ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT: FISHERY ECOSYSTEM PLAN FOR THE AMERICAN SAMOA ARCHIPELAGO 2015

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The ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION (SAFE) REPORT for the AMERICAN SAMOA ARCHIPELAGO FISHERY ECOSYSTEM PLAN 2015 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council, NMFS-Pacific Island Fisheries Science Center, Pacific Islands Regional Office, Division of Aquatic Resources (HI) Department of Marine and Wildlife Resources (AS), Division of Aquatic and Wildlife Resources (Guam), and Division of Fish and Wildlife (CNMI).

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

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Executive Summary

As part of its 5 year fishery ecosystem plan (FEP) review, the Council identified the annual reports as a priority for improvement. The former annual reports have been revised to meet National Standard regulatory requirements for the Stock Assessment and Fishery Evaluation (SAFE) reports. The purpose of the report is twofold: monitor the performance of the fishery and ecosystem, and maintain the structure of the FEP living document. The reports are comprised of three chapters: fishery performance, ecosystem considerations, and data integration. The 2015 American Samoa annual SAFE report does not contain the data integration chapter. The Council will iteratively improve the annual SAFE report as resources allow.

The fishery performance section of this report first presents a general description of the local commercial fishery including both the bottomfish and coral reef management unit species (MUS). The fishery data collection system is then explained and time series of meta-data dashboard statistics are provided. The collection system encompasses shore-based and boat-based creel surveys, commercial receipt books, and boat inventories. The fishery statistics for each MUS are organized into a summary dashboard table showcasing the values for the most recent fishing year and a comparison to short-term (10 years) and long-term (20 years) averages. Time series for catch and effort statistics are also provided. For 2015 catch in American Samoa, no MUS exceeded overfishing limit (OFL), allowable biological catch (ABC), or annual catch limit (ACL).

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

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

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 eight species of reef fish and 12 species of bottomfish.

Summarized length derived parameters for coral reef fish and bottomfish in American Samoa include: maximum fish length, mean length, sample size, sample size for L-W regression, and length-weight coefficients. Values for 23 species of reef fish and two species of bottomfish are presented for American Samoa.

Human dimensions data will be included in later versions of this report as resources allow.

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 the fisheries, and there is no other information to indicate that impacts to protected species have changed in recent years.

The 2015 Annual Report includes an inaugural section on indicators of current and changing climate and related oceanic conditions in the geographic areas for which the Western Pacific Regional Fishery Management Council has responsibility. In developing this section, the Council relied on a number of recent reports conducted in the context of the U.S. National Climate Assessment including, most notably, the 2012 Pacific Islands Regional Climate Assessment and the Ocean and Coasts chapter of the 2014 report on a Pilot Indicator System prepared by the National Climate Assessment and Development Advisory Committee. The primary goal for selecting the indicators used in this report is to provide fisheries-related communities, resource managers and businesses with climate-related situational awareness. In this context, indicators were selected to be fisheries relevant and informative, build intuition about current conditions in light of changing climate, provide historical context and recognize patterns and trends. The atmospheric concentration of carbon dioxide (CO_2) trend is increasing exponentially with the 2015 time series maximum at 400.83 ppm. The oceanic pH at Station Aloha, in Hawaii, is decreasing at a rate of 0.039 pH units per year, equivalent to 0.4% increase in acidity per year. A strong El Niño was present with sea surface temperature in waters surrounding most of American Samoa ranging between 29º and 30º C with waters around Rose Atoll ranging between 28 º and 29º C in 2015. Low water stands affecting coral reefs were reported in some parts of American Samoa in connection with El Niño; however, the monthly mean sea level trend is increasing. The year also saw an abundance of tropical cyclones including 18 named storms and nine major hurricanes in the Eastern Pacific, 14 named storms and five major hurricanes in the Central Pacific, and 27 named storms in the Western Pacific. Wave forcing, which can have major implications for coastal ecosystems and pelagic fishing operations, varied from the west with significant wave heights of 1.5 to 2.0 m to the east with significant wave heights near Rose Atoll at 2.0 to 2.5 m on average.

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. The 2015 annual report includes a draft update of the precious corals species descriptions. The guidelines also require a report on the condition of the habitat. In the 2015 annual report, mapping progress and benthic cover are included as indicators, pending development of habitat condition indicators for the American Samoa Archipelago not otherwise represented in other sections of this report. The annual report also addresses any Council directives toward its plan team. Toward this end, a report on the HAPC Process is included as an attachment to the report.

The marine planning section of the annual report tracks activities with multi-year planning horizons and begins to track the cumulative impact of established facilities. Development of the report in later years will focus on identifying appropriate data streams. No ocean activities with multi-year planning horizons were identified for American Samoa. However, the Pacific Islands Regional Planning Body, established under the National Ocean Policy, is actively developing an ocean plan for American Samoa. This plan will be used as the template for other jurisdictions represented in the RPB. American Samoa stakeholders have identified a vision, goals, and objectives for the ocean plan.

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TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

ACRONYMS AND ABBREVIATIONS

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

MPA	marine protected area
MPCC	Marine Planning and Climate Change
MPCCC	Council's MPCC Committee
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
MUS	management unit species
NCADAC	National Climate Assessment & Development Advisory Committee
NCDC	National Climatic Data Center
NEPA	National Environmental and Policy Act
NESDIS	National Environmental Satellite, Data, and Information Service
NMFS	National Marine Fisheries Service
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NWHI	Northwestern Hawaiian Islands
OFL	Overfishing Limits
ONI	Ocean Niño Index
OR&R	Office of Response and Restoration
OY	Optimum Yield
PacIOOS	Pacific Integrated Ocean Observing System
PCMUS	Precious Coral Management Unit Species
Pelagic FEP	Fishery Ecosystem Plan for the Pacific Pelagic Fisheries
PI	Pacific Islands
PIBHMC	Pacific Island Benthic Habitat Mapping Center
PIFSC	Pacific Island Fisheries Science Center
PIRCA	Pacific Islands Regional Climate Assessment
PIRO	NOAA NMFS Pacific Islands Regional Office
PMUS	pelagic management unit species
POES	Polar Operational Environmental Satellite
PRIA	Pacific Remote Island Areas
RAMP	Reef Assessment and Monitoring Program
RPB	Regional Planning Body
SAFE	Stock Assessment and Fishery Evaluation
SBRM	Standardized Bycatch Reporting Methodologies
SDC	Status Determination Criteria
SEEM	Social, Economic, Ecological, Management uncertainties
SPC	Stationary Point Count
SST	Sea Surface Temperature
USACE	United States Army Corps of Engineers
WPacFIN	Western Pacific Fishery Information Network
WPRFMC	Western Pacific Regional Fishery Management Council
WPSAR	Western Pacific Stock Assessment Review
WW3	Wave Watch 3

1 FISHERY PERFORMANCE

1.1 Fishery Descriptions

The Samoa Archipelago is a remote chain of 13 islands of varying sizes and an atoll, located 14^0 south of the equator near the International Date Line. The islands lie between 13° and 14° south latitude and 169° and 173° west longitude, 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 Hawai'i, in the central South Pacific Ocean. The archipelago is divided into two political entities: the Independent Samoa and American Samoa. The Independent Samoa has two large islands (Upolu and Savaii) and eight islets. American Samoa is comprised of five volcanic islands (Tutuila, Aunu'u, Ofu, Olosega, and Ta'u), one low-island (Swains Island) and a coral atoll (Rose Atoll). The five volcanic islands that are part of the American Samoa territory are very steep with mountainous terrain and high sea cliffs and of various sizes. Tutuila Island, the largest (137 km^2) and most populated island, is the most eroded with the most extensive shelf area and has banks and barrier reefs. Aunuu is a small island very close to Tutuila. Ofu and Olosega (together as 13 km^2) are twin volcanic islands separated by a strait which is a shallow and narrow break in the reef flat between the islands. Tau is the easternmost island (45 km^2) with a more steeply-sloping bathymetry.

The Samoa archipelago was formed by a series of volcanic eruptions from the "Samoan hotspot" (Hart et al. 2000). Based on the classic hotspot model, Savaii Island (the westernmost) in Samoa would be the oldest and Tau island (the easternmost) in American Samoa the youngest of the islands in the archipelago. Geological data indicate that Savaii is about four to five million years old, Upolu in Samoa about two to three million years old, Tutuila about 1.5 million years old, Ofu-Olosega about 300,000 years old and Tau about 100,000 years old. Swains and Rose are built on much older volcanoes 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 about 59-72 million years old (Neall and Trewick 2008, Konter et al 2008). There are numerous banks in the archipelago the origins of which are barely 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 from 1-13 years intervals with the six strong occurrences during the last 30 years (Esau,1981; Tusi, 1987; Ofa, 1990; Val, 1991; Heta, 2004 and; Olaf, 2005). The territory had two tsunamis in the last 100 years due to its proximity to the geologically active Tonga Trench.

It is in this geological and physical setting that the Samoans have established their culture in the last 3,500 years. For three millennia, the Samoans have relied on the ocean for their sustenance. Fishing activity and fish constitute an integral part of the 'fa'asamoa' or the Samoan culture. Chiefly position entitlements and other cultural activities use fish during the fa'alalave or ceremonies.

1.1.1 **Bottomfish Fishery**

Deep, zooxanthellate, scleractinian coral reefs 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 to 40 m up to 150 m and have been exploited by bottomfishing fishermen mainly targeting snappers, emperors and groupers. Bottomfishing utilizing traditional canoes by the indigenous residents of American Samoa has been a subsistence practice since the Samoans settled into the Tutuila, Manua and Aunu'u islands. It was not until the early 1970's that the bottomfish fishery developed into a commercial scheme utilizing motorized boats. The bottomfish fishery of American Samoa was typically commercial overnight bottomfish handlining using skipjack as bait, on 28-30 foot aluminum/plywood "alia" (A term used for larger boats in Samoa). Imported bottomfish from the independent state of Samoa help satisfy the demand for bottomfish however it weakens 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 fishing fleet and total landings. In 1982, a fisheries development project aimed at exporting high-priced deep-water snappers to Hawaii caused another notable increase in bottomfish landings and revenues. Between 1982 and 1988, the botttomfish fishery comprised as much as 50% (by weight) of the total commercial landings.

American Samoa's bottomfish fishery was relatively bigger between 1982 and 1985 when this fishery was new and booming. In 1988 a decline in bottomfish fisheries occurred as many skilled and full-time commercial fishermen converted to trolling. Profits and revenues in bottomfishing suffered devastating blows from four separate hurricanes; Tusi in 1987, Ofa in February of 1990,Val in December of 1991 and Heta in January of 2004 and finally 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 in the mid-1980s. Fuel prices have gradually soared in the past four years causing yet another strain in the bottomfish fisheries. The average price of bottomfish has also declined due to the shift of local bottomfish demand to imported bottomfish competing closely with local prices. In 2004, 60% of coolers imported from the independent state of Samoa on the Lady Naomi Ferry were designated for commercial purposes; from the Commercial Invoice System 50% of these coolers were bottomfish.

Beginning in 1988, the nature of American Samoa's fisheries changed dramatically with a shift in importance from bottomfish fishing towards trolling. In the past eight years, the dominant (by weight of fish landed) fishing method has been longlining. Bottomfishing has been in decline for years but was dealt a final devastating blow by the 2009 tsunami. A fishery failure was declared and the US 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 on the rising fuel prices. (The fuel price has since gone significantly lower.)

1.1.2 **Coral Reef Fishery**

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

Presumably, the change from traditional to present-day methods of fisheries 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 pelagic fisheries, bottomfishing in mesophotic reefs and the nearshore coral reef fisheries. For creel monitoring program purposes, fisheries is either subsistence (or shore-based and mostly for personal consumption) or commercial (or boat-based and mostly sold). Bottomfishing is actually a combination of mesophotic reef fishing and/or pelagic fishing (trolling). The coral reef fishery involve 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 only around 1997–1998 and finally banned in 2002 following recommendations by the biologists from the Department of Marine and Wildlife Resources and local scientists.

1.2 Fishery Data Collection System

American Samoa has been regularly conducting fishery-dependent monitoring since 1982 for the boat-based fishery and 1990 for the shore-based fishery. The boat-based fishery is mostly trolling for tuna, skipjacks and trevally, and bottomfishing for snappers, emperor and groupers. The shore-based fishery is mostly gleaning for shellfish and octopus, rod and reel for groupers and jacks and spearfishing for surgeon and parrotfishes. Both the boat-based and shore-based data collection involves two runs; first is the participation run to determine the number of boats/fisherman out to fish and identify the type of gear being used; while the second is the interview run where the fishermen are interviewed for the effort and economic data and concurrently measuring the length and weight of each fish identified to species level.

1.2.1 Boat-Based Creel Survey

The boat-based data collection focuses mostly on the main docks in Fagatogo and Pago Pago and opportunistically surveying off sites like Aunuu, Auasi, and Asili. The shore-based data collection conducts its run by randomly selecting eight hour periods and location four to five times per week. Survey locations are: west side of Tutuila from Poloa to Vaitogi; central Tutuila from Tafuna to Laulii; and eastern Tutuila from Laulii to Tula. Boat-based and shore-based data collection are also being conducted in Manua. The boat-based data collection in Ofu-Olosega and Tau are opportunistic since there is no set schedule for boats to go out and land their catches.

The survey follows a random stratified design. The stratification is by survey area, weekday/weekend, and time of day. The survey is divided into two phases: 1) participation run; and 2) catch interview phase. The participation run attempts to estimate the amount of participation by counting the number of boats “not on the dock” or the presence of trailers. The catch interview phase occurs after the participation run that documents catch composition, catch per unit effort (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. (in press).

1.2.2 Shore-Based Creel Survey

The shore-based data collection follows the same scheme as the boat-based creel survey. The following information are generated through these data collection programs: 1) catch landing; 2) effort; 3) CPUE; 4) catch composition; 5) length accurate to the nearest centimeter; 6) weights in pounds. The survey follows a random stratified design. The stratification is by survey area, weekday/weekend, and time of day. The survey is divided into 2 phases: 1) participation run; and 2) 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 gear, and number of fishers are recorded. The catch interview phase occurs after the participation run that documents catch composition, catch per unit effort (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. (in press).

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 througha receipt book system collected on the fifth day of every month. Information required to be reported are as follows: (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 in processed form; (i) which fish or shellfish were taken within and outside the territorial waters; and (j) other statistical information as the department may require.

1.2.4 Boat inventory

An annual boat inventory is being conducted to determine and track down fishing boats and 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 information used or data available to calculate the fishery-dependent information. Creel surveys are a sampling-based system that requires random-stratified design applied to pre-scheduled surveys. The creel surveys are comprised of: 1) participation run that captures effort and participation estimates and; 2) catch interviews that capture catch, effort, CPUE information, catch composition, size-weight information. The number of sampling days, participation runs, and catch interviews would determine if there are sufficient samples to run the expansion algorithm. The trends of these parameters over time may infer survey performance. Monitoring the survey performance is critical for explaining the reliability of the expanded information.

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

1.3.1 Creel surveys meta-data statistics

Calculations: Shore-based data

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

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

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

Calculation: Boat-based data

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

Catch Interviews: Count of the total number of data records found in the interview header data (number of interview headers). This is divided into two categories, interviews conducted during a complete survey (Regular), and opportunistic interviews (Opp) which are completed on days when the whole survey is not conducted.

Table 1. Summary of creel survey meta-data describing survey performance parameters with potential influence on the creel survey expansion

Year	Shore-based			Boat-based		
	# sample days	# participation runs	# catch interviews	# sample days	# recorded trips	# catch interviews
1985				41	252	222
1986				156	703	683
1987	31	NULL	26	146	358	346
1988	183	NULL	179	152	474	470
1989	204	NULL	184	149	527	514
1990	236	261	393	157	334	352
1991	204	458	349	142	283	285
1992	198	274	133	152	272	248
1993	221	305	255	148	289	293

Year	**Shore-based**			**Boat-based**		
	# sample days	**# participation runs**	**# catch interviews**	**# sample days**	**# recorded trips**	**# catch interviews**
1994	254	544	382	138	670	521
1995	261	524	302	137	893	646
1996	231	230	218	131	852	657
1997	162	NULL	108	147	1650	1136
1998	180	NULL	143	150	1648	1068
1999	69	NULL	51	132	1674	887
2000	115	NULL	67	120	1714	729
2001	115	293	80	126	1230	443
2002	60	196	18	120	1193	376
2003	175	437	55	183	1264	503
2004	195	695	110	214	1052	511
2005	218	1143	277	219	699	340
2006	228	904	140	207	503	332
2007	183	963	183	244	888	491
2008	190	892	181	208	830	314
2009	245	1234	285	172	458	183
2010	163	648	117	212	408	170
2011	204	1028	347	239	545	204
2012	237	907	104	262	602	299
2013	199	685	192	259	690	245
2014	31	NULL	26	237	662	380
2015	183	NULL	179	218	658	272

Year	Shore-based			Boat-based		
	# sample days	# participation runs	# catch interviews	# sample days	# recorded trips	# catch interviews
10-year Ave.	**189**	**934**	**185**	**225**	**631**	**294**
10-year SD	**58**	**191**	**91**	**26**	**148**	**94**
20-year Ave.	**174**	**719**	**152**	**187**	**958**	**485**
20-year SD	**63**	**329**	**94**	**49**	**429**	**278**

1.3.2 **Commercial receipt book statistics**

Calculations:

# of Vendors – Count of the number of unique buyer codes found in the commercial purchase header data.

Invoices – Count of the number of unique invoice numbers found in the commercial header data.

Table 2. Summary of commercial receipt book meta-data describing reporting performance parameters with potential influence on total commercial landing estimates (Note: Data will be reported only for years with ≥ 3 vendors reporting).

Year	Number of vendors	Number of invoices
2000	19	1169
2001	31	1371
2002	27	1076
2003	31	1263
2004	28	937
2005	68	1000
2006	60	1201
2007	65	1355
2008	47	1020
2009	45	806

Year	Number of vendors	Number of invoices
2010	34	620
2011	30	772
2012	29	827
2013	30	740
2014	39	1102
2015	36	915
10-year Ave.	**44**	**942**
10-year SD	**14**	**219**
20-year Ave.	**N.A.**	**N.A.**
20-year SD	**N.A.**	**N.A.**

1.4 Fishery Summary Dashboard Statistics

The Fishery Summary Dashboard Statics section consolidates all fishery-dependent information comparing the most recent year with the short-term (recent 10 years) and long-term (recent 20 years). The summary dashboard shows the most current year value: the difference between the current year value with the 10 year average and the 20 year 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 greater than, less than, or within one standard deviation of the mean of the full time series.

Legend Key:

- *increasing trend in the time series* - *greater than 1 standard deviation*

- *decreasing trend in the time series* - *less than 1 standard deviation*

- *no trend in the time series* - *within 1 standard deviation*

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

Table 3. Annual indicators for the coral reef and bottomfish fishery describing fishery performance comparing current estimates with the short-term (10 years) and the long-term (20 years) average.

Fishery	Fishery statistics	Short-term (recent 10 years)	Long-term (20 years)
Bottomfish	**Estimated catch (lbs)**		
All species caught in the BF gear	Boat and shore creel data estimated (expanded) total lbs (all BF trips)	121,158**[1,228]**	121,158**[22,236]**
	Estimated total lbs (all species) commercial purchase data	16,182**[-11,827]**	16,182**[11,606]**
Bottomfish management unit species only	Total creel data Estimated (expanded) total lbs (all BF trips)		
	Estimated total lbs (all species) commercial purchase data		
	Catch-per-unit effort (lbs/gear-hrs)		
	CPUE (creel data only)	8.8**[0.54]**	8.8**[-1.4]**
	Fishing effort *(only available for creel data)*		
	Estimated (expanded) total bottomfish # of trips	434**[101]**	434**[121]**
	Fishing participants		
	Estimated total # of boats that went bottomfishing	17**[-2]**	17**[-7]**
	Bycatch (all BB)		
	Total number of bycatch caught	14,505**[-5,521]**	14,505**[-4,467]**
	# bycatch released	0**[0]**	0**[-1]**
	# bycatch kept	14,505**[-5,521]**	14,505**[-4,467]**
	Federal permits		

	# federal permit holders (PIRO)		
Coral Reef	**Estimated catch (lbs all gears)**		
	Boat-based creel data (expanded estimate all gears, defined by a list of species?)	58,884**[8,858]** ↗ ⊕	58,884**[4,079]** ⇔ ⊕
	Shore-based creel (expanded estimate all gears, defined by a list of species?)	25,570**[-10,496]** ⇔ ⊖	25,570**[-15,869]** ⇔ ⊖
	Commercial Purchase	No 2015 value	No 2015 value
	Catch-per-unit-effort (lbs/gear-hrs)		
	BB mixed method	1.05**[-0.15]** ⇔ ⊕	1.05**[-0.40]** ⇔ ⊕
	BB spear	7.19**[1.08]** ⇔ ⊕	7.19**[0.72]** ⇔ ⊕
	BB troll	0.12**[-0.14]** ↘ ⊕	0.12**[-0.19]** ⇔ ⊕
	SB H&L		
	SB rod and reel	0.40**[0.09]** ⇔ ⊙	0.40**[0.09]** ⇔ ⊙
	SB spear	1.18**[0.28]** ⇔ ⊕	1.18**[0.31]** ⇔ ⊕
	SB gleaning	4.02**[2.33]** ↗ ⊕	4.02**[2.42]** ↗ ⊕
	SB handline	0.17**[-0.08]** ⇔ ⊕	0.17**[-0.08]** ⇔ ⊕
	Fishing effort (# of gear-hours by gear type)		
	BB mixed method	1,449**[610]** ↗ ⊙	1,449**[446]** ⇔ ⊕
	BB spear	300**[115]** ⇔ ⊖	300**[-169]** ⇔ ⊖
	BB troll	857**[226]** ⇔ ⊖	857**[-1,205]** ↘ ⊖

	SB H&L		
	SB rod and reel	10,138**[2,004]**	10,138**[457]**
	SB spear	794**[-2,605]**	794**[-2,782]**
	SB gleaning	1,449**[-1,546]**	1,449**[-2,781]**
	SB handline	175**[-284]**	175**[-2,219]**
	Fishing participants (# of gear)		
	BB mixed method	36**[-186]**	36**[-104]**
	BB spear	204**[-54]**	204**[21]**
	BB troll	147**[-43]**	147**[-327]**
	SB H&L		
	SB rod and reel	160**[78]**	160**[104]**
	SB spear	36**[-42]**	36**[-31]**
	SB gleaning	4**[-17]**	4**[-15]**
	SB handline	3**[-1]**	3**[-3]**
	Bycatch		
	Total number of bycatch caught		
	# bycatch released		
	# bycatch kept		
	Federal permits		
	# federal permit holders (PIRO)		

1.5 Catch statistics

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

1.5.1 Catch by data stream

This describes the estimated total catch from the shore and boat-based creel survey program and the commercial landing from the commercial receipt book system. The difference between the creel total and the commercial landing 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 is able to capture the fishery better than the creel survey (e.g. night time spearfishing)

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

Table 4. Summary catch time series of the ALL SPECIES caught using the bottomfishing gear: estimated lbs (expanded) from the boat and shore-based creel surveys and estimated total lbs from the commercial purchase system

Note: The creel survey estimates were not available for this report but will be included in next year's report.

Year	Creel survey Estimates		Creel Total	Commercial landings
	Shore-based	Boat-based		
1980				
1981				
1982			146,948	64,942
1983			232,417	126,327
1984			116,273	94,104
1985			100,338	143,225
1986			124,511	92,283
1987			94,639	31,214
1988			130,829	62,851

Year	**Creel survey Estimates**		**Creel Total**	**Commercial landings**
	Shore-based	**Boat-based**		
1989			121,158	46,476
1990			85,389	14,759
1991			75,606	18,699
1992			69,993	13,777
1993			48,135	17,719
1994			52,772	46,064
1995			30,708	36,254
1996			32,980	39,495
1997			46,672	40,544
1998			44,399	15,782
1999			98,884	19,345
2000			100,817	28,597
2001			105,125	49,201
2002			127,648	45,220
2003			124,354	26,759
2004			46,551	28,861
2005			102,030	18,577
2006			65,668	8,054
2007			84,416	34,601
2008			146,948	49,646
2009			232,417	72,143
2010			116,273	15,142

Year	Creel survey Estimates		Creel Total	Commercial landings
	Shore-based	Boat-based		
2011			100,338	35,328
2012			124,511	16,665
2013			94,639	35,204
2014			130,829	29,270
2015			121,158	42,683
10-year Avg.?				
20-year Avg.?				

Table 5. Summary of the available Bottomfish Management Unit Species (BMUS) catch time series: estimated lbs (expanded) from the boat and shore-based creel surveys and estimated total lbs from the commercial purchase system.

Note: The estimates were not available for this report but will be included in next year's report.

Year	Creel survey Estimates		Creel Total	Commercial landings
	Shore-based	Boat-based		
1980				
1981				
1982				
1983				
1984				
1985				
1986				
1987				
1988				
1989				
1990				

Year	**Creel survey Estimates**		**Creel Total**	**Commercial landings**
	Shore-based	**Boat-based**		
1991				
1992				
1993				
1994				
1995				
1996				
1997				
1998				
1999				
2000				
2001				
2002				
2003				
2004				
2005				
2006				
2007				
2008				
2009				
2010				
2011				
2012				
2013				
2014				

Year	**Creel survey Estimates**		**Creel Total**	**Commercial landings**
	Shore-based	**Boat-based**		
2015				
10-year Avg.?				
20-year Avg.?				

Calculations: Estimated landings are based on a pre-determined list of species (Appendix X) identified as the CREMUS Complex regardless of the gear used, for each data collection (shore-based creel, boat-based creel and the commercial purchase reports). Need to finalize the CREMUS list to use for Creel and commercial landings and verify non-overlap between Bottomfish Complex and CREMUS. Also need to verify all shallow bottomfish are not included in CREMUS list.

Table 6. Summary of the predefined "coral reef fishery" (?) catch time series (for a discrete list of species – taken from CB lbs and CS lbs from the CREMUS module) from the boat and shore-based creel surveys and the commercial purchase system.

Year	**Creel surveys**		**Creel Total**	**Commercial landing**
	Shore-based	**Boat-based**		
1982				4,484
1983				1,500
1984				949
1985				3,571
1986		123,082		2,636
1987		64,026		2,777
1988		99,799		8,783
1989		83,956		4,210
1990	129,760	17,186	146,948	150
1991	213,729	18,688	232,417	1,935
1992	101,738	14,535	116,273	684
1993	84,173	16,166	100,338	2,388

Year	**Creel surveys**		**Creel Total**	**Commercial landing**
	Shore-based	**Boat-based**		
1994	49,067	75,444	124,511	4,141
1995	54,684	39,958	94,639	4,175
1996	87,299	43,530	130,829	3,800
1997		121,158	121,158	9,217
1998		85,389	85,389	7,226
1999		75,606	75,606	5,504
2000		69,993	69,993	2,078
2001		48,135	48,135	1,916
2002		52,772	52,772	1,029
2003		30,708	30,708	1,945
2004		32,980	32,980	713
2005	29,793	16,877	46,672	4,091
2006	30,325	14,076	44,399	8,814
2007	44,681	54,203	98,884	8,113
2008	43,176	57,641	100,817	3,980
2009	14,049	91,077	105,125	3,028
2010	54,060	73,591	127,648	4,499
2011	65,746	58,608	124,354	2,931
2012	20,216	26,336	46,551	877
2013	47,963	54,066	102,030	2,488
2014	21,150	44,522	65,668	2,714
2015	25,570	58,844	84,416	
10-year ave.	**36,066**	**49,986**	**86,051**	**4,154**
10-year SD	**16,161**	**23,380**	**30,762**	**2,492**

Year	Creel surveys		Creel Total	Commercial landing
	Shore-based	Boat-based		
20-year ave.	**41,439**	**54,765**	**80,418**	**3,957**
20-year SD	**20,833**	**25,668**	**32,327**	**2,595**

1.5.2 Expanded catch estimates by fishing methods

Catch information is provided for the top shore-based and boat-based fishing methods that contribute >90% of the annual catch.

Calculations: The creel survey time series of catch will be the sum of the estimated weight by selected gear in all strata for all species except for trolling which would exclude PMUS and any pelagic species complex.

Table 7. Expanded catch time series estimates using boat and shore-based creel survey data sets by gear type.

Year	Shore-based methods (>90% of catch)						Boat-based methods (>90% of catch)			
	R&R	Spear	Gleaning	Gill	Handline	Throw	Bottom	Mix	Spear	Troll
1980										
1981										
1982										
1983										
1984										
1985										
1986							57,149	31,881	33,451	601
1987							8,578	20,536	32,837	2,074
1988							23,045	18,748	53,178	3,668
1989							17,930	24,175	40,779	1,071
1990	45,665	17,762	10,280	11,959	32,480	10,084	7,368	7,092	1,441	1,285
1991	87,365	28,694	22,361	30,639	38,083	4,644	11,657	5,810	825	396
1992	23,899	29,249	37,481	3,054	1,262	5,993	12,709			1,826

Year	**Shore-based methods (>90% of catch)**						**Boat-based methods (>90% of catch)**			
	R&R	**Spear**	**Gleaning**	**Gill**	**Handline**	**Throw**	**Bottom**	**Mix**	**Spear**	**Troll**
1993	6,734	40,535	29,255	4,076	562	2,693	12,836	2,033	734	562
1994	11,733	11,300	16,211	2,701	4,449	1,965	37,279	3,017	32,972	2,175
1995	5,981	13,624	26,456	2,002	3,355	2,155	13,951	16,821	6,526	2,660
1996	33,530	13,838	22,877	1,181	12,014	2,640	28,625	6,173	6,305	2,426
1997							29,375	5,059	84,083	2,623
1998							4,625	1,522	77,241	1,933
1999							8,935	2,066	63,115	1,490
2000							22,948	2,777	42,547	1,091
2001							36,451	954	9,803	828
2002							43,113	481	8,562	615
2003							24,026	595	5,533	460
2004							26,578	1,252	4,365	783
2005	6,177	5,407	8,781	3,944	311	4,529	14,346	1,253	416	863
2006	8,638	3,138	4,011	5,753	516	6,689	10,311	386	2,589	722
2007	14,944	11,290	4,179	4,407	220	8,259	31,016	336	19,070	354
2008	13,795	5,967	17,683	2,465	175	2,899	45,712	861	7,953	231
2009	2,757	4,796	3,751	775	83	1,720	73,028	486	17,011	19
2010	5,513	39,130	3,803	1,417	150	3,614	13,310	122	59,866	265
2011	27,749	27,989	3,267	2,336	1,204	3,181	23,220	2,351	32,799	207
2012	4,907	4,474	3,681	1,308	69	5,764	6,700	700	15,898	30
2013	15,983	8,814	12,284	621	280	9,761	20,914	1,156	31,609	348
2014	6,587	4,117	8,007	228		2,144	25,634	1,353	16,922	431
2015	10,279	3,443	5,822		131	5,615	32,715	2,344	23,532	254
10-year avg.	**10,666**	**10,779**	**6,843**	**2,325**	**314**	**4,925**	**26,991**	**1,032**	**20,697**	**339**

Year	Shore-based methods (>90% of catch)						Boat-based methods (>90% of catch)			
	R&R	**Spear**	**Gleaning**	**Gill**	**Handline**	**Throw**	**Bottom**	**Mix**	**Spear**	**Troll**
10-year SD	**7,152**	**11,782**	**4,582**	**1,835**	**339**	**2,566**	**18,997**	**761**	**16,622**	**259**
20-year avg.	**12,065**	**11,233**	**9,585**	**2,203**	**1,542**	**4,536**	**25,502**	**2,336**	**25,512**	**887**
20-year SD	**9,268**	**10,813**	**7,927**	**1,693**	**3,425**	**2,529**	**15,719**	**3,653**	**25,435**	**845**

1.5.3 **Top species in the catch for the boat and shore-based fisheries**

The time series for catch is an indicator of fishery performance. Fluctuations in the catch can be attributed to various factors and there is no single explanatory variable for the trends. The 10 species group in the boat and shore-based catch for the coral reef fishery make up 70% and 85% of the total annual catches, respectively.

Calculations: Catch by species complex can be summed directly from current boat-based expanded species composition data over all by gear or by gear and species, for all strata. (geographic, temporal).

The averages for the table this year were calculated from catch estimates from the entire time series for each of the CREMUS groupings. The average catch for each grouping is ranked from the highest to lowest catch. The dominant groups that make up more than 50% of the catch are reported.

Table 8. Catch time series of the 11 managed species complexes (rank ordered by management importance and average catch of recent 10 years) from the boat-based creel data. The CREMUS complex comprise > 70% of the total boat-based landing (Surg. = surgeonfish; Snap. = snapper; Empr. = emperor; Parrot. = parrotfish; Grpr. = grouper; Jack. = jacks; Crus. = crustacean; Sqrl. = squirrelfish; Atul. = atulai)

YEAR	All BF	BMUS	Surg.	Snap.	Empr.	Parrot	Grpr.	Jack.	Crus.	Sqrl.	Atul.
1980											
1981											
1982	64942										
1983	126327										
1984	94104										

YEAR	**All BF**	**BMU S**	**Surg.**	**Snap.**	**Empr.**	**Parrot**	**Grpr.**	**Jack.**	**Crus.**	**Sqrl.**	**Atul.**
1985	143225										
1986	92283			858	138		581	1,301	1,903	368	
1987	31214		2,014	340	56	918	75	405	2,545	122	
1988	62851		17,250	12,484	10,435	4,720	6,480	4,027	5,973	2,350	1,161
1989	46476		19,229	17,955	10,945	7,962	8,525	5,458	4,602	4,448	
1990	14759		823	5,643	4,607	319	1,405	1,570	186	148	108
1991	18699		388	7,881	4,594	166	2,035	1,335	155	271	
1992	13777			4,161	5,995		1,013	1,864		34	
1993	17719		221	5,931	3,547	330	2,733	1,081	50	234	
1994	46064		9,277	15,429	12,487	15,557	6,898	3,797	1,526	816	
1995	36254		1,588	11,090	6,519	2,960	5,527	6,443	293	458	2
1996	39495		3,558	11,968	10,959	1,409	3,722	4,338	413	679	22
1997	40544		49,629	15,688	7,282	17,552	8,925	5,742	5,319	3,697	272
1998	15782		35,791	2,577	1,340	22,231	5,204	2,869	4,729	1,265	
1999	19345		34,666	3,763	1,427	13,769	5,822	2,908	2,137	2,599	
2000	28597		22,285	11,445	8,977	10,906	4,781	3,849	1,769	2,547	631
2001	49201		5,801	13,974	16,471	953	3,482	3,018	1,677	509	55
2002	45220		4,752	17,605	14,709	1,528	6,129	3,050	753	1,381	
2003	26759		3,089	7,439	7,133	843	7,662	1,620	1,033	583	
2004	28861		2,338	7,827	7,796	732	2,879	2,279	645	525	
2005	18577		105	5,195	2,182	74	1,558	1,285	29	181	
2006	8054		754	2,294	1,016	481	1,047	2,495	253	275	35
2007	34601		5,615	8,628	6,834	3,069	2,368	2,615	1,682	739	2,585
2008	49646		3,203	17,871	13,361	2,220	4,337	3,463	1,151	1,094	1,759
2009	72143		7,872	33,274	23,610	4,889	5,414	5,234	2,861	1,315	199

YEAR	All BF	BMU S	Surg.	Snap.	Empr.	Parrot	Grpr.	Jack.	Crus.	Sqrl.	Atul.
2010	15142		25,302	6,716	4,590	14,712	2,042	1,344	14,357	2,243	15
2011	35328		10,516	11,277	8,091	6,909	2,404	1,094	3,160	1,727	37
2012	16665		1,589	2,165	1,889	1,761	372	1,637	574	371	3,484
2013	35204		6,733	7,608	2,910	2,384	1,266	1,541	1,791	993	1,092
2014	29270		8,538	15,522	5,748	7,071	2,851	1,974	140	809	157
2015	42683		11,162	20,249	10,902	9,697	2,423	1,870	8	936	
10-year ave.	**32,483**	**#DIV/0!**	**7,399**	**11,891**	**7,376**	**4,842**	**2,371**	**2,232**	**2,364**	**971**	**1,040**
10-year SD	**18,284**	**#DIV/0!**	**7,059**	**9,294**	**6,637**	**4,445**	**1,453**	**1,215**	**4,130**	**622**	**1,296**
20-year ave.	**32,732**	**#DIV/0!**	**11,661**	**11,151**	**7,797**	**6,007**	**3,820**	**2,889**	**2,132**	**1,187**	**739**
20-year SD	**14,873**	**#DIV/0!**	**13,736**	**7,395**	**5,751**	**6,418**	**2,248**	**1,505**	**3,163**	**912**	**1,110**

Calculations: Catch by species complex can be summed directly from current shore-based expanded species composition data over all by gear or by gear and species, for all strata (geographic, temporal).

The averages were for the table below was calculated from catch estimates from the entire time series for each of the CREMUS grouping. The average catch is ranked from the highest to lowest catch. The dominant groups that make up more than 60% of the catch are reported.

Table 9. Catch time series of the 10 managed species complexes (rank ordered by management importance and average catch of recent 10 years) from the shore-based creel data. The CREMUS complex comprise > 85% of the total boat-based landing. (Surg. = surgeonfish; Snap. = snapper; Mlsk. = mollusk; Parrot. = parrotfish; Grpr. = grouper; Wras. = wrasse; Crus. = crustacean; Sqrl. = squirrelfish; Atul. = atule; Mull. = mullet)

	Shorebased methods									
	Atul	Mlsk	Surg	Parrot	Mull	Grpr	Sqrl	Wras	Crus	Snap
1990	46,835	10,543	16,079	1,232	18,013	2,243	1,952	135	475	3,336
1991	113,228	18,046	14,730	2,220	1,543	5,483	4,772	759	725	2,363

	Shorebased methods									
	Atul	Mlsk	Surg	Parrot	Mull	Grpr	Sqrl	Wras	Crus	Snap
1992	7,412	9,439	17,771	2,736	4,189	5,749	10,570	171	302	648
1993	7,641	38,629	10,930	1,651	964	4,392	1,426	308	432	1,009
1994	12,942	16,559	1,648	2,035	583	1,502	640	293	559	1,088
1995	20	22,520	4,321	2,003	1,935	1,904	1,595	167	1,052	101
1996	25,428	24,900	1,969	2,475	1,230	1,174	8,764	167	971	250
1997										
1998										
1999										
2000										
2001										
2002										
2003										
2004										
2005	1,077	6,660	5,988	1,359	2,558	2,116	826	3,158	729	269
2006	733	2,529	5,387	1,619	3,432	3,654	447	1,936	590	869
2007	2,680	9,348	7,056	2,252	2,819	4,580	702	950	478	444
2008	5,640	16,460	3,853	1,158	1,189	2,662	1,147	2,277	69	27
2009	237	3,206	2,661	840	435	1,398	1,137	759	173	99
2010	2,110	4,596	12,441	20,381	2,236	1,985	4,281	229	2,262	384
2011	16,117	7,499	14,462	12,161	2,602	1,855	3,777	126	1,894	267
2012	4,001	4,544	4,869	1,046	1,242	958	547	181	482	75
2013	6,189	18,039	6,876	1,121	3,144	1,730	1,181	525	818	343
2014	463	8,167	3,596	483	576	2,413	1,683	165	117	203
2015	2,432	6,565	6,198	147	727	709	795	56	35	275

	Shorebased methods									
	Atul	Mlsk	Surg	Parrot	Mull	Grpr	Sqrl	Wras	Crus	Snap
10-year ave.	**26,823**	**18,412**	**9,180**	**1,964**	**3,877**	**3,070**	**3,818**	**645**	**656**	**1,133**
10-year SD	**38,148**	**10,363**	**6,522**	**525**	**5,821**	**1,842**	**3,857**	**1,036**	**263**	**1,147**
20-year ave.	**5,164**	**10,387**	**6,129**	**3,619**	**1,856**	**2,088**	**2,068**	**823**	**744**	**277**
20-year SD	**7,446**	**7,512**	**3,618**	**5,897**	**1,017**	**1,073**	**2,336**	**1,002**	**684**	**217**

1.6 Catch Per Unit Effort (CPUE) Statistics

This section summarizes the estimates for catch-per-unit effort in the boat and shore-based fisheries. The boat-based fisheries include the bottomfishing (handline gear), spearfishing (snorkel), troll, atulai nets, and castnets that comprise 84% of the total catch. Trolling method is primarily a pelagic fishing method but also catches coral reef fishes like jacks and gray jobfish. The shore-based fisheries include the hook-and-line, spearfishing and cast nets comprise 99% of the total coral reef fish catch. CPUE is reported as pounds per gear-hours for the shore-based methods whereas in the boat-based methods it's pounds per trip.

Calculations: The previous CREPT report generated CPUE estimates for the top CREMUS groups by fishing method. The top 3-4 CREMUS groups that dominate the catch by fishing method were used to represent the CPUE by method. The proportion of the dominant CREMUS groups relative to the total catch is described in the method header. The representative CPUE by method was calculated from the average CPUE for these CREMUS groups.

