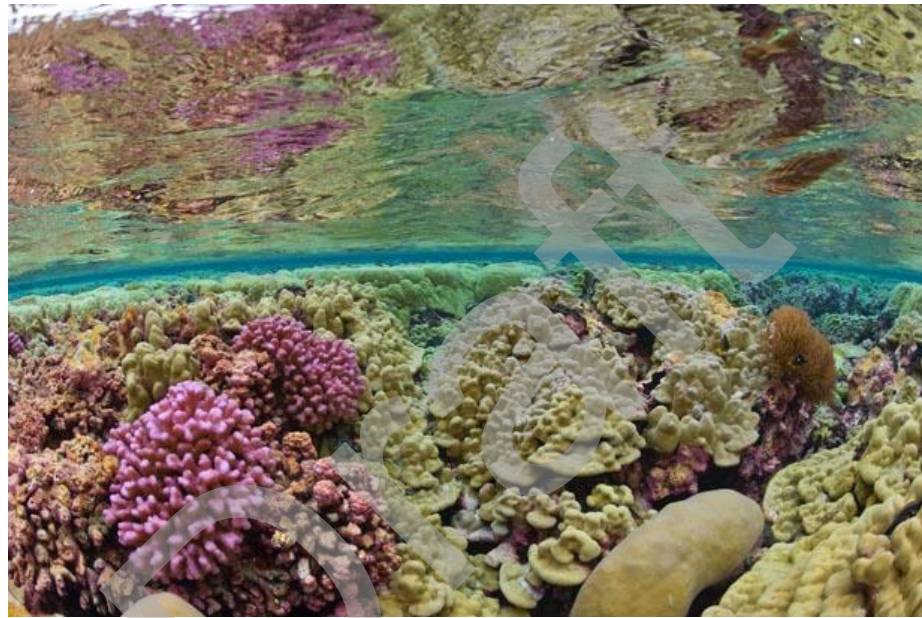


ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT: PACIFIC REMOTE ISLAND AREA FISHERY ECOSYSTEM PLAN 2017



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The ANNUAL STOCK ASSESSMENT AND FISHERY EVALUATION REPORT for the PACIFIC REMOTE ISLAND AREA FISHERY ECOSYSTEM 2017 was drafted by the Fishery Ecosystem Plan Team. This is a collaborative effort primarily between the Western Pacific Regional Fishery Management Council, NMFS-Pacific Island Fisheries Science Center, Pacific Islands Regional Office, 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 five-year fishery ecosystem plan (FEP) review, the Council identified the annual reports as a priority for improvement. The former annual reports have been revised to meet National Standard regulatory requirements for the Stock Assessment and Fishery Evaluation (SAFE) reports. The purpose of the reports is twofold: to monitor the performance of the fishery and ecosystem to assess the effectiveness of the FEP in meeting its management objectives, and to maintain the structure of the FEP living document. The reports are typically comprised of three chapters: fishery performance, ecosystem considerations, and data integration. The 2017 Pacific Remote Island Area (PRIA) annual SAFE report does not contain fully-developed fishery performance or data integration chapters. The Council will iteratively improve the annual SAFE report as resources allow.

An ecosystem considerations section was added to the annual SAFE report following the Council's review of its FEPs and revised management objectives (pending Secretarial transmittal). Fishery independent ecosystem survey data, socioeconomics, protected species, oceanic and climate indicators, essential fish habitat, and marine planning information are all included in the ecosystem considerations section. Fishery dependent data sections will continue to be included as resources allow.

Fishery independent ecosystem survey data were acquired through visual surveys conducted in the PRIA, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, the Main Hawaiian Islands, and the Northwestern Hawaiian Islands. This report describes mean fish biomass for coral reefs in each of these locations. Additionally, the mean reef fish biomass and mean size of fishes (>10 cm) for PRIA are presented by sampling year and reef area. Finally, the reef fish population estimates for each PRIA study site are provided for across hardbottom habitat (0-30 m).

The socioeconomics section outlines the pertinent economic, social, and community information available for assessing the successes and impacts of management measures or the achievements of the Fishery Ecosystem Plan for the PRIA. The section begins with an overview of the socioeconomic context for the region, and then provides a summary of relevant studies for the PRIA. Because human habitation is limited in the PRIA, socioeconomic information is also limited. The socioeconomics section of this report will be expanded in later years if activity increases. There were no new data reported for any fisheries within the PRIA.

