Fisheries; Exemption for Large U.S. Longline Vessels To Fish in Portions of the American Samoa Large Vessel Prohibited Area. Final Rule. 50 CFR Part 665. *Federal Register*. Vol. 81, No. 22. pp. 5619-5626.
- NOAA. 2017. Pacific Island Pelagic Fisheries; Exemption for Large U.S. Longline Vessels To Fish in Portions of the American Samoa Large Vessel Prohibited Area; Court Order; Final Rule. 50 CFR Part 665. *Federal Register*. Vol. 82, No. 181. pp. 43908-43909.
- NOAA. 2024a. Trends in Atmospheric Carbon Dioxide. NOAA Earth System Research Laboratory, Global Monitoring Division. Accessed from <https://gml.noaa.gov/ccgg/trends/data.html>. Accessed 13 March 2024.
- NOAA. 2024b. Pacific Decadal Oscillation (PDO). NOAA Physical Science Laboratory. Accessed from <https://psl.noaa.gov/pdo/>. Accessed 19 March 2024.
- NOAA. 2024c. NOAA's International Best Track Archive for Climate Stewardship (IBTrACS) data. Accessed from <https://www.ncei.noaa.gov/data/international-best-track-archive-for-climate-stewardship-ibtracs/v04r00/access/csv/>. Accessed 19 March 2024. Dataset identifier: <https://doi.org/10.25921/82ty-9e16>.
- NOAA, 2024d. NCEP Global Ocean Data Assimilation System (GODAS). NOAA Office of Oceanic and Atmospheric Research's Earth System Research Laboratories' Physical Sciences Laboratory. Accessed from <https://www.esrl.noaa.gov/psd/data/gridded/data.godas.html>. Accessed 4 April 2024.
- NOAA Climate Prediction Center (CPC). 2024. Oceanic Niño Index. Accessed from <https://www.cpc.ncep.noaa.gov/data/indices/oni.ascii.txt>. Accessed 19 March 2024.
- NOAA CoastWatch. 2024. Sea level Anomaly and Geostrophic Currents, multi-mission, global, optimal interpolation, gridded. Accessed from <https://coastwatch.noaa.gov/cwn/products/sea-level-anomaly-and-geostrophic-currents-multi-mission-global-optimal-interpolation.html>.
- NOAA Coral Reef Watch. 2024. Samoas 5 km Regional Virtual Station Time Series Graphs. NOAA National Environmental Satellite, Data, and Information Service. Accessed from <https://coralreefwatch.noaa.gov/product/vs/data/samoas.txt>.
- NOAA ESRL. 2024. CMAP Precipitation. Accessed from <https://psl.noaa.gov/data/gridded/data.cmap.html>.