Table 10. Catch per unit effort time series by dominant fishing methods from the shore-based fisheries. CPUE estimates were derived from the top three to five dominant taxonomic groups that make up more than 50% of the catch. The percentage of catch is shown in parenthesis beside the method.

Year	**Shore-based methods (annual est. total lbs/est. gear-hr)**				
	Lbs/Gear-hr Complex A				
	R&R (77%)	**Spear (63%)**	**Gleaning (73%)**	**Gill ()**	**Handline (81%)**
1990	0.61	0.62	0.67		0.21
1991	1.08	0.43	1.01		0.49
1992	1.05	0.80	1.43		0.25

Year	Shore-based methods (annual est. total lbs/est. gear-hr)				
	Lbs/Gear-hr Complex A				
	R&R (77%)	Spear (63%)	Gleaning (73%)	Gill ()	Handline (81%)
1993	0.16	1.00	0.66		0.05
1994	0.21	0.56	0.78		0.14
1995	0.23	0.78	1.19		0.29
1996	0.40	0.62	1.04		0.19
1997					
1998					
1999					
2000					
2001					
2002					
2003					
2004					
2005	0.14	0.34	0.46		0.21
2006	0.31	0.41	0.24		0.27
2007	0.29	1.72	1.55		0.30
2008	0.64	0.62	1.29		0.12
2009	0.13	0.50	1.25		0.15
2010	0.35	2.47	1.22		0.23
2011	0.57	1.56	1.46		0.55
2012	0.11	0.59	2.56		
2013	0.32	0.16	1.78		0.22

Year	Shore-based methods (annual est. total lbs/est. gear-hr)				
	Lbs/Gear-hr Complex A				
	R&R (77%)	Spear (63%)	Gleaning (73%)	Gill ()	Handline (81%)
2014	0.14	0.37	2.71		
2015	0.40	1.18	4.02		0.17
10-year ave.	0.31	0.90	1.69		0.25
10-year SD	0.18	0.73	1.07		0.13
20-year ave.	0.31	0.87	1.60		0.25
20-year SD	0.17	0.67	1.00		0.12

Table 11. Catch per unit effort time series by dominant fishing methods from the boat-based fisheries. CPUE estimates were derived from the top –three to five dominant taxonomic groups that make up more than 50% of the catch. The percentage of catch is shown in parenthesis beside the method.

	Boat-based methods (annual est. total lbs/est. trips)				
	Lbs/Hour Complex B				
Year	Bottomfishing (76%)	Mixed (BF&troll) (69%)	Spear (68%)	Troll (66%)	
1980					
1981					
1982	8.50				
1983	10.00				
1984	10.70				
1985	8.10				
1986	8.30	0.02		0.03	
1987	11.90	0.03	7.31	0.04	

	Boat-based methods (annual est. total lbs/est. trips)				
	Lbs/Hour Complex B				
Year	**Bottomfishing (76%)**	**Mixed (BF&troll) (69%)**	**Spear (68%)**	**Troll (66%)**	
1988	17.30	1.96	4.09	0.12	
1989	16.70	2.82	10.58	0.07	
1990	9.30	2.26	3.09	0.14	
1991	8.60	1.92	4.58	0.05	
1992	9.30			0.24	
1993	7.30	1.09	3.73	0.09	
1994	7.80	0.99	4.53	0.10	
1995	9.80	0.97	4.14	0.10	
1996	15.20	1.76	10.31	0.31	
1997	14.70	1.82	11.92	0.45	
1998	14.00	0.80	7.46	0.78	
1999	12.90	0.99	5.85	0.41	
2000	10.40	5.45	6.31	0.53	
2001	15.20	0.88	4.51	0.33	
2002	8.10	1.20	7.95	0.25	
2003	15.30	2.10	5.63	0.24	
2004	7.60	1.28	4.65	0.35	
2005	6.90	1.23	2.18	0.56	
2006	9.30	1.06	2.72	0.41	
2007	9.60	0.68	2.98	0.27	
2008	8.10	0.76	3.09	0.15	

	Boat-based methods (annual est. total lbs/est. trips)				
	Lbs/Hour Complex B				
Year	**Bottomfishing (76%)**	**Mixed (BF&troll) (69%)**	**Spear (68%)**	**Troll (66%)**	
2009	9.30	0.63	13.54	0.05	
2010	5.60	0.69	11.57	0.60	
2011	9.40	2.21	9.54	0.17	
2012	8.70	1.59	2.71	0.04	
2013	8.50	2.12	5.05	0.28	
2014	6.70	1.21	6.67	0.20	
2015	8.80	1.05	7.19	0.12	
10-year Ave	**8.3**	**1.2**	**6.1**	**0.3**	
10-year SD	**1.3**	**0.6**	**4.0**	**0.2**	
20-year Ave	**10.2**	**1.5**	**6.5**	**0.3**	
20-year SD	**3.1**	**1.0**	**3.3**	**0.2**	

NOTE: CPUE value for troll and spear are in lbs/hr

1.7 Effort Statistics

This section summarizes the effort trends in the coral reef and bottomfish fishery. Fishing effort trends provide insights on the level of fishing pressure through time. Effort information is provided for the top shore-based and boat-based fishing methods that contribute 70% and 85% of the annual catch.

Calculations: The values were derived from the shore and boat-based CPUE estimates and catch estimates extracted from the previous CREPT reports. For the bottomfish effort, values were derived from the old bottomfish fishery modules.

Effort estimates for the coral reef shore-based fisheries and boat-based non-bottomfish fisheries (expressed in gear-hours) were derived from the CPUE and catch of the dominant CREMUS groups per method. The catch (expressed in pounds) of the top 3-4 CREMUS groups per method was divided by its corresponding CPUE (expressed in pounds per gear-hours) from Table 10 and 11 to derive effort (expressed in gear-hours). For the bottomfish fishery, the sum of the total number of recorded trips constitutes the fishing effort.

Table 12. Time series of effort estimates from the coral reef and bottomfish fisheries

	Estimated Effort by Gear or Fishing Method								
	# of SB gear-hours (estimated annual expanded)					# of BB trips (estimated annual expanded)			
	R&R	Spear	Gleaning	Gill	Handline	Bottom	Spear	Mix	Troll
1980									
1981									
1982						548			
1983						621			
1984						468			
1985						1116			
1986						725			
1987						219	1,336	4,947	9,847
1988						351	2,163	2,819	5,642
1989						306	1,285	1,711	5,717
1990	23,701	7,237	7,525		38,955	126	185	2,225	7,573
1991	24,404	10,575	10,380		21,885	152	60	876	4,128
1992	5,793	7,854	10,174		1,251	104		831	3,663
1993	8,289	9,894	18,325		1,257	144	54		3,740
1994	14,627	4,936	9,467		8,923	345	2,054	412	2,835
1995	7,745	3,821	11,113		2,125	283	461	779	10,756
1996	28,639	5,276	10,932		20,071	265	168	4,220	11,212
1997						295	1,939	747	3,954
1998						99	2,859	646	2,886
1999						144	3,011	399	1,245

	Estimated Effort by Gear or Fishing Method								
	# of SB gear-hours (estimated annual expanded)					# of BB trips (estimated annual expanded)			
	R&R	**Spear**	**Gleanin g**	**Gill**	**Handline**	**Bottom**	**Spear**	**Mix**	**Troll**
2000						243	1,820	445	1,817
2001						344	514	154	1,036
2002						546	395	245	1,255
2003						295	348	92	1,226
2004						406	328	80	965
2005	6,493	2,812	6,249		355	249	42	252	1,096
2006	7,724	1,589	3,444		543	115	238	218	764
2007	9,894	1,785	2,509		254	312	1,413	85	833
2008	7,644	2,015	6,113		269	433	587	120	663
2009	2,739	2,003	1,906		115	499	466	254	745
2010	3,983	4,153	2,972		384	166	1,729	213	200
2011	14,444	4,732	2,056		1,415	279	656	47	221
2012	7,686	1,887	1,391			324	604	300	598
2013	13,748	13,256	3,384		623	505	873	103	355
2014	4,982	2,368	1,468			344	1,170	143	612
2015	10,138	794	1,449		175	434	1,449	300	857
10-year Avg.	**8,134**	**3,399**	**2,995**		**459**	**333**	**839**	**185**	**631**
10-year SD	**3,715**	**3,460**	**1,740**		**394**	**128**	**538**	**89**	**278**
20-year Avg.	**9,681**	**3,576**	**4,230**		**2,394**	**313**	**1,003**	**469**	**2,062**

	Estimated Effort by Gear or Fishing Method								
	# of SB gear-hours (estimated annual expanded)					**# of BB trips (estimated annual expanded)**			
	R&R	**Spear**	**Gleanin g**	**Gill**	**Handline**	**Bottom**	**Spear**	**Mix**	**Troll**
20-year SD	**6,630**	**3,202**	**3,408**		**5,895**	**125**	**857**	**886**	**3,092**

NOTE: Table below shows fishing effort in gear-hours divided by the number of gear per year.

	Estimated Effort by Gear or Fishing Method								
	# of SB gear-hours (estimated annual expanded)					**# of BB trips (estimated annual expanded)**			
	R&R	**Spear**	**Gleanin g**	**Gill**	**Handline**	**Bottom**	**Spear**	**Mix**	**Troll**
1980									
1981									
1982						20			
1983						16			
1984						10			
1985						24			
1986						20			
1987						10	9	21	16
1988						11	15	9	6
1989						9	7	8	5
1990	269		279	0	351	5	3		8
1991	222		315	0	246	7	1		6
1992	579		598	0	114	7	0		6
1993	184	230	426	0	629	6	1	0	6

	Estimated Effort by Gear or Fishing Method								
	# of SB gear-hours (estimated annual expanded)					# of BB trips (estimated annual expanded)			
	R&R	**Spear**	**Gleanin g**	**Gill**	**Handline**	**Bottom**	**Spear**	**Mix**	**Troll**
1994	178		133	0	235	14	14		2
1995	199	28	123	0	79	8	6	6	6
1996	699		405	0	772	8	1		9
1997						8	67		3
1998						3	150		4
1999						4	89	11	2
2000						7	38	13	3
2001						13		10	2
2002						30	28	18	3
2003						16	6		4
2004						16	5		2
2005	342	9				18		1	4
2006	140	11	265	0		5	6	1	2
2007	74	13	35	0	36	12	37	1	4
2008	163	4	306	0	90	19	21	0	3
2009	34		87	0	23	24			12
2010	78		270	0	64	10	34		4
2011	114	13	79	0	129	23	30	0	1
2012	122	5	99	0	0	23	15	1	7
2013	117	103	147	0	69	30	12	1	2
2014	116	17	367	0		14	1	1	2

	Estimated Effort by Gear or Fishing Method								
	# of SB gear-hours (estimated annual expanded)					**# of BB trips (estimated annual expanded)**			
	R&R	**Spear**	**Gleanin g**	**Gill**	**Handline**	**Bottom**	**Spear**	**Mix**	**Troll**
2015	63	4	362	0	58	26	40	1	6
10-year Avg.	**124**	**20**	**202**	**-**	**59**	**19**	**22**	**1**	**4**
10-year SD	**81**	**31**	**126**	**-**	**40**	**7**	**14**	**0**	**3**
20-year Avg.	**174**	**21**	**212**	**-**	**132**	**15**	**33**	**5**	**4**
20-year SD	**175**	**30**	**131**	**-**	**228**	**8**	**38**	**6**	**3**

1.8 Participants

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

Calculations:

For Boat-based – estimated number of participants is calculated by using and average number of boats out fishing per day multiplied by the numbers of dates in the calendar year by gear type. The total is a combination of weekend and weekday stratum estimates.

For Shore-based – estimated number of participants is calculated by using and average number of fishers out fishing per day multiplied by the numbers of dates in the calendar year by gear type. The total is a combination of weekend, weekday, day and night stratum estimates.

Table 13. Number of boats participating in the bottomfish fishery and number of gear in the boat and shore-based coral reef fishery. Cells marked with * indicates data is confidential due to less than three entities surveyed or reported.

Year	**Bottomfish**		**Coral Reef BB**			**Coral Reef SB Fishery**				
	No Boat	**No gear**	**Mix**	**Spear**	**Troll**	**R&R**	**Spear**	**Glean**	**Gilllnet**	**HL**

Year	Bottomfish		Coral Reef BB			Coral Reef SB Fishery				
	No Boat	No gear	Mix	Spear	Troll	R&R	Spear	Glean	Gilllnet	HL
1982	27									
1983	38									
1984	48								15	
1985	47	262	36	136	208				73	
1986	37	391	255	204	1224				79	
1987	21	56	146	239	614	0		0	50	
1988	32	144	144	325	924	0		0	55	0
1989	34	142	180	203	1251	0		0	48	0
1990	25	82	59	*	914	88		27	93	111
1991	23	125	65	*	654	110		33	119	89
1992	14	150	27	*	620	10		17	120	11
1993	26	169	59	43	675	45		43	98	2
1994	25	343	145	*	1169	82		71	108	38
1995	35	224	78	137	1689	39		90	146	27
1996	35	264	175	*	1182	41		27	83	26
1997	37	236	29	*	1188	0		0	139	0
1998	30	92	19	*	679	0		0	238	0
1999	34	180	34	35	802	0		0	172	
2000	34	145	48	35	584	0		0	147	
2001	27	179	*	16	470				112	
2002	18	235	14	14	476	64	5	12	83	0
2003	19	192	55	*	315	17	3	7	50	
2004	25	587	62	*	464				42	
2005	14	84	*	299	308	19	20	*	27	0

Year	Bottomfish		Coral Reef BB			Coral Reef SB Fishery				
	No Boat	**No gear**	**Mix**	**Spear**	**Troll**	**R&R**	**Spear**	**Glean**	**Gilllnet**	**HL**
2006	21	220	39	147	319	55	38	13	58	0
2007	26	396	38	137	237	134	66	71	44	7
2008	23	332	28	515	248	47	40	20	49	3
2009	21	393	*	*	61	81	43	22	21	5
2010	16	131	51	*	56	51	68	11	21	6
2011	12	169	22	371	166	127	178	26	34	11
2012	14	182	41	386	84	63	48	14	51	3
2013	17	337	74	129	183	118	249	23	28	9
2014	24	333	1669	136	286	43	76	4	14	0
2015	17	352	36	204	147	160	36	4	51	3
10-year Avg.	**19**	**266**	**222**	**258**	**190**	**75**	**78**	**21**	**36**	**4**
10-year SD	**5**	**111**	**543**	**141**	**97**	**54**	**71**	**19**	**15**	**4**
20-year Avg.	**24**	**251**	**140**	**183**	**474**	**50**	**67**	**19**	**77**	**6**
20-year SD	**8**	**121**	**383**	**155**	**427**	**49**	**70**	**24**	**60**	**9**

1.9 Bycatch estimates

This section focuses on MSA § 303(a)(11), which requires that all FMPs establish a standardized reporting methodology to assess the amount and type of bycatch occurring in the fishery, and 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:

Numbers caught = Sum of the total number of fish or invertebrates found in the raw interview (catch) data.

Numbers kept = Sum of values in the number of fish or invertebrates field from data records that are not marked as bycatch.

Numbers released = caught - kept

Coral reef fishery bycatch = Sum of the number of fish or invertebrates from data records that are marked as bycatch (unknown, alive or dead), for which the fishing methods is not trolling or bottomfishing (or for American Samoa also Troll-bottom Mix).

% bycatch should be % of numbers caught for the included gears. Need to discuss with FEPT. If coral reef is defined based on species, as opposed to by gear, the calculations may need to be adjusted.

“Total Bycatch”: Sum of the number of pieces field from all data records found in the interview database (all fishing methods are counted!)

Table 14. Time series of bycatch estimates in the boat-based fisheries. Percent bycatch is calculated from the numbers caught and identified as bycatch versus all caught in the fishery.

Year	Numbers caught	Kept	# ID's as bycatch	Released	% bycatch	% release
1982						
1983						
1984						
1985	0	0	0	0		
1986	0	0	0	0		
1987	0	0	0	0		
1988	134	134	0	0	0	0
1989	0	0	0	0		
1990	0	0	0	0		
1991	0	0	0	0		
1992	7,717	7,717	0	0	0	0
1993	5,031	5,031	0	0	0	0

Year	Numbers caught	Kept	# ID's as bycatch	Released	% bycatch	% release
1994	15,219	15,219	0	0	0	0
1995	13,684	13,684	0	0	0	0
1996	13,087	13,087	0	0	0	0
1997	30,170	30,170	0	0	0	0
1998	19,335	19,335	0	0	0	0
1999	22,339	22,339	0	0	0	0
2000	19,080	19,079	1	1	0.01	0.01
2001	14,853	14,851	2	2	0.01	0.01
2002	13,490	13,481	9	9	0.07	0.07
2003	16,733	16,727	6	6	0.04	0.04
2004	15,345	15,338	7	7	0.05	0.05
2005	8,720	8,720	0	0	0	0
2006	12,139	12,139	0	0	0	0
2007	24,491	24,491	0	0	0	0
2008	18,387	18,387	0	0	0	0
2009	29,151	29,151	0	0	0	0
2010	27,304	27,304	0	0	0	0
2011	26,018	26,018	0	0	0	0
2012	20,649	20,649	0	0	0	0
2013	18,444	18,444	0	0	0	0
2014	20,482	20,482	0	0	0	0
2015	14,505	14,505	0	0	0	0
10-year	**20,026**	**20,026**	**0.00**	**0.00**	**0.00**	**0.00**

Year	Numbers caught	Kept	# ID's as bycatch	Released	% bycatch	% release
Ave.						
10-year SD	**6,468**	**6,468**	**0.00**	**0.00**	**0.00**	**0.00**
20-year Ave.	**18,972**	**18,971**	**1.19**	**1.19**	**0.01**	**0.01**
20-year SD	**5,896**	**5,897**	**2.66**	**2.66**	**0.02**	**0.02**

Table 15. Time series of bycatch estimates in the shore-based fishery. Percent bycatch is calculated from the numbers caught and identified as bycatch versus all caught in the fishery.

Note: The estimates were not available for this report but will be included in next year's report.

Year	Numbers caught	Kept	# ID's as bycatch	Released	% bycatch	% release
1982						
1983						
1984						
1985						
1986						
1987						
1988						
1989						
1990						
1991						
1992						
1993						
1994						

Year	Numbers caught	Kept	# ID's as bycatch	Released	% bycatch	% release
1995						
1996						
1997						
1998						
1999						
2000						
2001						
2002						
2003						
2004						
2005						
2006						
2007						
2008						
2009						
2010						
2011						
2012						
2013						
2014						
2015						
10-year Ave.						

Year	Numbers caught	Kept	# ID's as bycatch	Released	% bycatch	% release
10-year SD						
20-year Ave.						
20-year SD						

1.10 Number of federal permit holders

In American Samoa, the following Federal permits are required for fishing in the EEZ:

1.10.1 **Special Coral Reef Ecosystem Permit**

The coral reef ecosystem special permit is required for anyone fishing for coral reef ecosystem management unit species in a low-use MPA, fishing for species on the list of Potentially Harvested Coral Reef Taxa, or using fishing gear not specifically allowed in the regulations. The permit expires one year after the date of issuance. Permit holder must submit a logbook to NOAA Fisheries within 30 days of each landing of coral reef harvest.

A transshipment permit is required for any receiving vessel used to land or transship potentially harvested coral reef taxa, or any coral reef ecosystem management unit species caught in a low-use MPA. Exceptions to this permit requirement are made for anyone issued a permit to fish under the other western Pacific fishery management plans (pelagic, bottomfish and seamount groundfish, crustacean, or precious corals) who catch coral reef management unit species incidentally while fishing for the management unit species covered by the permit they possess. Permit holders must submit a logbook to NOAA Fisheries within seven days following the date the vessel arrived in port to land transshipped fish. Regulations governing this fishery can be found in the Code of Federal Regulations, Title 50, Part 665.

Table 16. Number of federal permits holders over time

Note: The estimates were not available for this report but will be included in next year's report.

Year	**Coral reef**	**Bottomfish**
Start year		
2014		
10-year Avg.?		

Year	Coral reef	Bottomfish
20-year Avg.?		

1.11 Status Determination Criteria

1.11.1 Bottomfish Fishery

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

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

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

Table 17.

Table 17. Overfishing threshold specifications for the bottomfish management unit species in American Samoa

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

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

In cases where reliable estimates of $CPUE_{MSY}$ and E_{MSY} are not available, they will 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 one is used.

Since the MSY control rule specified here applies to multi-species stock complexes, it is important to ensure that no particular species within the complex has a mortality rate that leads to excessive depletion. In order to accomplish this, a secondary set of reference points is specified to evaluate stock status with respect to recruitment overfishing. A secondary "recruitment overfishing" control rule is specified to control fishing mortality with respect to that status. The rule applies only to those component stocks (species) for which adequate data are available. The ratio of a current spawning stock biomass proxy (SSB_{Pt}) to a given reference level (SSB_{PREF}) 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 SSB_{Pt}/SSB_{PREF}, 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 SSB_{PRMIN}. These two reference points and their associated recruitment overfishing control rule, which prescribe a target fishing mortality rate ($F_{RO\text{-}REBUILD}$) 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. Rebuilding control rules for the bottomfish management unit species in American Samoa

$\mathbf{F}_{RO\text{-}REBUILD}$	$\mathbf{SSBPR}_{MIN}$	$\mathbf{SSBPR}_{TARGET}$
$F(SSBPR) = 0$ for $SSBPR \leq 0.10$ $F(SSBPR) = 0.2\,F_{MSY}$ for $0.10 < SSBPR \leq SSBPR_{MIN}$ $F(SSBPR) = 0.5\,F_{MSY}$ for $SSBPR_{MIN} < SSBPR \leq SSBPR_{TARGET}$	0.20	0.30

1.11.2 **Coral Reef Fishery**

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

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

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

For the coral reef fishery, the multi-species complex as a whole is used to establish limits and reference points for each area. When possible, available data for a particular species are used to evaluate the status of individual MUS stocks in order to prevent recruitment overfishing. When better data and the appropriate multi-species stock assessment methodologies become available, all stocks will be evaluated independently, without proxy.

Establishing Reference Point Values

Standardized values of catch per unit effort (CPUE) and effort (E) are used to establish limit and reference point values, which act as proxies for relative biomass and fishing mortality, respectively. Limits and reference points are calculated in terms of $CPUE_{MSY}$ and E_{MSY} included in Table 19.

Table 19. Status determination criteria for the coral reef management unit species using CPUE-based proxies

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

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

1.11.3 **Current Stock Status**

1.11.3.1 Bottomfish

Biological and other fishery data are poor for all bottomfish species in the Mariana Archipelago. Generally, data are only available on commercial landings by species and catch-per-unit-effort (CPUE) for the multi-species complexes as a whole. At this time it is not possible to partition these effort measures among the various bottomfish MUS. The most recent stock assessment update (Yau et al. 2016) for the American Samoa bottomfish management unit species complex (comprised of 17 species of shallow and deep species of snapper, grouper, jacks, and emperors) was based on estimate of total catch, an abundance index derived from the nominal CPUE generated from the creel surveys, and a fishery-independent point estimate of MSY from the Our Living Oceans Report (Humphreys and Moffitt 1999, Moffitt & Humphreys 2009). The assessment utilized a state-space surplus production model with explicit process and observation error terms (Meyer and Millar 1999). Determinations of overfishing and overfished status can then be made by comparing current biomass and harvest rates to MSY-level reference points. To date, the American Samoa BMUS is not subject to overfishing and is not overfished (

Table 20).

Table 20. Stock assessment parameters for the American Samoa BMUS complex (Yau et al 2015)

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

1.11.3.2 Coral reef

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

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

Table 21. The SSC utilized the MSYs for the coral reef MUS complexes as the OFLs.

Table 21. Best available MSY estimates for the coral reef MUS in American Samoa

Coral Reef MUS Complex	MSY (lbs)
Selar crumenophthalmus – atulai or bigeye scad	45,300
Acanthuridae – surgeonfish	148,600
Carangidae – jacks	24,300
Crustaceans – crabs	7,800
Holocentridae – squirrelfish	16,800
Kyphosidae – chubs/rudderfish	2,600
Labridae – wrasses[1]	19,000
Lethrinidae – emperors	23,700
Lutjanidae – snappers	65,400
Mollusks – turbo snail; octopus; giant clams	12,700
Mugilidae – mullets	8,200
Mullidae – goatfish	29,600
Scaridae – parrotfish[2]	294,600
Serranidae – groupers	30,500
Siganidae – rabbitfish	200
All Other CREMUS Combined	28,500

Coral Reef MUS Complex	MSY (lbs)
- Other CRE-finfish - Other invertebrates - Misc. bottomfish - Misc. reef fish - Misc. shallow bottomfish	
Cheilinus undulatus – humphead (Napoleon) wrasse	N.A.
Bolbometopon muricatum – bumphead parrotfish	N.A.
Carcharhinidae – reef sharks	2,300

1.12 Overfishing Limit, Acceptable Biological Catch, and Annual Catch Limits

1.12.1 Brief description of the ACL process

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

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

1.12.2 Current OFL, ABC, ACL, and recent catch

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

Table 22. American Samoa Archipelago – American Samoa ACL table with 2015 catch (values are in pounds)

Fishery	**MUS**	**OFL**	**ABC**	**ACL**	**Catch**
Bottomfish	Bottomfish multi-species complex		106,000	106,000	21,870
Crustacean	Deepwater shrimp	N.A.	80,000	80,000	NAF
	Spiny lobster	7,300	5,100	4,845	1,287
	Slipper lobster	N.A.	30	30	2
	Kona crab	N.A.	3,200	3,200	NAF
Precious coral	Black coral	8,250	790	790	NAF
	Precious coral in AS expl. area	N.A.	2,205	2,205	NAF
Coral Reef	*Selar crumenophthalmus*	45,300	38,400	37,400	3,444
	Acanthuridae-surgeonfish	148,600	133,800	129,400	14,368
	Carangidae-jacks	24,300	20,800	19,900	6,002
	Crustaceans-crabs	7,800	4,700	4,300	969
	Holocentridae-squirrelfish	16,800	15,500	15,100	2,132
	Kyphosidae-rudderfish	2,600	2,200	2,000	640
	Labridae-wrasse	19,000	16,600	16,200	294
	Lethrinidae-emperors	23,700	20,400	19,600	6,799
	Lutjanidae-snappers	65,400	64,400	63,100	14,733
	Mollusk-turbo snails; octopus; clams	29,600	20,200	18,400	10,924
	Mullidae-goatfish	12,700	12,000	11,900	1,537
	Mugilidae-mullets	8,200	5,200	4,600	550
	Scaridae-parrotfish	294,600	280,100	272,000	6,967
	Serranidae-groupers	30,500	27,300	25,300	3,798
	Siganidae-rabbitfish	200	181	163	69

Fishery	MUS	OFL	ABC	ACL	Catch
	All other CREMUS combined	28,500	20,300	18,400	12,798
	Cheilinus undulatus	N.A.	1,743	1,743	0
	Bolbometopon muricatum	N.A.	235	235	0
	Carcharhinidae-reef sharks	2,300	1,700	1,615	0

The catch shown in Table 22 takes the average of the recent three years as recommended by the Council at its 160th meeting to avoid large fluctuations in catch due to data quality and outliers. NAF indicates no active fisheries as of date.

1.13 Best scientific information available

1.13.1 Bottomfish fishery

1.13.1.1 Stock assessment benchmark

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

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

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

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

1.13.1.2 Stock assessment updates

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

1.13.1.3 Other information available

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

1.13.2 **Coral reef fishery**

1.13.2.1 Stock assessment benchmark

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

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

Input data: The catch data was derived from the inshore and off-shore creel surveys. Commercial receipt book information was also used in combination of the creel data. A downward adjustment was done to address for potential overlap due to double reporting.

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

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

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

1.13.2.2 Stock assessment updates

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

1.13.2.3 Other information available

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

PIFSC and the Council conducted a workshop with various stakeholders in CNMI to identify factors and quantify uncertainties associated with the social, economic, ecological, and management of the coral reef fisheries (Sievanen and McCaskey, PIFSC internal report). The criteria developed from this workshop had been applied to American Samoa. Scoring was conducted with representatives from American Samoa. This was the basis for the SEEM analysis that determined the risk levels to specify ACLs.

1.14 Harvest capacity and extent

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

- Will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems.
- is prescribed on the basis of the MSY from the fishery, as reduced by any relevant social, economic, or ecological factor.
- in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery [50 CFR §600.310(f)(1)(i)].

Optimum yield in the coral reef and bottomfish fisheries is prescribed based on the MSY from the stock assessment and the best available scientific information. In the process of specifying ACLs, social, economic, and ecological factors were considered and the uncertainties around those factors defined the management uncertainty buffer between the ABC and ACL. OY for the bottomfish and coral reef fish MUS complexes is defined to be the level of harvest equal to the ACL consistent with the goals and objectives of the Fishery Ecosystem Plans and used by the Council to manage the stock.

The Council recognizes that MSY and OY are long-term values whereas the ACLs are yearly snapshots based on the level of fishing mortality at F_{MSY}. There are situations when the long-term means around MSY are going to be lower than ACLs especially if the stock is known to be productive or relatively pristine or lightly fished. One can have catch levels and catch rates exceeding that of MSY over short-term enough to lower the biomass to a level around the estimated MSY and still not jeopardize the stock. This situation is true for the territory bottomfish multi-species complex.

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

Table 23 summarizes the harvest extent and harvest capacity information for American Samoa in 2015

Table 23. American Samoa Archipelago – American Samoa proportion of harvest extent (values are in percentage), defined as the proportion of fishing year landing relative to the ACL or OY, and the harvest capacity, defined as the remaining portion of the ACL or OY that can potentially be harvested in a given fishing year.

Fishery	MUS	ACL	Catch	Harvest extent (%)	Harvest capacity (%)
Bottomfish	Bottomfish multi-species complex	106,000	21,870	20.6	79.4
Crustacean	Deepwater shrimp	80,000	NAF	#VALUE!	#VALUE!
	Spiny lobster	4,845	1,287	26.6	73.4
	Slipper lobster	30	2	6.7	93.3
	Kona crab	3,200	NAF	#VALUE!	#VALUE!
Precious coral	Black coral	790	NAF	#VALUE!	#VALUE!
	Precious coral in AS expl. area	2,205	NAF	#VALUE!	#VALUE!
Coral Reef	*Selar crumenophthalmus*	37,400	3,444	9.2	90.8
	Acanthuridae-surgeonfish	129,400	14,368	11.1	88.9
	Carangidae-jacks	19,900	6,002	30.2	69.8
	Crustaceans-crabs	4,300	969	22.5	77.5
	Holocentridae-squirrelfish	15,100	2,132	14.1	85.9
	Kyphosidae-rudderfish	2,000	640	32.0	68.0
	Labridae-wrasse	16,200	294	1.8	98.2
	Lethrinidae-emperors	19,600	6,799	34.7	65.3
	Lutjanidae-snappers	63,100	14,733	23.3	76.7
	Mollusk-turbo snails; octopus; clams	18,400	10,924	59.4	40.6

Fishery	MUS	ACL	Catch	Harvest extent (%)	Harvest capacity (%)
	Mullidae-goatfish	11,900	1,537	12.9	87.1
	Mugilidae-mullets	4,600	550	12.0	88.0
	Scaridae-parrotfish	272,000	6,967	2.6	97.4
	Serranidae-groupers	25,300	3,798	15.0	85.0
	Siganidae-rabbitfish	163	69	42.3	57.7
	All other CREMUS combined	18,400	12,798	69.6	30.4
	Cheilinus undulatus	1,743	0	0.0	100.0
	Bolbometopon muricatum	235	0	0.0	100.0
	Carcharhinidae-reef sharks	1,615	0	0.0	100.0

1.15 Administrative and Regulatory Actions

This summary describes management actions PIRO has taken since the April 2015 Joint FEP Plan Team meeting, as reported to the 163rd to 165th Western Pacific Fishery Management Council meetings held June 2015, October 2015, and March 2016.

On August 31, 2015, NMFS published a final rule to implement annual catch limits for 2015 Pacific Island bottomfish, crustacean, precious coral, and coral reef ecosystem fisheries, and accountability measures to correct or mitigate any overages of catch limits (80 FR 52415). The catch limits and accountability measures.

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2 ECOSYSTEM CONSIDERATIONS

2.1 Coral Reef Fish Ecosystem Parameters

2.1.1 Regional Reef Fish Biomass

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

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

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

Spatial Scale:

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

Data Source: Data used to generate biomass estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods are described in detail elsewhere (http://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_15-07.pdf), but in brief involve teams of divers conducting stationary point count cylinder (SPC) surveys within a target domain of <30m 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 is used here. At each SPC, divers record the number, size and species of all fishes within or passing through paired 15m-diameter cylinders in the course of a standard count procedure. Fish sizes and abundance are converted to biomass using standard length-to-weight conversion parameters, taken largely from FishBase (http://www.fishbase.org), and converted to biomass per unit area, by dividing by the area sampled per survey. Site-level data were pooled into island-scale values by first calculating mean and variance within strata, and then calculating weighted island-scale mean and variance using the formulas given in (Smith et al., 2011), with strata weighted by their respective sizes.

Rationale: Reef Fish biomass, i.e. the weight of fish per unit area has been widely used as an indicator of relative status, and has repeatedly been shown to be changes in fishing pressure, habitat quality, and oceanographic regime.

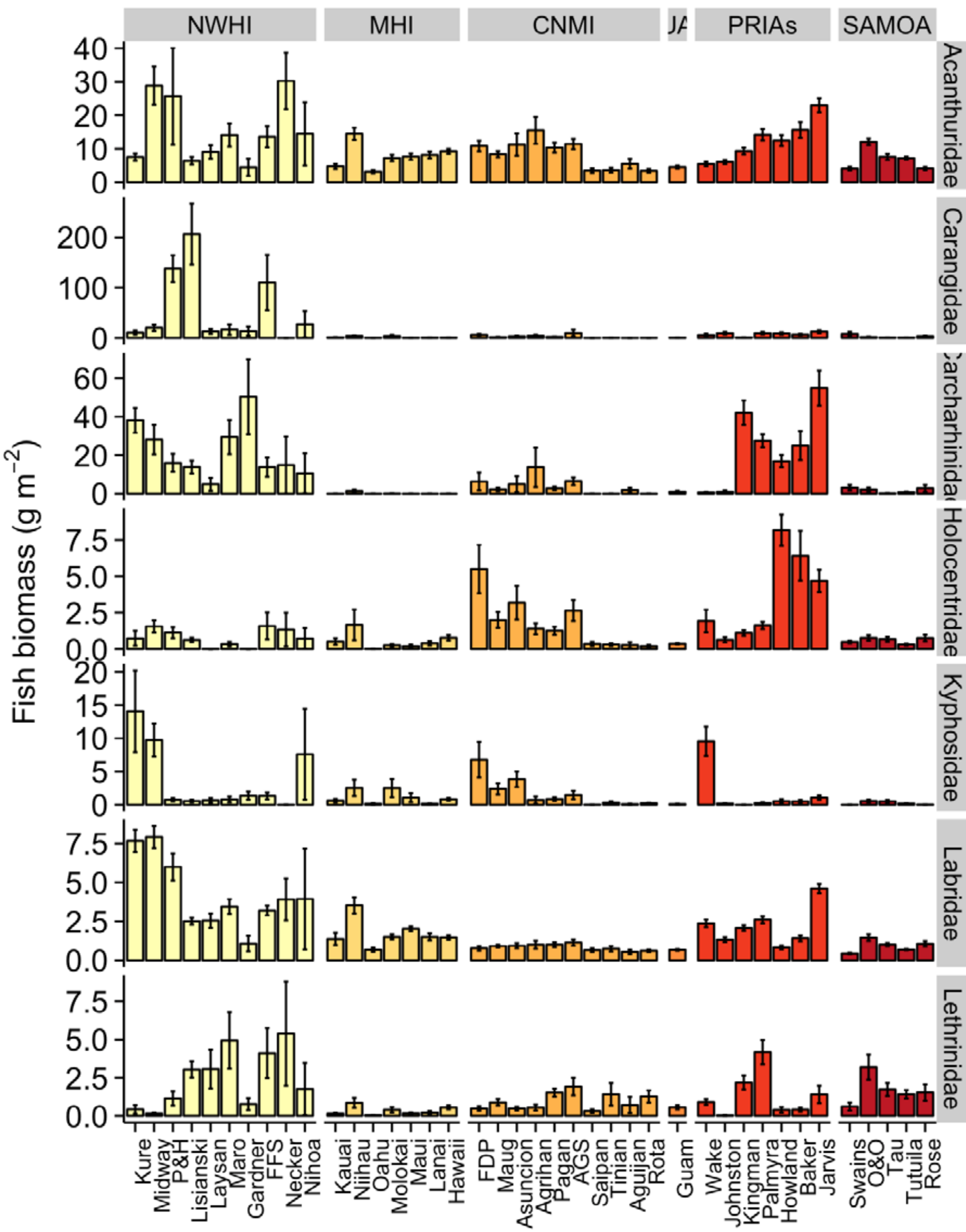
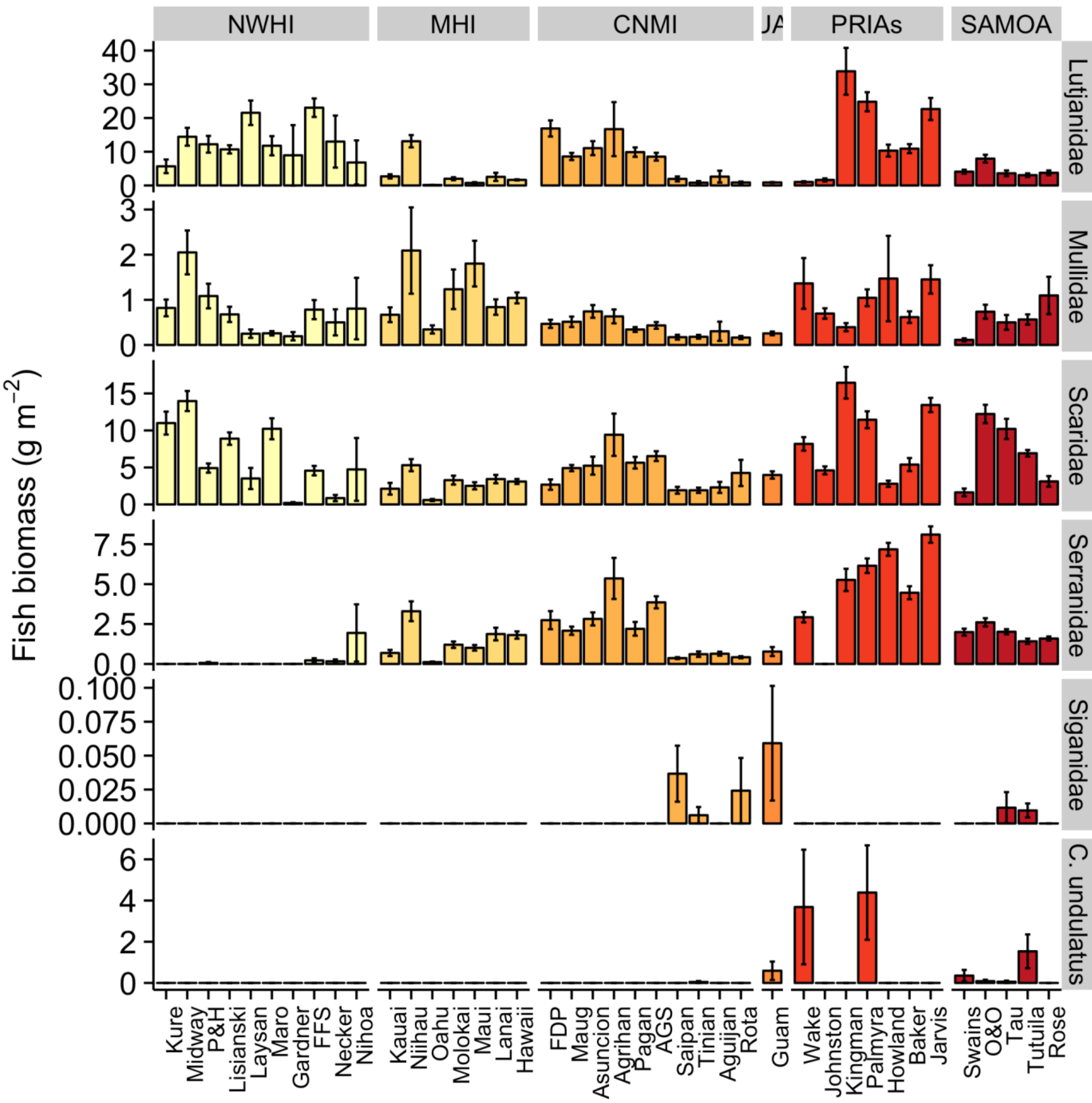


Figure 1. Mean fish biomass by Coral Reef Management Unit Species (CREMUS) grouping per US Pacific reef area. Mean fish biomass (± standard error) per CREMUS grouping per reef area pooled across survey years (2009-2015). Islands ordered within region by latitude. Continues to next page.