The protected species section of this report describes monitoring and summarizes protected species interactions in fisheries managed under the PRIA FEP. There are currently no bottomfish, crustacean, coral reef, or precious coral fisheries operating in the PRIA, and no historical observer data are available for fisheries under this FEP. No new fishing activity has been reported, and there is no other information to indicate that impacts to protected species from PRIA fisheries have changed in recent years.

The climate change section of this report includes measurements of changing climate and related oceanic conditions in the geographic areas that the Western Pacific Regional Fishery Management Council has jurisdiction. 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 as well as the ‘Ocean and Coasts’ chapter of the 2014 Pilot Indicator Systems report prepared by the National Climate Assessment and Development Advisory Committee. The primary goal for selecting the climatic 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 fishery-relevant, be informative, build intuition about current conditions in light of changing climate, provide historical context, and distinguish patterns and trends. The trend of atmospheric concentration of carbon dioxide (CO₂), for example, is increasing exponentially with a time series maximum at 406.53 ppm. Since 1989, the oceanic pH at Station Aloha in Hawaii has shown a significant linear decrease of -0.0386 pH units, or roughly a 9% increase in acidity ([H⁺]). The year 2017 had some high temperature anomalies, with values surpassing seven degree heating weeks in the Wake Island region. The East Pacific hurricane season saw 18 named storms in 2017, nine of which were hurricanes and four major. The north central Pacific, conversely, had no storms over the course of the previous year.

The effective fish habitat (EFH) section of the 2017 annual SAFE report includes cumulative impacts on EFH, and is supplemented by a detailed coral reef crustacean life history and habitat review found in the Appendix. Guidelines also require a report on the condition of the habitat; mapping progress and benthic cover are included as preliminary indicators pending development of habitat condition indicators for the PRIA not otherwise represented in other sections of this report. The annual SAFE report also addresses any Council directives toward its plan team, though there were no directives in 2017.

The marine planning section of the 2017 annual SAFE 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 to be presented. No new ocean activities with multi-year planning horizons were identified for the PRIA in 2017.

The data integration section of this report is under development. The Council hosted a data integration workshop in late 2016 with participants from the NMFS Pacific Islands Regional Office and Pacific Islands Fisheries Science Center (PIFSC) to identify policy-relevant fishery ecosystem relationships. The archipelagic data integration chapters of the 2017 annual SAFE reports were updated for Hawaii, American Samoa, Guam, and CNMI in 2017, however no updates were made for the PRIA data integration chapter as there are currently no fisheries operating in the PRIA. The data integration chapter will be expanded in later years if activity increases in these regions.

The Archipelagic Plan Team made the following recommendations with respect to the Archipelagic FEPs.

Regarding the monitoring of the management unit species, the Archipelagic Plan Team recommends the Council to direct staff to work with the Territory fishery agencies to identify

and resolve issues with regards to real-time accurate reporting, such as regulatory gaps, and potential solutions, such as mandatory licensing and reporting (e.g. log books).