- NOAA OceanWatch. 2024a. Sea Surface Temperature, Coral Reef Watch, CoralTemp, v3.1 - Monthly, 1985-present. Accessed from https://oceanwatch.pifsc.noaa.gov/erddap/griddap/CRW_sst_v3_1_monthly.html. Accessed 3 April 2024.
- NOAA OceanWatch. 2024b. Chlorophyll a concentration, ESA OC CCI - Monthly, 1997-2023. v6.0. Accessed from <https://oceanwatch.pifsc.noaa.gov/erddap/griddap/esa-cci-chla-monthly-v6-0.html>. Accessed 4 April 2024 & 3 May 2023.
- NWS-AS. National Weather Service Forecast Office, Pago Pago, American Samoa. NOAA National Weather Service. Accessed March 2017.
- O'Malley JM, Wakefield CB, Oyafuso Z, Nichols RS, Taylor BM, Williams AJ, Sapatu M, Marsik M. 2019. Effects of exploitation evident in age-based demography of 2 deepwater snappers, the goldeneye jobfish (*Pristipomoides flavipinnis*) in the Samoa Archipelago and the goldflag jobfish (*P. auricilla*) in the Mariana Archipelago. Fisheries Bulletin, 117:322-336. doi: 10.7755/FB.117.4.5.
- Ocean Colour Climate Change Initiative dataset, Version 3.1, European Space Agency. Available from <http://www.esa-oceancolour-cci.org/>.
- Ochavillo D. 2012. Coral Reef Fishery Assessment in American Samoa. Pago Pago: Department of Marine and Wildlife Resources.
- Oram R, TuiSamoa N, Tomanogi J, Sabater M, Quach M, Hamm D, Graham C. 2011. American Samoa Boat-Based Creel Survey Documentation. NOAA, National Marine Fishery Service, Pacific Island Fishery Science Center, Administrative Report.
- Pacific Islands Report. 2016. American Samoa Cannery to Scale Back Operations Due To Fish Shortages. 28 September 2016. <http://www.pireport.org/articles/2016/09/28/american-samoa-cannery-scale-back-operations-due-fish-shortages>.
- Pacific Islands Report. 2017. Tri Marine Has 'No Plans' To Reopen Tuna Cannery In American Samoa. 20 April 2017. <http://www.pireport.org/articles/2017/04/20/tri-marine-has-no-plans-reopen-tuna-cannery-american-samoa>.
- Pardee C, Taylor BM, Felise S, Ochavillo D, Cuetos-Bueno J. 2020. Growth and maturation of three commercially important coral reef species from American Samoa. Fisheries Science, 86:985-993. <https://doi.org/10.1007/s12562-020-01471-9>.
- Pawluk M, Matthews T, Ahrens R 2023. Exploring bias and precision in the Guam and CNMI Boat-based creel survey design: a simulation study Pacific Islands Fisheries Science Center, PIFSC Internal Report, IR-23-09, 19 p.
- PIFSC. 2011. Coral reef ecosystems of American Samoa: a 2002–2010 overview. NOAA Fisheries Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-11-02.
- PIFSC. 2021. Indo-Pacific Snapper, Emperor, Jack, and Grouper Age, Growth, Mortality, Maturity, and Habitat Review and Recommendations for Use in Stock Assessments and Management. Pacific Islands Fisheries Science Center, PIFSC Internal Report, IR-21-010.
- Peck JE. 2016. Multivariate Analysis for Ecologists: Step-by-Step, Second edition. Glenden Beach (OR): MjM Software Design.

- Remington TR, Field DB. 2016. Evaluating biological reference points and data-limited methods in Western Pacific coral reef fisheries. Honolulu: Western Pacific Regional Fishery Management Council.
- Restrepo VR, Thompson GG, Mace PM, Gabriel WL, Low LL, MacCall AD, Methot RD, Powers JE, Taylor BL, Wade PR, and Witzig JF. 1998. Technical Guidance on the use of precautionary approaches to implementing National Standard 1 of the Magnuson-Stevens Fishery Conservation and Management Act. NOAA-TM-NMGS-F/SPO-31.
- Richards BL, Williams ID, Vetter OJ, Williams GJ. 2012. Environmental factors affecting large-bodied coral reef fish assemblages in the Mariana Archipelago. PLoS ONE 7(2):e31374.
- Richmond L, Levine A. 2012. Institutional analysis of community-based marine resource management initiatives in Hawaii and American Samoa. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-PIFSC-35. Retrieved from https://www.pifsc.noaa.gov/library/pubs/tech/NOAA_Tech_Memo_PIFSC_35.pdf.
- Roemmich D, McGowan J. 1995. Climatic warming and the decline of zooplankton in the California Current. *Science*, 267(5202):1324-1324.
- Reynolds RW. 1988. A real-time global sea surface temperature analysis. *Journal of Climate*, 1(1):75-87.
- Sabater M, Schumacher B, Borges P, Hospital J, Makaiau J, Jones TT, Walker R, Chow M. 2023. Fishery Management Scenarios for the Monument Adjacent Area within the Proposed Pacific Remote Islands Sanctuary. Pacific Islands Fisheries Science Center, PIFSC White Paper, 23 p.
- Sievanen L, Grace-McCaskey CA. 2014. Saipan Fisheries Workshop Data for Use in Reef Fishery SEEM Analysis. Invited presenter at SEEM Working Group Meeting. Honolulu: Western Pacific Regional Fishery Management Council.
- Smith SG, Ault JS, Bohnsack JA, Harper DE, Luo J, McClellan DB. 2011. Multispecies survey design for assessing reef-fish stocks, spatially explicit management performance, and ecosystem condition. *Fisheries Research*, 109(1):29-41.
- 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*, 29, 439–455. <https://doi.org/10.1111/fme.12567>.
- Spencer RW. 1993. Global oceanic precipitation from the MSU during 1979-91 and comparisons to other climatologies. *Journal of Climate*, 6(7):1301-1326.
- Stawitz C. 2022. nmfspalette: A Color Palette for NOAA Fisheries. R package version 0.0.0.9000. <https://nmfs-fish-tools.github.io/nmfspalette/>.
- Thoning KW, Tans PP, Komhyr WD. 1989. Atmospheric carbon dioxide at Mauna Loa Observatory 2. Analysis of the NOAA GMCC data, 1974-1985. *Journal of Geophysical Research*, 94:8549-8565.
- Williams ID, Baum JK, Heenan A, Hanson KM, Nadon MO, Brainard RE. 2015. Human, Oceanographic and Habitat Drivers of Central and Western Pacific Coral Reef Fish Assemblages. PLoS ONE 10(5):e0129407.