NWHI
MHI
CNMI
JA
PRIAs
SAMOA
Lutjanidae
Mullidae
Scaridae
Serranidae
Siganidae
C. undulatus
Fish biomass (g m^{-2})
Kure
Midway
P&H
Lisianski
Laysan
Maro
Gardner
FFS
Necker
Nihoa
Kauai
Niihau
Oahu
Molokai
Maui
Lanai
Hawaii
FDP
Maug
Asuncion
Agrihan
Pagan
AGS
Saipan
Tinian
Aguijan
Rota
Guam
Wake
Johnston
Kingman
Palmyra
Howland
Baker
Jarvis
Swains
O&O
Tau
Tutuila
Rose

2.1.2 Archipelagic Reef Fish Biomass

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

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

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

Scale:

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

Data Source: Data used to generate biomass estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods are described in detail elsewhere (http://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_15-07.pdf), but in brief involve teams of divers conducting stationary point count cylinder (SPC) surveys within a target domain of <30m hard-bottom habitat at each island, stratified by depth zone and, for larger islands, by section of coastline. For consistency among islands, only date from forereef habitats is used here. At each SPC, divers record the number, size and species of all fishes within or passing through paired 15m-diameter cylinders in the course of a standard count procedure. Fish sizes and abundance are converted to biomass using standard length-to-weight conversion parameters, taken largely from FishBase (http://www.fishbase.org), and converted to biomass per unit area, by dividing by the area sampled per survey. Site-level data were pooled into island-scale values by first calculating mean and variance within strata, and then calculating weighted island-scale mean and variance using the formulas given in (Smith et al., 2011), with strata weighted by their respective sizes.

Rationale: Reef Fish biomass, i.e. the weight of fish per unit area has been widely used as an indicator of relative status, and has repeatedly been shown to be changes in fishing pressure, habitat quality, and oceanographic regime.

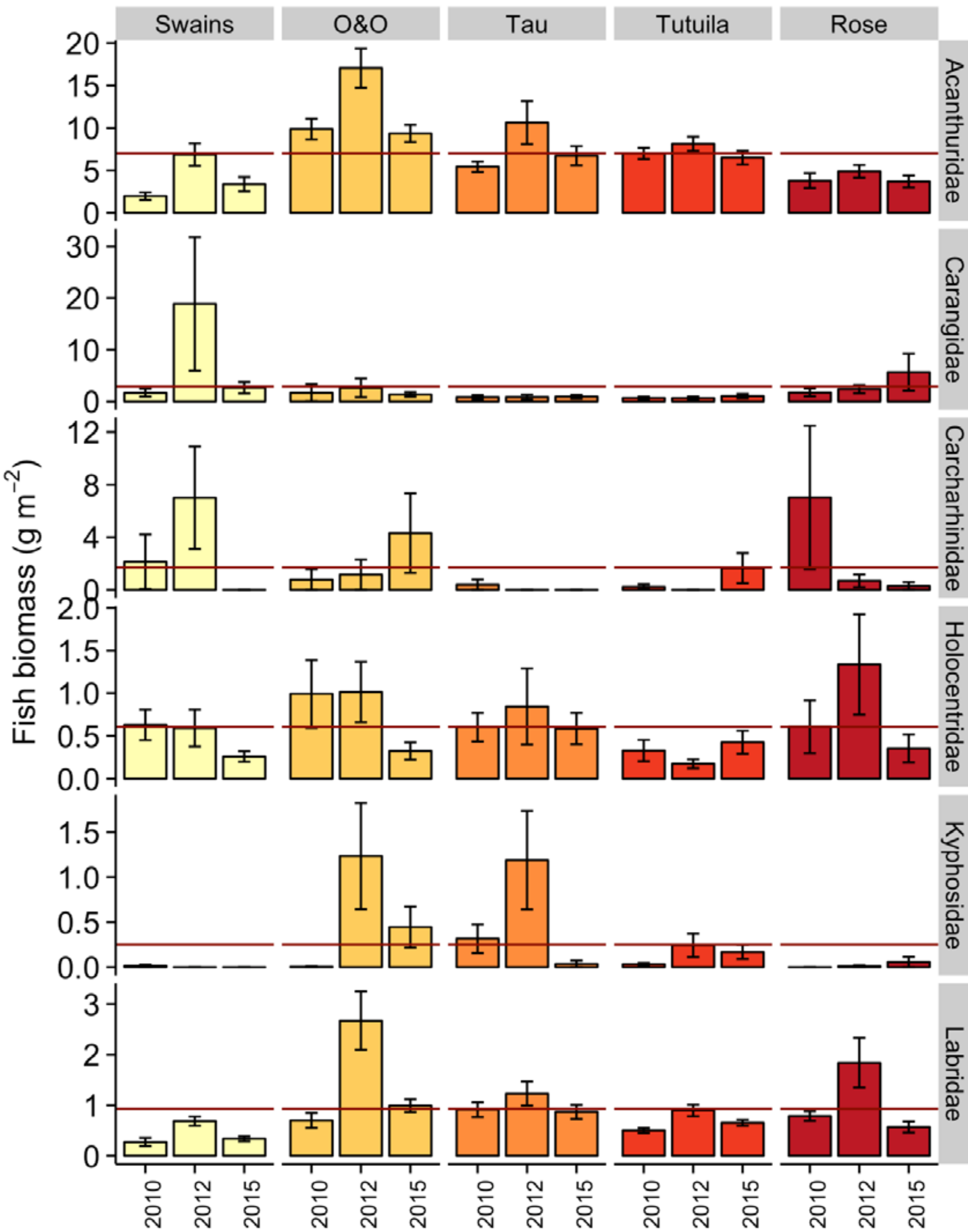
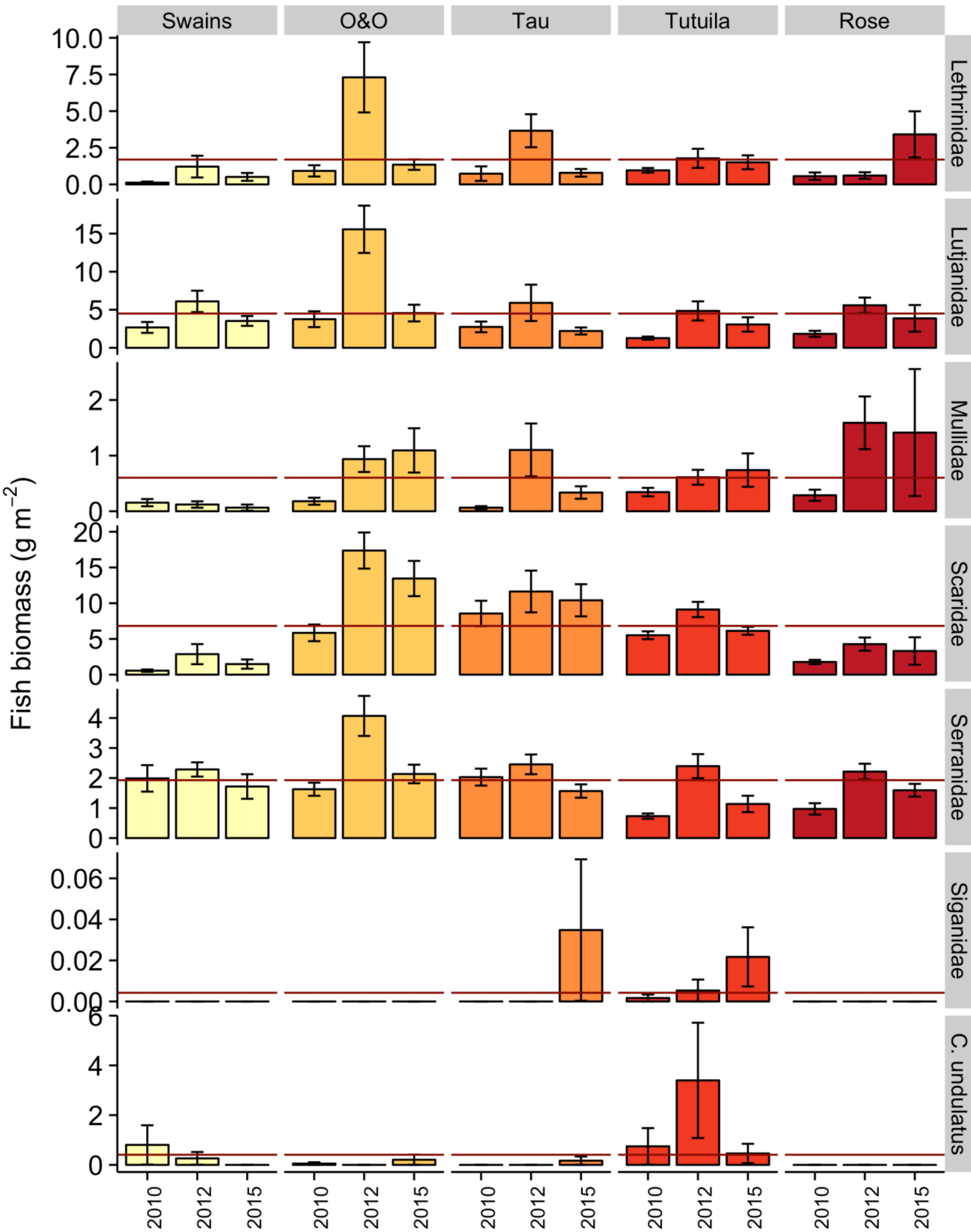


Figure 2. American Samoa showing the biomass of fish (g m-2 ± SE) per CREMUS grouping per year. The American Samoa archipelago mean estimates are plotted for reference (red line). Continues on to the next page.



2.1.3 Archipelagic Mean Size

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

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

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

Scale:

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

Data Source: Data used to generate mean size estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods are described in detail elsewhere (http://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_15-07.pdf), but in brief involve teams of divers conducting stationary point count cylinder (SPC) surveys within a target domain of <30m 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 is used here. At each SPC, divers record the number, size (total length, TL) and species of all fishes within or passing through paired 15m-diameter cylinders in the course of a standard count procedure. Fishes smaller than 10 cm TL are excluded so that the fish assemblage measured more closely reflects fishes that are potentially fished, and so that mean sizes are not overly influenced by variability in space and time of recent recruitment. Site-level data were pooled into island-scale values by first calculating mean and variance within strata, and then calculating weighted island-scale mean and variance using the formulas given in (Smith et al., 2011), with strata weighted by their respective sizes.

Rationale: Mean size is important as mean size is widely used as an indicator of fishing pressure – not only do fishers sometimes preferentially target large individuals, but also because one effect of fishing is to reduce the number of fishes reaching older (and larger) size classes. Large fishes also contribute disproportionately to community fecundity and can have important ecological roles – for example, excavating bites by large parrotfishes probably have a longer lasting impact on reef benthos than bites by smaller fishes.

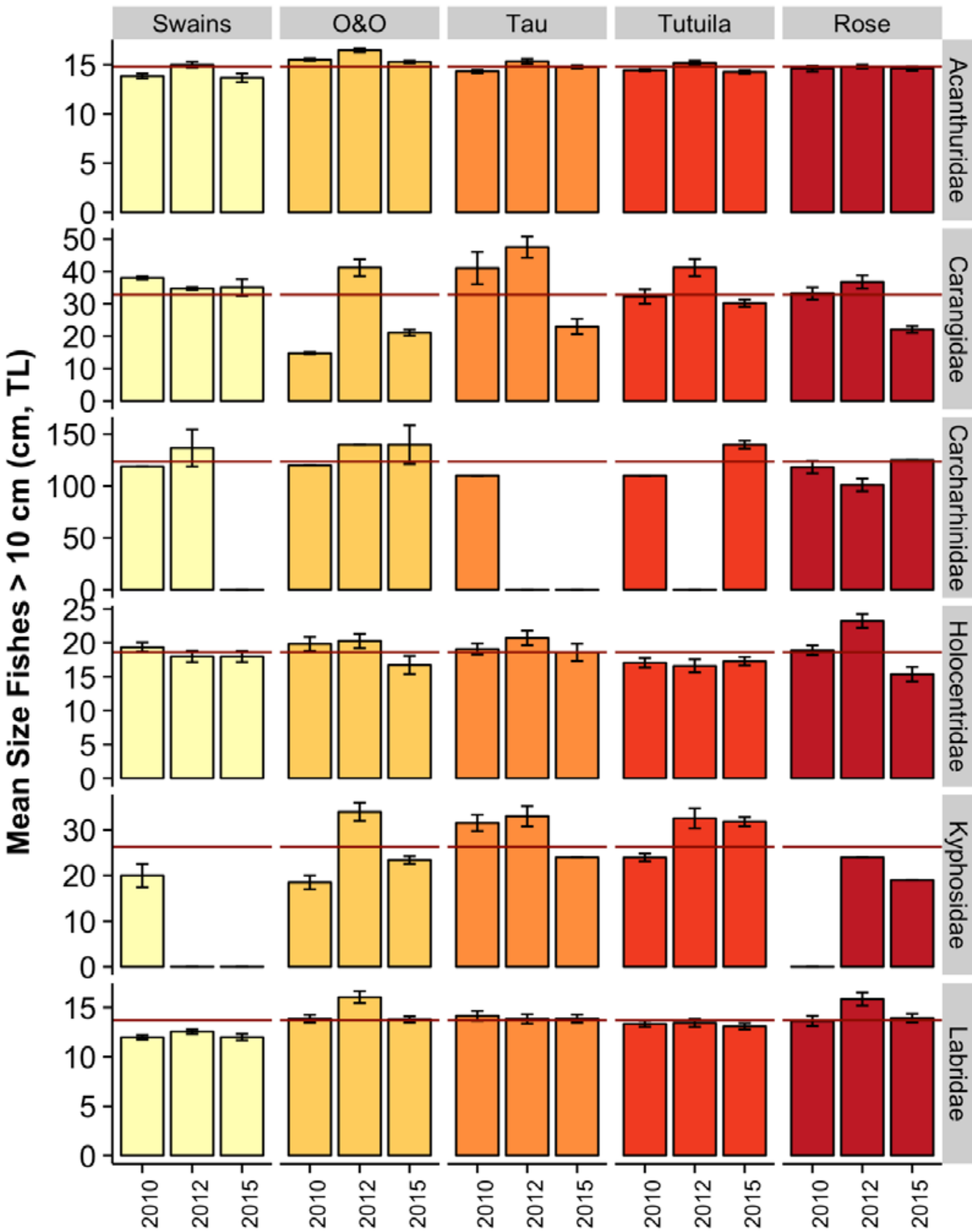
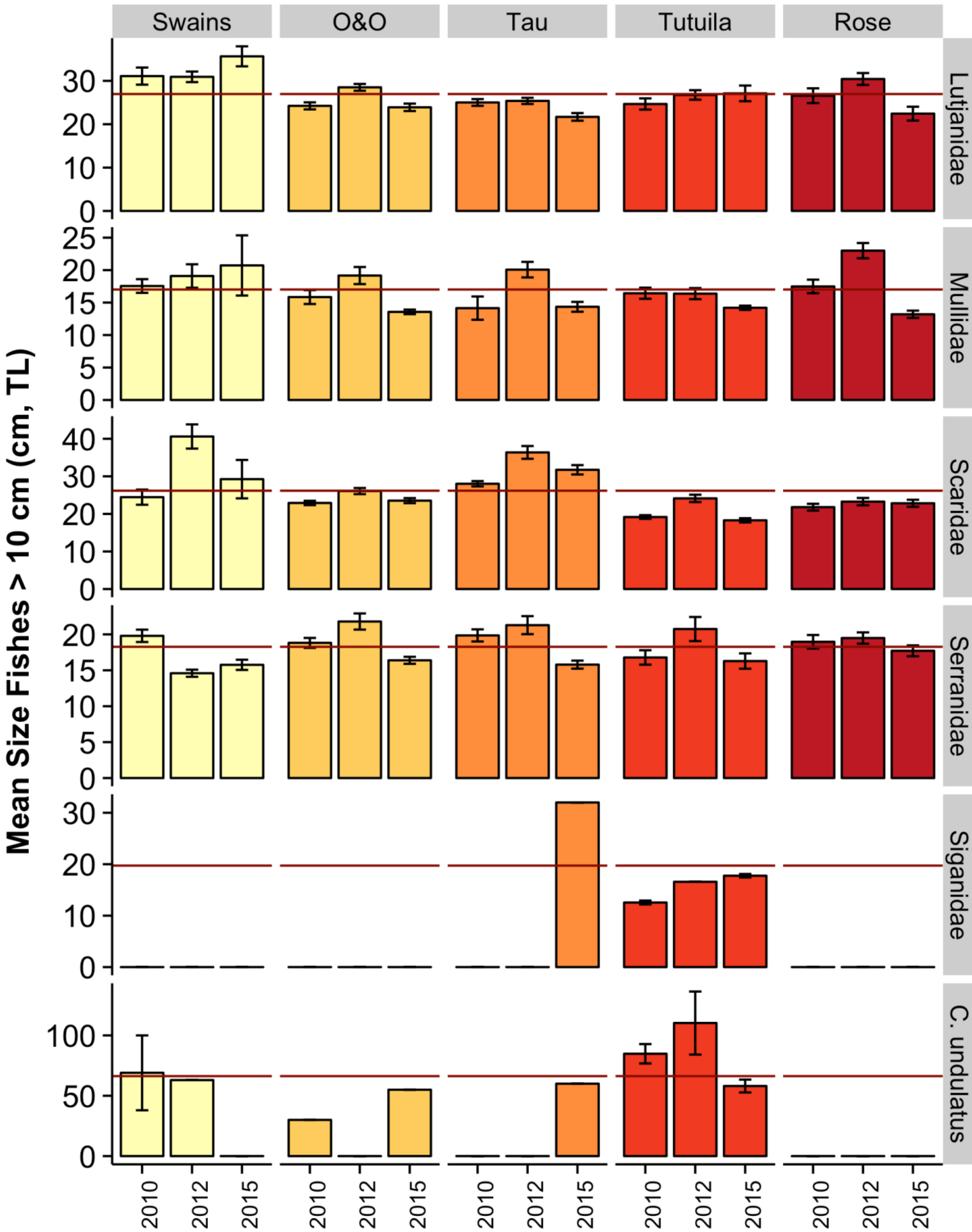


Figure 3. American Samoa showing the mean reef fish size (cm ± SE) per CREMUS grouping per year. The American Samoa archipelago mean estimates are plotted for reference (red line). Continues on to the next page.


Swains
O&O
Tau
Tutuila
Rose
Lutjanidae
Mullidae
Scaridae
Serranidae
Siganidae
C. undulatus
Mean Size Fishes > 10 cm (cm, TL)
2010
2012
2015

2.1.4 Reef Fish Population Estimates

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

Category:

- ✓ Fishery independent
- ☐ Fishery dependent
- ☐ Biological

Timeframe: Triennial

Jurisdiction:

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

Scale:

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

Data Source: Data used to generate mean size estimates comes from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (SECTION: REEF FISH BIOMASS). Those estimates are converted to population estimates by multiplying biomass (g/m2) per island by the estimated area of hardbottom habitat <30m deep at the island, which is the survey domain for the monitoring program that biomass data comes from. Estimated habitat areas per island are derived from GIS bathymetry and habitat maps maintained by NOAA Coral Reef Ecosystems Program. It is important to recognize that many reef fishes taxa are present in other habitats and in deeper water than is surveyed by that program, and even that some taxa likely have the majority of their populations in deeper water. Additionally, fish counts have the potential to be biased by the nature of fish responses to divers. Curious fishes, particularly in locations where divers are not perceived as a threat, will tend to be overcounted by visual survey, and skittish fishes will tend to be undercounted. Likely numbers of jacks and sharks in some locations (particularly the NWHI) are overcounted by visual survey. Nevertheless, in spite of these issues, the data shown here are consistently gathered across space and time.

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

Table 24. Reef fish population estimates for American Samoa. Fish species are pooled by CREMUS groupings. Estimated population biomass is for 0-30 m hardbottom habitat only. (n) is number of sites surveyed per island. Each site is surveyed by means of two to four 7.5 m diameter SPCs -– however, those are not considered to be independent samples, so data from those is pooled to site level before other analysis.

			ESTIMATED POPULATION BIOMASS (metric Tonnes) in SURVEY DOMAIN OF <30m HARDBOTTOM					
ISLAND	Total Area of reef (Ha)	N	Acanthuridae	Carangidae	Carcharhinids	Holocentridae	Kyphosidae	Labridae
Swains	281	94	11.4	21.7	8.6	1.4	0.0	1.2
Ofu & Olosega	793	112	95.9	14.9	16.5	6.2	4.5	11.5
Tau	904	92	68.6	7.7	1.2	6.1	4.6	9.1
Tutuila	4,182	374	301.4	32.4	26.5	12.9	6.2	28.6
Rose	442	129	18.2	14.4	11.8	3.4	0.1	4.7
South Bank	25	2	0.3	0.9	-	0.0	-	0.0
TOTAL	**6,627**	**803**	**497.0**	**91.7**	**64.8**	**30.1**	**15.5**	**55.3**
ISLAND	Total Area of reef (Ha)	N	Lethrinidae	Lutjanidae	Mullidae	Scaridae	Serranidae	Siganidae
Swains	281	94	1.7	11.5	0.3	4.6	5.6	-
Ofu & Olosega	793	112	25.3	63.2	5.8	97.0	20.7	-
Tau	904	92	15.6	32.7	4.5	92.2	18.2	0.1
Tutuila	4,182	374	59.2	128.1	23.6	289.5	59.4	0.4
Rose	442	129	6.8	16.6	4.9	13.8	7.0	-
South Bank	25	2	0.1	-	-	-	-	-
TOTAL	**6,627**	**803**	**109.0**	**252.9**	**39.3**	**498.5**	**111.4**	**0.5**

Note (1): No *Bolbometopon muricatum* were recorded during American Samoa surveys.

(2) *Cheilinus undulatus* were observed at Swains (1.0 t), Ofu&Olosega (0.7 t), Tau (0.5t) & Tutuila (64.2 t)

2.2 Life History Information and Length Derived Variables

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

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

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

2.2.1 **Coral Reef Fish Life History**

2.2.1.1 Age, Growth, & Reproductive Maturity

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

Length at reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved then subsequently cut into five micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex and these data are fitted to a three- or four-parameter logistic function to determine the best fit of these data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region), such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes, standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three- or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and 50% sex reversal ($A\Delta_{50}$) is typically derived by referencing the von Bertalanffy growth function for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age & growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Category:

- ☐ Fishery independent
- ☐ Fishery dependent
- ✓ Biological

Timeframe: N/A

Jurisdiction:

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

Spatial Scale:

- ☐ Regional
- ☐ Archipelagic

- ✓ Island
- ☐ Site

Data Source: Sources of data are directly derived from market samples collected by the American Samoa contracted bio-sampling team which samples the catch of fishermen and local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC Life History Program. Refer to the "Reference" column in Table 1 for specific details on data sources by species.

Parameter definitions:

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

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

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

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

M (natural mortality) – this is a measure of mortality rate for a fish stock not under the influence of fishing pressure and is considered to be directly related to stock productivity (i.e., high M indicates high productivity and low M indicates low stock productivity). M can be derived through use of various equations that link M to T_{max} and k, or in some instances, by calculating the value of the slope from a regression fit to a declining catch curve (regression of the natural logarithm of abundance versus age class) derived from fishing an unfished or lightly fished population.

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

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

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

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

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. Currently, the assessment of coral reef fish resources in American Samoa is data-limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and also provide important biological inputs for future stock assessment efforts and enhance our understanding of the species-likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 25. Available age, growth, and reproductive maturity information for coral reef species targeted for life history sampling (otoliths and gonads) in American Samoa. Parameter estimates are for females unless otherwise noted (F=females, M=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm fork length (FL); k in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are denoted in "Reference" column.

Species	Age, growth, reproductive maturity parameters									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	

Myripristis amaena							NA		NA	
Myripristis berndti							NA	166[b]	NA	
Myripristis murdjan							NA		NA	
Naso unicornis	X[a]	X[a]	X[a]	X[a]		X[a]	NA	X[a]	NA	
Sargocentron caudimaculatum							NA		NA	
Sargocentron spiniferum							NA		NA	
Sargocentron tiere							NA	150[b]	NA	
Scarus rubrovioaceus										

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

[b] signifies a preliminary estimate taken from ongoing analyses

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

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

2.2.1.2 Fish Length Derived Parameters

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

- Broad scale look at commercial landings (by fisher/trip, gear & 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
- Develop accurate local length-weight curves

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

Category:

- ☐ Fishery independent
- ☐ Fishery dependent

- ✓ Biological

Timeframe: N/A

Jurisdiction:

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

Spatial Scale:

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

Data Source: NMFS BioSampling Program

Parameter definition:

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

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

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

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

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

Rationale: Length-derived information is being used as an indicator of population status particularly for data-poor stocks like coral reef fish. Average length (L_{bar}) was used as a principal stock assessment indicator variable for exploited reef fish population (Nadon et al 2015). Average length was also shown to be correlated with population size (Kerr and Dickle 2001).

Maximum length (L_{max}), typically coupled with maximum age, is typically used as a proxy for fish longevity which has implications on the productivity and susceptibility of a species to fishing pressure. The length-weight coefficients (a & b values) are used to convert length to weight for fishery-dependent and fishery-independent data collection where length are typically recorded but weight is the factor being used for management. This section of the report presents the best available information for the length-derived variables for the CNMI coral reef and bottomfish fisheries.

Table 26. Available length-derived information for various coral reef species in American Samoa.

Species	***Length derived parameters***						**Referenc e**
	L_{max}	L_{bar}	***n***	***L-W***	***a***	***b***	
Acanthurus lineatus	24.5	18.8	1955	0.87	0.068	2.68	
Ctenochaetus striatus	25.2	18.0	424	0.87	0.043	2.83	
Naso lituratus	47.4	22.2	8752	0.93	0.022	3.02	
Sargocentron tiere	25.0	18.0	3002	0.85	0.069	2.62	
Chlorurus japanensis	46.2	26.4	6852	0.97	0.018	3.07	
Naso unicornis	55.0	32.3	5042	0.99	0.033	2.85	
Scarus rubroviolaceus	54	34.9	4556	0.99	0.012	3.17	
Panulirus penicillatus	15.8	9.1	3365	0.94	2.614	2.41	
Scaru oviceps	44.5	23.6	3987	0.97	0.013	3.17	
Myripristis berndti	27.2	17.8	4228	0.89	0.100	2.53	
Acanthurus nigricans	36.0	16.9	3003	0.79	0.171	2.42	
Lutjanus gibbus	56.8	30.9	2291	0.96	0.04	2.8	
Lethrinus xanthochilus	54.5	36.8	2186	0.97	0.028	2.85	
Epinephelus melanostigma	54.9	26.5	2653	0.95	0.012	3.10	
Myripristis amaena	22.5	16.9	2849	0.82	0.149	2.39	
Acanthurus guttatus	24.5	16.8	1872	0.87	0.084	2.69	

Species	***Length derived parameters***						**Reference**
	L_{max}	L_{bar}	***n***	***L-W***	***a***	***b***	
Panulirus sp.	15.3	8.6	3331	0.91	5.755	2.06	
Myripristis murdjan	27.5	17.0	1707	0.84	0.72	1.83	
Scarus frenatus	44.5	26.9	1777	0.98	0.014	3.14	
Selar crumenopthalmus	32.7	19.3	298	0.96	0.007	3.30	
Parupeneus bifasciatus	34.5	22.6	1413	0.96	0.015	3.12	
Variola albimarginatus	43.6	27.0	965	0.89	0.122	2.42	
Scarus globiceps	33.9	23.5	1258	0.95	0.02	3.03	

2.2.2 **Bottomfish Life History**

2.2.2.1 Age, Growth, & reproductive Maturity

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

Length at reproductive maturity is based on the histological analyses of small tissue samples of gonad material that are typically collected along with otoliths when a fish is processed for life history studies. The gonad tissue sample is preserved then subsequently cut into five micron sections, stained, and sealed onto a glass slide for subsequent examination. Based on standard cell structure features and developmental stages within ovaries and testes, the gender, developmental stage, and maturity status (immature or mature) is determined via microscopic evaluation. The percent of mature samples for a given length interval are assembled for each sex and these data are fitted to a three- or four-parameter logistic function to determine the best fit of these data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish have achieved reproductive maturity (L_{50}). For species that undergo sex reversal (primarily female to male in the tropical Pacific region), such as groupers and deeper-water emperors among the bottomfishes, and for parrotfish, shallow-water emperors, and wrasses among the coral reef fishes, standard histological criteria are used to determine gender and reproductive developmental stages that indicate the transitioning or completed transition from one sex to another. These data are similarly analyzed using a three- or four-parameter logistic function to determine the best fit of the data based on statistical analyses. The mid-point of this fitted function provides an estimate of the length at which 50% of fish of a particular species have undergone or are undergoing sex reversal ($L\Delta_{50}$).

Age at 50% maturity (A_{50}) and 50% sex reversal ($A\Delta_{50}$) is typically derived by referencing the von Bertalanffy growth function for that species and using the corresponding L_{50} and $L\Delta_{50}$ values to obtain the corresponding age value from this growth function. In studies where both age & growth and reproductive maturity are concurrently determined, estimates of A_{50} and $A\Delta_{50}$ are derived directly by fitting the percent of mature samples for each age (one-year) interval to a three- or four-parameter logistic function using statistical analyses. The mid-point of this fitted logistic function provides a direct estimate of the age at which 50% of fish of a particular species have achieved reproductive maturity (A_{50}) and sex reversal ($A\Delta_{50}$).

Category:

- ☐ Fishery independent
- ☐ Fishery dependent
- ✓ Biological

Timeframe: N/A

Jurisdiction:

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

Spatial Scale:

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

Data Source: Sources of data are directly derived from field samples collected at sea on NOAA research vessels and from the American Samoa contracted bio-sampling team which samples the catch of fishermen and local fish vendors. Laboratory analyses and data generated from these analyses reside with the PIFSC Life History Program. Refer to the "Reference" column in Table 3 for specific details on data sources by species.

Parameter definitions:

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

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

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

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

***M* (natural mortality) –** This is a measure of mortality rate for a fish stock not under the influence of fishing pressure and is considered to be directly related to stock productivity (i.e., high *M* indicates high productivity and low *M* indicates low stock productivity). *M* can be derived through use of various equations that link *M* to T_{max} and *k*, or in some instances, by calculating the value of the slope from a regression fit to a declining catch curve (regression of the natural logarithm of abundance versus age class) derived from fishing an unfished or lightly-fished population.

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

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

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

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

Rationale: These nine life history parameters provide basic biological information at the species level to evaluate the productivity of a stock - an indication of the capacity of a stock to recover once it has been depleted. Currently, the assessment of coral reef fish resources in American Samoa is data-limited. Knowledge of these life history parameters support current efforts to characterize the resilience of these resources and also provide important biological inputs for future stock assessment efforts and enhance our understanding of the species likely role and status as a component of the overall ecosystem. Furthermore, knowledge of life histories across species at the taxonomic level of families or among different species that are ecologically or functionally similar can provide important information on the diversity of life histories and the extent to which species can be grouped (based on similar life histories) for future multi-species assessments.

Table 27. Available age, growth, and reproductive maturity information for bottomfish species targeted for life history sampling (otoliths and gonads) in American Samoa. Parameter estimates are for females unless otherwise noted (F=females, M=males). Parameters T_{max}, t_0, A_{50}, and $A\Delta_{50}$ are in units of years; L_∞, L_{50}, and $L\Delta_{50}$ are in units of mm fork length (FL); *k* in units of year^{-1}; X=parameter estimate too preliminary or Y=published age and growth parameter estimates based on DGI numerical integration technique and likely to be inaccurate; NA=not applicable. Superscript letters indicate status of parameter estimate (see footnotes below table). Published or in press publications ([d]) are denoted in "Reference" column.

Species	*Age, growth, and reproductive maturity parameters*									Reference
	T_{max}	L_∞	k	t_0	M	A_{50}	$A\Delta_{50}$	L_{50}	$L\Delta_{50}$	
Aphareus rutilans							NA		NA	
Aprion virescens							NA		NA	
Etelis carbunculus							NA		NA	

Etelis coruscans							NA		NA	
Lethrinus amboinensis										
Lethrinus xanthochilus										
Lutjanus gibbus							NA		NA	
Pristipomoides auricilla							NA		NA	
Pristipomoides filamentosus							NA		NA	
Pristipomoides flavipinnis							NA		NA	
Pristipomoides sieboldii							NA		NA	
Pristipomoides zonatus							NA		NA	

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

[b] signifies a preliminary estimate taken from ongoing analyses

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

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

2.2.2.2 Fish Length Derived Parameters

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

- Broad scale look at commercial landings (by fisher/trip, gear & 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
- Develop accurate local length-weight curves

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

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

Category:

- ☐ Fishery independent
- ☐ Fishery dependent
- ✓ Biological

Timeframe: N/A

Jurisdiction:

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

Spatial Scale:

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

Data Source: NMFS BioSampling Program

Parameter definition:

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

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

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

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

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

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

Table 28. Available length-derived information for various bottomfish species in American Samoa.

Species	*Length derived parameters*						Reference
	L_{max}	L_{bar}	*n*	*L-W*	*a*	*b*	
Lutjanus kasmira	35.0	22.3	459	0.92	0.017	3.02	
Lethrinus rubrioperculatus	57	27.3	2348	0.97	0.029	2.86	

2.3 Human Dimensions

Human dimensions data will be made available in subsequent reports as resources allow.

2.4 Protected Species

This section of the report summarizes information on protected species interactions in fisheries managed under the American Samoa FEP. Protected species covered in this report include sea turtles, seabirds, marine mammals, sharks and corals.

Lists of species protected under the Endangered Species Act and the Marine Mammal Protection Act that occur around American Samoa and their listing status can be found online at: http://www.fpir.noaa.gov/Library/PRD/ESA%20Consultation/American_Samoa_Species_List_Jan_2015.pdf

2.4.1 **Indicators for Monitoring Protected Species Interactions in the American Samoa FEP Fisheries**

In this report, the Council monitors 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. Discussion of protected species interactions is focused on fishing operations in federal waters and associated transit through Territorial waters.

2.4.1.1 FEP Conservation Measures

Bottomfish, precious coral, coral reef and crustacean fisheries managed under this FEP have not had reported interactions with protected species, and no specific regulations are in place to mitigate protected species interactions. Destructive gear such as bottom trawls, bottom gillnets, explosives and poisons are prohibited under this FEP, and these provide benefit to protected species by preventing potential interactions with non-selective fishing gear.

2.4.1.2 ESA Consultations

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

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

Crustacean Fishery

An informal consultation completed by NMFS on September 28, 2007 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). NMFS also concluded in an informal consultation dated April 9, 2015 that fisheries managed under the American Samoa FEP are not likely to adversely affect the Indo-West Pacific DPS of scalloped hammerhead shark and ESA-listed reef-building corals.

Coral Reef Ecosystem Fishery

An informal consultation completed by NMFS on March 7, 2002 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). NMFS also concluded in an informal consultation dated April 9, 2015 that fisheries managed under the American Samoa FEP are not likely to adversely affect the Indo-West Pacific DPS of scalloped hammerhead shark and ESA-listed reef-building corals.

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. An informal consultation completed by NMFS on December 20, 2000 concluded that American Samoa precious coral fisheries are not likely to adversely affect humpback whales, green turtles or hawksbill turtles. An additional information consultation completed by NMFS on April 9, 2015 concluded that fisheries managed under the American Samoa FEP are not likely to adversely affect the Indo-West Pacific DPS of scalloped hammerhead shark and ESA-listed reef-building corals.

2.4.1.3 Non-ESA Marine Mammals

The MMPA requires NMFS to annually publish a List of Fisheries (LOF) that classifies commercial fisheries in one of three categories based on the level of mortality and serious injury of marine mammals associated with that fishery. According to the 2016 LOF (81 FR 20550, April 8, 2016), the American Samoa bottomfish fishery is classified as a Category III fishery (i.e. a remote likelihood of or no known incidental mortality and serious injury of marine mammals).

2.4.2 Status of Protected Species Interactions in the American Samoa FEP Fisheries

Bottomfish Fishery

There are no observer data available for the American Samoa bottomfish fishery. However based on the information in the 2002 BiOp for fisheries operating under the American Samoa FEP, these fisheries are not expected to interact with any ESA-listed species in Federal waters around

American Samoa. NMFS has also concluded that the American Samoa bottomfish commercial fisheries will not affect marine mammals in any manner not considered or authorized under the Marine Mammal Protection Act.

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

Crustacean Fishery

There are no observer data available for the American Samoa crustacean fisheries. However based on current ESA consultations, these 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 commercial fisheries will not affect marine mammals in any manner not considered or authorized under the Marine Mammal Protection Act.

Based on fishing effort and other characteristics described in Section 1, 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.

Coral Reef Fishery

There are no observer data available for the American Samoa coral reef fisheries. However based on current ESA consultations, these 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 coral reef commercial fisheries will not affect marine mammals in any manner not considered or authorized under the Marine Mammal Protection Act.

Based on fishing effort and other characteristics described in Section 1, 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.

Precious Coral Fishery

There are no observer data available for the American Samoa precious coral fisheries. However based on current ESA consultations, these 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 precious coral commercial fisheries will not affect marine mammals in any manner not considered or authorized under the Marine Mammal Protection Act.

Based on fishing effort and other characteristics described in Section 1, 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.

2.4.3 **Identification of research, data and assessment needs**

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

- Improve the precision of non-commercial fisheries data to improve understanding of potential protected species impacts.

- Develop innovative approaches to derive robust estimates of protected species interactions in insular fisheries.

- Update analysis of fishing-gear related strandings of Hawaii green turtles.

2.5 Climate and Oceanic Indicators

2.5.1 Introduction

The 2015 Annual Report includes an inaugural chapter on indicators of current and changing climate and related oceanic conditions in the geographic areas for which the Western Pacific Regional Fishery Management Council has responsibility. There are a number of reasons for the Council's decision to provide and maintain an evolving discussion of climate conditions as an integral and continuous consideration in their deliberations, decisions and reports:

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

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

2.5.2 Conceptual Model

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

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

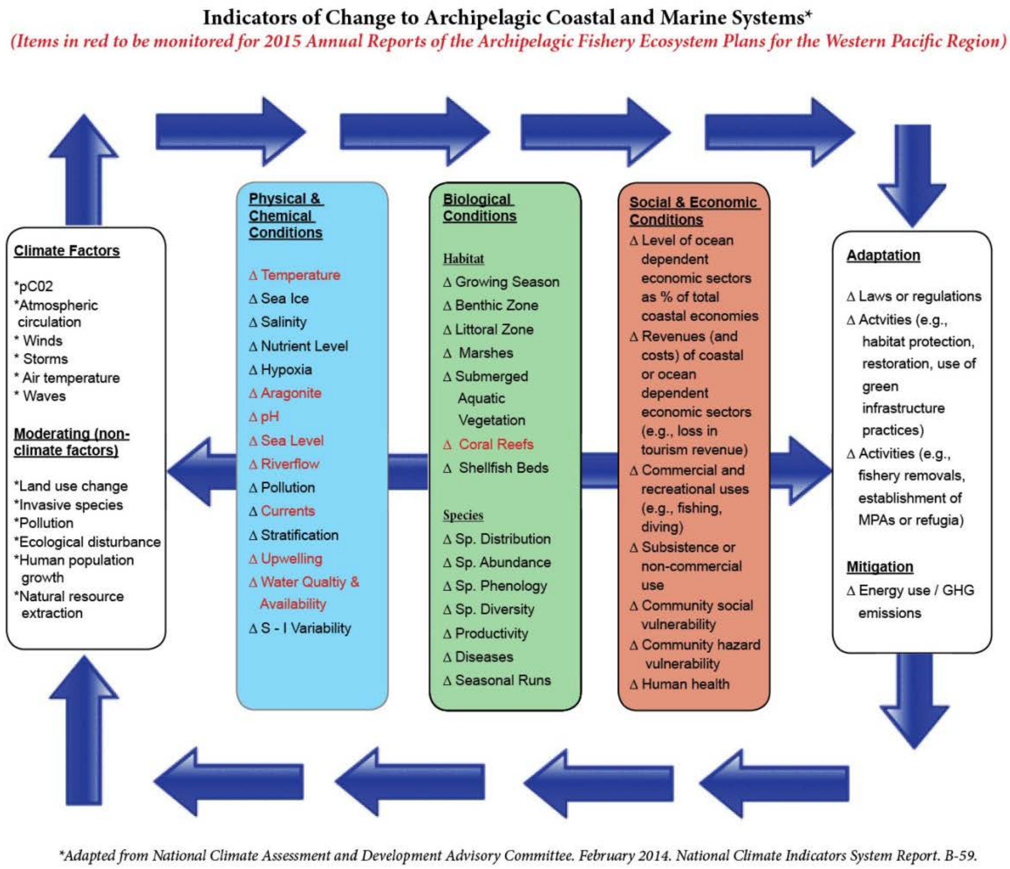


Figure 4. Simplified representation of the climate and non-climate stressors in the coastal and marine ecosystems.

As described in the 2014 NCADAC report, the conceptual model represents a "simplified representation of climate and non-climate stressors in coastal and marine ecosystems." For the purposes of this Annual Report, the modified Conceptual Model allows the Council and its partners to identify indicators of interest to be monitored on a continuing basis in coming years. The indicators shown in red were considered for inclusion in the 2015 Annual Report; the specific indicators used in the Report are listed in Section 2.3. Other indicators will be added over time as datasets become available and understanding of the nature of the causal chain from stressors to impacts emerges.