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

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

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

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

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

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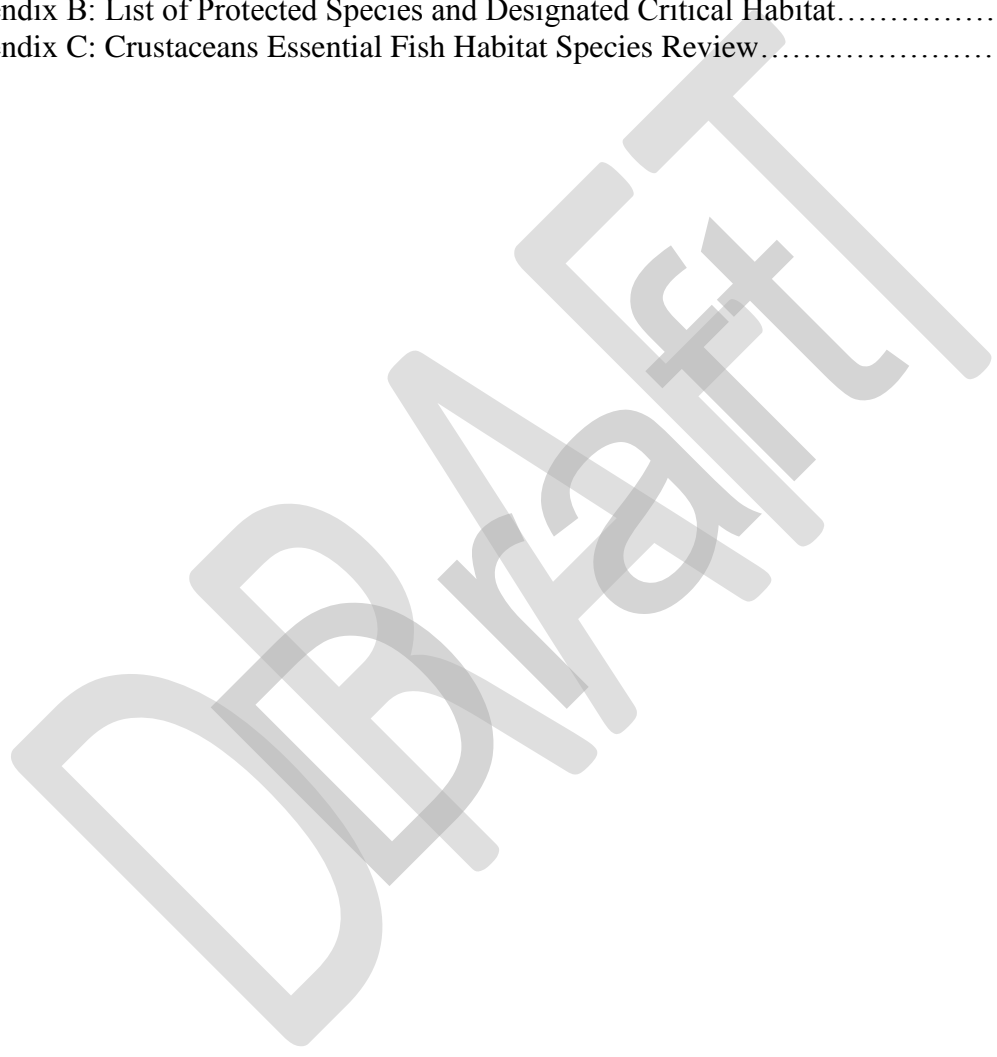