- WPRFMC. 2009. Fishery Ecosystem Plan for the American Samoan Archipelago. Honolulu: Western Pacific Regional Fishery Management Council.
- WPRFMC. 2011. Omnibus Amendment for the Western Pacific Region to Establish a Process for Specifying Annual Catch Limits and Accountability Measures. Honolulu: Western Pacific Regional Fishery Management Council.
- WPRFMC. 2018. Amendment 4 to the Fishery Ecosystem Plan for American Samoa – Ecosystem Components. RIN 0648-BH63. Honolulu: Western Pacific Regional Fishery Management Council.
- WPRFMC. 2023a. Annual SAFE Report for the Pacific Pelagic Fisheries Fishery Ecosystem Plan 2022. T Remington, M Fitchett, A Ishizaki (Eds.). Honolulu: Western Pacific Regional Fishery Management Council.
- WPRFMC. 2023b. Annual SAFE Report for the Mariana Archipelago Fishery Ecosystem Plan 2022. T Remington, J DeMello, A Ishizaki (Eds.). Honolulu: Western Pacific Regional Fishery Management Council.
- WPRFMC. 2023c. Annual SAFE Report for the American Samoa Archipelago Fishery Ecosystem Plan 2022. T Remington, J DeMello, A Ishizaki (Eds.). Honolulu: Western Pacific Regional Fishery Management Council.
- WPRFMC. 2023d. Annual SAFE Report for the Hawaii Archipelago Fishery Ecosystem Plan 2022. T Remington, J DeMello, A Ishizaki (Eds.). Honolulu: Western Pacific Regional Fishery Management Council.
- Xie P, Arkin PA. 1997. Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bulletin of the American Meteorological Society*, 78(11): 2539-2558.
- Yau A, Nadon M, Richards B, Brodziak J, Fletcher E. 2016. Stock assessment updates of the Bottomfish Management Unit species of American Samoa, the Commonwealth of the Northern Mariana Islands, and Guam in 2015 using data through 2013. U.S. Dept. of Commerce, NOAA Technical Memorandum, NMFS-PIFSC-51.
- Zeebe RE, Wolf-Gladrow DA 2001. CO₂ in Seawater Systems: Equilibrium, Kinetics, Isotopes. Elsevier, 65. Accessed from https://www.soest.hawaii.edu/oceanography/faculty/zeebe_files/CO2_System_in_Seawater/csys.html.