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

2.5.3 Selected Indicators

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

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

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

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

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

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

Sea Surface Temperature – Monthly sea surface temperature anomaly from 2003-2015 from the AVHRR instrument aboard the NOAA Polar Operational Environmental Satellite (POES). Sea surface temperature is one of the most directly observable measures we have for tracking increasing ocean temperature.

Sea Surface Temperature Anomaly – Sea surface temperature Anomaly highlights long term trends. Filtering out seasonal cycle is one of the most directly observable measures we have for tracking increasing ocean temperature.

Sea Level (Sea Surface Height) and Anomaly – Rising sea levels can result in a number of coastal impacts, including inundation of infrastructure, increased damage resulting from storm-driven waves and flooding, and saltwater intrusion into freshwater supplies. NOTE that no water level gauges are available in PRIA so only regional information on this Indicator is included.

Heavy Weather (Tropical Cyclones) -- Measures of tropical cyclone occurrence, strength, and energy. Tropical cyclones have the potential to significantly impact fishing operations.

Wave Data -- To describe patterns in wave forcing, we present data from the Wave Watch 3 global wave model run by the Department of Ocean and Resources Engineering at the University of Hawaiʻi in collaboration with NOAA/NCEP and NWS Honolulu. Wave forcing can have major implications for both coastal ecosystems and pelagic fishing operations.

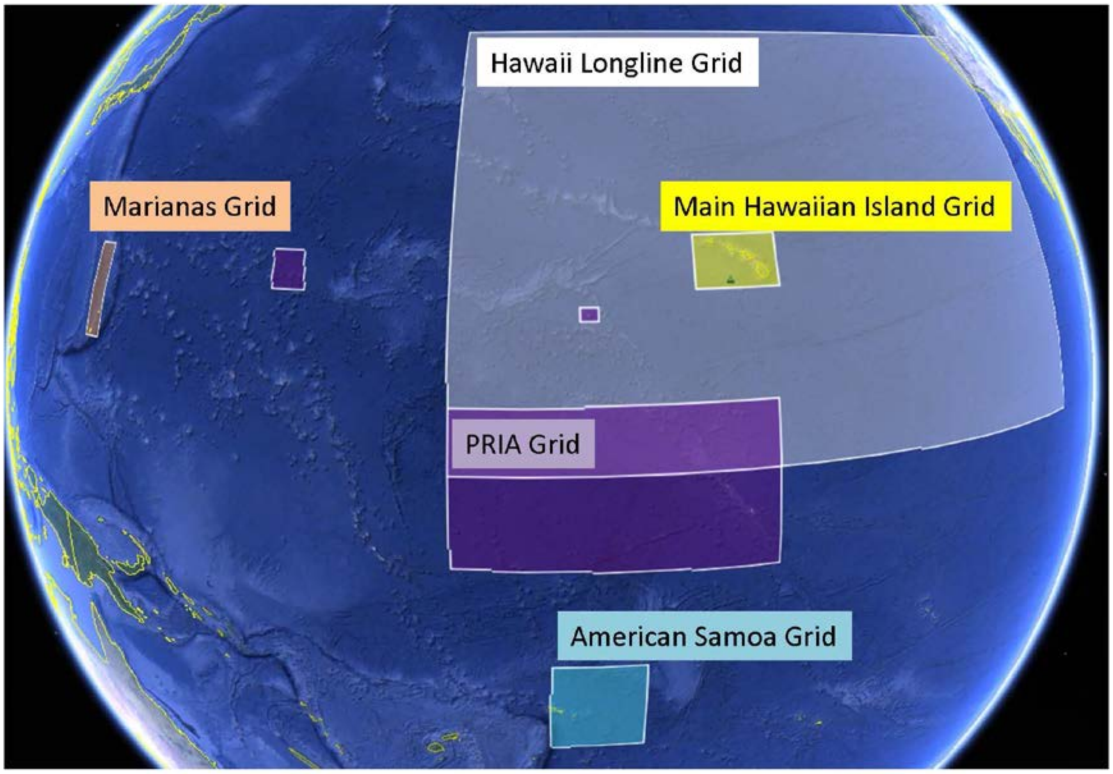


Figure 5. Regional spatial grids representing the scale of the climate change indicators being monitored.

Table 29. Climate and Ocean Indicator Summary

Indicator	Definition and Rationale	Indicator Status
Atmospheric Concentration of Carbon Dioxide (CO_2)	Atmospheric concentration CO_2 at Mauna Loa Observatory. Increasing atmospheric CO_2 is a primary measure of anthropogenic climate change.	Trend: increasing exponentially 2015: time series maximum 400.83 ppm
Oceanic pH	Ocean surface pH at Station ALOHA. Ocean pH provides a measure of ocean acidification. Increasing ocean acidification limits the ability of marine organisms to build shells and other hard structures.	Trend: pH is decreasing at a rate of 0.039 pH units per year, equivalent to 0.4% increase in acidity per year
Oceanic Niño Index (ONI)	Sea surface temperature anomaly from Niño 3.4 region (5°N - 5°S, 120° - 170°W). This index is used to determine the phase of the El Niño – Southern Oscillation (ENSO), which has implications across the region, affecting migratory patterns of key commercial fish stocks which in turn affect the location, safety, and costs of commercial fishing.	2015: Strong El Niño
Sea Surface Temperature* (SST)	Satellite remotely-sensed sea surface temperature. SST is projected to rise, and impacts phenomena ranging from winds to fish distribution.	SST in waters surrounding most of American Samoa ranged between 29-30º C with waters around Rose Atoll ranging between 28-29º C in 2015.
Tropical Cyclones	Measures of tropical cyclone occurrence, strength, and energy. Tropical cyclones have the potential to significantly impact fishing operations.	Eastern Pacific, 2015: 18 named storms, time series maximum nine major hurricanes Central Pacific, 2015: 14 named storms, time series maximum five major hurricanes
Sea Level/Sea Surface Height	Monthly mean sea level time series, including extremes. Data from satellite altimetry & in situ tide gauges. Rising sea levels can result in a number of coastal impacts, including inundation of infrastructure, increased damage resulting from storm-driven waves and flooding, and saltwater intrusion into freshwater supplies.	Low water stands affecting coral reefs reported in some parts of American Samoa in connection with El Niño. Although varying over time the monthly mean sea level trend is

		increasing.
Wave Energy	WaveWatch III (WW3) Global Wave Model Wave forcing can have major implications for both coastal ecosystems and pelagic fishing operations.	Significant wave heights varied from west (1.5-2.0m) increasing to the east where significant wave heights near Rose Atoll were in the 2.0-2.5 m on average.

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

Description: Monthly mean atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii in ppm from March 1958 to present. The carbon dioxide data is measured as the mole fraction in dry air, on Mauna Loa. A dry mole fraction is defined as the number of molecules of carbon dioxide divided by the number of molecules of dry air multiplied by one million (ppm). This constitutes the longest record of direct measurements of CO_2 in the atmosphere. The measurements were started by C. David Keeling of the Scripps Institution of Oceanography in March of 1958 at a facility of the National Oceanic and Atmospheric Administration [Keeling, 1976]. NOAA started its own CO2 measurements in May of 1974, and they have run in parallel with those made by Scripps since then [Thoning, 1989].

The observed increase in monthly average carbon dioxide data is due primarily to CO_2 emissions from fossil fuel burning. Carbon dioxide remains in the atmosphere for a very long time, and emissions from any location mix throughout the atmosphere in about one year. The annual oscillations at Mauna Loa, Hawaii are due to the seasonal imbalance between the photosynthesis and respiration of plants on land. During the summer photosynthesis exceeds respiration and CO_2 is removed from the atmosphere, whereas outside the growing season respiration exceeds photosynthesis and CO_2 is returned to the atmosphere. The seasonal cycle is strongest in the northern hemisphere because of the presence of the continents. The difference between Mauna Loa and the South Pole has increased over time as the global rate of fossil fuel burning, most of which takes place in the northern hemisphere, has accelerated.

Timeframe: Yearly (by month)

Region/Location: Hawaii but representative of global concentration of carbon dioxide.

Data Source: “Full Mauna Loa CO_2 record” at http://www.esrl.noaa.gov/gmd/ccgg/trends/ , NOAA ESRL Global Monitoring Division. The National Oceanic and Atmospheric Administration (NOAA) Global Monitoring Division provides high-precision measurements of the abundance and distribution of long-lived greenhouse gases that are used to calculate global average concentrations.

Measurement Platform: In-situ Station

Rationale: Atmospheric carbon dioxide is a measure of what human activity has already done to affect the climate system through greenhouse gas emissions. It provides quantitative information in a simplified, standardized format that decision makers can easily understand. This indicator demonstrates that the concentration (and, in turn, the warming influence) of greenhouse gases in the atmosphere has increased substantially over the last several decades. In 2015, the annual mean concentration of CO2 was 400.83 ppm. In 1959, the onset year it was 315.9 ppm. It passed 350 ppm in 1988.

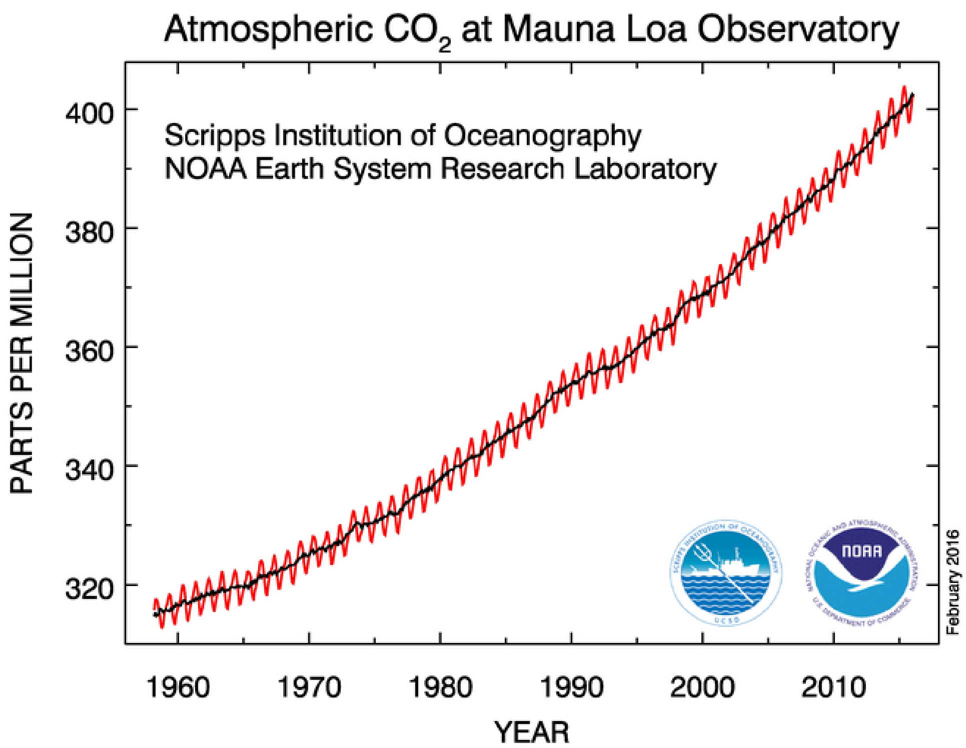


Figure 6**. Monthly mean atmospheric carbon dioxide at Mauna Loa Observatory, Hawaii. The carbon dioxide data (red curve), measured as the mole fraction (ppm), in dry air, on Mauna Loa. The black curve represents the seasonally corrected data.**

2.5.3.2 Ocean pH

Description: Trends in surface (0-10m) pH and pCO2 at Station ALOHA, North of Oahu (22° 45’ N, 158° W), collected by the Hawai‘i Ocean Time-series (HOT). Green dots represent directly measured pH, blue dots represent pH calculated from total alkalinity (TA) and dissolved inorganic carbon (DIC).

The 25+ year time-series at Station ALOHA represents the best available documentation of the significant downward trend of ocean pH since 1989. Actual ocean pH varies in both time and space, but over the last 25 years, the HOTS Station ALOHA time series has shown a significant linear decrease of -0.0386 pH units, or roughly a 9% increase in acidity ([H+]) over that period.

Timeframe: Updated Monthly

Region/Location: North Oahu.

Data Source/Responsible Party: Hawai'i Ocean Time Series. (http://hahana.soest.hawaii.edu/hot/)

Measurement Platform: Oceanographic research station, shipboard collection.

Rationale: Increasing ocean acidification affects coral reef growth and health which in turn affects the health of coral reef ecosystems and the ecosystems and resources that they sustain. Monitoring pH on a continuous basis provides a foundational basis for documenting, understanding and, ultimately, predicting the effects of ocean acidification.

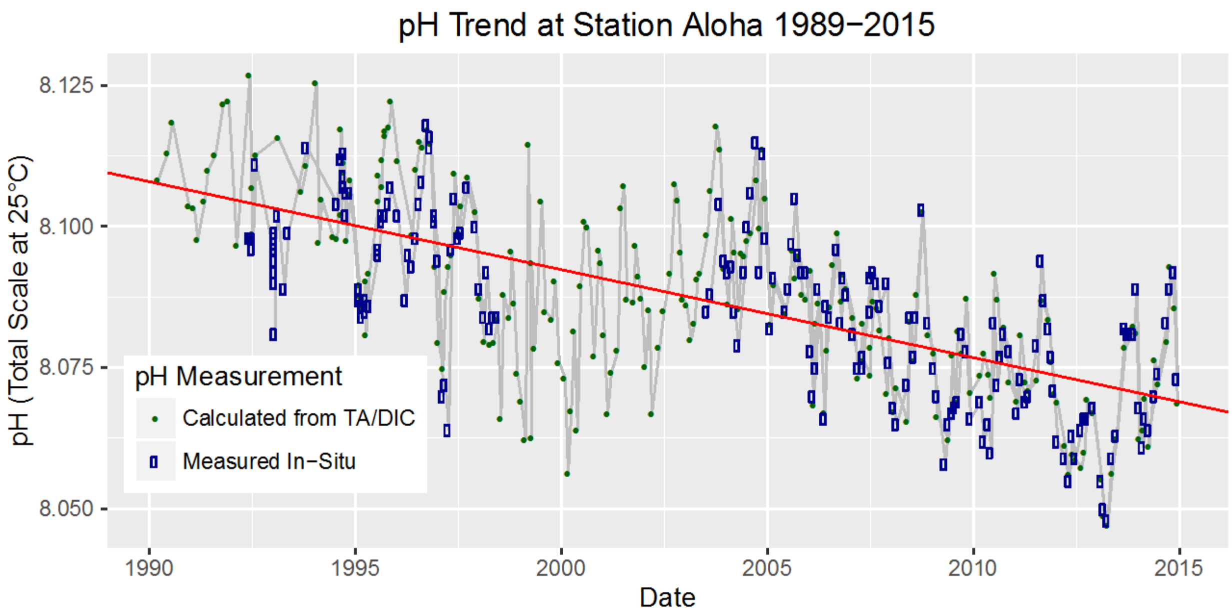


Figure 7. Time series trend of pH from Station Aloha from 1989-2015.

2.5.3.3 Oceanic Niño Index (ONI)

Description: Warm (red) and cold (blue) periods based on a threshold of +/- 0.5^{o}C for the Oceanic Niño Index (ONI) [three-month running mean of ERSST.v4 SST anomalies in the Niño 3.4 region (5^{o}N-5^{o}S, 120^{o}-170^{o}W)], based on centered 30-year base periods updated every five years.

For historical purposes, periods of below and above normal sea surface temperatures (SSTs) are colored in blue and red when the threshold is met for a minimum of five consecutive overlapping seasons. The ONI is one measure of the El Niño-Southern Oscillation, and other indices can confirm whether features consistent with a coupled ocean-atmosphere phenomenon accompanied these periods.

Description was inserted from:
http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Timeframe: Every three months.

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

Data Source/Responsible Party: NOAA NCEI Equatorial Pacific Sea Surface Temperatures (www.ncdc.noaa.gov/teleconnections/enso/indicators/sst.php)

Measurement Platform: In-situ Station, Satellite, Model, Other…

Rationale: The ONI focuses on ocean temperature which has the most direct effect on those fisheries. The atmospheric half of this Pacific basin oscillation is measured using the Southern Oscillation Index.

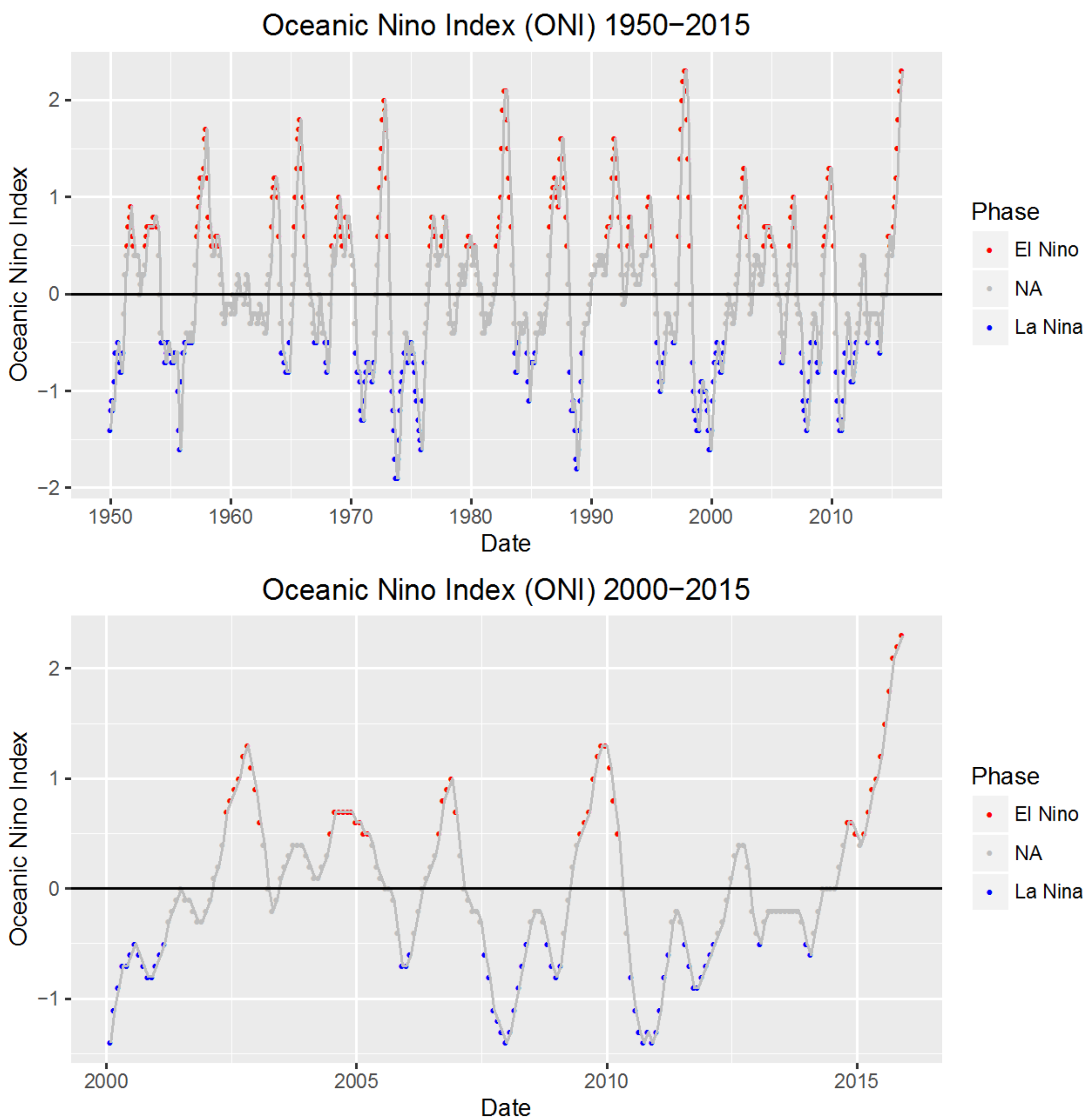
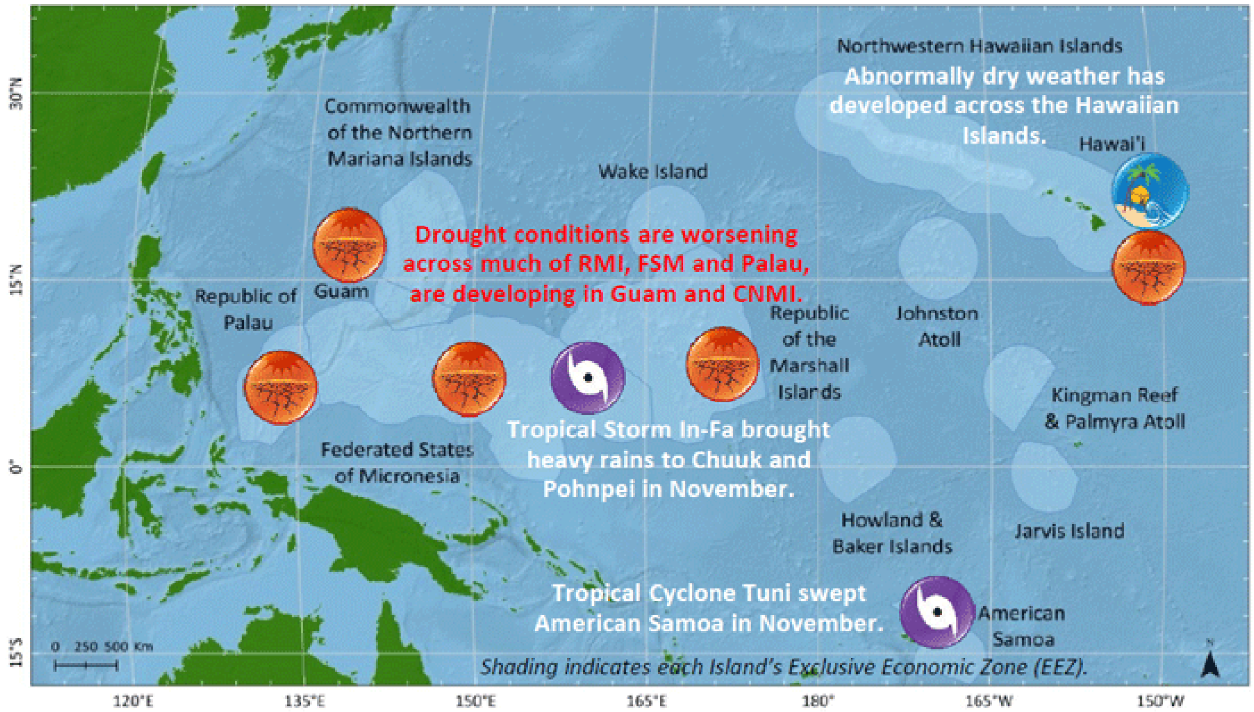


Figure 8**. Ocean Nino index**

The 2015-2016 El Niño

From: http://www.pacificcis.org/dashboard



Significant Events and Archipelagic Impacts

Facilities and Infrastructure – Significant surf-induced coastal flooding occurred on the north shore of Oahu in late January from 40' waves. The swell was enough to wash over Kam Highway, sending onlookers into the sea. In American Samoa, tropical cyclone Tuni resulted in flooding which closed much of the main road around the Independent Samoa island of Upolu.

Water Resources – The water storage reservoir on Majuro, RMI was 60% full as of 1 February, but household water tanks were critically low and some have gone dry. **As a result, the RMI Government has declared a State of Emergency,** activating the emergency operations center and mobilizing additional resources. Meanwhile, CNMI and Guam are being advised to begin water conservation measures as drought sets in. Residents on the islands of Palau, Yap, Chuuk, and the Marshalls are encouraged to check their water wells for excessive salinity as drought intensifies across the region.

Agriculture – Significant yellowing of food crops and vegetation have been observed in Guam, CNMI, Palau, and Yap, along with an increase in grass fires due to severe drought conditions. Yellowing of breadfruit tree leaves and pandanus fronds have been observed in Majuro.

Natural Resources **– Coral bleaching HotSpots are concentrated on the central equatorial Pacific Ocean but have diminished throughout most of the northeastern Pacific Ocean. Taimasa (low stands) conditions have been reported in American Samoa.**

Public Health – Drought is causing school attendance rates to drop across the Pacific Islands as hungry and dehydrated children face a high risk of malnutrition due to crop failure, water shortages, and poor sanitation.

The current El Niño has reached its peak and a slow decline towards neutral conditions is expected to begin in the 1st quarter 2016. However, many islands will continue to feel the effects of El Niño throughout much of 2016. The SST anomaly outlook for the first quarter indicates near-normal values in American Samoa, with slightly below normal values across CNMI, FSM, and Palau. Above-normal SST anomalies are forecast to continue across the Hawaiian Islands. The four-month coral bleaching outlook projects continued thermal stress to last through at least the end of May across the central equatorial Pacific. Alert Level 2 is expected to be widespread in the Eastern Pacific while the southwestern Pacific around the Great Barrier Reef, Vanuatu, and Fiji, reaches Alert Level 1.

The forecast values for sea level in the first quarter indicate that most of the USAPI stations are likely to be much closer to normal. American Samoa is expected to be marginally below normal, with further falls expected as the year continues. In Hawaii, both Honolulu and Hilo are likely to be slightly elevated. Severe drought is expected to develop and/or continue across nearly all of the USAPI, including Palau, Yap, Chuuk, Pohnpei, and Kosrae, as well as all islands in the RMI, Guam and CNMI, and the Hawaiian Islands. Below-normal rainfall is projected for American Samoa. Tropical cyclone (TC) activity in the western north Pacific is expected to be quiet in the first quarter. During the last major El Niño event in 1998, Feb-Apr saw zero typhoons or tropical storms. In the southwest Pacific, due to strong El Niño conditions, the chances for TC activity remains

Figure 9. 2015-2016 El Nino event infographic.

2.5.3.4 Sea Surface Temperature

Description: Monthly sea surface temperature from 2003-2015 from the Advanced Very High Resolution Radiometer (AVHRR) instrument aboard the NOAA Polar Operational Environmental Satellite (POES). These data take us back to 2003, if we were to blend this record with Pathfinder, we could reach back to 1981.

Background Below Inserted From CoastWatch West Coast Node.. We would like to acknowledge the NOAA CoastWatch Program and the NOAA NWS Monterey Regional Forecast Office.

Short Description:
The global area coverage (GAC) data stream from NOAA | NESDIS | OSDPD provides a high-quality sea surface temperature product with very little cloud contamination. This data is used for a variety of fisheries management projects, including the El Niño Watch Report, which stress data quality over high spatial resolution.

Technical Summary: CoastWatch offers global sea surface temperature (SST) data from the Advanced Very High Resolution Radiometer (AVHRR) instrument aboard NOAA's Polar Operational Environmental Satellites (POES). Two satellites are currently in use, NOAA-17 and NOAA-18. The AVHRR sensor is a five channel sensor comprised of two visible radiance channels and three infrared radiance channels. During daytime satellite passes, all five radiance channels are used. During nighttime passes, only the infrared radiance channels are used.

The POES satellite stores a sub-sample of the AVHRR radiance measurements onboard, generating a global data set. The satellite downloads this dataset once it is within range of a receiving station. The sub-sampling reduces the resolution of the original data from 1.47km for the HRPT SST product to 11km for the global data product.

AVHRR radiance measurements are processed to SST by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), Office of Satellite Data Processing and Distribution (OSDPD) using the non-linear sea surface temperature (NLSST) algorithm detailed in *Walton et al., 1998*. SST values are accurate to within 0.5 degrees Celsius. Ongoing calibration and validation efforts by NOAA satellites and information provide for continuity of quality assessment and algorithm integrity (e.g., *Li et al., 2001a and Li et al., 2001b*). In addition, the CoastWatch West Coast Regional Node (WCRN) runs monthly validation tests for all SST data streams using data from the NOAA National Weather Service and National Data Buoy Center (NDBC).

The data are cloud screened using the CLAVR-x method developed and maintained by NOAA Satellites and Information (e.g., *Stowe et al., 1999*). The data are mapped to an equal angle grid (0.1 degrees latitude by 0.1 degrees longitude) using a simple arithmetic mean to produce individual and composite images of various durations (e.g., 1, 3, 8, 14-day).

Timeframe: 2003-2015, Daily data available, Monthly means shown.

Region/Location: Global.

Data Source: "SST, POES AVHRR, GAC, Global, Day and Night (Monthly Composite)" http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdAGsstamday.html.

Measurement Platform: *AVHRR, POES Satellite*

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

References: Li, X., W. Pichel, E. Maturi, P. Clemente-Colón, and J. Sapper, 2001a. Deriving the operational nonlinear multi-channel sea surface temperature algorithm coefficients for NOAA-15 AVHRR/3, Int. J. Remote Sens., Volume 22, No. 4, 699 - 704.

Li, X, W. Pichel, P. Clemente-Colón, V. Krasnopolsky, and J. Sapper, 2001b. Validation of coastal sea and lake surface temperature measurements derived from NOAA/AVHRR Data, Int. J. Remote Sens., Vol. 22, No. 7, 1285-1303.

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

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

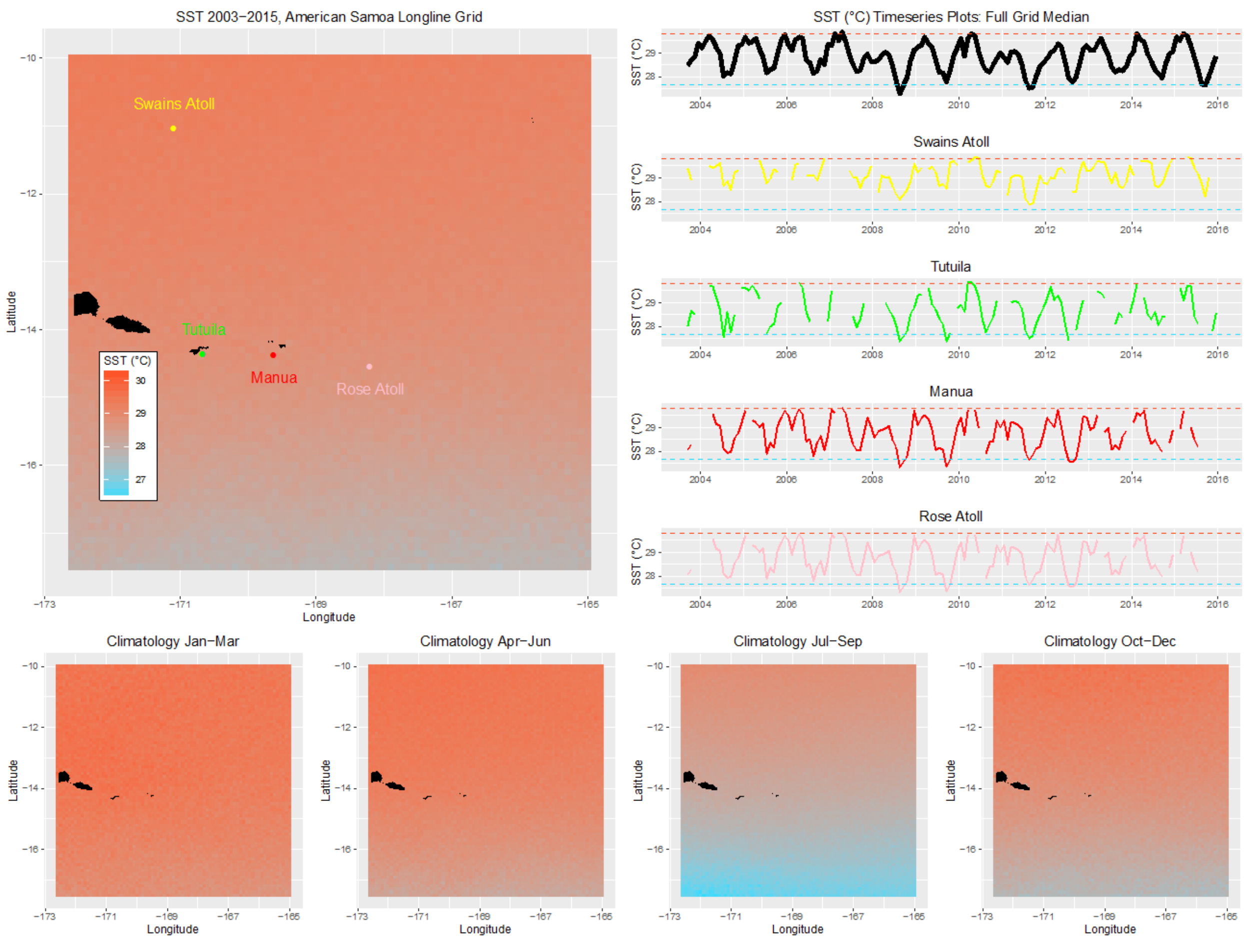


Figure 10**. Sea surface temperature plots**

2.5.3.5 Sea Surface Temperature Anomaly

Description: Monthly sea surface temperature anomaly from 2003-2015 from the AVHRR instrument aboard the NOAA Polar Operational Environmental Satellite (POES), compared against the Casey and Cornillon Climatology (Casey and Cornillion 1999). These data take us back to 2003, if we were to blend this record with Pathfinder, we could reach back to 1981.

Background Below Inserted From CoastWatch West Coast Node
[http://coastwatch.pfeg.noaa.gov/infog/AG_tanm_las.html]. We would like to acknowledge the NOAA CoastWatch Program and the NOAA NESDIS Office of Satellite Data Processing and Distribution.

Short Description: The SST anomaly product is used to show the difference between the surface temperature at a given time and the temperature that is normal for that time of year. This effectively filters out seasonal cycles and allows one to view intra-seasonal and inter-annual signals in the data. The global SST anomaly product is produced by comparing the AVHRR GAC SST with a climatology by *Casey and Cornillon, 1999*, for the region and time period specified. The AVHRR GAC SST is a high quality data set provided by NOAA | NESDIS | OSDPD.

Technical Summary: SST anomaly data are distributed at 11km resolution. AVHRR GAC SST values are accurate to within plus or minus 0.5 degrees Celsius. The time-averaged SST from AVHRR GAC is compared to the climatological SST from *Casey and Cornillon, 1999*, for the specific time period and region. The data are mapped to an equal angle grid of 0.1 degrees latitude by 0.1 degrees longitude using a simple arithmetic mean to produce composite images of various duration (e.g., 1, 3, 8, 14-day).

Reference: Casey, K.S. and P. Cornillon. 1999. A comparison of satellite and in situ based sea surface temperature climatologies. J. Climate. Vol. 12, no. 6, 1848-1863.

Timeframe: 2003-2015, Daily data available, Monthly means shown.

Region/Location: Global.

Data Source: "SST Anomaly, POES AVHRR, Casey and Cornillon Climatology, Global (Monthly Composite)"
http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdAGtanmmday_LonPM180.html

Measurement Platform: *POES, AVHRR Satellite*

Rationale: Sea surface temperature Anomaly highlights long term trends. Filtering out seasonal cycle is one of the most directly observable measures we have for tracking increasing ocean temperature.

References: Casey, K.S. and P. Cornillon. 1999. A comparison of satellite and in situ based sea surface temperature climatologies. J. Climate. Vol. 12, no. 6, 1848-1863.

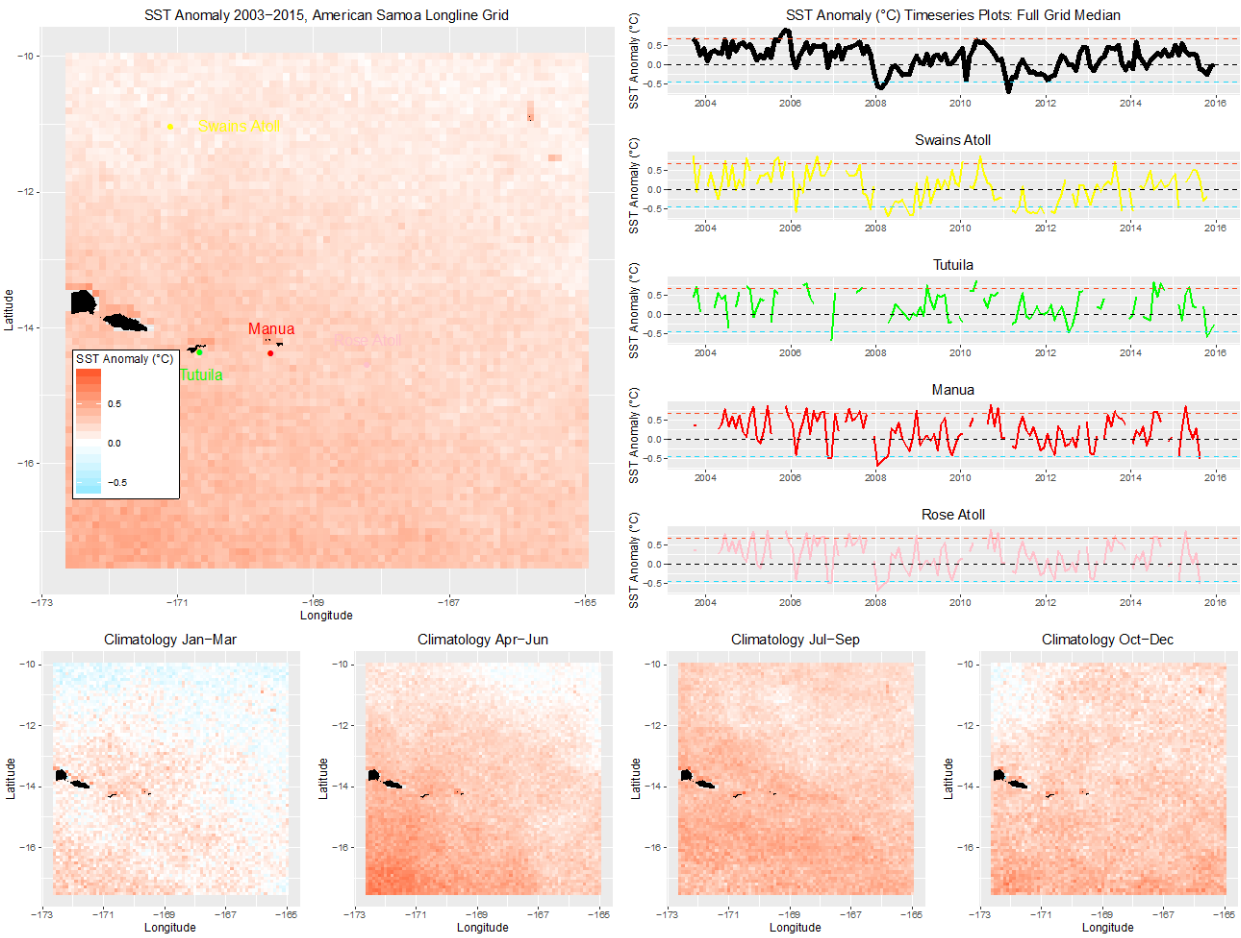


Figure 11. **Sea surface temperature anomaly**

2.5.3.6 Heavy Weather (Tropical Cyclones)

Description: This indicator uses historical data from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) International Best Track Archive for Climate Stewardship (IBTrACS) to track the number of tropical cyclones in the western, central, and south Pacific basins. This indicator also monitors the Accumulated Cyclone Energy (ACE) Index and the Power Dissipation Index (PDI) 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 the western North Pacific basin is tracked and a stacked time series plot will show the representative breakdown of the Saffir-Simpson hurricane categories. Three solid lines across the graph will also be plotted representing a) the annual long-term average number of named storms, b) the annual average number of typhoons, and c) the annual average number of major typhoons (Cat 3 and above). Three more lines will also be shown (in light gray) representing the annual average number of named-storms for ENSO a) neutral, b) warm, and c) cool.

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 knot; 39 mph). Therefore, a storm's ACE Index value accounts for both strength and duration. This plot will show the historical ACE values for each typhoon season and will have a solid line representing the annual average ACE value. Three more lines will also be shown (in light gray) representing the annual average ACE values for ENSO a) neutral, b) warm, and c) cool.

Timeframe: Yearly

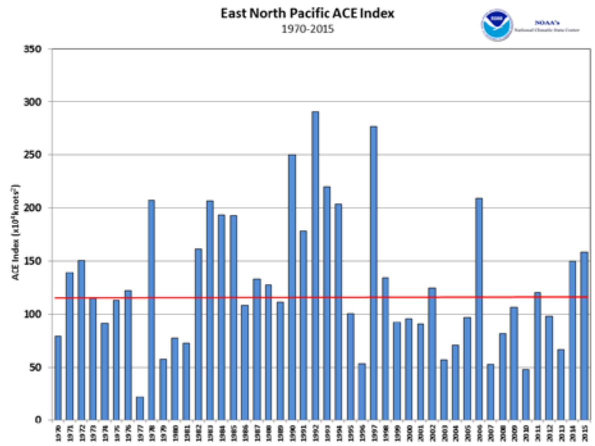
Region/Location: Hawaii and U.S. Affiliated Pacific Islands

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

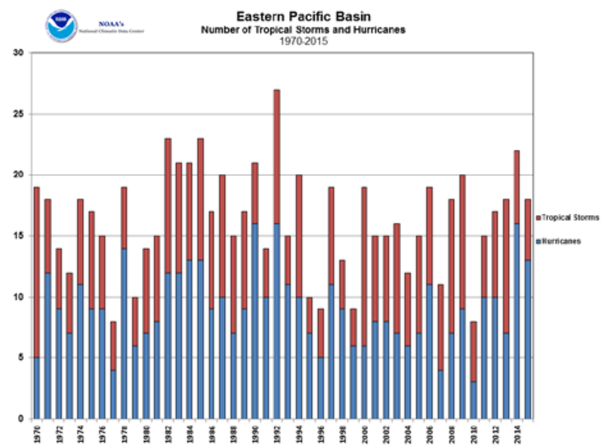
Measurement Platform: Satellite

Rationale: The effects of tropical cyclones are numerous and well-known. At sea, storms disrupt and endanger shipping traffic as well as fishing effort and safety. The Hawaii longline fishery, for example, had serious problems between August and November 2015 with vessels dodging storms at sea, delayed departures and inability to make it safely back to Honolulu because of bad weather. When cyclones encounter land, their intense rains and high winds can cause severe property damage, loss of life, soil erosion, and flooding. The associated storm surge, the large volume of ocean water pushed toward shore by the cyclone's strong winds, can cause severe flooding and destruction.