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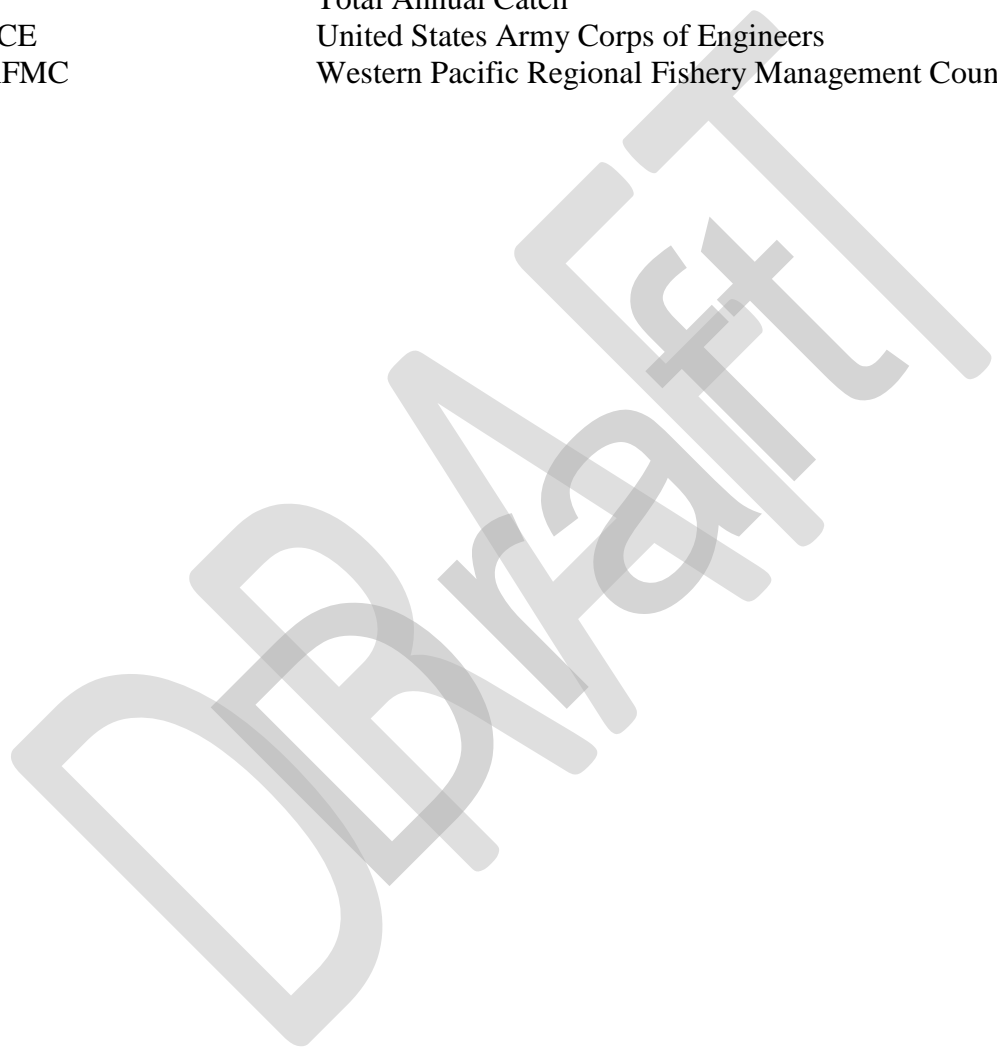
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ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
ABC	Acceptable Biological Catch
ACL	Annual Catch Limits
AM	Accountability Measures
BiOp	Biological Opinion
BOEM	Bureau of Ocean Energy Management
BSIA	best scientific information available
CFR	Code of Federal Regulations
CMS	coastal and marine spatial
CNMI	Commonwealth of the Northern Mariana Islands
CPUE	Catch per Unit Effort
CREMUS	Coral Reef Eco Management Unit Species
CREP	Coral Reef Ecosystem Program (PIFSC)
EEZ	Exclusive Economic Zone
EFH	Essential Fish Habitat
EO	Executive Order
ESA	Endangered Species Act
FEP	Fishery Ecosystem Plan
FMP	Fishery Management Plan
HAPC	Habitat Area of Particular Concern
ITS	Incidental Take Statement
LOF	List of Fisheries
MFMT	Maximum Fishing Mortality Threshold
MHI	Main Hawaiian Islands
MMA	marine managed area
MPA	marine protected area
MPCC	Marine Planning and Climate Change
MPCCC	Council's MPCC Committee
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSST	Minimum Stock Size Threshold
MSY	Maximum Sustainable Yield
MUS	management unit species
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
NEPA	National Environmental and Policy Act
NMFS	National Marine Fisheries Service
NWHI	Northwestern Hawaiian Islands
OFL	Over-fishing Limit
OY	Optimum Yield
Pelagic FEP	Fishery Ecosystem Plan for the Pacific Pelagic Fisheries
PI	Pacific Islands
PIFSC	Pacific Islands Fisheries Science Center

PIRO	NOAA NMFS Pacific Islands Regional Office
PMUS	pelagic management unit species
RAMP	Reef Assessment and Monitoring Program (CREP)
ROA	Risk of Overfishing Analysis
RPB	Regional Planning Body
SAFE	Stock Assessment and Fishery Evaluation
SDC	Status Determination Criteria
SEEM	Social, Ecological, Economic, and Mgmt. Uncertainty Analysis
TAC	Total Annual Catch
USACE	United States Army Corps of Engineers
WPRFMC	Western Pacific Regional Fishery Management Council



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1 FISHERY PERFORMANCE

Fisheries in the Pacific Remote Island Areas (PRIA), including Palmyra Atoll, Kingman Reef, Jarvis Island, Baker Island, Howland Island, Johnston Atoll, and Wake Island, are limited. Fishery performance will be made available for the PRIA in future reports as resources allow.