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)	<i>Aphareus rutilans</i>
239	grey snapper, jobfish	<i>Aprion virescens</i>
111	black trevally, jack	<i>Caranx lugubris</i>
229	lunar tail grouper (yellow edge lyretail)	<i>Variola louti</i>
249	red snapper	<i>Etelis carbunculus</i>
248	longtail snapper	<i>Etelis coruscans</i>
267	redgill emperor	<i>Lethrinus rubrioperculatus</i>
231	blueline snapper	<i>Lutjanus kasmira</i>
242	pink snapper (paka)	<i>Pristipomoides filamentosus</i>
241	yelloweye snapper	<i>Pristipomoides flavipinnis</i>
245	flower snapper (gindai)	<i>Pristipomoides zonatus</i>

MONITORED ECOSYSTEM COMPONENT SPECIES**1. Species Selected for Monitoring by DMWR**

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

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

The species presented here 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	<i>Naso lituratus</i>	H	Browsing Surgeons
Acanthuridae	<i>Naso tonganus</i>	H	Browsing Surgeons
Acanthuridae	<i>Naso unicornis</i>	H	Browsing Surgeons
Acanthuridae	<i>Naso brachycentron</i>	H	Browsing Surgeons
Acanthuridae	<i>Ctenochaetus cyanocheilus</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Ctenochaetus strigosus</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Acanthurus nigroris</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Ctenochaetus hawaiiensis</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Ctenochaetus striatus</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Ctenochaetus marginatus</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Acanthurus lineatus</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Acanthurus blochii</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Acanthurus dussumieri</i>	H	Mid-Large Target Surgeons
Acanthuridae	<i>Acanthurus xanthopterus</i>	H	Mid-Large Target Surgeons
Chaetodontidae	<i>Chaetodon flavocoronatus</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon multicinctus</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon punctatofasciatus</i>	MI	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon mertensii</i>	H	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon citrinellus</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon pelewensis</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon lunulatus</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon melannotus</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon rafflesii</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon ulietensis</i>	MI	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon fremblii</i>	SI	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon quadrimaculatus</i>	Cor	Non-PK Butterflyfish
Chaetodontidae	<i>Chaetodon meyeri</i>	Cor	Non-PK Butterflyfish

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX B: LIST OF PROTECTED SPECIES AND DESIGNATED CRITICAL HABITAT

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

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

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
Tahiti Petrel	<i>Pterodroma rostrata</i>	Not Listed	N/A	Resident	Craig, 2005
Wedge-Tailed Shearwater	<i>Ardenna pacifica</i>	Not Listed	N/A	Resident?	Craig, 2005
White-Necked Petrel	<i>Pterodroma cervicalis</i>	Not Listed	N/A	Visitor	Craig, 2005
White-Faced Storm-Petrel	<i>Pelagodroma marina</i>	Not Listed	N/A	Visitor	Craig, 2005
White-Tailed Tropicbird	<i>Phaethon lepturus</i>	Not Listed	N/A	Resident	Craig, 2005
White-Throated Storm-Petrel	<i>Nesofregatta fuliginosa</i>	Not Listed	N/A	Resident?	Craig, 2005
Sea Turtles					
Green Sea Turtle	<i>Chelonia mydas</i>	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	<i>Eretmochelys imbricata</i>	Endangered ^a	N/A	Frequently seen. Nest at Rose Atoll, Swain's Island, and Tutuila.	35 FR 8491, NMFS & USFWS 2013, Tuato'o-Bartley <i>et al.</i> , 1993
Leatherback Sea Turtle	<i>Dermochelys coriacea</i>	Endangered ^a	N/A	Very rare. One juvenile recovered dead in experimental longline fishing.	35 FR 8491, Grant, 1994
Loggerhead Sea Turtle	<i>Caretta caretta</i>	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, Utzurum 2002, Dodd, 1990
Olive Ridley Sea Turtle	<i>Lepidochelys olivacea</i>	Threatened (Entire species, except for the breeding population on the Pacific coast of Mexico, which is listed as endangered)	N/A	Rare. Three known sightings.	43 FR 32800, Utzurum, 2002
Marine mammals					
Blainville's Beaked Whale	<i>Mesoplodon densirostris</i>	Not Listed	Non-strategic	Found worldwide in tropical and temperate waters	Mead, 1989
Blue Whale	<i>Balaenoptera musculus</i>	Endangered	Strategic	No known sightings. Occur worldwide and are known to be found in the western South Pacific.	35 FR 18319, Olson <i>et al.</i> , 2015
Bottlenose Dolphin	<i>Tursiops truncatus</i>	Not Listed	Non-strategic	Distributed worldwide in tropical and warm-temperate waters	Perrin <i>et al.</i> , 2009