East Pacific Basin 2015 Season Summary:



[2015 East Pacific Tropical Cyclone ACE 1970-2015]



[East Pacific Tropical Cyclone Count 1970-2015]

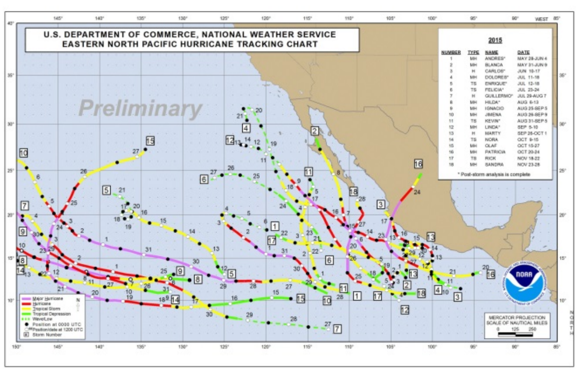


Figure 12. Annual Climatology of Tropical Cyclones in the Pacific Source: NOAA's National Hurricane Center

The NOAA National Centers for Environmental Information, State of the Climate: Hurricanes and Tropical Storms for Annual 2015, published online January 2016, notes that "the 2015 East Pacific hurricane season had 18 named storms, including 13 hurricanes, nine of which became major. The 1981-2010 average number of named storms in the East Pacific is 16.5, with 8.9 hurricanes, and 4.3 major hurricanes. This is the first year since reliable record keeping began in 1971 that the eastern Pacific saw nine major hurricanes. The Central Pacific also saw an above-average tropical cyclone season, with 14 named storms, eight hurricanes, and five major hurricanes, the most active season since reliable record-keeping began in 1971. Three major hurricanes (Ignacio, Kilo and Jimena) were active across the two adjacent basins at the same time, the first time this occurrence has been observed." Inserted from: http://www.ncdc.noaa.gov/sotc/tropical-cyclones/201513

The ACE index for the East Pacific basin during 2015 was 158 (x10^4 knots^2), which is above the 1981-2010 average of 132 (x10^4 knots^2) and the highest since 2006. The Central Pacific basin ACE during 2015 was 124 (x10^4 knots^2).

Cyclone Tracks 2015 (http://weather.unisys.com/hurricane)

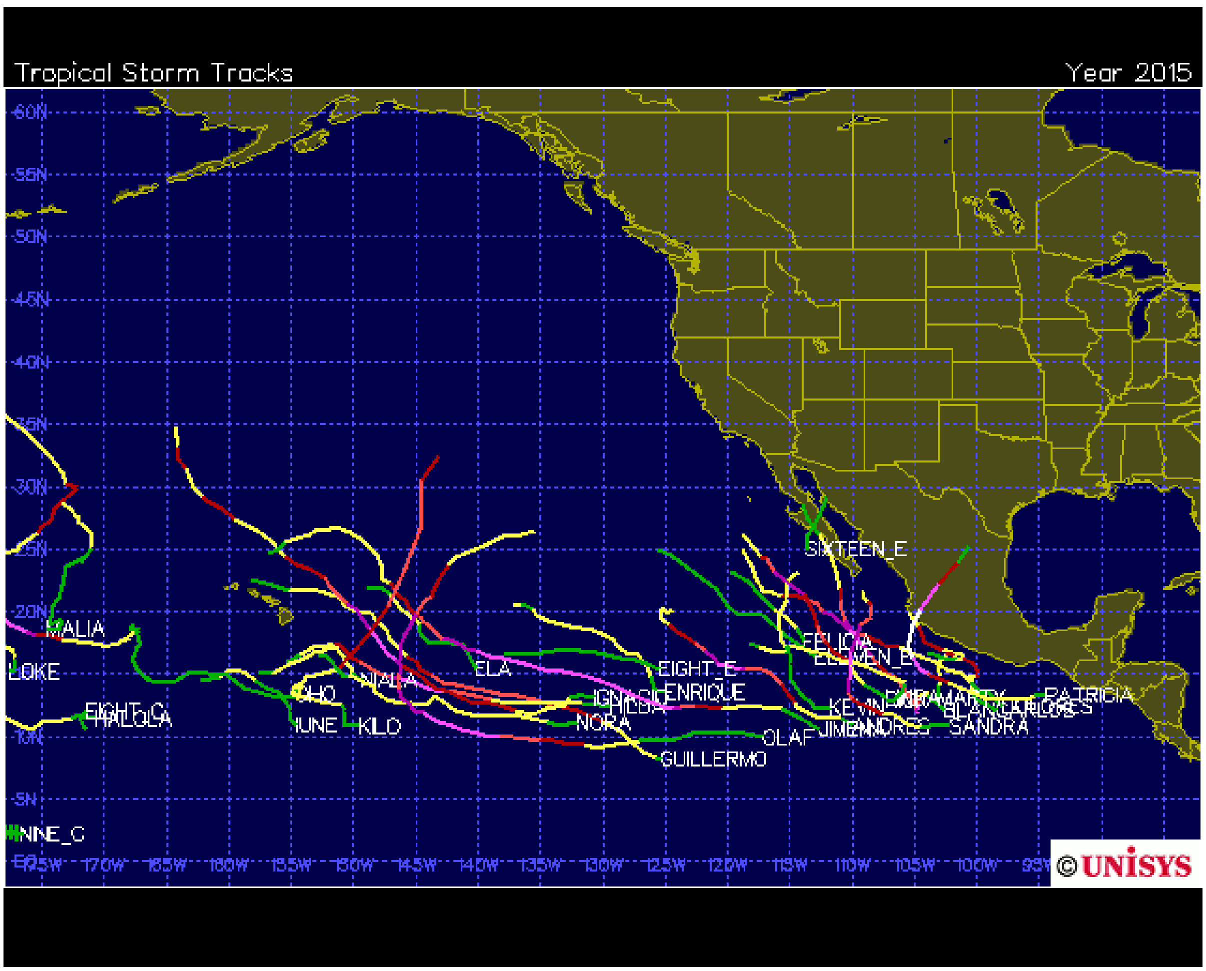


Figure 13**. Eastern Pacific Cyclone Tracks in 2015**

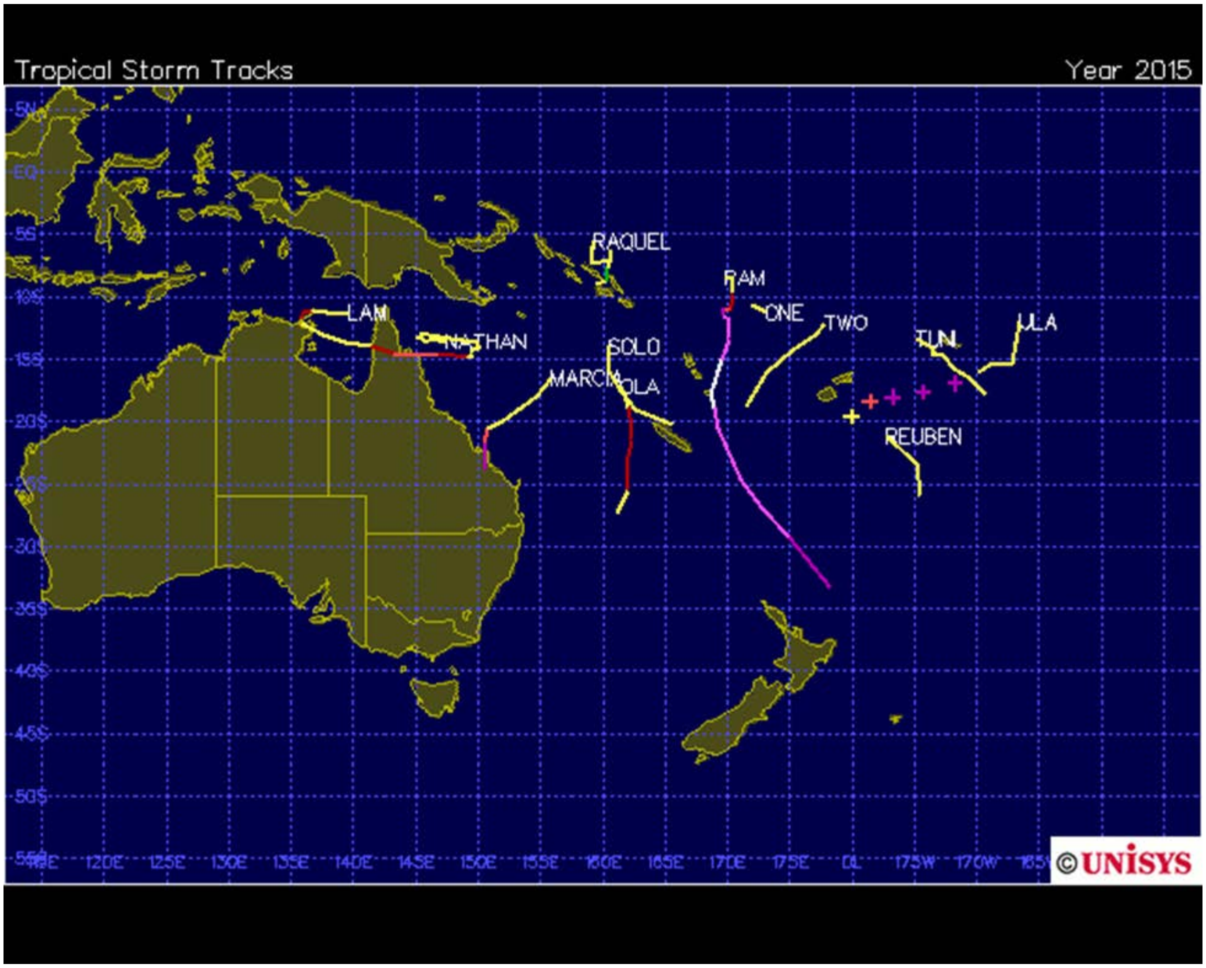


Figure 14. **Southern Pacific Cyclones in 2015**

References: NOAA National Centers for Environmental Information, State of the Climate: Hurricanes and Tropical Storms for Annual 2015, published online January 2016, retrieved on August 5, 2016 from http://www.ncdc.noaa.gov/sotc/tropical-cyclones/201513.

2.5.3.7 Sea Level (Sea Surface Height and Anomaly)

Description: Monthly mean sea level time series, including extremes

Timeframe: Monthly

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

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

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

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

Measurement Platform: Satellite and *in situ* tide gauges

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

2.5.3.7.1 Basin-Wide Perspective

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

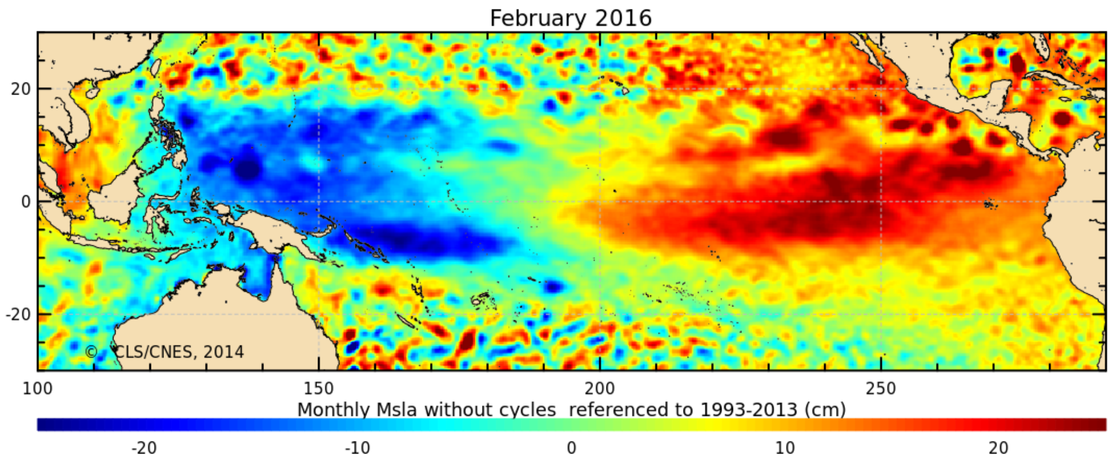
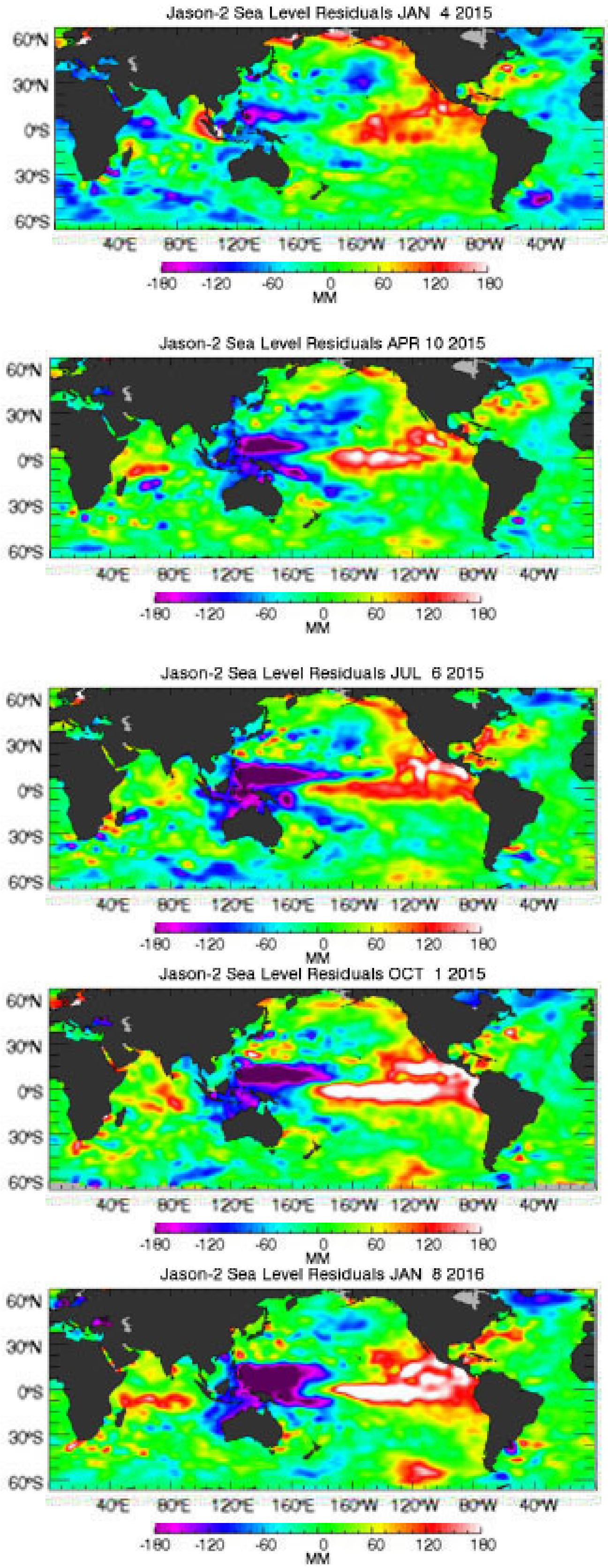
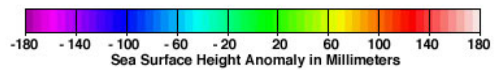


Figure 15. Sea surface height and anomaly



Quarterly time series of mean sea level anomalies during 2015 provide a glimpse into the evolution of the 2015-2016 El Niño throughout the year using satellite altimetry measurements of sea level height

http://sealevel.jpl.nasa.gov/science/elninopdo/latestdata/archive/index.cfm?y=2015)



2.5.3.7.2 Local Sea Level

These time-series from *in situ* tide gauges provide a perspective on sea level trends within each Archipelago (Tide Station Time Series from NOAA/COOPS).

The following figures and descriptive paragraphs were inserted from https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=1770000.

Figure 16 shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS. The calculated trends for all stations are available as a table in millimeters/year and in feet/century (0.3 meters = 1 foot). If present, solid vertical lines indicate times of any major earthquakes in the vicinity of the station and dashed vertical lines bracket any periods of questionable data or datum shift.

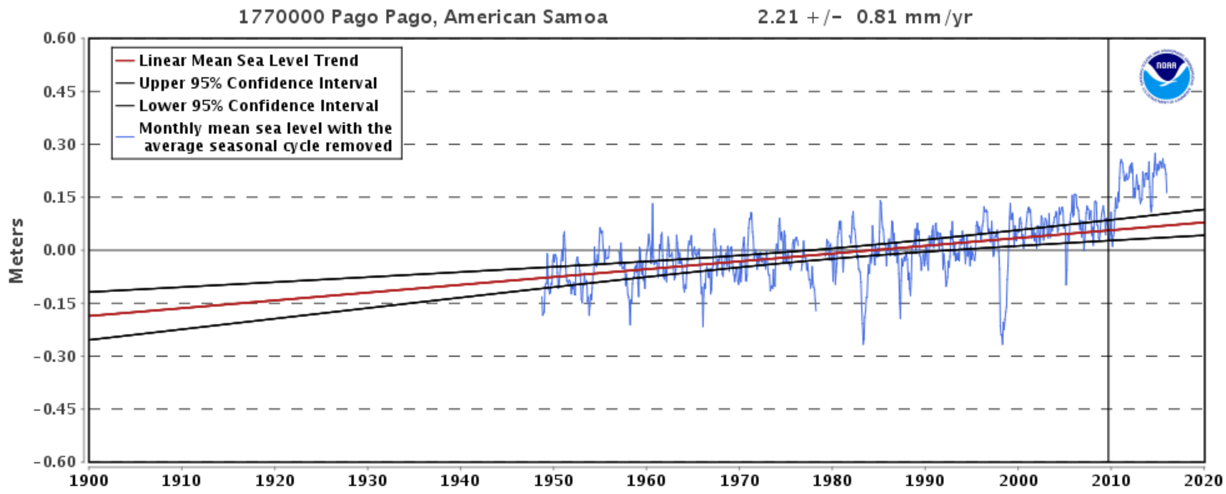
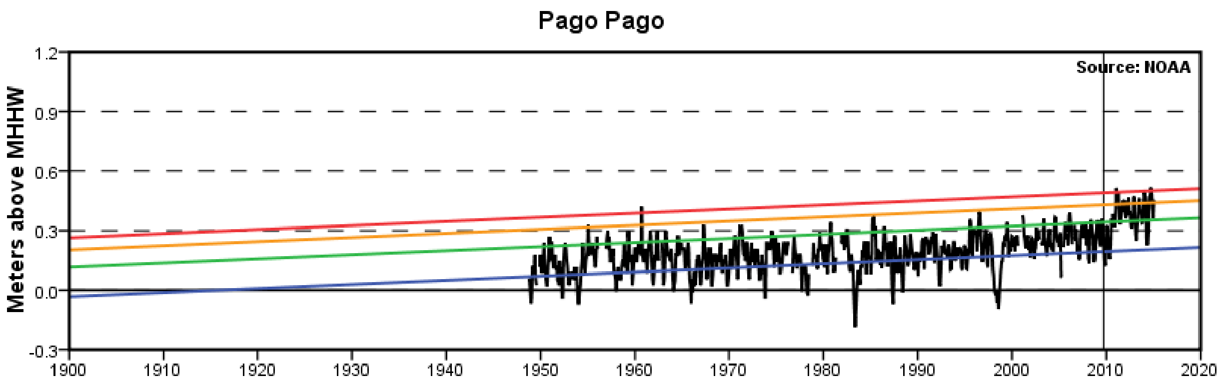


Figure 16. Monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents.

Figure 17 show the monthly highest and lowest water levels with the 1%, 10%, 50%, and 99% annual exceedance probability levels in red, orange, green, and blue. The plotted values are in meters relative to the Mean Higher High Water (MHHW) or Mean Lower Low Water (MLLW) datums established by CO-OPS (1 foot = 0.3 meters). On average, the 1% level (red) will be exceeded in only one year per century, the 10% level (orange) will be exceeded in ten years per century, and the 50% level (green) will be exceeded in fifty years per century. The 99% level (blue) will be exceeded in all but one year per century, although it could be exceeded more than once in other years.



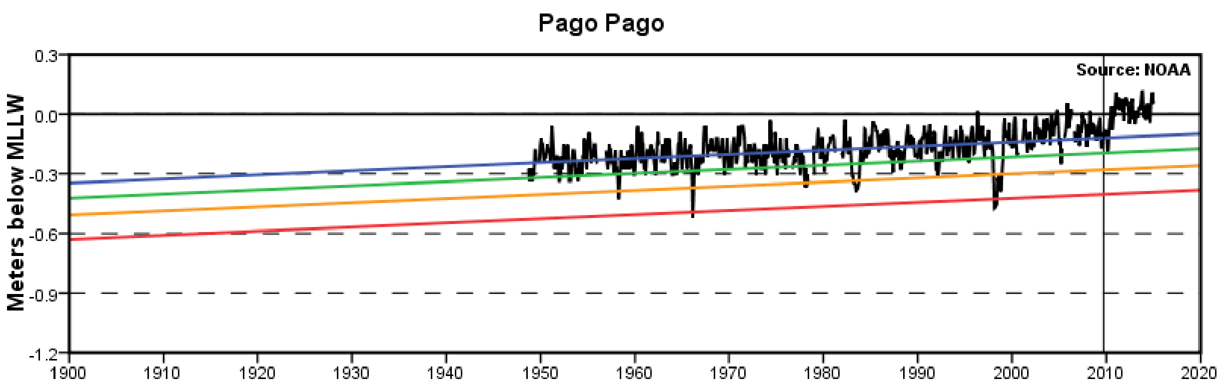


Figure 17**. The monthly extreme water levels include a Mean Sea Level (MSL) trend of 2.07 millimeters/year with a 95% confidence interval of +/- 0.9 millimeters/year based on monthly MSL data from 1948 to 2006 which is equivalent to a change of 0.68 feet in 100 years.**

2.5.3.8 Wave Watch 3 Global Wave Model

Description: To describe patterns in wave forcing, we present data from the Wave Watch 3 global wave model run by the Department of Ocean and Resources Engineering at the University of Hawai‘i in collaboration with NOAA/NCEP and NWS Honolulu. PacIOOS describes the model at http://oos.soest.hawaii.edu/pacioos/focus/modeling/wave_models.php: “The global model is initialized daily and is forced with NOAA/NCEP's global forecast system (GFS) winds. This model is designed to capture the large-scale ocean waves, provide spectral boundary conditions for the Hawai‘i and Mariana Islands regional WW3 model, and most importantly, the 7 day model outputs a 5 day forecast.”

Data presented here come from the global model, but regional WW3 models with higher resolution exist for Hawaii, Marianas and Samoa, and in some cases, very high resolution SWAN models exist for islands within those groups.

Timeframe: 2010-2016, Daily data.

Region/Location: Global.

Data Source: "WaveWatch III (WW3) Global Wave Model"
http://oos.soest.hawaii.edu/erddap/griddap/NWW3_Global_Best.html

Measurement Platform: *Global Forecast System Winds, WW3 mode*

Rationale: Wave forcing can have major implications for both coastal ecosystems and pelagic fishing operations.

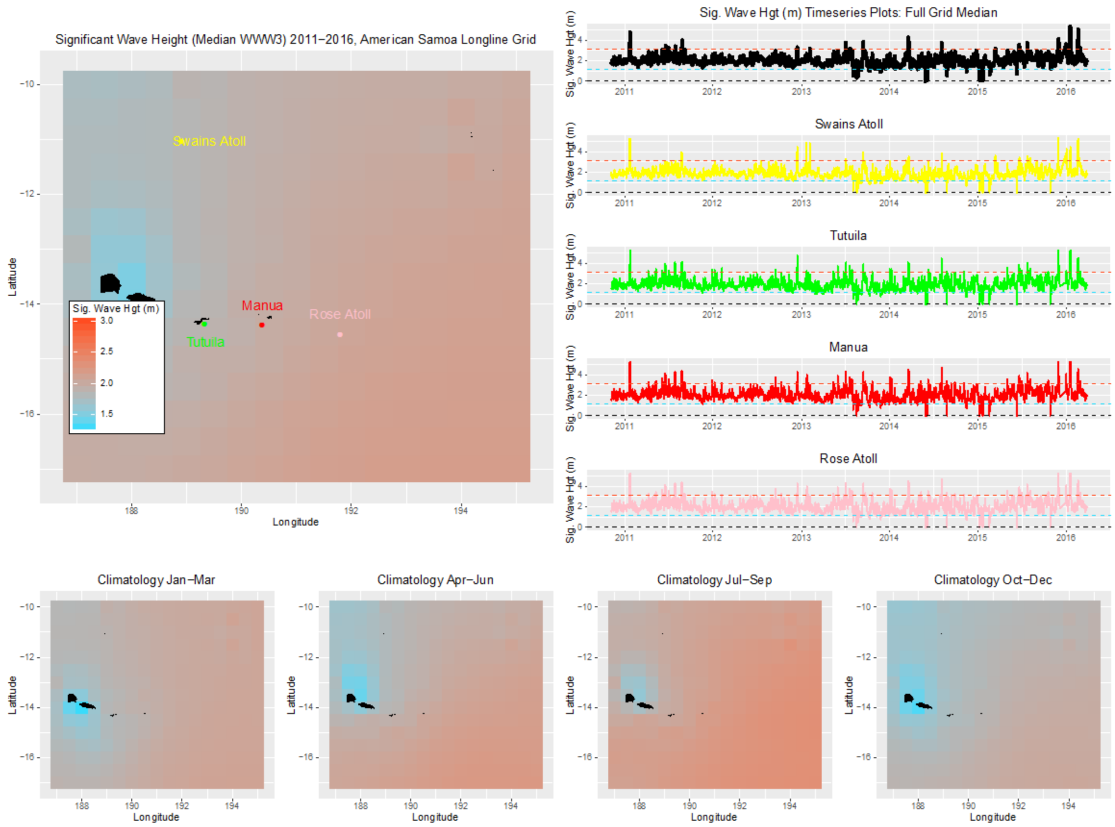


Figure 18. American Samoa Wave Watch grids

2.5.4 Observational and Research Needs

Through preparation of the 2015 Archipelagic Annual Reports, the Council has identified a number of observational and research needs that, if addressed, would improve the information content of future Climate and Ocean Indicators chapters. This information would provide fishery managers, fishing industry and community stakeholders with better understanding and predictive capacity vital to sustaining resilient and vibrant fishery systems in the Western Pacific.

- Emphasize the importance of continuing the climate and ocean indicators used in this report so that a consistent, long-term record can be maintained;
- Develop agreements among stakeholders and research partners to ensure the sustainability, availability and accessibility of climate and ocean indicators, their associated datasets and analytical methods used in this and future reports;

- Improve monitoring and understanding of the impacts of changes in ocean temperature, pH and ocean acidity, ocean oxygen content and hypoxia, and sea level rise through active collaboration by all fishery stakeholders and research partners;
- Develop, test and provide access to additional climate and ocean indicators that can improve the Archipelagic Conceptual Model;
- Investigate the connections between climate variables and other indicators in the Archipelagic Conceptual Model to improve understanding of changes in physical, biochemical, biologic and socio-economic processes and their interactions in the regional ecosystem;
- Explore the connections among sea surface conditions, stratification and mixing;
- Improve understanding of mahi and swordfish size in relation to the orientation of the TZCF;
- Explore the biological implications of tropical cyclones;
- Standardize fish community size structure data for gear type;
- Develop predictive models that can be used for scenario planning to account for unexpected changes and uncertainties in the regional ecosystem and fisheries;
- Foster applied research in ecosystem modeling to better describe current conditions and to better anticipate the future under alternative models of climate and ocean change including changes in expected human benefits and their variability;
- Clarify and elucidate the interactions among (1) changes in climate, (2) ecosystems and (3) social, economic and cultural impacts on fishing communities;
- Explore the implications and effectiveness of large marine protected areas including intergenerational losses of knowledge due to lack of access to traditional fishing areas;
- Cultural knowledge and practices for adapting to changing climate in the past and how they might contribute to future climate adaptation.
- Enhanced information on social, economic and cultural impacts of a changing climate and increased pressure on the ocean and its resources.
- Analysis of potential relationship(s) between traditional runs of fish and climate change indicators.
- Explore the use of electronic monitoring and autonomous vehicles including small vessel prototypes.
- Cultural knowledge and practices for adapting to changing climate in the past and how they might contribute to future climate adaptation.
- Explore additional and/or alternative climate and ocean conditions that may have important effects on archipelagic fisheries systems including:
    - Ocean currents and anomalies;
    - Near-surface wind velocities and anomalies;
    - Wave forcing anomalies and wave power;
    - Estimates of phytoplankton abundance and size from satellite remotely-sensed SST and chlorophyll measurements;
    - Nutrients;
    - Eddy kinetic energy (EKE) which can be derived from satellite and remotely-sensed sea surface height data and can be indicative of productivity-enhancing eddies;
    - Degree Heating Weeks for coral reef ecosystems;

- Time series of species richness and diversity from catch data which could potentially provide insight into how the ecosystem is responding to physical climate influences;
- Identifying and monitoring key socio-economic and cultural indicators of the impacts of changing climate on resources, fishing communities, operations and resilience.

2.5.5 **A Look to the Future**

Future Annual Reports will include additional indicators as they become available and their relevance to the development, evaluation and revision of ecosystem-fishery plans becomes clear. 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 Essential Fish Habitat

2.6.1 Introduction

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

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

The EFH Final Rule strongly recommends regional fisheries management councils and NMFS to conduct a review and revision of the EFH components of fisheries management plans every 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 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. To this point, the annual report summarizes the available information on habitat condition for all fisheries.

2.6.1.1 EFH Information

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

The Council has described EFH for five management unit species (MUS) under its management authority: pelagic (PMUS), bottomfish (BMUS), crustaceans (CMUS), coral reef ecosystem (CREMUS), and precious corals (PCMUS). The AS FEP describes EFH for the BMUS, CMUS, CREMUS, and PCMUS. The 2015 SAFE report summarizes the precious corals EFH information, which was prioritized for review in 2015 by Council, PIRO, and PIFSC habitat staff because the Council's consideration of EFH was most out of date with respect to available abundance information.

2.6.1.2 Habitat Objectives of FEP

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

a. Review EFH and HAPC designations every five years based on the best available scientific information and update such designations based on the best available scientific information, when available

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

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

2.6.1.3 Response to Previous Council Recommendations

At its 163rd meeting in Honolulu, HI, the Council endorsed a plan team working group on the HAPC process: "The working group will produce a report exploring HAPC designation options for the Western Pacific region within a year." The working group report is included as Appendix 1 to the habitat section of this report.

At its 165th meeting in Honolulu, HI, the Council recommended the revised Regional Operating Agreement be adopted as presented including the ESA-MSA Integration Agreement, Action Plan Template and Council diagram as appendixes and directs staff to finalize the EFH Policy to include the five-year EFH review and the EFH consultation coordination processes. The Council endorsed the inclusion of major federal actions with more than minimal adverse effect on EFH and those identified by the Council or its advisory bodies in the scope of the EFH consultation agreement.

In developing the EFH policy, staff will consider the HAPC Process working group report findings.

There are no additional outstanding American Samoa habitat recommendations for the plan team.

2.6.2 Habitat Use by MUS and Trends in Habitat Condition

American Samoa is made up of five high volcanic islands (Tutuila, Aunu'u, Ofu, Olosega, and Ta'u) with fringing reefs, two coral atolls (Rose Atoll or Muliava and Swains Island), and several seamounts and banks. The high islands have surrounding banks where sand can accumulate, in contrast with the Rose and Swains, where slopes plunge steeply to abyssal depths (PIFSC 2008). Tutuila is the largest island in the territory, and has banks (320 sq km) surrounding the island that extend between one and nine km offshore (PIBHMC) and extends more than three km from shore in most places (PIFSC 2008). The islands of Ofu, Olosega, and Ta'u make up the Manu'a Islands group, which have more limited shallow submerged banks (Figure **19**). The nearshore habitat consists of narrow reef flat lagoons and fringing coral reefs (PIFSC 2008). 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 & Trewick 2008). Rose Atoll's geological origin is not well studied.

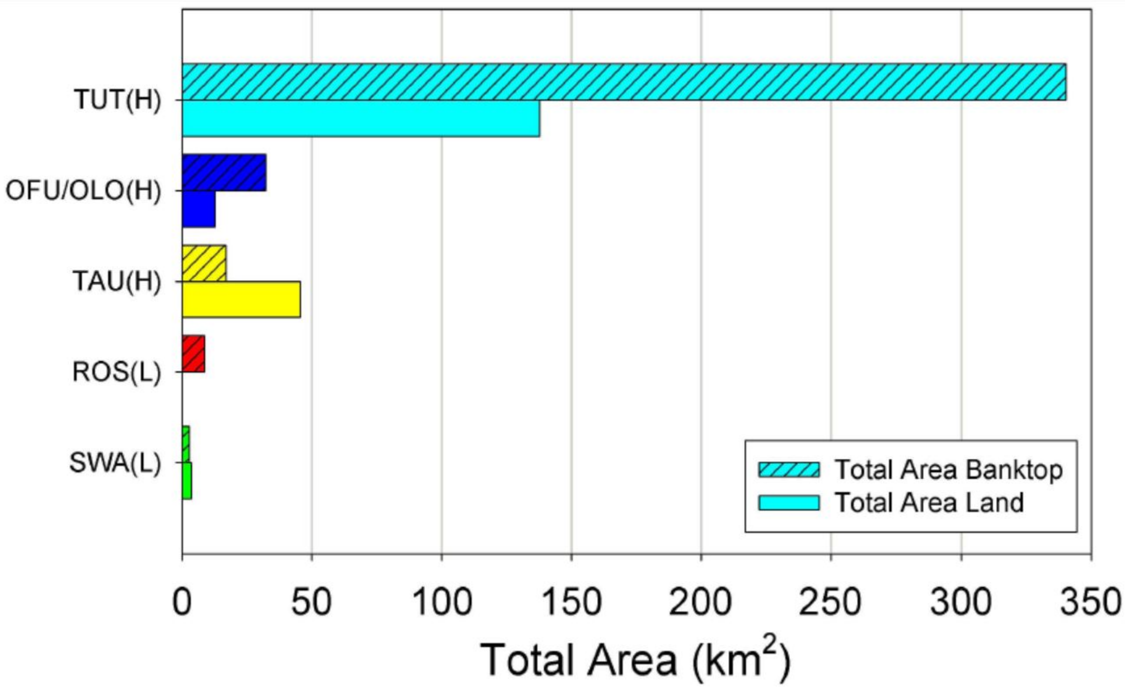


Figure 19**. Total banktop area and total terrestrial land area of Tutuila and Aunu'u (TUT), Ofu and Olosega (OFU/OLU), Ta'u (TAU), Rose (ROS) and Swains (SWA). High volcanic islands are denoted with the letter H, low carbonate islands/atolls with the letter L. From PIFSC 2008.**

Essential fish habitat in the Territory of American Samoa for the four MUS comprises all substrate from the shoreline to the 700 m isobath (Figure 20). The entire water column is described as EFH from the shoreline to the 700 m isobath, and the water column to a depth of 400 m is described as EFH from the 700 m isobath to the limit or boundary of the exclusive economic zone (EEZ). While the coral reef ecosystems surrounding the islands in American Samoa have been the subject of a comprehensive monitoring program through the PIFSC Coral Reef Ecosystem Division (CRED), the offshore banks and pelagic environment in which MSA-managed fisheries operate have been less studied.
The mission of the PIFSC Coral Reef Ecosystem Division (CRED) is to "provide high-quality, scientific information about the status of coral reef ecosystems of the U.S. Pacific islands to the public, resource managers, and policymakers on local, regional, national, and international levels" (PIFSC 2011). CRED's Reef Assessment and Monitoring Program (RAMP) conducts

comprehensive ecosystem monitoring surveys at about 50 island, atoll, and shallow bank sites in the Western Pacific Region on a one to three year schedule (PIFSC 2008). CRED coral reef monitoring reports provide the most comprehensive description of nearshore habitat quality in the region. The benthic habitat mapping program provides information on the quantity of habitat.

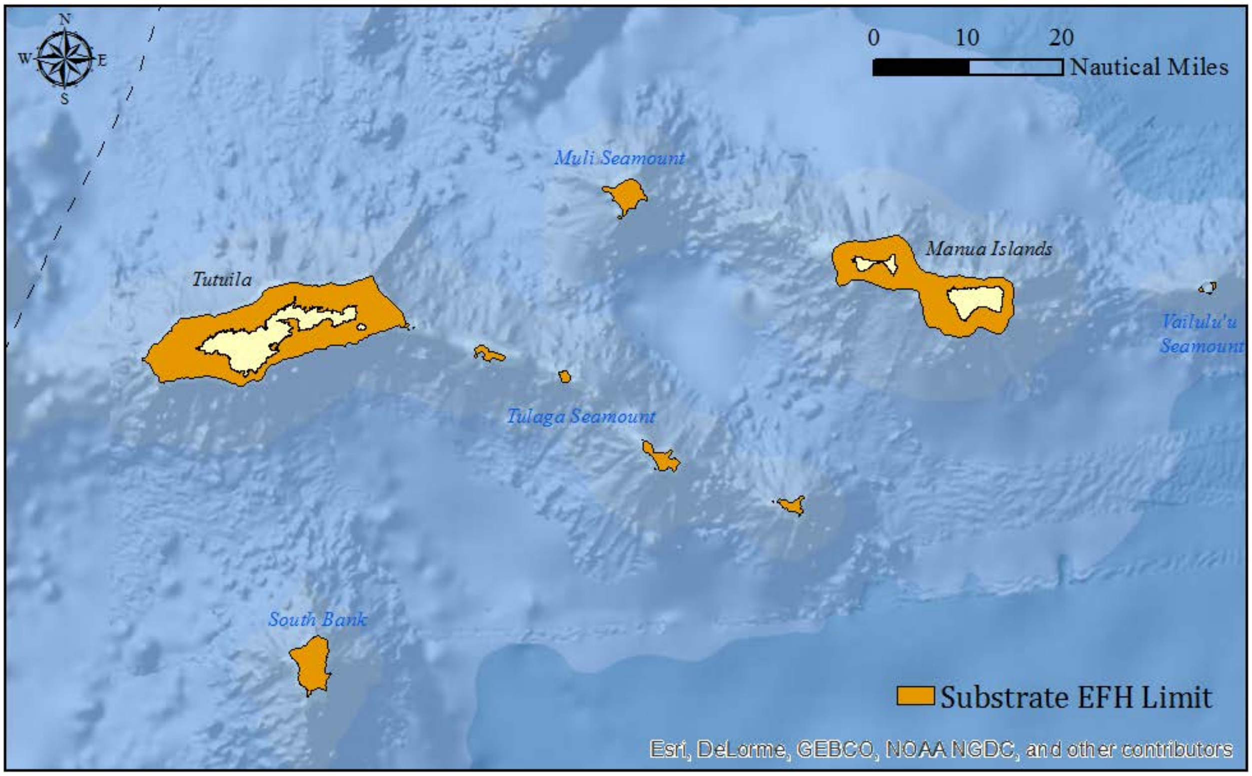


Figure 20. Substrate EFH limit of 700 m isobath around the high islands and surrounding banks of American Samoa. Data source: GMRT.