1.1 NUMBER OF FEDERAL PERMIT HOLDERS

The Code of Federal Regulations, Title 50 Part 665 requires the following Federal permits for fishing in the EEZ of the PRIA:

1.1.1 Special Coral Reef Ecosystem Permit

Regulations require this special coral reef ecosystem fishing permit for anyone fishing for coral reef ecosystem management unit species (MUS) in a low-use MPA, fishing for species on the list of Potentially Harvested Coral Reef Taxa, or using fishing gear not specifically allowed in the regulations. NMFS will make an exception to this permit requirement for any person issued a permit to fish under any fishery ecosystem plan who incidentally catches American Samoa coral reef ecosystem MUS while fishing for bottomfish MUS, crustacean MUS, western Pacific pelagic MUS, precious coral, or seamount groundfish.

1.1.2 Western Pacific Precious Corals Permit

Regulations require a Western Pacific Precious Corals permit for anyone harvesting or landing black, bamboo, pink, red, or gold corals in the exclusive economic zones (EEZs) of the U.S. Western Pacific.

1.1.3 Western Pacific Crustaceans Permit (Lobster or Deepwater Shrimp)

Regulations require a Western Pacific Crustaceans permit for the owner of a U.S. fishing vessel used to fish for lobster or deepwater shrimp in the EEZs around American Samoa, Guam, Hawaii, CNMI, and the PRIA.

1.1.4 PRIA Bottomfish Permit

Regulations require obtaining a PRIA Bottomfish permit for anyone using bottomfish gear to fish for bottomfish MUS in the EEZ around the PRIA. Commercial fishing is prohibited within the boundaries of the Pacific Remote Islands Marine National Monument.

There is no record of coral reef or precious coral fishery permits issued for the EEZ around the PRIAs since 2008. Table 1 provides the number of permits issued for PRIA fisheries from 2008 to 2017. Historical data from the PIFSC were accessed on February 9, 2017, and data for 2018 are from the PIRO Sustainable Fisheries Division permits program as of January 3, 2018.

Table 1. Number of federal permit holders in the lobster, shrimp, and bottomfish fisheries of the PRIA from 2008 to 2017.

PRIA Fisheries	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Lobster	2	3								
Shrimp			1							
Bottomfish	2	3	6	5	4	1	2		1	1

1.2 ADMINISTRATIVE AND REGULATORY ACTIONS

This summary describes management actions for PRIA fisheries that NMFS implemented after the April 2017 Joint FEP Plan Team meeting.

On April 21, 2017, NMFS specified final 2016 annual catch limits (ACLs) for Pacific Island bottomfish, crustacean, precious coral, and coral reef ecosystem fisheries as well as accountability measures (AMs) to correct or mitigate any overages of catch limits. The final specifications were applicable from January 1, 2016, through December 31, 2016, except for precious coral fisheries, which were applicable from July 1, 2016, through June 30, 2017. Although the 2016 fishing year ended for most stocks, NMFS evaluated 2016 catches against these final ACLs when data became available in mid-2017. The ACLs and AMs support the long-term sustainability of fishery resources of the U.S. Pacific Islands. This rule was effective on May 22, 2017.

On December 11, 2017, NMFS specified final 2017 ACLs for Pacific Island crustacean, precious coral, and territorial bottomfish fisheries as well as AMs to mitigate any overages of catch limits. The ACLs and AMs were effective for fishing year 2017. Although the 2017 fishing year had nearly ended for most stocks, NMFS would evaluate 2017 catches against these final ACLs when data become available in mid-2018. The ACLs and AMs support the long-term sustainability of fishery resources of the U.S. Pacific Islands. The final specifications were applicable from January 1, 2017, through December 31, 2017, except for precious coral fisheries, which are applicable from July 1, 2017, through June 30, 2018.

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 coral reef fishes per unit area derived from visual survey data between 2009 and 2015. These data are shown in Figure 1.

Category:

- Fishery independent
- Fishery dependent
- Biological

Timeframe: Triennial

Jurisdiction:

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

Spatial Scale:

- Regional
- Archipelagic
- Island
- Site

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

unit area by dividing by the area sampled per survey. Site-level data were pooled into island-scale values by first calculating mean and variance within strata, and then calculating weighted island-scale mean and variance using the formulas given in Smith *et al.*, (2011), with strata weighted by their respective sizes.