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
Bryde's Whale	<i>Balaenoptera edeni</i>	Not Listed	Unknown	Distributed widely across tropical and warm-temperate Pacific Ocean.	Leatherwood <i>et al.</i> , 1982
Common Dolphin	<i>Delphinus delphis</i>	Not Listed	N/A	Found worldwide in temperate and subtropical seas.	Perrin <i>et al.</i> , 2009
Cuvier's Beaked Whale	<i>Ziphius cavirostris</i>	Not Listed	Non-strategic	Occur worldwide.	Heyning, 1989
Dwarf Sperm Whale	<i>Kogia sima</i>	Not Listed	Non-strategic	Found worldwide in tropical and warm-temperate waters.	Nagorsen, 1985
False Killer Whale	<i>Pseudorca crassidens</i>	Not Listed	Unknown	Found in waters within the US EEZ of A. Samoa	Bradford <i>et al.</i> , 2015
Fin Whale	<i>Balaenoptera physalus</i>	Endangered	Strategic	No known sightings. Found worldwide.	35 FR 18319, Hamilton <i>et al.</i> , 2009
Fraser's Dolphin	<i>Lagenodelphis hosei</i>	Not Listed	Non-strategic	Found worldwide in tropical waters.	Perrin <i>et al.</i> , 2009
Humpback Whale	<i>Megaptera novaeangliae</i>	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 <i>et al.</i> , 2007, SPWRC, 2008
Killer Whale	<i>Orcinus orca</i>	Not Listed	Non-strategic	Found worldwide. Prefer colder waters within 800 km of continents.	Leatherwood & Dalheim, 1978, Mitchell, 1975, Baird <i>et al.</i> , 2006
Longman's Beaked Whale	<i>Indopacetus pacificus</i>	Not Listed	Non-strategic	Found in tropical waters from the eastern Pacific westward through the Indian Ocean to the eastern coast of Africa.	Dalebout, 2003
Melon-Headed Whale	<i>Peponocephala electra</i>	Not Listed	Non-strategic	Found in tropical and warm-temperate waters worldwide, primarily found in equatorial waters.	Perryman <i>et al.</i> , 1994
Minke Whale	<i>Balaenoptera acutorostrata</i>	Not Listed	Non-strategic	Uncommon in this region, usually seen over continental shelves in the Pacific Ocean.	Brueggeman <i>et al.</i> , 1990
Pantropical Spotted Dolphin	<i>Stenella attenuata</i>	Not Listed	Non-strategic	Found in tropical and subtropical waters worldwide.	Perrin <i>et al.</i> , 2009
Pygmy Killer Whale	<i>Feresa attenuata</i>	Not Listed	Non-strategic	Found in tropical and subtropical waters worldwide.	Ross & Leatherwood, 1994
Pygmy Sperm Whale	<i>Kogia breviceps</i>	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	<i>Grampus griseus</i>	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide.	Perrin <i>et al.</i> , 2009
Rough-Toothed Dolphin	<i>Steno bredanensis</i>	Not Listed	Unknown	Found in tropical to warm-temperate waters worldwide. Common in A. Samoa waters.	Perrin <i>et al.</i> , 2009, Craig, 2005
Sei Whale	<i>Balaenoptera borealis</i>	Endangered	Strategic	Generally found in offshore temperate waters.	35 FR 18319, Barlow, 2003, Bradford <i>et al.</i> , 2013
Short-Finned Pilot Whale	<i>Globicephala macrorhynchus</i>	Not Listed	Non-strategic	Found in tropical to warm-temperate waters worldwide.	Shallenberger, 1981, Baird <i>et al.</i> , 2013, Bradford <i>et al.</i> , 2013
Sperm Whale	<i>Physeter macrocephalus</i>	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 <i>et al.</i> , 2000, Shallenberger, 1981
Spinner Dolphin	<i>Stenella longirostris</i>	Not Listed	Unknown	Common in American Samoa, found in waters with mean depth of 44 m.	Reeves <i>et al.</i> , 1999, Johnston <i>et al.</i> , 2008
Striped Dolphin	<i>Stenella coeruleoalba</i>	Not Listed	Non-strategic	Found in tropical to warm-temperate waters throughout the world.	Perrin <i>et al.</i> , 2009
Elasmobranchs					
Giant manta ray	<i>Manta birostris</i>	Threatened	N/A	Found worldwide in tropical, subtropical, and temperate waters. Commonly found in upwelling zones, oceanic island groups, offshore pinnacles, and seamounts, and on shallow reefs.	Dewar <i>et al.</i> , 2008, Marshall <i>et al.</i> , 2009, Marshall <i>et al.</i> , 2011.
Oceanic whitetip	<i>Carcharhinus longimanus</i>	Threatened	N/A	Found worldwide in open ocean waters from the surface to 152 m depth. It is most commonly found in waters > 20°C	Bonfil <i>et al.</i> , 2008, Backus <i>et al.</i> , 1956, Strasburg, 1958, Compagno, 1984