2.6.2.1 Habitat Mapping

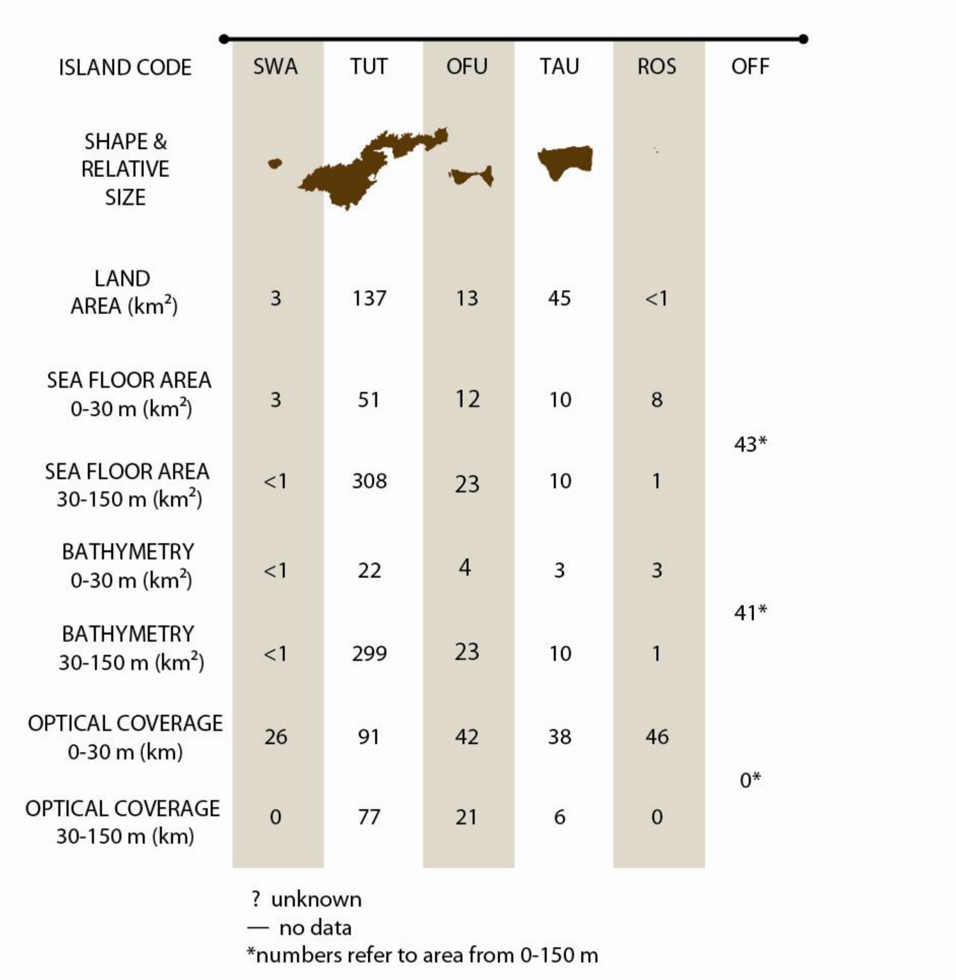
Interpreted IKONOS benthic habitat maps in the 0 – 30 m depth range have been completed for all islands in American Samoa (CRCP 2011). Between the PIBHMC and academically collected data, there is nearly 100% multibeam coverage of the territory between 20 and 3000 m depths (PIBHMC).

Table 30. Summary of habitat mapping in American Samoa

Depth Range	Timeframe/Mapping Product	Progress	Source
0-30 m	2000-2010 Bathymetry	39%	DesRochers 2016
	IKONOS Benthic Habitat Maps	All	NCCOS Data Collections: Territory Benthic Habitat Maps

Depth Range	**Timeframe/Mapping Product**	**Progress**	**Source**
	2011-2015 Satellite WorldView 2 Bathymetry	1%	DesRochers 2016
	2011-2015 Multibeam Bathymetry	-	DesRochers 2016
30-150 m	2000-2010 Bathymetry	97%	DesRochers 2016
	2011 – 2015 Multibeam Bathymetry	-	DesRochers 2016
20-3000 m	Multibeam Bathymetry	Nearly 100% mapping coverage	Pacific Islands Benthic Habitat Mapping Center

The land and seafloor area surrounding the islands of American Samoa as well as primary data coverage are reproduced from CRCP 2011 in Figure 21.



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

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

Figure 21. American Samoa Land and Seafloor Area and Primary Data Coverage from CRCP 2011.

2.6.2.1.1 Benthic Habitat

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

Table 31 shows the depths of geologic features, the occurrence of MUS EFH at that feature, and the availability of long-term monitoring data at diving depths.

Table 31. Occurrence of EFH by feature. 1PIBMHC

Feature	Summit Minimum Depth	Coral Reef/Crustaceans exc. Deepwater Shrimp	Bottomfish	Deepwater Shrimp	Long Term Monitoring
Tutuila	Emergent	✓	✓	✓	✓
Manu’a Group	Emergent	✓	✓	✓	✓
Swains Island	Emergent	✓	✓	✓	✓
Rose Atoll	Emergent	✓	✓	✓	✓
Muli Seamount	50 m[1]	✓	✓	✓	
Tulaga Seamount		✓	✓	✓	
South Bank		✓	✓	✓	2010 only
Vailulu’u Seamount	580 m[1]			✓	

2.6.2.1.2 RAMP Indicators

Benthic percent cover of coral, macroalgae, and crustose coralline algae from CRED are found in the following tables. CRED uses the benthic towed-diver survey method to monitor changes in benthic composition. In this method, “a pair of scuba divers (one collecting fish data, the other collecting benthic data) is towed about one meter above the reef roughly 60 m behind a small boat at a constant speed of about 1.5 kt. Each diver maneuvers a towboard platform, which is connected to the boat by a bridle and towline and outfitted with a communications telegraph and various survey equipment, including a downward-facing digital SLR camera (Canon EOS 50D, Canon Inc., Tokyo). The benthic towed diver records general habitat complexity and type (e.g., spur and groove, pavement), percent cover by functional-group (hard corals, stressed corals, soft corals, macroalgae, crustose coralline algae, sand, and rubble) and for macroinvertebrates (crown-of-thorns seastars, sea cucumbers, free and boring urchins, and giant clams).
Towed-diver surveys are typically 50 min long and cover about two to three km of habitat. Each survey is divided into five-min segments, with data recorded separately per segment to allow for later location of observations within the ~ 200-300 m length of each segment. Throughout each survey, latitude and longitude of the survey track are recorded on the small boat using a GPS; and after the survey, diver tracks are generated with the GPS data and a layback algorithm that accounts for position of the diver relative to the boat. (PIFSC Website, 2016).

Table 32. Mean percent cover of live coral from RAMP sites collected from towed-diver surveys in American Samoa

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

Table 33. Mean percent cover of macroalgae from RAMP sites collected from towed-diver surveys in American Samoa

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

Table 34. Mean percent cover of crustose coralline algae from RAMP sites collected from towed-diver surveys in American Samoa

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

2.6.2.2 Oceanography and Water Quality

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

2.6.3 Report on Review of EFH Information

The precious corals biological components were reviewed through production of this annual report. The non-fishing impact and cumulative impacts components are scheduled for review in 2016. Precious corals information can be found in Attachment 2.

2.6.4 EFH Levels

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

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

The Council adopted a fifth level, denoted Level 0, for situations in which there is no information available about the geographic extent of a particular managed species' life stage. The existing level of data for individual MUS in each fishery are presented in tables per fishery. Each fishery section also includes the description of EFH method used to assess the value of the habitat to the species, description of data sources used if there was analysis; and description of method for analysis. A section summarizing the annual review that was performed follows.

2.6.4.1 Precious Corals

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

Table 35. Level of EFH information available for Western Pacific precious corals management unit species.

Species	Pelagic phase (larval stage)	Benthic phase
Pink Coral		
Corallium secundum	0	4
C. regale	0	2
C. laauense	0	2
Gold Coral		
Gerardia spp	0	2
Callogorgia gilberti	0	2

Species	Pelagic phase (larval stage)	Benthic phase
Narella spp.	0	2
Bamboo Coral		
Lepidisis olapa	0	2
Acanella spp.	0	2
Black Coral		
Antipathes dichotoma	0	4
A. grandis	0	4
A. ulex	0	2

2.6.4.2 Bottomfish and Seamount Groundfish

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

Table 36. Level of EFH information available for the Western Pacific bottomfish and seamount groundfish management unit species complex.

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

Life History Stage	Eggs	Larvae	Juvenile	Adult
Seamount Groundfish:				
Beryx splendens (alfonsin)	0	1	2	2
Hyperoglyphe japonica (ratfish/butterfish)	0	0	0	1
Pseudopentaceros richardsoni (armorhead)	0	1	1	3

2.6.4.3 Crustaceans

Essential Fish Habitat for crustaceans MUS was originally designated in Amendment 10 to the Crustaceans FMP (64 FR 19067, April 19, 1999). EFH definitions were also approved for deepwater shrimp through an amendment to the Crustaceans FMP in 2008 (73 FR 70603, November 21, 2008).

Table 37. Level of EFH information available for the crustacean management unit species complex.

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

2.6.4.4 Coral Reef

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

2.6.5 Research and Information Needs

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

2.6.5.1 All FMP Fisheries

- Distribution of early life history stages (eggs and larvae) of management unit species by habitat

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

2.6.5.2 Bottomfish Fishery

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

2.6.5.3 Crustaceans Fishery

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

2.6.5.4 Precious Corals Fishery

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

2.6.6 References

Annette DesRochers. "Benthic Habitat Mapping." NOAA Fisheries Center, Honolulu, HI. Presentation. April 6, 2016.

Coral Reef Ecosystem Program; Pacific Islands Fisheries Science Center 2016. Benthic Percent Cover Derived from Analysis of Benthic Images Collected during Towed-diver Surveys of the U.S. Pacific Reefs Since 2003 (NCEI Accession <unassigned>). NOAA National Centers for Environmental Information. Unpublished Dataset. April 5, 2016.

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Annette DesRochers. "Benthic Habitat Mapping." NOAA Fisheries Center, Honolulu, HI. Presentation. April 6, 2016.

2.7 Marine Planning

2.7.1 Introduction

Marine planning is a science-based tool being utilized regionally, nationally and globally to identify and address issues of multiple human uses, ecosystem health and cumulative impacts in the coastal and ocean environment. The Council's efforts to incorporate marine planning in its actions began in response to Executive Order (EO) 13547, Stewardship of the Ocean, Our Coasts, and the Great Lakes, issued by President Barack Obama on June 19, 2010. EO 13547 adopted the recommendations of the Interagency Ocean Policy Task Force and directed executive agencies to implement those recommendations as the National Ocean Policy. A third of the Task Force document addressed marine planning.

In 2015, the Council adopted its Marine Planning and Climate Change (MPCC) Policy, drafted by the Council's MPCC Committee, to help it coordinate development and amendment of its fishery ecosystem plans, programs, and other relevant activities. The policy uses the definition of marine planning from the National Ocean Policy Implementation Plan. The MPCC policy recognizes a set of overarching and specific principles and specific policy points for the Council, its advisory bodies and its staff to consider and incorporate in the American Samoa Archipelago Fishery Ecosystem Plan (FEP). Of the MPCC policy's overarching principles, three relate to marine planning. The MPCC policy recognizes marine planning as an appropriate approach to reconciling intersecting human use, ocean resource, and ecosystem health at multiple geographic scales. The MPCC policy also recognizes that traditional resource management systems, such as the ahupua`a system in Hawai`i and Fa`a Samoa in American Samoa can provide an appropriate context for marine planning. Lastly, the MPCC Policy states that marine protected areas (MPAs), a tool used in marine planning, can and should be used for climate change reference and human use and impact research.

In promoting the ecosystem approach to management, the Council will carefully consider the impact on fisheries and fishery resources, including traditional fisheries, resources, knowledge, and fishing rights when participating in marine planning for activities such as offshore energy development. A key component of the MPCC policy is collaboration with existing organizations in data and information collection, dissemination and outreach. The Council intends to work with the Pacific Islands Regional Planning Body (RPB), community members, the private sector, schools, policymakers and others in Hawai`i, American Samoa, Guam and the Commonwealth of the Northern Mariana Islands (CNMI). The MPCC Policy can be found on the Council's website.

The Council's Plan Team (restructured in 2015) includes a marine planning expert to oversee inclusion of marine planning in the annual report. The marine planning annual report attempts to bring together available data related to marine planning that are relevant to the Council's roles in marine planning on an annual scale. Marine planning concerns with timelines shorter than a year are not included in this report. These roles are:

1. Implementation of the Magnuson-Stevens Fishery Conservation and Management Act (MSA)
2. Implementation of the National Environmental Policy Act (NEPA)

3. Stakeholder in non-MSA planned ocean activities
4. Member of the Pacific Islands RPB

2.7.1.1 MSA and NEPA Implementation

Marine planning is relevant to the implementation of the MSA through:

- Responding to previous Council recommendations relevant to its marine planning role
- Monitoring achievement of FEP objectives
- Defining essential fish habitat (EFH) and EFH Information
- Working with the National Marine Fisheries Service (NMFS) Pacific Islands Regional Office (PIRO) to identify and provide conservation and enhancement recommendations on activities that may cause adverse effects to essential fish habitat (EFH), and
- Tracking any changes in the cumulative impact of fishing, non-MSA fishing, and non-fishing activities on EFH.

Similarly, NEPA requires federal agencies to analyze the cumulative impacts of their actions with past, present, and reasonably foreseeable future activities.

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

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

In order to meet the EFH and NEPA mandates, this annual report tracks activities that occur in the ocean that are of interest to the Council and incidents that may contribute to cumulative impact. While the Council is not responsible for NEPA compliance, monitoring the environmental effects of ocean activities for the FEP's EFH cumulative impacts section is duplicative of the agency's NEPA requirement, and therefore, this report can provide material or suggest resources to meet both mandates.

2.7.1.2 Stakeholder in Non-fishing Activities

Tracking activities also assists the Council in its role as a stakeholder in other offshore activities. In the Western Pacific Region, fisheries compete with other activities for access to and use of fishing grounds. These activities include, but are not limited to, military bases and training activities, commercial shipping, marine protected areas, recreational activities and off-shore energy projects. Between the Bureau of Ocean Energy Management (BOEM), the Army Corps of Engineers (USACE), and the National Marine Fisheries Service (NMFS), most permits for offshore energy development, dredging or mooring projects that occur in the waters of the US, and offshore aquaculture are captured. Department of Defense activities regarding military bases and training are assessed in environmental impact statements (EISs) on a five year cycle and include assessments of potential conflict with fisheries; the EISs are available through the Federal Register. Due to the sheer volume of ocean activities and the annual frequency of this report, only major activities on multi-year planning cycles or those permitted by NMFS Sustainable Fisheries Division are tracked in this report.

The Council may comment on actions of any type that interact with fisheries and fishing communities. The Council may specifically provide conservation and enhancement recommendations (MSA §305(b)(3)) on activities that may adversely affect EFH in coordination with or independently from the NMFS PIRO Habitat Conservation Division.

2.7.1.3 Member of the Pacific Islands Regional Planning Body

EO 13547 (July 22, 2010), Stewardship of the Ocean, Our Coasts, and the Great Lakes, established the National Ocean Council and among other things, directed "the development of coastal and marine spatial plans that build upon and improve existing Federal, State, tribal, local, and regional decision-making and planning processes." The EO described the Pacific Islands (includes American Samoa, CNMI, Guam, and Hawaii) as one of nine regions where a regional planning body (RPB) would be established for development of a coastal and marine spatial (CMS) plan. The EO adopted the Final Recommendations of the Interagency Ocean Policy Task Force as the National Ocean Policy.

The Council is a member of the Pacific Islands (PI) RPB and as such, the interests of the Council will be incorporated into the CMS plan. It is through the Council member that the Council may submit recommendations to the PI RPB. Section 2.7.4 contains a summary of the PI RPB progress to date in developing CMS plan for the Pacific Islands region.

2.7.1.4 Organization of the Report

The annual report is organized by MMAs, activities, incidents that may contribute to cumulative impact, the RPB report, references, and finally a maps section.

2.7.2 Marine Managed Areas

2.7.2.1 MMAs established under FMPs

Council-established marine managed areas (MMAs) were compiled in Table 38 from 50 CFR § 665, Western Pacific Fisheries, the Federal Register, and Council amendment documents. Geodesic areas were calculated in square kilometers in ArcGIS 10.2. These marine managed areas are shown in the Spatial Management Areas Established under FMPs map in the maps section. Standing Council recommendations indicating review deadlines and follow up recommendations are copied below.

At its 147th meeting: ***Regarding fishing in the Rose Atoll Marine National Monument, the Council:***

1. Recommended a no-take area from 0-12 nautical miles around Rose Atoll with the Council to review the no-take regulations after three years.

At its 162nd meeting: ***Regarding a temporary exemption to the American Samoa Large Vessel Prohibited Area, the Council:***

1. Recommended a regulatory amendment for the temporary exemption to the LVPA by American Samoa longline limited entry permitted vessels greater than 50ft in length. The LVPA exempted area is defined as the area seaward of 12 nautical miles from Tutuila, Manua Islands, and Swains Island. The temporary exemption is authorized for an indeterminate period, but the Council will review the LVPA exemption on an annual basis with regards, but not limited to, the following topics:
    a. Catch rates of fishery participants
    b. Small vessel participation
    c. Fisheries development initiatives

At its 165th meeting: ***Regarding the American Samoa Large Vessel Prohibited Area, the Council:***

1. Requested NMFS PIFSC provides pelagic catch rates and other fishery statistics for the newly opened sections of the American Samoa Large Vessel Prohibited Area.

Table 38. MMAs established under FEPs from 50 CFR § 665.

Name	FEP	Island	50 CFR /FR /Amendment Reference	Marine Area (km^2)	Fishing Restriction	Goals	Most Recent Evaluation	Review Deadline
Pelagic Restrictions								
Large Vessel Prohibited Area	Pelagic (American Samoa)	Tutuila, Manu’a, and Rose Atoll	665.806 (b)(1) 81 FR 5619	74,857.32	Vessels ≥ 50 feet prohibited	Prevent gear conflict with smaller alia vessels; longline vessels >50 feet 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	Jan 29, 2017 (March meeting)

Name	FEP	Island	50 CFR /FR /Amendment Reference	Marine Area (km^2)	Fishing Restriction	Goals	Most Recent Evaluation	Review Deadline
Large Vessel Prohibited Area	Pelagic (American Samoa)	Swains Island	665.806 (b)(2) 81 FR 5619 Pelagic FEP	28,352.17	Vessels ≥ 50 feet prohibited	Prevent gear conflict with smaller alia vessels; longline vessels over 50 feet exempted between 12 and 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	Jan 29, 2017 (March meeting)
Other Restrictions								

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

2.7.2.2 Other MPAs in the Region

Marine Protected Area (MPA) data were downloaded from the NOAA Marine Protected Areas Center Data Inventory. Data are current through 2014.

The Excel MPA Inventory was filtered to retain only those records without GIS data for the following management agencies: American Samoa, Bureau of Ocean Energy Management, Marine National Monuments, National Estuarine Research Reserve System, National Marine Fisheries Service, National Park Service, or National Wildlife Refuge System.

MPAs within the 200 nautical mile limit around Hawaii, American Samoa, Guam, the CNMI, Wake Island, Johnston Atoll, Palmyra Atoll and Kingman Reef, Jarvis Island, and Howland and Baker Islands were selected from the MPA GIS inventory and their attributes were exported to a spreadsheet. Fields that matched the Excel inventory were retained.

Type, size, location, and fishery measures are summarized in Table 39. MPAs are shown in the overview maps found in the map section.

Table 39. Marine Protected Areas in the Western Pacific Region from the MPA Inventory unless otherwise noted

Site ID	**Name**	**State**	**Marine Area (km^2)**	**Fishing Restrictions**
NMS3	National Marine Sanctuary of American Samoa	National Marine Sanctuaries	35,373.70	Commercial and Recreational Fishing Restricted
MNM6	Rose Atoll Marine National Monument	Marine National Monuments	35,004.60	Commercial Fishing Prohibited, Recreational Fishing Restricted
NWR95	Rose Atoll National Wildlife Refuge	National Wildlife Refuge System	158.62	Commercial and Recreational Fishing Prohibited
NPS26	National Park of American Samoa	National Park Service	43.41	Commercial and Recreational Fishing Restricted
AS500	Nu'uuli Pala Special Management Area	American Samoa	2.08	Commercial and Recreational Fishing Restricted
AS501	Pago Pago Harbor Special Management Area	American Samoa	1.63	Commercial and Recreational Fishing Restricted
MP4	Lighthouse Reef Trochus Reserve	Mariana Islands	1.11	Commercial and Recreational Fishing Restricted
AS504	Vatia Village Marine Protected Area	American Samoa	0.63	Commercial Fishing Prohibited

Site ID	Name	State	Marine Area (km^2)	Fishing Restrictions
AS508	Fagamalo Village Marine Protected Area	American Samoa	0.45	Commercial Fishing Prohibited
AS1	Ofu Vaoto Marine Park	American Samoa	0.38	Commercial and Recreational Fishing Prohibited
AS11	Amaua & Auto Village Marine Protected Area	American Samoa	0.37	Commercial and Recreational Fishing Prohibited
AS506	Poloa Village Marine Protected Area	American Samoa	0.36	Commercial and Recreational Fishing Prohibited
AS505	Aua Village Marine Protected Area	American Samoa	0.35	Commercial Fishing Prohibited
AS512	Amanave Village Marine Protected Area	American Samoa	0.34	Commercial Fishing Prohibited, Recreational Fishing Restricted
AS507	Alofau Village Marine Protected Area	American Samoa	0.32	Commercial and Recreational Fishing Prohibited
AS509	Matu'u & Faganeanea Village Marine Protected Area	American Samoa	0.32	Commercial Fishing Prohibited
AS503	Masausi Village Marine Protected Area	American Samoa		Commercial Fishing Prohibited

Site ID	Name	State	Marine Area (km^2)	Fishing Restrictions
			0.20	
AS513	Alega Village Marine Protected Area	American Samoa	0.15	Commercial Fishing Prohibited
AS2	Leone Pala Special Management Area	American Samoa	0.09	Commercial and Recreational Fishing Restricted
AS511	Sa'ilele Village Marine Protected Area	American Samoa	0.08	Commercial Fishing Prohibited
AS510	Aoa Village Marine Protected Area	American Samoa	-	Commercial Fishing Prohibited
AS514	Fagasa No-take MPA	American Samoa	-	Commercial and Recreational Fishing Prohibited
AS515	Fagamalo No-take MPA	American Samoa	-	Commercial and Recreational Fishing Prohibited

2.7.3 **Activities and Facilities**

The following section includes activities or facilities associated with known uses and predicted future uses. The Plan Team will add to this section as new facilities are proposed and/or built.

2.7.3.1 Aquaculture facilities

There are no offshore aquaculture projects in Federal waters, proposed or existing, in American Samoa.

2.7.3.2 Alternative energy facilities

There are no alternative energy facilities in Federal waters, proposed or existing, in American Military training and testing activities and impacts.

2.7.3.3 Incidents Contributing to Cumulative Impact

The Coast Guard and NOAA Office of Response and Restoration responds to marine pollution events related to vessels. The following table of incidents since 2011is from selected oil spills off US coastal waters and other incidents where NOAA's Office of Response and Restoration (OR&R) provided scientific support for the spill response (NOAA OR&R). These incidents are included in the overview maps of the map section.

2.7.3.4 Interpretation

The algal bloom in Pago Pago Harbor, American Samoa, was not the first algal bloom. DMWR investigated the algal blooms and determined phosphate levels to be one of the causes (pers.comm., MPCCC, March 30, 2016).

There is also a vessel grounded in American Samoa that was not reported in the NOAA ORR dataset (pers. comm., MPCCC, March 30, 2016.)

Table 40. NOAA ORR Incident Response since 2011

Name	**Location**	**Date**	**Commodity**	**Cause**	**Other Cause/Notes**
Algal Bloom Pago Pago harbor	American Samoa	10/23/2013	Hazardous algal bloom	Other / Unknown	Reason for bloom unknown

2.7.4 Pacific Islands Regional Planning Body Report

The Pacific Islands Regional Planning Body (PI RPB) will meet on March 30-31, 2016, to discuss a number of items. The PI RPB will be brought up to date on the planning activities in American Samoa and then will discuss how much participation the PI RPB would like to have in the development of the American Samoa Ocean Plan, given cross membership. The PI RPB will discuss its operations in the bigger context of efforts associated with climate change, planning efforts, and GIS efforts, as well as discuss a capacity assessment to inform the needs of the PI RPB. PI RPB members will then discuss their data and tools needs, as well as their stakeholder engagement progress.

The American Samoa Ocean Planning Team is meeting on March 28, 29, and April 1, 2016, to finalize their vision for the ocean in American Samoa and develop draft goals and objectives for their ocean plan.

2.7.5 References

Emergency Response Division, Office of Response and Restoration, National Ocean Service, National Oceanic and Atmospheric Administration 2016. Raw Incident Data. Dataset. March 1, 2016. Downloaded from http://incidentnews.noaa.gov/raw/index.

"Fisheries in the Western Pacific." Title 50 *Code of Federal Regulations*, Pt. 665. Electronic Code of Federal Regulations data current as of March 16, 2016. Viewed at http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=b28abb7da3229173411daf43959fcbd1&n=50y13.0.1.1.2&r=PART&ty=HTML#_top.

"Fisheries Off West Coast States and in the Western Pacific; Coral Reef Ecosystems Fishery Management Plan for the Western Pacific, Final Rule." *Federal Register* 69 (24 February 2004): 8336-8349. Downloaded from http://www.wpcouncil.org/precious/Documents/FMP/Amendment5-FR-FinalRule.pdf.

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National Marine Protected Areas Center; National Oceanic and Atmospheric Administration 2014. Marine Protected Areas Inventory GIS Spatial Data. Dataset. January 15, 2016. Downloaded from http://marineprotectedareas.noaa.gov/dataanalysis/mpainventory/.

"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." *Federal Register* 81 (3 February 2016): 5619-5626. Downloaded from https://www.gpo.gov/fdsys/pkg/FR-2016-02-03/pdf/2016-01891.pdf.

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"Western Pacific Fisheries; Fishing in the Marianas Trench, Pacific Remote Islands, and Rose Atoll Marine National Monuments, Final Rule." *Federal Register* 78 (3 June 2013): 32996-33007. Downloaded from http://www.wpcouncil.org/precious/Documents/FMP/Amendment5-FR-FinalRule.pdf.

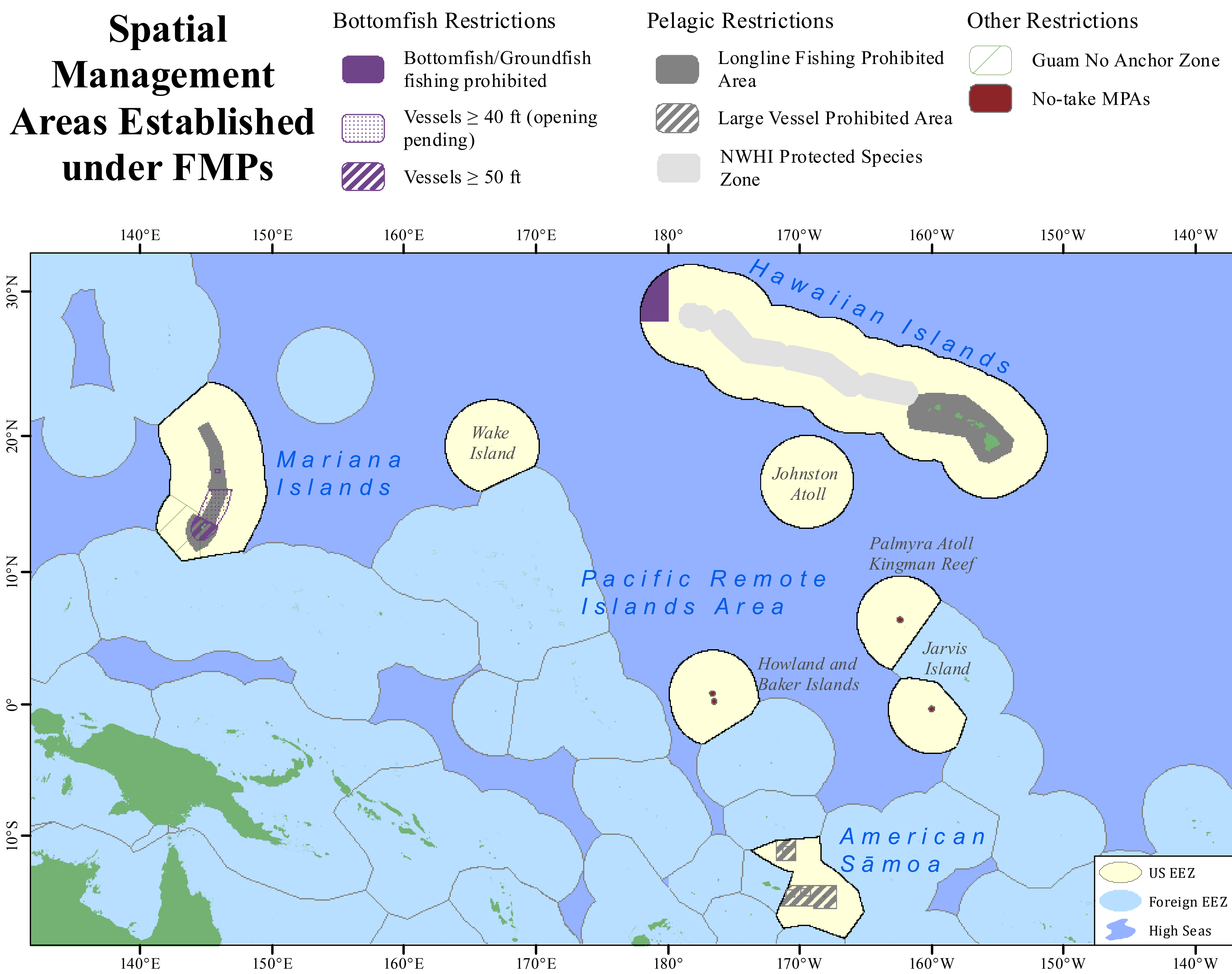
Western Pacific Regional Fishery Management Council. Fishery Management Plan and Fishery Ecosystem Plan Amendments available from http://www.wpcouncil.org/.

2.7.6 **Maps**

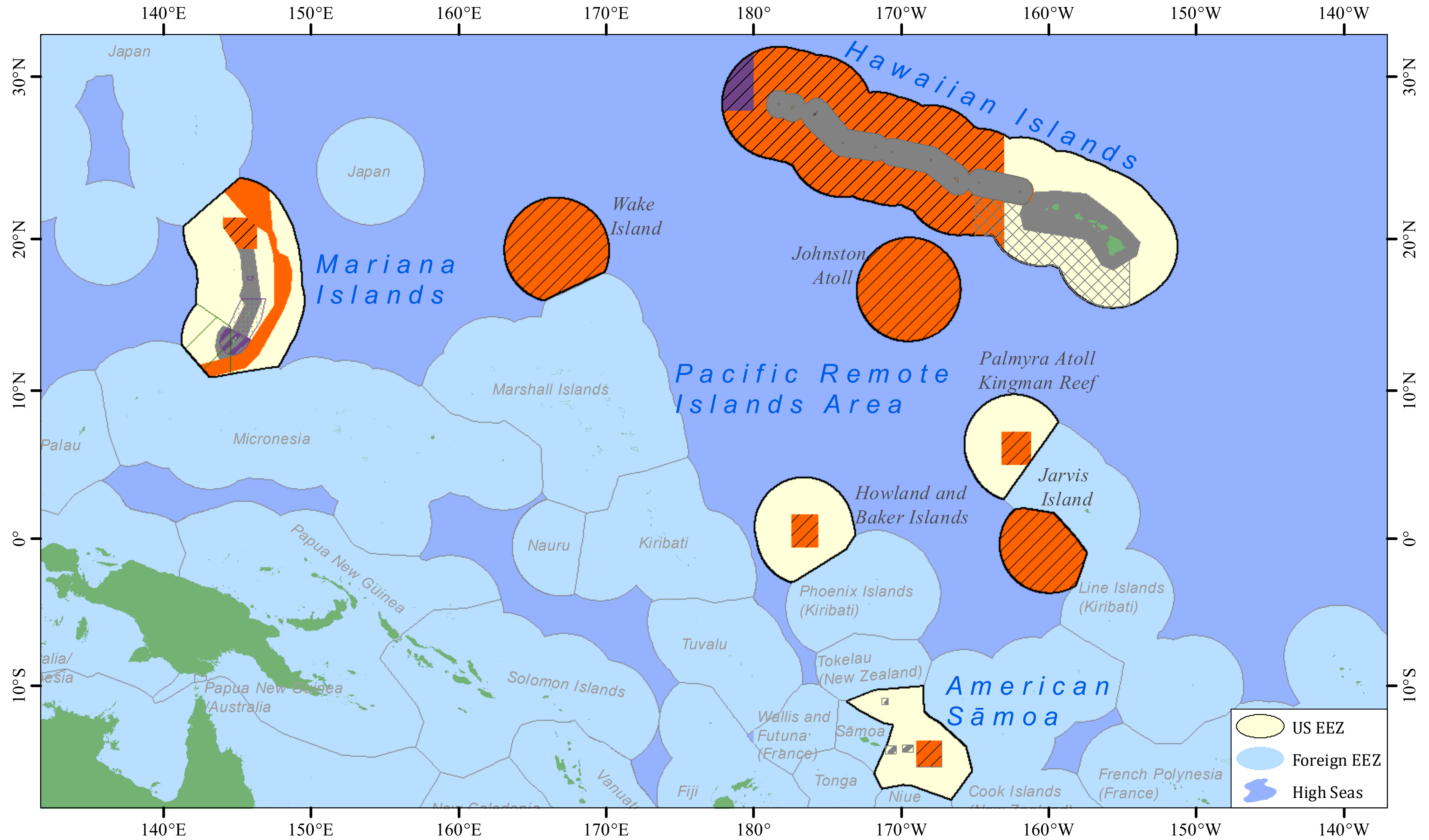
American Samoa Archipelago FEP

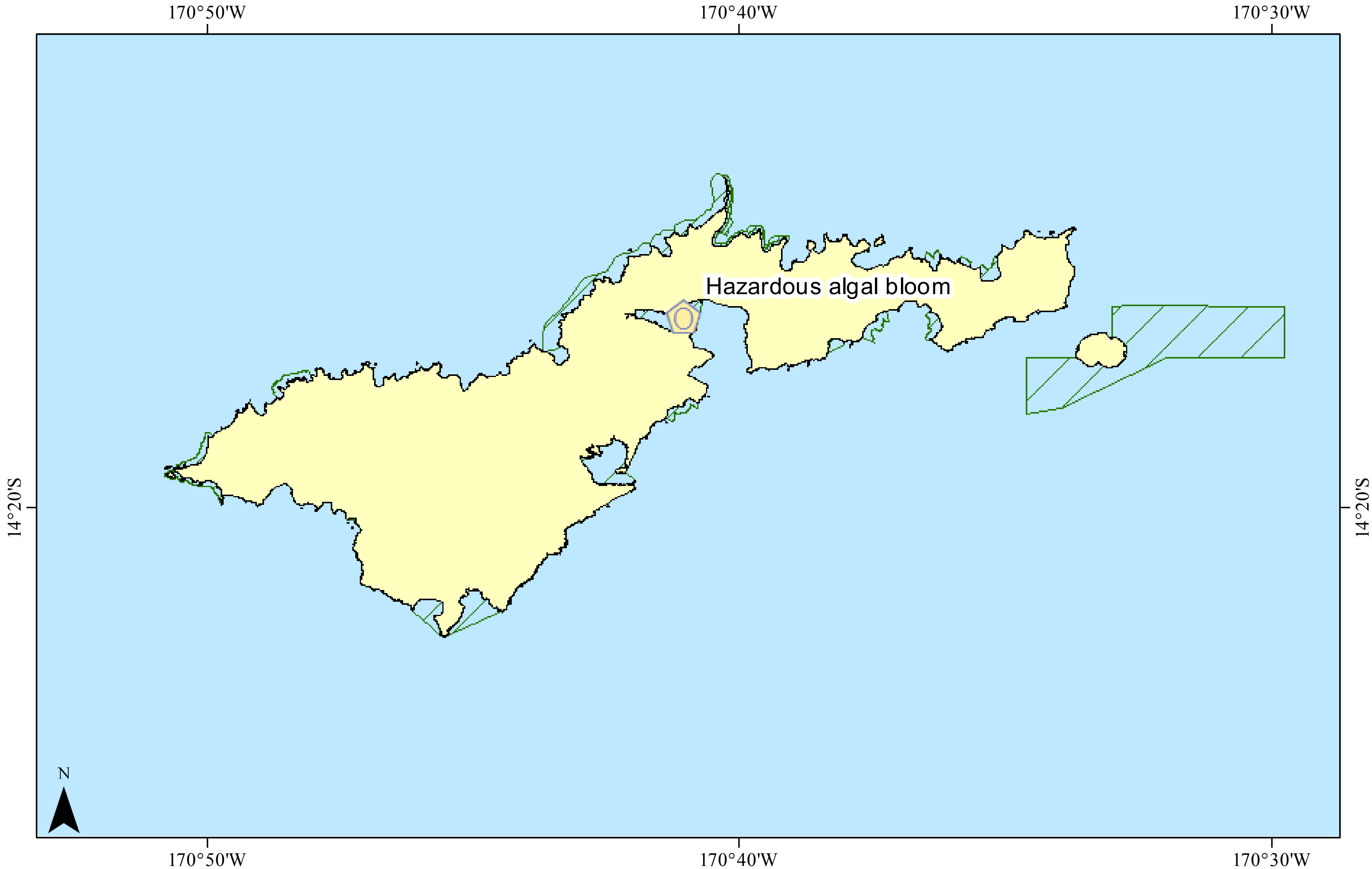
1. Spatial Management Areas Established under FMPs
2. Large, Regulated Commercial Fishing Areas of the Western Pacific Region
3. Tutuila, American Samoa Overview Map
4. Manu'a Group, American Samoa Overview Map

Spatial Management Areas Established under FMPs



Large, Regulated Commercial Fishing Areas of the US EEZ, Western Pacific Region





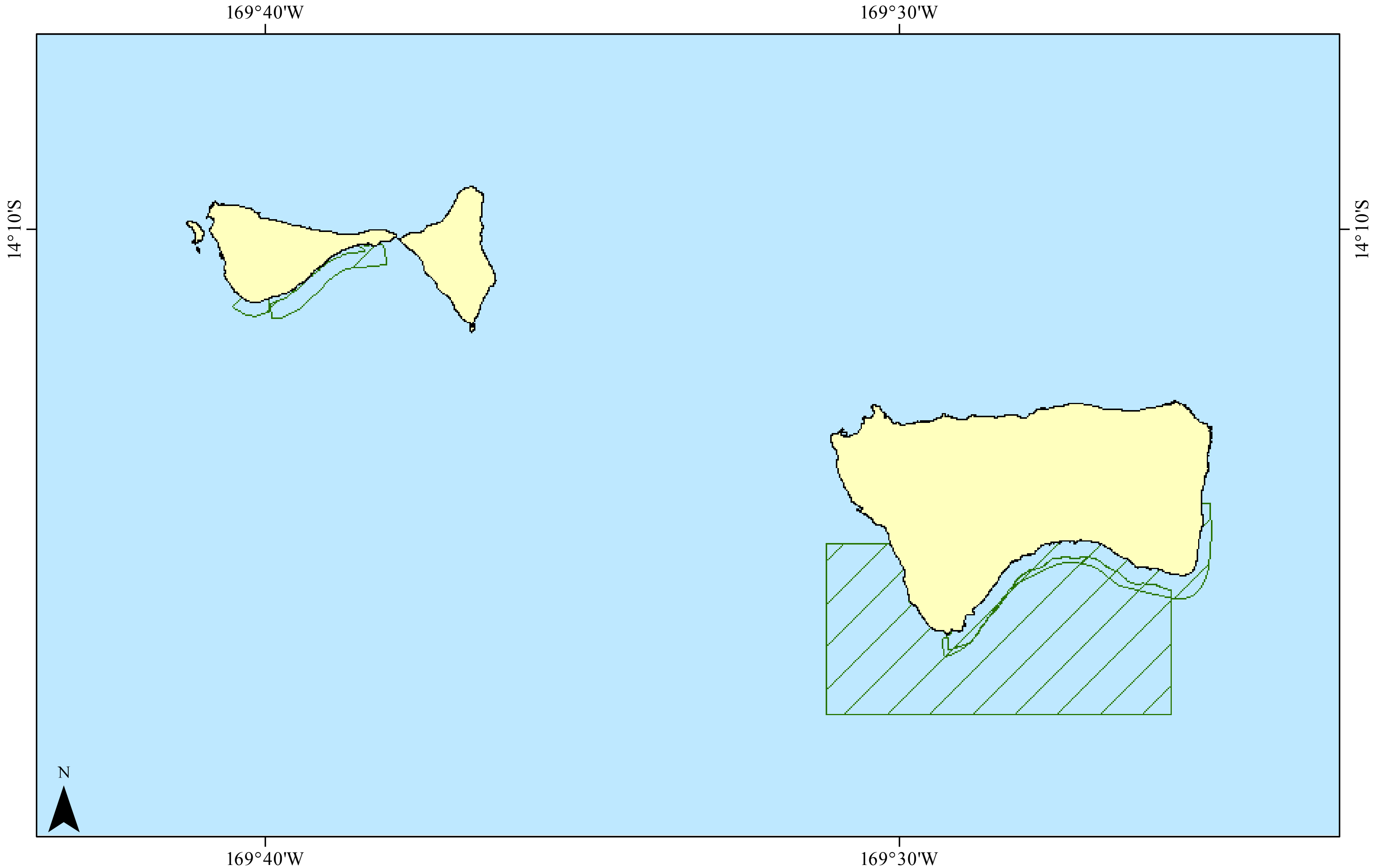
Marine Planning Annual Report

Overview Map

Tutuila, American Samoa

Marine Protected Area

Other / Unknown



Marine Planning Annual Report

Overview Map

Manu'a Group, American Samoa

Marine Protected Area

3 DATA INTEGRATION

This report will include a data integration chapter in subsequent years, as resources allow.

Attachment 1: Report to the Plan Team

Process Options for Designation of Habitat Areas of Particular Concern

April 11, 2016

Ala Moana Hotel

Background

In 2014 and 2015, the Western Pacific Regional Fishery Management Council (Council) underwent a five year review of its Fishery Ecosystem Plans (FEPs) and management process. Through this process, the Council, its staff, and stakeholders identified areas for change and update of its plans. Essential Fish Habitat (EFH) was an area identified for update and review. The EFH Final Rule[1] strongly encourages Councils to review the EFH information included in fishery management plans on a five year cycle[2]. This report considers the last component of EFH information identified in the EFH Final Rule: the EFH update and review procedure.

The Council recommended that new EFH information be reviewed, as necessary, during preparation of the annual reports by the Plan Teams. EFH designations may be changed under the FEP framework processes if information presented in an annual review indicates that modifications are justified[3]. Habitat Areas of Particular Concern (HAPC) are a subset of the EFH designations. The FEPs do not provide explicit direction in how the Council will designate HAPCs.

According to the EFH Final Rule, Councils may designate HAPCs based on one of the four following considerations:

(i) The importance of the **ecological function** provided by the habitat.
(ii) The extent to which the habitat is **sensitive** to human-induced environmental degradation.
(iii) Whether, and to what extent, development activities are, or will be, **stressing** the habitat type.
(iv) The **rarity** of the habitat type.[4]

While an HAPC designation process is not required, it may focus review efforts and increase consistency, transparency, and defensibility in the implementation of the EFH provisions of the Magnuson-Stevens Act in the Western Pacific Region. The 2015 Plan Team took up the question of how the Council should designate HAPC. They were presented with the following four process options:

1. Continue to address HAPC on a case-by-case basis as issues arise.
2. Consider clarifying the Coral Reef HAPC language only, which suggests designation of previously existing MPAs as HAPC.

[1] 67 FR 2376, Jan. 17, 2002
[2] 50 CFR §600.815(a)(10)
[3] Please see Chapter 6 of any FEP developed by the Western Pacific Fishery Management Council.
[4] 50 C.F.R. 600.815(a)(7)

3. Modify and adopt the process used in the Hawaiian Archipelago bottomfish EFH review.
4. Create a new process through which HAPC candidates areas can be identified and filtered.

The Plan Team formed a working group to explore the options for this process, which was performed through two webinars facilitated by Council staff. The members of the working group were Samuel Kahng (Hawai`i), Brent Tibbats (Guam), Mike Tenorio (CNMI), Mareike Sudek/Domingo Ochavillo (American Samoa), with support from Danielle Jayewardene, Mathew Dunlap, and Michael Parke (NMFS). The findings are reported below.

Working Group Sessions

On the first call on September 2, 2015, working group participants heard a background on the Western Pacific's EFH and HAPC designations, and reviewed the HAPC designation processes used by other Councils. Participants reviewed the options presented to the 2015 Plan Team, discussed if any options should be added, and selected options to address in further detail on the next call. The following three options were chosen for further development:

- No Action, i.e. address HAPC on a case-by-case basis
- Adopting the Hawaiian Archipelago bottomfish EFH review model
- Creating a New Process

The second option, modifying the coral reef language, was rejected from further development. Language in the FEPs is not prescriptive of how coral reef HAPCs will be designated in the future, and therefore does not speak to the HAPC designation process. Concerns were expressed that designating HAPCs based on existing protective status can create overly broad HAPC designations and does not necessarily effectively meet the intent of HAPC designation as per the EFH final rule. Additionally, the Council at its 163rd meeting directed staff to further explore and provide the Council with details in improving the ACL specification process through an omnibus amendment of the Fishery Ecosystem Plans to include, among other item, reclassification of appropriate management unit species into ecosystem components. As EFH does not need to be designated for species listed as ecosystem components, it would be most effective to address coral reef EFH once the ecosystem component species amendment is further developed.

Participants on the first call identified that a successful HAPC designation process would:

- be realistically implementable;
- effectively use the expertise in the region;
- be compatible with jurisdictional management;
- encourage the development of usable HAPC candidate area proposals; and
- occur within a reasonable amount of time.

Based on the first call, Council staff split the HAPC designation process into five separate components: the HAPC designation proposal development phase, the HAPC designation proposal review phase, development of a policy on weighting of HAPC considerations, standardizing the interpretation of the HAPC considerations, and timing for the HAPC designation process (Figure 4). A new process would involve some or all of these components; the bottomfish model for example included all components.

During a second call on November 23, 2015 , participants discussed the pros and cons of options for each of five components to evaluate each HAPC designation process.

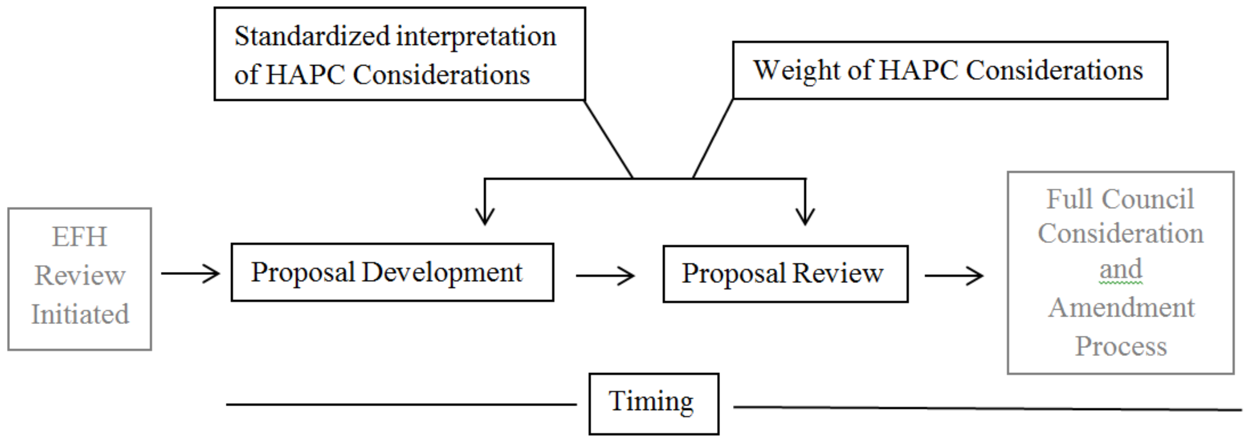


Figure 1. HAPC process components evaluated by the working group. The Council process is included for context.

Evaluation of HAPC Process Components

1. *Proposal Development Options*

During the proposal development phase**,** the participants agreed that it is key to identify a party who has the responsibility, dedication, expertise, and manpower to accomplish the task of submitting HAPC proposals. An option would be to develop and award service contracts, including for a graduate student, to develop proposals. Contractors would be dedicated to the effort, however acquiring funding for EFH review focused work is an ongoing challenge also requires management of the contract. Additionally, stakeholder involvement can be challenging when proposals are developed by contractors outside the Council process. A second option discussed was for fishermen, who are a key stakeholder group with specialized knowledge of habitat, to develop proposals. However, fisherman constitute only one stakeholder group so may not provide a broad enough perspective. The third option for proposal developers could be the general public.as they would give access to more experts and have increased stakeholder involvement. However according to the experience of other Councils, this approach presents a real risk of an unmanageable number of HAPC proposals being developed that may be irrelevant or incongruent with the Council's management objectives[5]. A fourth option was to have the Council's plan team develop proposals as they have the responsibility for the EFH review already in place. The concern with this approach is that plan team membership may change, and there may not be enough time dedicated in the process to develop supporting rationale for candidate areas. Finally, other Council bodies had the same pros and cons with the exception that the Plan Team is specifically responsible for the EFH review.

Finding

Plan Team members or their staff, and/or contractors seem the most reasonable entities to develop HAPC proposals, i.e. identify candidate HAPC areas for the Council's consideration in

[5] Habitat Working Group of the Council Coordinating Committee , Group Discussion, October 3, 2014

updating FEPs. Use of contractors allows flexibility when additional funding opportunities are available. When candidate HAPCs areas are identified outside the Council process, which would be the case with a contractor, the contract must be carefully managed to ensure the proposal addressed Council priorities and objectives and stakeholders are involved.

2. *Proposal Review Options*

In the proposal review phase, participants discussed the importance for the Pacific Island Fisheries Science Center (PIFSC) stock assessment authors to weigh in on the review of proposals for their stocks. Time management was the leading concern for Council staff and Advisory Panel review of the proposals. In the North Pacific region, Council staff review HAPC proposals to ensure consistency with Council priorities.[6] Advisory Panel review, however, would increase stakeholder participation in the HAPC designation process in the fishing community. This was considered an essential lesson learned from the Hawaiian Archipelago bottomfish EFH review. The Scientific and Statistical Committee (SSC) was recognized as the responsible body for review of all scientific information, and therefore HAPC proposals. The SSC is familiar with the fisheries, giving it an advantage over Center for Independent Expert (CIE) reviews. CIE reviews are managed at PIFSC.

Western Pacific Stock Assessment Review (WPSAR) is an existing peer review procedure for the scientific information that may be used as a basis for federal fisheries management in the region. A WPSAR review would occur as supplemental to the SSC's review, but may slow down the process. The WPSAR Coordinating Committee anticipates what WPSAR reviews may be needed for the region and advises the Steering Committee. The Steering Committee prioritizes and schedules regional science products for review based on its potential influence, available resources, and other factors as appropriate. Due to the implications stock assessments have on setting Annual Catch Limits, the assessments usually get higher priority than other scientific information like EFH or HAPC reviews. An HAPC proposal may be considered by the Steering Committee for the WPSAR schedule through two avenues: recommendation of the Coordinating Committee, or recommendation of the SSC.

Overall, interim checkpoints and the review methodology are important to ensure enough stakeholder involvement without prolonging the process. More levels of review mitigates the risk of rejection by various stakeholders, which may prolong the timeline of the review substantially.

Finding

Flexibility in the process is again important, so that as many reviewers may be exposed to the draft HAPC proposal without unnecessarily prolonging the process. Because the level of review is anticipated to be different for different managed fisheries, a concurrent initial review by Council staff, the PIRO regional EFH Coordinator, and Plan Team Habitat team members as well as the relevant PIFSC stock assessment authors will help to focus further review of the HAPC proposals through the Council process. These desktop reviewers will review the draft for scientific quality and consistency with Council objectives. The reviewers may make recommendations for additional stakeholder meetings if necessary. Comments should be

[6] HAPC Process Document, North Pacific Fishery Management Council and National Marine Fisheries Service, Alaska Region. September 2010.

provided within 45 days to prevent delays in the review process. A flow chart depicting how the review process is integrated with the Council process is shown in Figure 5.

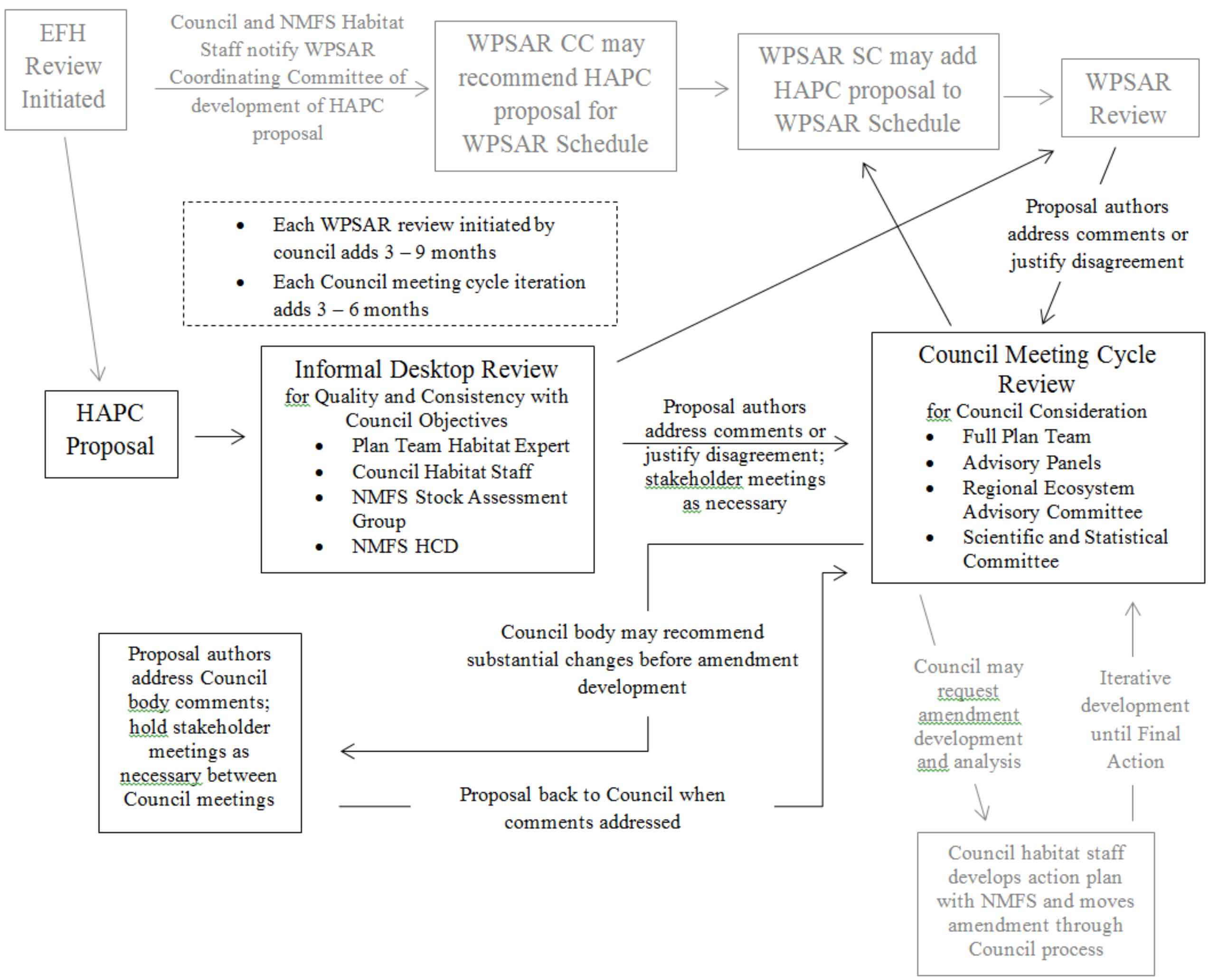


Figure 2. Integration of HAPC Proposal Review with the Council process. HAPC-specific phases are in black while established Council processes are in gray.

3. Weighting of HAPC Considerations

The working group discussed the weighting of considerations. In the WPSAR review of the bottomfish candidate areas, the panel determined that all candidate HAPCs must be ecologically important and meet one additional consideration in order to become an HAPC. The working group recognized that if the weighting is left up to the proposal writers or reviewers, the result could be subjective. Without any consideration of weighting, there are fewer restrictions on the proposal process and less quality control built into the process. However, the working group did not feel that recommending particular weights for the considerations was appropriate at this time, as some of the concerns with having no weighting for the considerations could be alleviated through developing terms of reference for candidate HAPC proposals.

4. Interpretation of Considerations

Further interpreting the considerations for the region had similar pros and cons as weighting the considerations. Interpreting them for the region may result in a more objective process, but runs the danger of producing overly restrictive proposals. Other Councils have interpreted the HAPC considerations further than in the EFH Final Rule, such as the North Pacific. This may be more appropriate in other regions that do authorize fishing gears with substantial adverse effects on EFH, where HAPC has been associated with gear closures. However, the Western Pacific Council does not authorize these gear types.

The working group did discuss the interpretation of the third consideration: "Whether, and to what extent, development activities are, or will be, stressing the habitat type." Participants agreed that local or regional actions/ threats should be given more consideration than global threats when the stressor/s associated with the global threats are not identifiable at a habitat and/or site specific scale.

Findings

The primary purpose of further interpreting and weighting the HAPC considerations is to increase the quality and refine the HAPC candidate areas received in a proposal. Terms of reference for the development of HAPC proposals could address these goals, while involving members of other Council bodies that are more appropriate for policy, not FEP, development.

Proposed HAPC Process and Recommendations

The working group recommends to the Plan Team that Council staff develop an HAPC policy from the working group discussions. The policy should include terms of reference for proposals from the HAPC guidance documents, working group discussions, and additional input from other relevant sources including Council bodies. If contractors are used to identify candidate areas, a term of the contract must be to gather information from the Council's advisory bodies and NMFS before submitting a final proposal for review to the Plan Team, Scientific and Statistical Committee, Advisory Panels, and Council. In addition to the regular Council process and WPSAR process, the HAPC process will include an initial desktop review of the HAPC proposal by Council habitat staff and Plan Team member, stock assessment scientists from the PIFSC Stock Assessment group, and NMFS Habitat Conservation Division. Producing a policy, instead of amending the FEPs with an HAPC update procedure, will facilitate flexibility in the process by not requiring a new amendment for revision of the process.

ATTACHMENT 2: DRAFT Precious Corals Species Descriptions Update

1 PRECIOUS CORALS SPECIES

1.1 General Distribution of Precious Corals

This document is an update of the 2015 "Essential Fish Habitat Source Document for Western Pacific Archipelagic, Remote Island Areas, and Pelagic Fishery Ecosystem Plan Management Unit Species" for precious corals. Important new references and data points have been added to the original documentation. Many older observations continue to be cited because no newer studies have been completed, with a few notable exceptions. While the original sources are still relevant, new research has revealed important distribution, life history, growth rate, age, and abundance information that is relevant to precious coral management. Some progress has also been made toward clarifying some of the vexing taxonomic challenges presented by these organisms. First, the name of the most important species of gold coral, *Gerardia* sp., has been updated to *Kulamanamana haumeaae* by Sinniger, *et al.* (2013). Second, two of the most important species in the family Coralliidae, *Corallium secundum* (pink coral) and *Corallium regale* (red coral) have been placed into separate genera, the latter also becoming a different species (Figueroa & Baco, 2014). Their new names are now *Pleurocorallium secundum* and *Hemicorallium laauense*, respectively. Third, two changes have taken place in the black corals. *Antipathes dichotoma* is now *Antipathes griggi* and *Antipathes ulex* has been moved to a different genus and is now *Myriopathes ulex* (Opresko, 2009). These changes are shown in Table 1.

Most research related to precious corals has been limited to the Hawaiian archipelago, and the majority of the more recent efforts have been directed at taxonomy or simply documenting species distributions, with a few works on growth and life history (*Parrish et al.*, 2015). However, significant new insights have been gained into the genetics (Baco and Cairns, 2012; Sinniger, *et al*., 2013; Figueroa and Baco, 2014), reproductive biology (Waller and Baco, 2007; Wagner, *et al.*, 2011; Wagner *et al.*, 2012; Wagner *et al.*, 2015), growth and age (Parrish and Roark 2009; Roark *et al.*, 2009), and community structure (Kahng *et al*., 2010; Long and Baco, 2014; Parrish, 2015; Wagner, *et al*., 2015) of precious coral and black coral species.

The U.S. Pacific Islands Region under jurisdiction of the Western Pacific Regional Fisheries Management Council consists of more than 50 oceanic islands, including the Hawaiian and Marianas archipelagos, American Samoa, Johnston, Wake, Palmyra, Kingman, Jarvis, Baker and Howland, and numerous seamounts in proximity to each of these groups. These islands fall under a variety of political jurisdictions, and include the State of Hawaii, the Commonwealth of the Northern Mariana Islands (CNMI), and the territories of Guam and American Samoa, as well as nine sovereign Federal territories—Midway Atoll, Johnston Atoll, Kingman Reef, Palmyra Atoll, Jarvis Island, Howland Island, Baker Island, Rose Atoll, and Wake Island. Precious corals (with currently accepted species names) are known to exist in American Samoa, Guam, Hawaii and the Northern Mariana Islands, as well as throughout the other US islands in the Pacific (Tables 1 and 2), but the only detailed assessments of precious corals have been in Hawaii (Parrish and Baco, 2007, Parrish *et al*., 2015; Wagner, *et al*., 2015). Over the last 10 years, we have begun to better understand the distribution and abundance of these corals, but many areas remain unexplored, and conditions which lead to their settlement, growth and distribution are still uncertain. Modelling efforts have provided some insight into the global distribution and habitat requirements of deep-water corals (Rogers *et al.*, 2007; Tittensor *et al.*, 2009, Clark *et al.*, 2011, Yesson *et al.*, 2012, Schlacher *et al.,* 2013), but have provided little certainty regarding localized distribution or the specific conditions required for growth of precious corals. Antipatharians, commonly known as black corals, have been exploited for years, but are still among the taxonomic groups containing precious corals that have been inadequately surveyed, as evidenced by the high rates of species discoveries from deep-water surveys around the Hawaiian Islands (Opresko 2003b; Opresko 2005a; Baco 2007; Parrish & Baco 2007; Parrish *et al.*, 2015; Roark, 2009; Wagner *et al.*, 2011, 2015; Wagner, 2011, 2013). Despite this ongoing research, only a few places are known to have dense agglomerations of precious corals. A summary of the known distribution and abundance of precious corals in the central and western Pacific Islands region follows.

Table 1: Precious corals covered under the FMP

Species	Common name
Pleurocorallium secundum (prev. *Corallium secundum*)	Pink coral
Hemicorallium laauense (prev. *C. regale*)	Red coral
Kulamanamana haumeaae (prev. *Gerardia* sp.)	Gold coral
Narella sp.	Gold coral
Calyptrophora sp.	Gold coral
Callogorgia gilberti	Gold coral
Lepidisis olapa	Bamboo coral
Acanella sp.	Bamboo coral
Antipathes griggi (prev. *A. dichotoma)*	Black coral
Antipathes grandis	Black coral
*Myriopathes ulex (*prev. *Antipathes ulex*)	Black coral

<u>American Samoa</u>

There is little information available for the deepwater species of precious corals in American

Samoa. Much of the information available comes from the personal accounts of fishermen. In the South Pacific there are no known commercial beds of pink coral (Carleton and Philipson 1987). Survey work begun in 1975 by the Committee for Co-ordination of Joint Prospecting for Mineral Resources in South Pacific Offshore Areas (CCOP/SOPAC) identified three areas of *Corralium* off Western Samoa: off eastern Upolu, off Falealupo and at Tupuola Bank (Carleton and Philipson 1987). Pink coral has been reported off Cape Taputapu, but no information concerning the quality or quantity of these corals or the depths where they occur is available. Unidentified precious corals have also been reported in the past off Fanuatapu at depths of around 90 m. Precious corals are known to occur at an uncharted seamount, about three-fourths of a mile off the northwest tip of Falealupo Bank at depths of around 300 m.

Commercial quantities of one or more species of black coral are known to exist at depths of 40 m and deeper. However, these are found in the territorial waters of American Samoa and, therefore, are not subject to the Council’s authority. Wagner (personal communication, 2015) has tentatively identified as many as 12 species (not previously catalogued in Am. Samoa) of black corals in depths between 50m and 90m, with 6 of these potential new species exhibiting growth forms that could lead to harvestable sizes. However, Wagner did not see find any locations with the types of densities and sizes that would support any commercial harvest of these corals.

Guam and the Commonwealth of the Northern Marianas

There are no known commercial quantities of precious corals in the Northern Mariana Islands archipelago (Grigg and Eldredge 1975). In the past, Japanese fishermen claimed to have taken some *Corralium* north of Pagan Island and off Rota and Saipan. Surveys are planned for the Marianas Islands in 2016 that may provide more information regarding abundance and distribution of certain precious corals found in waters deeper than 250 m.

U.S. Pacific Island Remote Areas

There are no known commercial quantities of precious corals in the remote Pacific Island areas, though individual colonies of precious corals have been seen at Jarvis, Palmyra, Kingman (Parrish and Baco, 2007) and Johnston Atoll, and planned surveys in 2017 may provide more information about abundance and distribution of precious corals found in waters deeper than 250 meters in these areas.

Hawaii

In the Hawaiian Archipelago there are seven legally-defined beds of pink, gold and bamboo corals, which are shown in Table 2. It is difficult to determine from the publication record exactly why these particular areas were singled out for legal recognition, other than the fact that they contain some unspecified densities of precious corals within their geographic boundaries. In the MHI, the Makapuu bed is located off Makapuu, Oahu, at depths of between 250 and 575 meters. Discovered in 1966, it the precious coral bed that has been most extensively surveyed in the Hawaiian chain. Its total area is about 4.5 km^2. Its substrate consists largely of hard limestone (Grigg, 1988). Careful examination during numerous dives with a submersible has determined that about 20% of the total area of the Makapuu bed is comprised of irregular lenses of thin sand, sediments and barren patches (WPRFMC, 1979). These sediment deposits are found primarily in low lying areas and depressions (Grigg, 1988). Thus, the total area used for extrapolating coral density is 3.6 km^2, or 80% of 4.5 km^2 (WPRFMC, 1979).

Precious coral beds have also been found in the deep inter-island channels such as Auau, Alalakeiki, and Kolohi channels off of Maui, around the edges of Penguin Banks, off promontories such as Keahole Point, on older lava flows south from Keahole to Ka Lae, and off of Hilo Harbor, and off of Cape Kumukahi on the Big Island of Hawaii (Oishi, 1990; Grigg, 2001, 2002). On Oahu, there is a bed off Kaena Point, and multiple precious coral observations have been made from offshore Barber's Point extending to offshore Pearl Harbor, Oahu. On Kauai, a bed of black corals has been identified offshore of Poipu (WPRFMC, 1979).

A dense bed has been located on the summit of Cross Seamount, southwest of the island of Hawaii. This bed covers a pinnacle feature on the top of the summit, but does not contain numbers of corals large enough to sustain commercial harvests (Kelley, pers. comm., 2015).

Table 2: Location of legally-defined precious coral beds. Source: WPRFMC 1979

Area Name	Description
Makapu'u (Oahu)	includes the area within a radius of 2.0 nm of a point at 21°18.0′ N. lat., 157°32.5′ W. long.
Auau Channel, Maui	includes the area west and south of a point at 21°10′ N. lat., 156°40′ W. long., and east of a point at 21° N. lat., 157° W. long., and west and north of a point at 20°45′ N. lat., 156°40′ W. long.
Keahole Point, Hawaii	includes the area within a radius of 0.5 nm of a point at 19°46.0′ N. lat., 156°06.0′ W. long.
Kaena Point, Oahu	includes the area within a radius of 0.5 nm of a point at 21°35.4′ N. lat., 158°22.9′ W. long.
Brooks Banks	includes the area within a radius of 2.0 nm of a point at 24°06.0′ N. lat., 166°48.0′ W. long.
180 Fathom Bank, north of Kure Island	N.W. of Kure Atoll, includes the area within a radius of 2.0 nm of a point at 28°50.2′ N. lat., 178°53.4′ W. long.
WesPac Bed, between Nihoa and Necker Islands	includes the area within a radius of 2.0 nm of a point at 23°18′ N. lat., 162°35′ W. long. *

* This area falls within the boundaries of the Papahanaumokuakea National Marine so

precious corals here are no longer subject to harvest or removal.
In the NWHI, a small bed of deepwater precious corals have been found on WestPac bed, between Nihoa and Necker Islands and east of French Frigate Shoals. This bed is not large enough to sustain commercial harvests. Precious coral beds have also been discovered at Brooks Banks, Pioneer Bank, Bank 8, Seamount 11, Laysan, and French Frigate shoals (Parrish and Baco, 2007; Parrish *et al*., 2015). ROV surveys conducted throughout the NWHI by the Okeanos Explorer during 2015 discovered multiple places that had dense colonies of deep-sea corals. Few of these colonies were precious corals, but these dives were mostly conducted in waters deeper than normal distributions of precious corals (>1500 meters). However, large areas of potential habitat exist in the NWHI on seamounts and banks near 400 m depth. Based on the abundance of potential habitat, it is thought that stocks of precious corals may be more abundant in the northwestern end of the island chain. All precious coral stocks within the boundaries of the Paphanaumokuakea National Marine Monument are protected from harvest, and most habitat suitable for precious corals growth falls within the boundaries of the monument.

Precious corals have also been discovered at the 180 Fathom Bank, north of Kure Island. The extent of this bed is not known. Precious corals have been observed during submersible and ROV dives throughout the Northwestern Hawaiian Islands, and in EEZ waters surrounding Johnston, Jarvis, Palmyra, and Kingman atolls, but little can be definitively said about the overall distribution and abundance of precious corals in the central Pacific region.

In addition to these legally defined areas of precious corals, many other sites have been discovered that sustain populations of precious corals (Parrish and Baco, 2007; Parrish *et al*., 2015; Wagner *et al*., 2015). The map below (Figure 1) provides a color-coded illustration of some of these 8600 observations (Kelley and Drysdale, 2012, *unpublished data*). Given the number of observations and the wide distribution of precious corals in the main Hawaiian Islands, it is almost certain that undiscovered beds of precious corals exist in the EEZ waters of the region managed by the WPRFMC. Whether these beds would contain organisms at sufficient densities and size distributions to support commercial harvests is yet to be determined.

1.2 Systematics of the Deepwater Coral Species

Published records of deep corals from the Hawaiian Archipelago include more than 137 species of gorgonian octocorals and 63 species of azooxanthellate scleractinians (Parrish and Baco, 2007). A total of 6 new genera and 20 new species of octocorals, antipatharians, and zoanthids have been discovered in Hawaii since the 2007 report (Parrish *et al.*, 2015). These are either new to science, or new records for the Hawaiian Archipelago (Cairns & Bayer 2008, Cairns 2009, Opresko 2009, Cairns 2010, Wagner *et al.*, 2011a, Opresko *et al.*, 2012, Sinniger *et al.*, 2013). Taxonomic revisions currently underway for several groups of corals, e.g., isidids, coralliids, plexaurids and paragorgiids, are also likely to yield additional species new to science and new records for Hawaii (Parrish *et al.*, 2015). Only a handful of these deep coral species are considered economically *precious* and have any history of exploitation.

Recent molecular phylogenetic and morphologic studies of the family Coralliidae, including Hawaiian precious corals, have illuminated taxonomic relationships. These studies synonymized

Paracorallium into the genus Corallium, and resurrected the genera Hemicorallium (Ardila *et al*., 2012; Figueroa & Baco, 2014; Tu *et al*., 2015) and Pleurocorallium (Figueroa & Baco, 2014; Tu *et al*.,2015) for several species, including several species in the precious coral trade. A molecular and morphological analysis of octocoral-associated zoanthids collected from the deep slopes in the Hawaiian Archipelago revealed the presence of at least five different genera including the gold coral (Sinniger *et al*.,2013). This study describes the five new genera and species and proposes a new genus and species for the Hawaiian gold coral, *Kulamanamana haumeaae*, an historically important species harvested for the jewelry trade and the only Hawaiian zoanthid that appears to create its own skeleton.

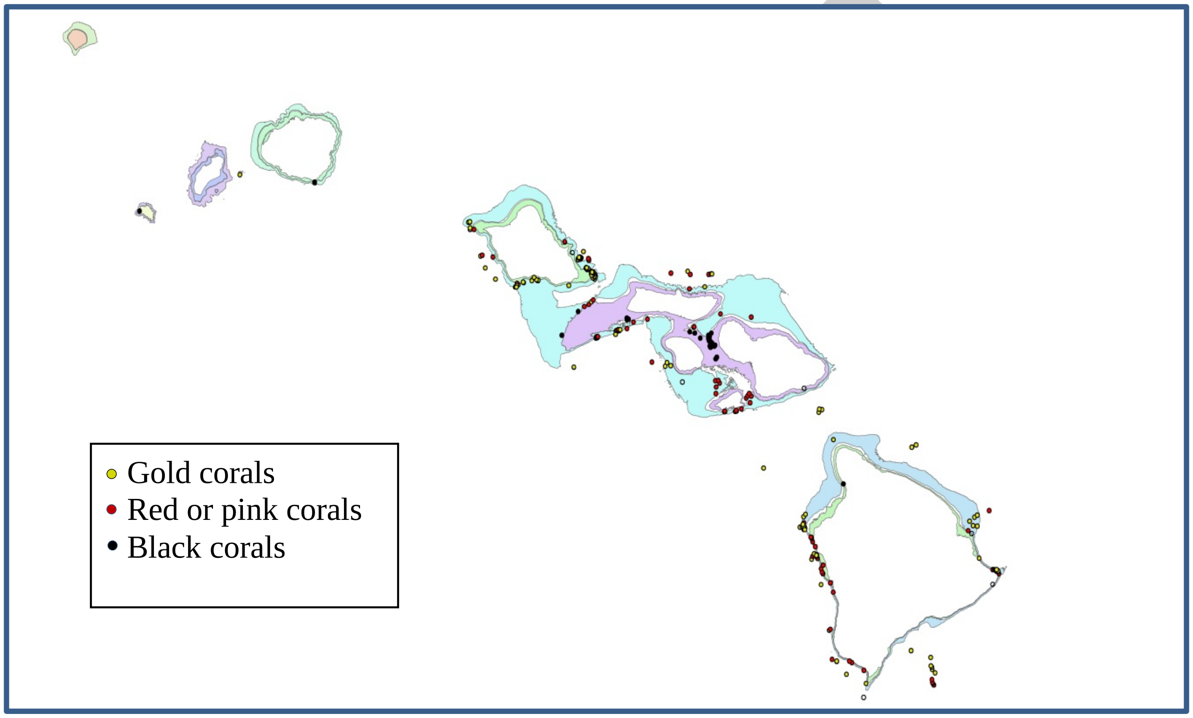


Figure 1. Observations of precious corals in the main Hawaiian Islands

Precious corals are found principally in three orders of the class Anthozoa: Gorgonacea, Antipatharia, and Zoanthiae (Grigg, 1984). In the western Pacific region, pink coral (*Pleurocorallium secundum*), red coral (*Hemicorallium laauense*), gold coral (*Kulamanamana haumeaae*), black coral (*Antipathes* sp.) and bamboo coral (*Lepidisis olapa*) are the primary species/genera of commercial importance. Of these, the most valuable precious corals are species of the genera *Pleurorallium* and *Hemicorallium*, the pink and red corals (Grigg, 1984). Pink coral (*P. secundum*) and Midway deep-sea coral (*Corallium* sp. nov,) are two of the principal species of commercial importance in the Hawaiian and Emperor Seamount chain (Grigg, 1984). *P. secundum*, is found in the Hawaiian archipelago from Milwaukee Banks in the Emperor Seamounts (36°N) to the Island of Hawaii (18°N); *Corallium* sp. nov. is found between 28°–36°N, from Midway to the Emperor Seamounts (Grigg, 1984). In addition to the pink corals, the bamboo corals, *Lepidistis olapa* and *Acanella* sp., are commercially important precious corals in the western Pacific region (Grigg, 1984). Pink coral and bamboo coral are found in the order

Gorgonacea in the subclass Octocorallia of the class Anthozoa, in the Phylum Coelenterata (Grigg, 1984).

The final two major groups of commercially important precious corals, gold coral and black coral, are found in separate orders, Zoanthidea and Antipatharia, in the subclass Hexacorallia, in the class Anthozoa and the phylum Coelenterata. The gold coral, *Kulamanamana haumeaae* (prev. *Gerardia* sp.) (Sinneger, *et.al.*, 2013), is endemic to the Hawaiian and Emperor Seamount chain (Grigg 1984). It inhabits depths ranging from 300–400 m (Grigg 1974, 1984). In Hawaii, gold coral, *Kulamanamana haumeaae,* grows mostly on bamboo hosts (e.g. *Acanella, Keratoisis*) as a parasitic overgrowth (Brown, 1976; Grigg, 1984; Parrish, 2015). Gold coral is, therefore, only found growing in areas that were previously inhabited by colonies of *Acanella* (Grigg, 1993) and possibly other bamboo corals (Parrish, 2015). Despite its ecological significance and long history of exploitation, the Hawaiian gold coral has never been subject to taxonomic studies or a formal species description. As a result of this, the nomenclature concerning the Hawaiian gold coral has been relatively confused. Symptomatic of the order, a suite of other zoanthids, besides the Hawaiian gold coral, have been observed and collected in Hawaii, but far less is known of their biology and ecology and they have not been described taxonomically.(Sinnegar *et al.,* 2013).

Grigg (1984) classified black corals in the order *Antipatharia*, and identified fourteen genera of black corals reported from the Hawaii-Pacific region with species found in both shallow and deep habitats Grigg, 1965). Wagner (2015) noted that there are over 235 known species of black coral that occur in the oceans of the world, and of this total, only about 10 species are of commercial importance (Grigg, 1984). Wagner (2011) confirmed 8 species of black corals in Hawaii, including (1) *Antipathes griggi* Opresko, 2009, (2) *Antipathes grandis* Verrill, 1928, (3) *Stichopathes echinulata* Brook, 1889, (4) an undescribed *Stichopathes* sp., (5) *Cirrhipathes* cf. *anguina* Dana, 1846, (6) *Aphanipathes verticillata* Brook, 1889, (7) *Acanthopathes undulata* (Van Pesch, 1914), and (8) *Myriopathes* cf. *ulex* Ellis & Solander, 1786. A new name for the Hawaiian species of antipatharian coral previously identified as *Antipathes dichotoma* (Grigg and Opresko, 1977) is described as *Antipathes griggi* (Opresko, 2009).

Many species of gorgonian corals are known to occur within the habitat of pink, gold and bamboo corals in the Hawaiian Islands. At least 37 species of precious corals in the order Gorgonacea have been identified from the Makapuu bed (Grigg and Bayer, 1976). In addition, 18 species of black coral (order Antipatharia) have been reported to occur in Hawaiian waters (Grigg and Opresko, 1977; Oishi, 1990; Wagner, 2011.), but only 3 of these species have been subject to commercial harvest (Oishi, 1990; Wagner *et al.,* 2015).

1.3 Biology and Life History

The management and conservation of deep-sea coral communities is challenged by their commercial harvest for the jewelry trade and damage caused by deep-water fishing practices. In light of their unusual longevity, a better understanding of deep-sea coral ecology and their interrelationships with associated benthic communities is needed to inform coherent international conservation strategies for these important deep-sea habitat-forming species (Bruckner, 2013).

Most of the interior of the global ocean remains unobserved. This leaves questions of trophic connectivity, longevity, and population dynamics of many deep-sea communities unanswered. Deep-sea megafauna provide a complex, rich, and varied habitat that promotes high biodiversity and provides congregation points for juvenile and adult fish (Freiwald *et al.,* 2004; Husebo *et al.,* 2002; Smith *et al.,* 2008).

Precious corals may be divided primarily into two groups of species based on their depth ranges: the deepwater species (200-600m) and the shallow water species (20-120m). Other precious corals can be found in depths down to 2000 m, but these species are not exploited in the U.S. for commercial purposes. Deep-sea corals are found on hard substrates on seamounts and continental margins worldwide at depths of 300 to 3,000 m.

Deep Corals

The Pacific Islands deepwater precious coral species include pink coral, *Pleurocorallium secundum* (prev. *Corallium secundum*), red coral, *Hemicorallium laauense* (prev. *C. regale or C. laauense*), gold coral, *Kulamanamana haumeaae (*prev. *Gerardia sp*.) and bamboo coral, *Lepidistis olapa*. As previously discussed, the most valuable precious corals are gorgonian octocorals (Grigg, 1984). There are seven varieties of pink and red precious corals in the western Pacific region, six of which used to be recognized as distinct species of *Corallium* (Grigg, 1981), but have been reclassified (Parrish *et al.,* 2015). The two species of commercial importance in the EEZ around the Hawaiian Islands are the pink coral *Pleurocorallium secundum* (prev. *Corallium secundum*), and the red coral, *Hemicorallium laauense* (prev. *C. laauense*). The Gorgonian octocorals are by far the most abundant and diverse corals in the Hawaiian Archipelago. Two species, *Pleurocorallium secundum* and *Hemicorallium laauense* are known to occur at depths of 300-600 m on islands and seamounts throughout the Hawaiian Archipelago (Grigg 1974, 1993; Parrish *et al.,* 2015; Parrish and Baco, 2007). Parrish (2007) surveyed *Pleurocorallium secundum* and *Hemicorallium laauense* at 6 precious coral beds in the lower Hawaiian chain, from Brooks Bank to Keahole Point, Hawaii, in depths ranging from 350m to 500m. He found corals on summits, flanks, and shallow banks, with bottom substrate and relief at these sites ranging from a homogenous continuum of one type to a combination of many types at a single site. The survey results show that all three coral taxa colonize both carbonate and basalt/manganese substrates, and the corals favor areas where bottom relief enhances or modifies flow characteristics that may improve the colony's feeding success.

These corals can grow to more than 30 cm in height, and are often found in large beds with other octocorals, zoanthids, and sometimes scleractinians (Parrish *et al.,* 2015; Parrish and Baco, 2007). These species are relatively long lived, with some of the oldest colonies observed within Makapuu Bed about 0.7 m in height and at least 80 years old (Grigg, 1988b, Roark, 2006). Populations of *P. secundum* appear to be recruitment limited, although in favorable environments (e.g., Makapuu Bed) populations are relatively stable, suggesting that recruitment and mortality are in a steady state (Grigg, 1993). A study by Roark *et al.* (2006) showed that the radial growth rate for specimens of *P. secundum* in the Hawaiian Islands is ~170 μm yr^{-1} and average age is 67 to 71 years, o;der than previously calculated. Individual colonies have been measured as tall as 28 cm. Bruckner (2009) suggested that the minimum allowable size for genus Corallium for harvest should be increased, and supported a potential listing for Corallium within the Appendices of the Convention on International Trade in Endangered Species (CITES). The current size restriction in the 2010 Code of Federal Regulations for Pacific Islands Region is 10 in (25.4 cm).