Common Name	Scientific Name	ESA Listing Status	MMPA Status	Occurrence	References
Scalloped Hammerhead	<i>Sphyrna lewini</i>	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	<i>Acropora globiceps</i>	Threatened	N/A	Occur on upper reef slopes, reef flats, and adjacent habitats in depths from 0 to 8 m	Veron, 2014
N/A	<i>Acropora jacquelineae</i>	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	<i>Acropora retusa</i>	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	<i>Acropora speciosa</i>	Threatened	N/A	Found in protected environments with clear water and high diversity of <i>Acropora</i> 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	<i>Euphyllia paradivisa</i>	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	<i>Isopora crateriformis</i>	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	<i>Eretmochelys imbricata</i>	Endangered	None in the Pacific Ocean.	63 FR 46693
Leatherback Sea Turtle	<i>Dermochelys coriacea</i>	Endangered	Approximately 16,910 square miles (43,798 square km) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles (64,760 square km) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour.	77 FR 4170
Hawaiian Monk Seal	<i>Neomonachus schauinslandi</i>	Endangered	Ten areas in the Northwestern Hawaiian Islands (NWHI) and six in the main Hawaiian Islands (MHI). These areas contain one or a combination of habitat types: Preferred pupping and nursing areas, significant haul-out areas, and/or marine foraging areas, that will support conservation for the species.	53 FR 18988, 51 FR 16047, 80 FR 50925
North Pacific Right Whale	<i>Eubalaena japonica</i>	Endangered	Two specific areas are designated, one in the Gulf of Alaska and another in the Bering Sea, 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>.

REFERENCES

- Backus RH, Springer S, Arnold EL. 1956. A contribution to the natural history of the white tip shark, *Pterolamiops longimanus* (Poey). Deep-Sea Res. 3:178- 188.
- Baird RW, McSweeney DJ, Bane C, Barlow J, Salden DR, Antoine LRK, LeDuc RG, Webster DL. 2006. Killer Whales in Hawaiian Waters: Information on Population Identity and Feeding Habits 1. Pac Sci, 60(4):523-530.
- Baird RW, Webster DL, Aschettino JM, Schorr GS, McSweeney DJ. 2013. Odontocete cetaceans around the main Hawaiian Islands: Habitat use and relative abundance from small-boat sighting surveys. Aquat Mamm, 39(3):253-269.