In Cairn's reviews (2008; 2009; 2010), he summarized the research conducted on Hawaiian Octocorallia taxa, including three gold coral PCMUS genuses, *Narella*, *Calyptrophora* and *Callogorgia*. Octocorallia are distributed over all ocean basins, found in depths ranging from shallow (~ 50m) to deep (~ 4,600) in Alaska. All gold PCMUS in Hawaii were collected in deep water (> 270m), throughout the Hawaiian archipelago and adjacent seamounts. Although these octocorals are managed as PCMUS, the only commercially exploited gold coral is the zoantharian, *Kulamanamana haumeaae* (prev. *Gerardia* sp.). It is probably the most common and largest of the zoanthids in Hawaii, and is widely distributed throughout the Hawaiian Archipelago and into the Emperor Seamount Chain at depths of 350–600 meters (Parrish *et al.*, 2015; Parrish and Baco, 2007). While subject to commercial exploitation from the 1970's until 2001 with an interruption between 1979 and 1999 (Grigg, 2001), the gold coral is not currently exploited in Hawaii due to a moratorium on the fishery. The Hawaiian gold coral is one of the largest and numerically dominant benthic macro-invertebrates in its depth range on hard substrate habitats of the Hawaiian Archipelago, and plays an important ecological role in Hawaiian seamount benthic assemblage (Parrish, 2006; Parrish and Baco, 2007; Parrish, *et al.*, 2015). The Hawaiian gold coral has also been found to be one of the longest-lived species on earth. Earlier ageing attempts on the gold coral focused on ring counts (Grigg, 1974; Grigg, 2002) and led to a maximal estimated age of 70 years and a radial growth rate (increase in branch diameter) of 1 mm/year. Recent studies using radiometric data suggest colonies of Hawaiian gold coral are as old as 2740 year with a radial growth rate of only 15 to 45 µm/year (Roark *et al.*, 2006; Roark *et.al.*, 2009; Parrish and Roark, 2009).

Parrish (2015) has found the host of the parasitic *Kulamanamana haumeaae* to be primarily the bamboo corals (e.g. Acanella, Keratoisis). *K. haumeaae* secretes a protein skeleton that over millennia can grow and more than double the original mean size of the host colony. It is relatively common and even dominant at geologically older sample sites, but recruitment is probably infrequent (Parrish, 2015). Although it can be relatively common compared to some other deep corals, it grows very slowly. Parrish and Roark (2009) determined that the Hawaiian gold coral *Kulamanamana haumeaae* has a mean life span of 950 yrs with an overall radial growth of ~41 µm yr^{-1}, and a gross radiocarbon linear growth rate of 2.2 ± 0.2 mm yr^{-1}. This is a much slower growth rate and longer life span than given in previous studies. Grigg (2002) reported a 1 mm yr^{-1} radial growth rate, equivalent to a 6.6 cm yr^{-1} linear growth for a maximum life span of roughly 70 yrs. This means these corals are growing much slower than previously thought, and have much longer life spans if undisturbed. Newly applied radiocarbon age dates from the deep water proteinaceous corals *Gerardia* and *Leiopathes* show that radial growth rates are as low as 4 to 35 micometers per year and that individual colony longevities are on the order of thousands of years (Roark *et al.*, 2009, 2006). The longest-lived *Gerardia* sp. and *Leiopathes* specimens were estimated to be 2,742 years old and 4,265 years old, respectively. *Gerardia* sp. is a colonial zoanthid with a hard skeleton of hard proteinaceous matter that forms tree-like structures with heights of several meters and basal diameters up to 10s of a centimeter. Black corals of *Leiopathes sp*. also has a hard proteinaceous skeleton and grows to heights in excess of 2 m. In Hawai'ian waters, these corals are found at depths of 300 to 500 m on hard substrates, such as seamounts and ledges.

The two bamboo coral PCMUS in the Pacific Islands Region are classified under two genera, Acanella and Lepidisis. Not much work has been done specifically on these genera, but Parrish (2015) identified branched bamboo colonies such as Acanella as a preferred host for *Kulamanamana haumeaae*. Because of the long colony life span of >3000 yrs and the bony hard bodied calcareous internodes of bamboo corals (family Isididae), geochemists are interested in using them to analyze paleo-oceanographic events and long-term climate change (Hill *et al*. 2011), while biologists use them to size and age deep-sea coral populations. Recent studies show that the subfamily Keratoisidinae (family Isididae) consists of four genera (*Acanella*, *Isidella*, *Lepidisis*, and *Keratoisis*), with two genera (*Tenuisis* and *Australisis*) perhaps belonging elsewhere in the Isididae family (Etnoyer 2008; France 2007). Bamboo corals commonly colonize intermediate to deep water depths (400m to >3000m) of continental slopes and seamounts in the Pacific Ocean.

Shallow Corals

The second group of precious coral species is found in shallow water between 20 and 120 m (Grigg, 1993 and Drysdale, *unpublished data*, 2012; Wagner *et al.*, 2015). The shallow water fishery is comprised of three species of black coral, *Antipathes griggi*, *A. grandis* and *Myriopathes ulex*, which have historically been harvested in Hawaii (Oishi 1990), but over 90% of the coral harvested by the fishery consists of *A. griggi* (Oishi 1990; Parrish *et al.*, 2015; Wagner *et al.*, 2015). Other black coral species are found in the NWHI in a wider depth range (20m to 1,400m), but with lower colony density (Wagner *et al.*, 2011). Surveys performed in depths of 40-110 meters in the Au‘au Channel in 1975 and 1998, suggested stability in both recruitment and growth of commercially valuable black coral populations, and thus indicated that the fishery had been sustainable over this time period (Grigg, 2001). Subsequent surveys performed in the channel in 2001 indicated a substantial decline in the abundance of black coral colonies, with likely causes including increases in harvesting pressure and overgrowth of black coral colonies by the invasive octocoral *Carijoa sp.* and the red alga, *Acanthophora spicifera*, especially on reproductively mature colonies at mesophotic depths (Grigg 2003; Grigg 2004; Kahng & Grigg 2005; Kahng, 2006). Together, these factors renewed scrutiny on the black coral fishery and raised questions about whether regulations need to be redefined in order to maintain a sustainable harvest (Grigg, 2004). In addition to these challenges, Wagner has suggested that taxonomic misidentification has led to the mistaken belief that there is a depth refuge that exists for certain harvested species (Wagner *et al.,* 2012; Wagner, 2011). All of these uncertainties and lack of basic life history information regarding black corals complicates effective management of the resource (Grigg, 2004).

In Hawaii, *A. griggi* accounts for around 90% of the commercial harvest of black coral (Oishi 1990). *A. grandis* accounts for 9% and *M. ulex* 1% of the total black corals harvested. In Hawaii, roughly 85% of all black coral harvested are taken from within state waters. Black corals are managed jointly by the State of Hawaii and the Council. Within state waters (0–3 nmi), black corals are managed by the State of Hawaii (Grigg, 1993).

A new name for the Hawaiian species of antipatharian coral previously identified as *Antipathes dichotoma* (Grigg and Opresko, 1977) is described as *Antipathes griggi* Opresko, n. sp. (Opresko, 2009). The shallow water black coral *A. dichotoma* (*A. griggi)* collected at 50m exhibited growth rates of 6.42 cm yr^{-1} over a 3.5 yrs study.

1.4 Growth and Reproduction

There is very limited published literature regarding coral spawning of the PCMUS in the Pacific Islands Region. However, studies by Gleason, *et al*. (2006) and Waller and Baco (2007) indicate that the gold coral *Kulamanamana haumaae* may have seasonal reproduction, and that two pink coral species have a periodic or quasi-continuous reproductive periodicity. Although limited studies about growth rates and life spans of adult PCMUS in the Pacific Islands Region are available, early life history data on larvae, polyps, and juvenile colonies of the PCMUS are unavailable. Many other questions related to genetic connectivity and spatial distribution across the Pacific also remain unanswered. Recent mesophotic coral reef ecosystem studies provide an outline of essential knowledge for the limited deep water coral ecosystem (Kahng, *et al*. 2010). Slow-growing deep-water coral ecosystems are sensitive to many disturbances, such as temperature change, invasive species and destructive fishing techniques.

While different species of precious corals inhabit distinct depth zones, their habitat requirements are strikingly similar. Grigg (1984) noted that these corals are non-reef building and inhabit depth zones below the euphotic zone. In an earlier study, Grigg (1974) determined that precious corals are found in deep water on solid substrate in areas that are swept relatively clean by moderate to strong bottom currents (>25 cm/sec). Strong currents help prevent the accumulation of sediments, which would smother young coral colonies and prevent settlement of new larvae. Grigg (1984) notes that, in Hawaii, large stands of *Corralium* are only found in areas where

Table 3: Depth zonation of precious corals in the Western Pacific. (Source: Grigg 1993, Baco-Taylor, 2007, HURL and Drysdale, 2012)

Species and Common Name	Depth Range (m)
Paracorallium secundum Angle skin coral	250–575
Hemicorallium laauense Red coral	250–575
Corallium sp nov. Midway deepsea coral	1,000–1,500
Kulamanamana haumeaae (prev. *Gerardia* sp.) Hawaiian gold coral	350–575
Lepidisis olapa, *Acanella* spp. bamboo coral	250–1800
Antipathes griggi (prev. *A. dichotoma*), black coral	20–120
Antipathes grandis, pine black coral	20–120
Cirrhipathes cf. *anguina* (prev. *Antipathes anguina*), wire black coral	20–120
Myriopathes ulex (prev. *Antipathes ulex*),	20–220

Species and Common Name	Depth Range (m)
fern black coral	

sediments almost never accumulate, and *P. secundum* appears in large numbers in areas of high flow over carbonate pavement (Parrish *et al.,* 2015; Parrish and Baco, 2007). *Hemicorallium laauense* grows in an intermediate relief of outcrops; and *Kulamanamana haumaae* is most commonly seen growing in high relief areas on pinnacles, walls, and cliffs. These habitat differences may reflect preferred flow regimes for the different corals (e.g., laminar flow for *P. secundum*, alternating flow for *Kulamanamana haumaae*) (Parrish *et al.*, 2015).

Surveys of all potential sites for precious corals in the MHI conducted using a manned submersible show that most shelf areas in the MHI near 400 m are periodically covered with a thin layer of silt and sand (Grigg, 1984). Precious corals are known to grow on a variety of bottom substrate types. Precious coral yields, however, tend to be higher in areas of shell sandstone, limestone and basaltic or metamorphic rock with a limestone veneer. Grigg (1988) concludes that the concurrence of oceanographic features (strong currents, hard substrate, low sediments) necessary to create suitable precious coral habitat are rare in the MHI. Depth clearly influences the distribution of different coral taxa and certainly there is patchiness associated with the presence of premium substrate and environmental conditions (flow, particulate load, etc.). The environmental suitability for colonization and growth is likely to differ among coral taxa.

The habitat sustaining precious corals is generally in pristine condition. There are no known areas that have sustained damage due to resource exploitation, notwithstanding the alleged heavy foreign fishing for corals in the Hancock Seamounts area. Although unlikely, if future development projects are planned in the proximity of precious coral beds, care should be taken to prevent damage to the beds. Projects of particular concern would be those that suspend sediments or modify water-movement patterns, such as deep-sea mining or energy-related operations.

There has been very little research conducted concerning the food habits of precious corals. Precious corals are filter feeders (Grigg, 1984; 1993). The sparse research available suggests that particulate organic matter and microzooplankton are important in the diets of pink and bamboo coral (Grigg, 1970). Many species of pink coral, gold coral (*Kulamanamana haumeaae (*prev. *Gerardia* sp.*)* and black coral (*Antipathes*) form fan shaped colonies (Grigg, 1984; 1993). This type of morphological adaption maximizes the total area of water that is filtered by the polyps (Grigg, 1984; 1993). Bamboo coral (*Lepidisis olapa*), unlike other species of precious corals, is unbranched (Grigg, 1984). Long coils that trail in the prevailing currents maximize the total amount of seawater that is filtered by the polyps (Grigg, 1984). While clearly, the presence of strong currents is a vital factor determining habitat suitability for precious coral colonies, their role to date is not fully understood.

Light is one of the most important determining factors of the upper depth limit of many species of precious corals (Grigg, 1984).The larvae of two species of black coral, *Antipathes grandis* and *A. griggi*, are negatively phototaxic**.**

Grigg (1984) states that temperature does not appear to be a significant factor in delimiting suitable habitat for precious corals. In the Pacific Ocean, species of *Corallium* are found in temperature ranges of 8^{o} to 20^{o}C, he observes. Temperature may determine the lower depth limits of some species of precious coral, including two species of black corals in the MHI. In the MHI, the lower depth range of two species of black corals (*A.griggi* and *A. grandis*) coincides with the top of the thermocline (about 100 m). Although, *A. griggi* can be found to depths of 100 m, it is rare below the 75 m depth limit at which commercial harvest occurs in Hawai‘i. Thus, the supposed depth refuge from harvest does not really exist, and was probably based on taxonomic misidentification, thereby calling into question population models used for the management of the Hawaiian black coral fishery (Wagner *et al.*, 2012; Wagner, 2011).

In pink coral (*P. secundum*), the sexes are separate (Grigg, 1993). Based on the best available data, it is believed that *P. secundum* becomes sexually mature at a height of approximately 12 cm (13 years) (Grigg, 1976). Pink coral reproduce annually, with spawning occurring during the summer, during the months of June and July. Coral polyps produce eggs and sperm. Fertilization of the oocytes is completed externally in the water column (Grigg, 1976; 1993). The resulting larvae, called planulae, drift with the prevailing currents until finding a suitable site for settlement.

Pink, bamboo and gold corals all have planktonic larval stages and sessile adult stages. Larvae settle on solid substrate where they form colonial branching colonies. Grigg (1993) notes that the lengths of the larval stage of all deepwater species of precious corals is unknown. Clean swept areas exposed to strong currents provide important sites for settlement of the larvae, Grigg adds. The larvae of several species of black coral (*Antipathes*) are negatively photoactic, he notes. They are most abundant in dimly lit areas, such as beneath overhangs in waters deeper than 30 m. In an earlier study, Grigg (1976) found that “within their depth ranges, both species are highly aggregated and are most frequently found under vertical dropoffs. Such features are commonly associated with terraces and undercut notches relict of ancient sea level still stands. Such features are common off Kauai and Maui in the MHI. Both species are particularly abundant off of Maui and Kauai, suggesting that their abundance is related to suitable habitat.” Off of Oahu, many submarine terraces that otherwise would be suitable habitat for black corals are covered with sediments (Grigg, 1976).

A variety of invertebrates and fish are known to utilize the same habitat as precious corals. These species of fish include onaga (*Etelis coruscans*), kahala (*Seriola dumerallii*) and the shrimp (*Heterocarpus ensifer*). These species do not seem to depend on the coral for shelter or food.

Densities of pink, gold and bamboo coral have been estimated for an unexploited section of the Makapuu bed (Grigg, 1976). As noted in the FMP for precious corals, the average density of pink coral in the Makapuu bed is 0.022 colonies/m^2. This figure was extrapolated to the entire bed (3.6 million m^2), giving an estimated standing crop of 79,200 colonies. At the 95% confidence limit, the standing crop is 47,500 to 111,700 colonies. The standing crop of colonies was converted to biomass ($3N_iW_i$), resulting in an estimate of 43,500 kg of pink coral in the Makapuu bed. These estimates need to be revised with more rigorous statistical enumeration methodologies.

In addition to coral densities, Grigg (1976) determined the age-frequency distribution of pink coral colonies in Makapuu bed. He applied annual growth rates to the size frequency to calculate the age structure of pink coral at Makapuu Bed (Table 4). More recent work by Roark *et al.* (2006) suggests that annual growth ring dating may underestimate the ages of many species of deep water corals, and that most of the colonies that have been dated using the ring method are probably older and slower growing than first estimated.

Estimates of density were also made for bamboo (*Lepidisis olapa*) and gold coral (*Kulamanamana haumeaae (*prev. *Gerardia* sp.*)* for Makapuu bed. The distributions of both these species are patchy. As noted in the FMP, the area where they occur comprises only half of that occupied by pink coral (1.8 km^2). Estimates of the unexploited abundance of bamboo and gold coral were 18,000 and 5,400 colonies, respectively. Estimates of density for the unexploited bamboo coral and gold coral in the Makapuu bed are 0.01 colonies/m^2 and 0.003 colonies/m^2. Using a rough estimate for the mean weights of gold and bamboo coral colonies (2.2 kg and 0.6 kg), a standing crop of about 11,880 kg of gold coral and 10,800 kg for bamboo for Makapuu bed was obtained. These estimates need to be revised with more rigorous statistical enumeration methodologies.

Growth rates for several species of precious corals found in the western Pacific region have been calculated. Grigg (1976) determines that the height of pink coral (*P. secundum*) colonies increases about 0.9 cm/yr up to about 30 years of age. These growth rates are probably overestimated, and should be revisited using modern methodologies. As noted in the FMP for precious corals, the height of the largest colonies of *Pleurocorallium secundum* at Makapuu bed rarely exceed 60 cm. Colonies of gold coral are known to grow up to 250 cm tall while bamboo corals may reach 300 cm. The natural mortality rate of pink coral at Makapuu bed is believed to be 0.066, equivalent to an annual survival rate of about 93%.

Table 4: Age-Frequency Distribution of *Pleurocorallium secundum* (Source: Grigg, 1973)

Age Group (years)	Number of Colonies
0–10	44
10–20	73
0–30	22
30–40	12
40–50	7
50–60	0

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Attachment 3: Species list table for the American Samoa FEP

1. Bottomfish Multi-species Stock Complex (FSSI)

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

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

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

3. Crustacean spiny lobster complex (non-FSSI)

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

4. Crustacean slipper lobster complex (non-FSSI)

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

5. Crustacean Kona crab complex (non-FSSI)

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

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

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

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

DMWR Creel Species Code	Species Name	Scientific Name
none	Pink coral	*Corallium secundum*
none	Pink coral	*Corallium regale*
none	Pink coral	*Corallium laauense*
none	Bamboo coral	*Lepidisis olapa*
none	Bamboo coral	*Acanella* spp.
none	Gold Coral	*Gerardia* spp.
none	Gold Coral	*Callogorgia gilberti*
none	Gold Coral	*Narella* spp.
none	Gold Coral	*Calyptrophora* spp.

8. Coral reef ecosystem (non-FSSI)

DMWR Creel Species Code	**Species Name**	**Scientific Name**	**Grouping**
328	Achilles tang	*Acanthurus achilles*	Acanthuridae
337	Barred unicornfish	*Naso thynnoides*	Acanthuridae
3311	Bignose unicornfish	*Naso vlamingii*	Acanthuridae
336	Black tongue unicornfish	*Naso hexacanthius*	Acanthuridae
3205	Blackstreak surgeonfish	*Acanthurus nigricauda*	Acanthuridae
321	Blue-banded surgeonfish	*Acanthurus lineatus*	Acanthuridae
3206	Bluelined surgeonfish	*Acanthurus nigroris*	Acanthuridae
339	Bluespine unicornfish	*Naso unicornis*	Acanthuridae
326	Brown surgeonfish	*Acanthurus nigrofuscus*	Acanthuridae
323	Convict tang	*Acanthurus triostegus*	Acanthuridae
3203	Elongate surgeonfish	*Acanthurus mata*	Acanthuridae
3201	Eye-striped surgeonfish	*Acanthurus dussumeiri*	Acanthuridae
335	Gray unicornfish	*Naso caesius*	Acanthuridae
333	Humpback unicornfish	*Naso brachycentron*	Acanthuridae
338	Humpnose unicornish	*Naso tuberosus*	Acanthuridae
3208	Mimic surgeonfish	*Acanthurus pyorferus*	Acanthuridae
327	Naso tang	*Naso spp.*	Acanthuridae
332	Orangespine unicornfish	*Naso lituratus*	Acanthuridae
3207	Orange-spot surgeonfish	*Acanthurus olivaceus*	Acanthuridae
3281	Pacific sailfin tang	*Zebrasoma veliferum*	Acanthuridae

329	Ringtail surgeonfish	*Acanthurus blochii*	Acanthuridae
334	Spotted unicornfish	*Naso brevirostris*	Acanthuridae
322	Striped bristletooth	*Ctenochaetus striatus*	Acanthuridae
320	Surgeonfishes/tangs	*Acanthurus sp.*	Acanthuridae
3221	Twospot bristletooth	*Ctenochaetus binotatus*	Acanthuridae
330	Unicornfishes (misc)	*Naso spp.*	Acanthuridae
3202	Whitebar surgeonfish	*Acanthurus leucopareius*	Acanthuridae
3204	Whitecheek surgeonfish	*Acanthurus nigricans*	Acanthuridae
331	Whitemargin unicornfish	*Naso annulatus*	Acanthuridae
325	Whitespotted surgeonfish	*Acanthurus guttatus*	Acanthuridae
3222	Yellow-eyed bristletooth	*Ctenochaetus strigosus*	Acanthuridae
324	Yellowfin surgeonfish	*Acanthurus xanthopterus*	Acanthuridae
390	Inshore snappers	*Lutjanidae*	Lutjanidae
238	Brown jobfish	*Aphareus furca*	Lutjanidae
256	Scarlet snapper	*Etelis radiosus*	Lutjanidae
392	Red snapper	*Lutjanus bohar*	Lutjanidae
235	Twinspot/red snapper	*Lutjanus bohar*	Lutjanidae
233	Yellow margined snapper	*Lutjanus fulvus*	Lutjanidae
236	Humpback snapper	*Lutjanus gibbus*	Lutjanidae
234	Onespot snapper	*Lutjanus monostigma*	Lutjanidae
232	Rufous snapper	*Lutjanus rufolineatus*	Lutjanidae
237	Blood snapper	*Lutjanus sanguineus*	Lutjanidae
257	Timor snapper	*Lutjanus timorensis*	Lutjanidae
251	Black snapper	*Macolor niger*	Lutjanidae

253	Kusakar's snapper	*Paracaesio kusakarii*	Lutjanidae
252	Stone's snapper	*Paracaesio stonei*	Lutjanidae
250	Multidens snapper	*Pristipomoides multidens*	Lutjanidae
102	Bigeye scad	*Selar crumenophthalmus*	Atule
524	Mangrove clam	*Anodontia edentula*	Mollusk
522	Pen shell clam	*Atrina rigida*	Mollusk
523	Pipi clam	*Donax deltoides*	Mollusk
510	Squid	*Teuthida*	Mollusk
521	Clams (misc)	*Bivalvia*	Mollusk
531	Cone snail	*Conus* sp.	Mollusk
5061	Octopus (cyanea)	*Octopus cyanea*	Mollusk
5062	Octopus (ornatus)	*Octopus ornatus*	Mollusk
506	Octopus	*Octopus* sp.	Mollusk
520	Giant clam	*Tridacna* sp.	Mollusk
530	Turban snail	*Trochus* sp.	Mollusk
536	Green snails	*Turbo* sp.	Mollusk
116	Blue kingfish trevally	*Carangoides caeruleopinnatus*	Carangidae
114	Goldspot trevally	*Carangoides orthogrammus*	Carangidae
109	Trevally (misc)	*Carangoides* sp.	Carangidae
110	Jacks (misc)	*Caranx* sp.	Carangidae
113	Bluefin trevally	*Caranx melampygus*	Carangidae
115	Brassy trevally	*Caranx papuensis*	Carangidae
112	Bigeye trevally	*Caranx sexfasciatus*	Carangidae

410	Rainbow runner	*Elagatis bipinnulatus*	Carangidae
106	Leatherback	*Scomberoides lysan*	Carangidae
127	Snubnose pompano	*Trachinotus blochii*	Carangidae
117	Whitemouth trevally	*Uraspis secunda*	Carangidae
104	Mackerel scad (opelu)	*Decapterus* sp.	Carangidae
260	Emperors (misc)	Lethrinidae	Lethrinidae
255	Goldenline bream	*Gnathodentex aureolineatus*	Lethrinidae
264	Yellowspot emperor	*Gnathodentex aurolineatus*	Lethrinidae
263	Blueline bream	*Gymnocranius grandoculis*	Lethrinidae
266	Orangespot emperor	*Lethrinus erythracanthus*	Lethrinidae
261	Longnose emperor	*Lethrinus elongatus*	Lethrinidae
254	Bigeye emperor	*Monotaxis grandoculis*	Lethrinidae
2601	Sweetlip emperor	*Lethrinus miniatus*	Lethrinidae
3501	Stareye parrotfish	*Calotomus carolinus*	Scaridae
3503	Longnose parrotfish	*Hipposcarus longiceps*	Scaridae
3502	Yellowband parrotfish	*Scarus schlegeli*	Scaridae
350	Parrotfishes (misc)	*Scarus* sp.	Scaridae
380	Inshore groupers	Serranidae	Serranidae
211	Eightbar grouper	*Epinephelus octofasciatus*	Serranidae
206	Giant grouper	*Epinephelus lanceolatus*	Serranidae
202	Golden hind	*Cephalopholis aurantia*	Serranidae
212	Greasy grouper	*Epinephelus tauvina*	Serranidae
210	Groupers (misc)	*Epinephelus* sp.	Serranidae
224	Hexagon grouper	*Epinephelus hexagonatus*	Serranidae

209	Honeycomb grouper	*Epinephelus merra*	Serranidae
207	Longspine grouper	*Epinephelus longispinnis*	Serranidae
228	Netfin grouper	*Epinephelus miliaris*	Serranidae
208	One-bloch grouper	*Epinephelus melanostigma*	Serranidae
213	Peacock grouper	*Cephalopholis argus*	Serranidae
205	Pygmy grouper	*Cephalopholis spiloparaea*	Serranidae
217	Saddleback grouper	*Plectropomus laevis*	Serranidae
204	Six-banded grouper	*Cephalopholis sexmaculatus*	Serranidae
201	Slender grouper	*Anyperodon leucogrammicus*	Serranidae
227	Smalltooth grouper	*Epinephelus microdon*	Serranidae
226	Spotted grouper	*Epinephelus maculatus*	Serranidae
216	Squaretail grouper	*Plectropomus areolatus*	Serranidae
223	Striped grouper	*Epinephelus morrhua*	Serranidae
215	Tomato grouper	*Cephalopholis sennerati*	Serranidae
203	Ybanded grouper	*Cephalopholis igarashiensis*	Serranidae
222	Yellowspot grouper	*Epinephelus timorensis*	Serranidae
218	Leopard coral trout	*Plectropomus leopardus*	Serranidae
219	Powell's grouper	*Saloptia powelli*	Serranidae
220	White-edged lyretail	*Variola albimarginata*	Serranidae
345	Bigscale soldierfish	*Myripristis berndti*	Holocentridae
348	Blackfin squirrelfish	*Neoniphon opercularis*	Holocentridae
359	Blackspot squirrelfish	*Sargocentron melanospilos*	Holocentridae
3414	Blotcheye soldierfish	*Myripristis murdjan*	Holocentridae
3511	Bluelined squirrelfish	*Sargocentron tiere*	Holocentridae

3411	Brick soldierfish	*Myripristis amaena*	Holocentridae
342	Bronze soldierfish	*Myripristis adusta*	Holocentridae
353	Crown squirrelfish	*Sargocentron diadema*	Holocentridae
3413	Double tooth soldierfish	*Myripristis hexagona*	Holocentridae
356	Filelined squirrelfish	*Sargocentron microstoma*	Holocentridae
3513	Hawaiian squirrelfish	*Sargocentron xantherythrum*	Holocentridae
343	Pearly soldierfish	*Myripristis kuntee*	Holocentridae
354	Peppered squirrelfish	*Sargocentron punctatissimum*	Holocentridae
3512	Pink squirrelfish	*Sargocentron tieroides*	Holocentridae
341	Saber squirrelfish	*Sargocentron spiniferum*	Holocentridae
351	Sammara squirrelfish	*Neoniphon sammara*	Holocentridae
344	Scarlet soldierfish	*Myripristis pralinius*	Holocentridae
340	Squirrelfish	*Sargocentron* sp.	Holocentridae
352	Tailspot squirrelfish	*Sargocentron caudimaculatum*	Holocentridae
346	Violet soldierfish	*Myripristis violaceus*	Holocentridae
358	Violet squirrelfish	*Sargocentron violaceum*	Holocentridae
3415	Whitetip soldierfish	*Myripristis vittata*	Holocentridae
3412	Yellowfin soldierfish	*Myripristis chryseres*	Holocentridae
347	Yellowstriped squirrelfish	*Neoniphon aurolineatus*	Holocentridae
130	Mullets	Mullets	Mugilidae
1301	Fringelip mullet	Mullets	Mugilidae
1303	Diamond scale mullet	Mullets	Mugilidae
1302	False mullet	Mullets	Mugilidae

	Crabs	Decapoda	CRE-crustacean
509	Grapsid crab	Graspidae	CRE-crustacean
5013	Pa'a crab	*Ocypode ceratopthalma*	CRE-crustacean
5011	Seven-11 crab	*Carpilius maculatus*	CRE-crustacean
5012	Small crab	Decapoda	CRE-crustacean
503	Mangrove crab	*Scylla serrate*	CRE-crustacean
5014	Large red crab	*Sesama erythrodactyla*	CRE-crustacean
507	Hermit crab	*Coenobita clypeatus*	CRE-crustacean
	Bumphead parrotfish	*Bolbometopon muricatum*	Bumphead parrotfish
3601	Napoleon wrasse	*Cheilius undulatus*	Napoleon wrasse
1540	Reef sharks (misc)	Carcharhinidae	Carcharhinidae
1541	Silvertip shark	*Carcharhinus albimarginatus*	Carcharhinidae
1542	Grey reef shark	*Carcharhinus amblyrhynchos*	Carcharhinidae
1543	Galapagos shark	*Carcharhinus galapagenis*	Carcharhinidae
154	Blacktip reef shark	*Carcharhinus melanopterus*	Carcharhinidae
	White tip reef shark	*Carcharhinus triaenodon*	Carcharhinidae
158	Hammerhead shark	Sphyrnidae	Carcharhinidae
500	Invertebrates (misc)	n/a	Invertebrate
550	Sea urchins (misc)	Diadema	Invertebrate
553	Black sea urchin	Diadema	Invertebrate
552	White sea urchin	*Salmacis* spp.	Invertebrate
827	Cubed loli	*Holothuria atra* (cubed)	Invertebrate
828	Cubed leapord sea cucumber	*Bahadschia argus* (cubed)	Invertebrate
824	Surf redfish	*Actinopyga maurtiana*	Invertebrate

822	Sea cucumber (misc)	Cucumariidae	Invertebrate
823	Sea cucumber - gau	Cucumariidae	Invertebrate
821	Sea cucumber gonads	Cucumariidae	Invertebrate
825	Leapord sea cucumber	*Bahadschia argus*	Invertebrate
820	Loli	*Holothuria atra*	Invertebrate
132	Flyingfish	Exocoetidae	Other CRE-Finfish
133	Cornetfish	*Fistularia commersonii*	Other CRE-Finfish
135	Mojarras	Gerreidae	Other CRE-Finfish
181	Gobies	Gobiidae	Other CRE-Finfish
357	Sweetlips	*Plectorhinchus* sp.	Other CRE-Finfish
136	Halfbeaks	Hemiramphidae	Other CRE-Finfish
363	Flagtails	Kuhliidae	Other CRE-Finfish
3631	Barred flagtail	*Kuhlia mugil*	Other CRE-Finfish
720	Mountain bass	*Kuhlia* sp.	Other CRE-Finfish
137	Ponyfish	Leiognathidae	Other CRE-Finfish
368	Tilefishes	Malacanthus sp.	Other CRE-Finfish
460	Sunfish	*Masturus lanceolatus*	Other CRE-Finfish
138	Filefishes	*Monacanthidae*	Other CRE-Finfish
139	Silver batfish	*Monodactylus argenteus*	Other CRE-Finfish
176	Moray eels	*Gymnothorax* sp.	Other CRE-Finfish
175	Dragon eel	*Enchelycore pardalis*	Other CRE-Finfish
1741	Yellowmargin moray eel	*Gymnothorax flavimarginatus*	Other CRE-Finfish
1742	Giant moray eel	*Gymnothorax javanicus*	Other CRE-Finfish
174	Spotted moray eels	*Gymnothorax* sp.	Other CRE-Finfish

1743	Undulated moray eel	*Gymnothorax undulatus*	Other CRE-Finfish
160	Rays	Batiodea	Other CRE-Finfish
162	Eagle ray	*Aetobatis narinari*	Other CRE-Finfish
906	Monogram monocle bream	*Scolopsis monogramma*	Other CRE-Finfish
152	Nurse shark	*Pempheris* sp.	Other CRE-Finfish
379	Sweepers	Pempheridae	Other CRE-Finfish
185	Prettyfins	Cyprinididae	Other CRE-Finfish
140	Threadfin	*Polynemus* sp.	Other CRE-Finfish
143	Angelfishes	*Centropyge flavissimus*	Other CRE-Finfish
1431	Emperor angelfish	*Pomacanthus imperator*	Other CRE-Finfish
3181	Banded sergeant	*Abudefduf septemfasciatus*	Other CRE-Finfish
318	Sergeant major	*Abudefduf sp.*	Other CRE-Finfish
142	Damselfish	*Dascyllus trimaculatus*	Other CRE-Finfish
365	Bigeyes	Priacanthidae	Other CRE-Finfish
367	Glasseye	*Heteropriacanthus cruentatus*	Other CRE-Finfish
366	Paeony bulleye	*Priacanthus blochii*	Other CRE-Finfish
369	Moontail bullseye	*Priacanthus hamrur*	Other CRE-Finfish
349	Bigeye squirrelfish	Priacanthus sp.	Other CRE-Finfish
184	Dottybacks	Pseudochromidae	Other CRE-Finfish
144	Scorpionfishes	Scorpaenidae	Other CRE-Finfish
146	Lionfish	Pterois sp.	Other CRE-Finfish
145	Stonefish	Synaceia sp.	Other CRE-Finfish
122	Small barracuda	Sphyraenidae	Other CRE-Finfish
121	Great barracuda	*Sphyraena barracuda*	Other CRE-Finfish

123	Bigeye barracuda	*Sphyraena forsteri*	Other CRE-Finfish
124	Heller's barracuda	*Sphyraena helleri*	Other CRE-Finfish
125	Blackfin barracuda	*Sphyraena qenie*	Other CRE-Finfish
120	Barracudas (misc)	*Sphyraena sp.*	Other CRE-Finfish
191	Seahorses	Sygnathidae	Other CRE-Finfish
147	Lizardfish	Synodontidae	Other CRE-Finfish
355	Terapon perch	*Terapon jarbua*	Other CRE-Finfish
388	Moorish Idol	*Zanclus cornutus*	Other CRE-Finfish
710	Freshwater eel	*Anguilla marmorata*	Other CRE-Finfish
187	Flashlightfishes	*Anomalopidae*	Other CRE-Finfish
189	Frogfishes	*Antennariidae*	Other CRE-Finfish
315	Cardinalfish	*Apogonidae*	Other CRE-Finfish
103	Silversides	*Hypoathernia temminckii*	Other CRE-Finfish
101	Trumpetfish	*Aulostomus chinensis*	Other CRE-Finfish
383	Triggerfish	*Balistidae*	Other CRE-Finfish
3821	Orangestripe triggerfish	*Balistapus undulatus*	Other CRE-Finfish
382	Clown triggerfish	*Balistoides conspicillum*	Other CRE-Finfish
387	Titan triggerfish	*Balistoides viridescens*	Other CRE-Finfish
134	Needlefish	*Belonidae*	Other CRE-Finfish
105	Blennies	*Blennidae*	Other CRE-Finfish
3051	Angler flatfish	*Asterorhombus fijiensis*	Other CRE-Finfish
107	Gold banded fusilier	*Caesio caerulaurea*	Other CRE-Finfish
186	Coral crouchers	*Caracanthus maculatus*	Other CRE-Finfish
385	Butterflyfishes (misc)	*Chaetodon sp.*	Other CRE-Finfish

3851	Butterflyfish (auriga)	*Chaetodon auriga*	Other CRE-Finfish
3854	Saddleback butterflyfish	*Chaetodon ephippium*	Other CRE-Finfish
3852	Racoon butterflyfish	*Chaetodon lunula*	Other CRE-Finfish
3853	Butterflyfish (melanotic)	*Chaetodon melannotus*	Other CRE-Finfish
180	Milkfish	*Chanos chanos*	Other CRE-Finfish
700	Tilapia	*Tilapia zillii*	Other CRE-Finfish
319	Two spotted hawkfish	*Amplycirrhitus bimacula*	Other CRE-Finfish
3191	Stocky hawkfish	*Cirrhitus pinnalatus*	Other CRE-Finfish
3192	Flame hawkfish	*Neocirrhites armatus*	Other CRE-Finfish
131	Herrings	*Clupeidae*	Other CRE-Finfish
173	White eel	*Conger cinereus*	Other CRE-Finfish
172	Conger eels	*Conger sp.*	Other CRE-Finfish
386	Porcupinefish	*Diodon (Porcupine) sp.*	Other CRE-Finfish
183	Remoras	*Echeneidae*	Other CRE-Finfish
188	Anchovies	*Engraulidae*	Other CRE-Finfish
182	Batfishes	*Ephippidae*	Other CRE-Finfish
200	Bottomfish (misc)	*n/a*	Misc. Bottomfish
300	Reef fish (misc)	*n/a*	Misc. Reef Fish
3606	Arenatus wrasse	*Oxycheilinus arenatus*	Wrasse
3605	Bandcheck wrasse	*Oxycheilinus diagrammus*	Wrasse
3610	Barred thicklip	*Hemigymnus fasciatus*	Wrasse
3614	Bird wrasse	*Hemigymnus fasciatus*	Wrasse
3609	Blackeye thicklip	*Hemigymnus melapterus*	Wrasse
3616	Checkerboard wrasse	*Halichoeres hortulanus*	Wrasse

3615	Cheilinus wrasse (misc)	*Cheilinus sp.*	Wrasse
361	Christmas wrasse	*Thalassoma trilobata*	Wrasse
3608	Cigar wrasse	*Cheilio inermus*	Wrasse
3613	Red ribbon wrasse	*Thalassoma quinquevittaitum*	Wrasse
3619	Rockmover wrasse	*Novaculichthys taeniorus*	Wrasse
3611	Sunset wrasse	*Thalassoma lutescens*	Wrasse
3612	Surge wrasse	*Thalassoma purpureum*	Wrasse
3602	Triple tail wrasse	*Cheilinus trilobatus*	Wrasse
3617	Weedy surge wrasse	*Halichoeres margaritaceus*	Wrasse
3607	Whitepatch wrasse	*Xyrichtys aneitensis*	Wrasse
360	Wrasses (misc)	*Labridae*	Wrasse
3603	Floral wrasse	*Cheilinus chlorourus*	Wrasse
3604	Harlequin tuskfish	*Cheilinus fasciatus*	Wrasse
3033	Rudderfish (biggibus)	*Kyphosus bigibus*	Rudderfish
303	Rudderfish (cinerascens)	*Kyphosus cinerascens*	Rudderfish
3032	Western drummer	*Kyphosus cornelii*	Rudderfish
3034	Rudderfish	*Kyphosus sp.*	Rudderfish
3031	Lowfin drummer	*Kyphosus vaigiensis*	Rudderfish
3734	Goatfish (misc)	*Mullidae*	Goatfish
371	Yellowstripe goatfish	*Mulloidichthys flavolineatus*	Goatfish
375	Orange goatfish	*Mulloidichthys pfluegeri*	Goatfish
370	Yellow goatfishes	*Mulloidichthys sp.*	Goatfish
372	Yellowfin goatfish	*Mulloidichthys vanicolensis*	Goatfish
373	Dash-and-dot goatfish	*Parupeneus barberinus*	Goatfish

3731	Doublebar goatfish	*Parupeneus bifasciatus*	Goatfish
3732	White-lined goatfish	*Parupeneus ciliatus*	Goatfish
374	Yellowsaddle goatfish	*Parupeneus cyclostomus*	Goatfish
376	Redspot goatfish	*Parupeneus heptacanthus*	Goatfish
377	Indian goatfish	*Parupeneus indicus*	Goatfish
378	Parupenus insularis	*Parupeneus insularis*	Goatfish
3733	Multi-barred goatfish	*Parupeneus multifasciatus*	Goatfish
381	Side spot goatfish	*Parupeneus pleurostigma*	Goatfish
3370	Banded goatfish (misc)	*Parupeneus sp.*	Goatfish
310	Rabbitfish	*Siganidae*	Rabbitfish
3101	Forktail rabbitfish	*Siganus aregenteus*	Rabbitfish
311	Scribbled rabbitfish	*Siganus spinus*	Rabbitfish
801	Red algae	Red Algae	Rabbitfish
800	Seaweeds	Seaweeds	Rabbitfish