- Balazs GH, Craig P, Winton BR, Miya RK. 1994. Satellite telemetry of green turtles nesting at French Frigate Shoals, Hawaii, and Rose Atoll, American Samoa. In: Bjorndal KA, Bolten AB, Johnson DA, Eliazar PJ [eds.]. Proceedings of the fourteenth annual symposium on sea turtle biology and conservation: 184-186.
- Barlow J. 2003. Preliminary Estimates of the Abundance of Cetaceans Along the US West Coast, 1991-2001. US Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.
- Barlow J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. *Mar Mamm Sci*, 22(2):446-464.
- Bonfil R, Clarke S, Nakano H, Camhi MD, Pikitch EK, Babcock EA. 2008. The biology and ecology of the oceanic whitetip shark, *Carcharhinus longimanus*. In: Camhi MD, Pikitch EK, Babcock EA [eds.]. *Sharks of the Open Ocean: Biology, Fisheries, and Conservation*:128-139.
- Bradford AL, Oleson EM, Baird RW, Boggs CH, Forney KA, Young NC. 2015. Revised stock boundaries for false killer whales (*Pseudorca crassidens*) in Hawaiian waters. NOAA Tech. Memo. NMFS-PIFSC-47.
- Caldwell DK, Caldwell MC. 1989. Pygmy sperm whale *Kogia breviceps* (de Blainville, 1838) & dwarf sperm whale *Kogia simus* (Owen, 1866). *Handbook of marine mammals*, 4:235-260.
- Compagno LJ. 1984. FAO Species Catalogue. Vol. 4. Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species Known to Date. Carcharhiniformes. FAO Fish. Synop., 124(4):Part 2.
- Craig P. 2005. Natural history guide to American Samoa. National Park of American Samoa, Department of Marine and Wildlife Resources, American Samoa Community College.
- Dalebout ML, Baker CS, Anderson RC, Best PB, Cockcroft VG, Hinsz HL, Peddemors V, Pitman RL. 2003. Appearance, distribution, and genetic distinctiveness of Longman's beaked whale, *Indopacetus pacificus*. *Mar Mamm Sci*, 19(3):421-461.
- Dewar H, Mous P, Domeier M, Muljadi A, Pet J, Whitty J. 2008. Movements and site fidelity of the giant manta ray, *Manta birostris*, in the Komodo Marine Park, Indonesia. *Mar Biol*, 155:121-133.
- Dodd CK. 1990. *Caretta caretta* (Linnaeus) Loggerhead Sea Turtle. *Catalogue of American Amphibians and Reptiles*, 48:1-483.
- Garrigue C, Franklin T, Russell K, Burns D, Poole M, Paton D, Hauser N, Oremus M, Constantine R, Childerhouse S, Mattila D, Gibbs N, Franklin W, Robbins J, Clapham P, Baker CS. 2007. First assessment of interchange of humpback whales between Oceania and the east coast of Australia. International Whaling Commission, Anchorage, Alaska. SC/59/SH15 (available from the IWC office).
- Grant GS. 1994. Juvenile leatherback turtle caught by longline fishing in American Samoa. *Marine Turtle Newsletter*, 66:3-5.

- Hamilton TA, Redfern JV, Barlow J, Ballance LT, Gerrodette T, Holt RS, Forney KA, Taylor BL. 2009. Atlas of Cetacean Sightings for Southwest Fisheries Science Center Cetacean and Ecosystem Surveys, 1986-2005.
- Heyning JE. 1989. Cuvier's beaked whale *Ziphius cavirostris* (G. Cuvier, 1823). In: Ridgway SH, Harrison R [eds.]. Handbook of Marine Mammals. Vol. 4. River Dolphins and the Larger Toothed Whales. London (UK): Academic Press.
- Johnston DW, Robbins J, Chapla ME, Mattila DK, Andrews KR. 2008. Diversity, habitat associations and stock structure of odontocete cetaceans in the waters of American Samoa, 2003-2006. J Cetacean Res Manag., 10(1):59-66.
- Klimley AP. 1993. Highly directional swimming by scalloped hammerhead sharks, *Sphyrna lewini*, and subsurface irradiance, temperature, bathymetry, and geomagnetic field. Mar Biol, 117(1):1-22.
- Leatherwood JS, Dahlheim ME. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean System Center Technical Report, 443:1-39.
- Marshall A, Compagno LJV, Bennett MB. 2009. Redescription of the genus *Manta* with resurrection of *Manta alfredi* (Kreffft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae). Zootaxa, 2301:1-28.
- Marshall A, Bennett MB, Kodja G, Hinojosa-Alvarez S, Galvan-Magana F, Harding M, Stevens G, Kashiwagi T. 2011. *Manta birostris*. The IUCN Red List of Threatened Species 2011: e.T198921A9108067.
- Mead JG. 1989. Beaked whales of the genus *Mesoplodon*. In: Ridgeway SH, Harrison R [eds.]. Handbook of marine mammals. Volume 4. River dolphins and the larger toothed whales. London (UK): Academic Press Ltd.
- Mitchell E. 1975. Report on the meeting on smaller cetaceans, Montreal, Apr 1-11, 1974. J Fish Res Bd Can, 32(7):914-16
- Mobley Jr. JR, Spitz SS, Forney KA, Grotenfendt R, Forestell PH. 2000. Distribution and abundance of odontocete species in Hawaiian waters: preliminary results of 1993-98 aerial surveys. Southwest Fisheries Science Center, SWFSC Administrative Report, LJ-00-14C.
- Nagorsen D. 1985. *Kogia simus*. Mammalian Species, 239:1-6.
- Olson PA, Ensor P, Olavarria C, Bott N, Constantine R, Weir J, Childerhouse S, van der Linde M, Schmitt N, Miller BS, Double MC. 2015. New Zealand Blue Whales: Residency, Morphology, and Feeding Behavior of a Little-Known Population. Pac Sci, 69(4):477-485.
- Perrin WF, Wursig B, Thewissen JGM [eds.]. 2009. Encyclopedia of marine mammals. London (UK): Elsevier.
- Perryman WL, Au DWK, Leatherwood S, Jefferson TA. 1994. Melon-headed whale *Peponocephala electra* Gray, 1846. In: Ridgway SH, Harrison R [eds.]. Handbook of marine mammals. Volume 5. The first book of dolphins. London (UK): Academic Press.

- Rice DW. 1960. Distribution of the bottle-nosed dolphin in the leeward Hawaiian Islands. *J Mamm*, 41(3):407-408.
- Ross GJB, Leatherwood S. 1994. Pygmy killer whale *Feresa attenuata* (Gray, 1874). *Handbook of marine mammals*, 5:387-404.
- Schulze-Haugen M, Kohler NE [eds.]. 2003. *Guide to Sharks, Tunas, & Billfishes of the U.S. Atlantic and Gulf of Mexico*. RI Sea Grant/National Marine Fisheries Service.
- Shallenberger EW. 1981. The status of Hawaiian cetaceans. *Marine Mammal Commission Report No. MMC-77/23 (NTIS PB82-109398)*.
- Strasburg DW. 1958. Distribution, abundance, and habits of pelagic sharks in the central Pacific Ocean. *Fisheries*, 1:2S.
- Tuato'o-Bartley N, Morrell TE, Craig P. 1993. Status of sea turtles in American Samoa in 1991. *Pac Sci*, 47(3):215-221.
- Utzurum R. 2002. Sea turtle conservation in American Samoa. *In*: Kinan, I. [ed.]. *Proceedings of the western Pacific sea turtle cooperative research and management workshop*.
- Veron JEN. 2014. Results of an update of the Corals of the World Information Base for the Listing Determination of 66 Coral Species under the Endangered Species Act. Honolulu: Western Pacific Regional Fishery Management Council.