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

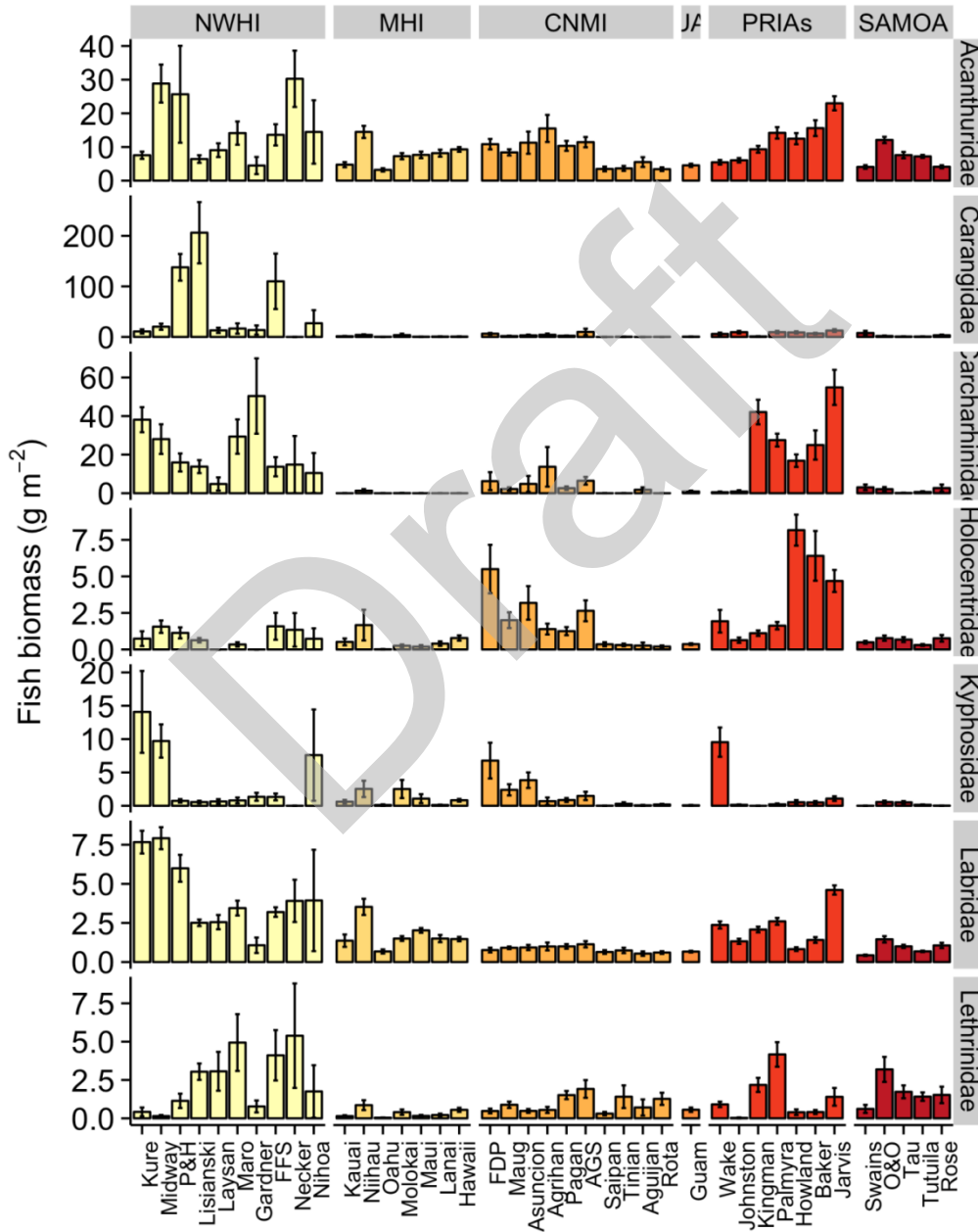
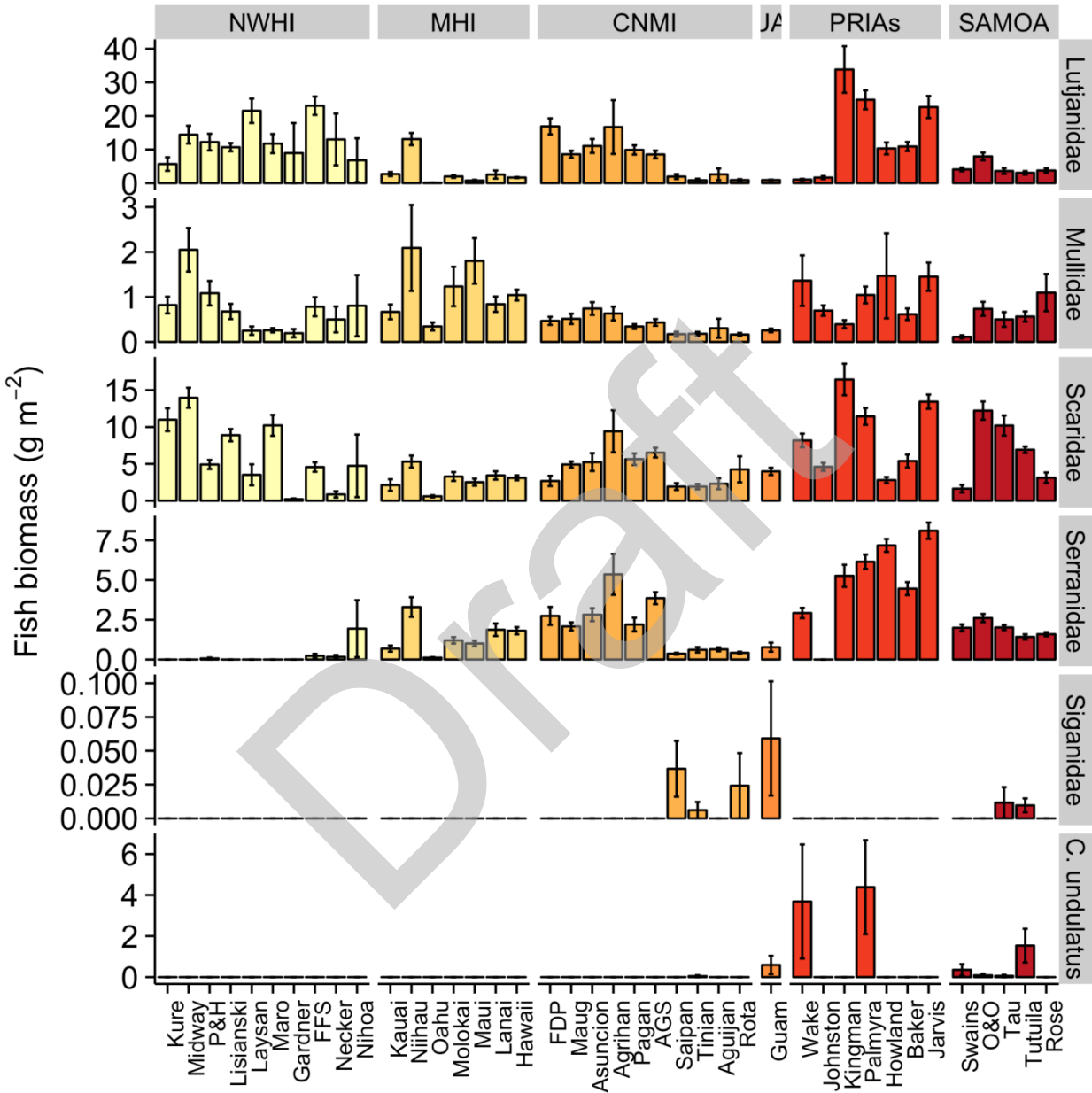


Figure 1. Mean fish biomass ($\text{g/m}^2 \pm$ standard error) of Coral Reef Management Unit Species (CREMUS) grouped by U.S. Pacific reef area from the years 2009-2015. Islands are ordered within region by latitude. Figure continued from previous page.



2.1.2 Archipelagic Reef Fish Biomass

Description: ‘Reef fish biomass’ is mean biomass of coral reef fishes per unit area derived from visual survey data between 2009 and 2015. These data are shown in Figure 2.

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

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 and sampling design, and methods to generate reef fish biomass are described above (Section 2).

Rationale: Identical to the rationale described in Section 2.

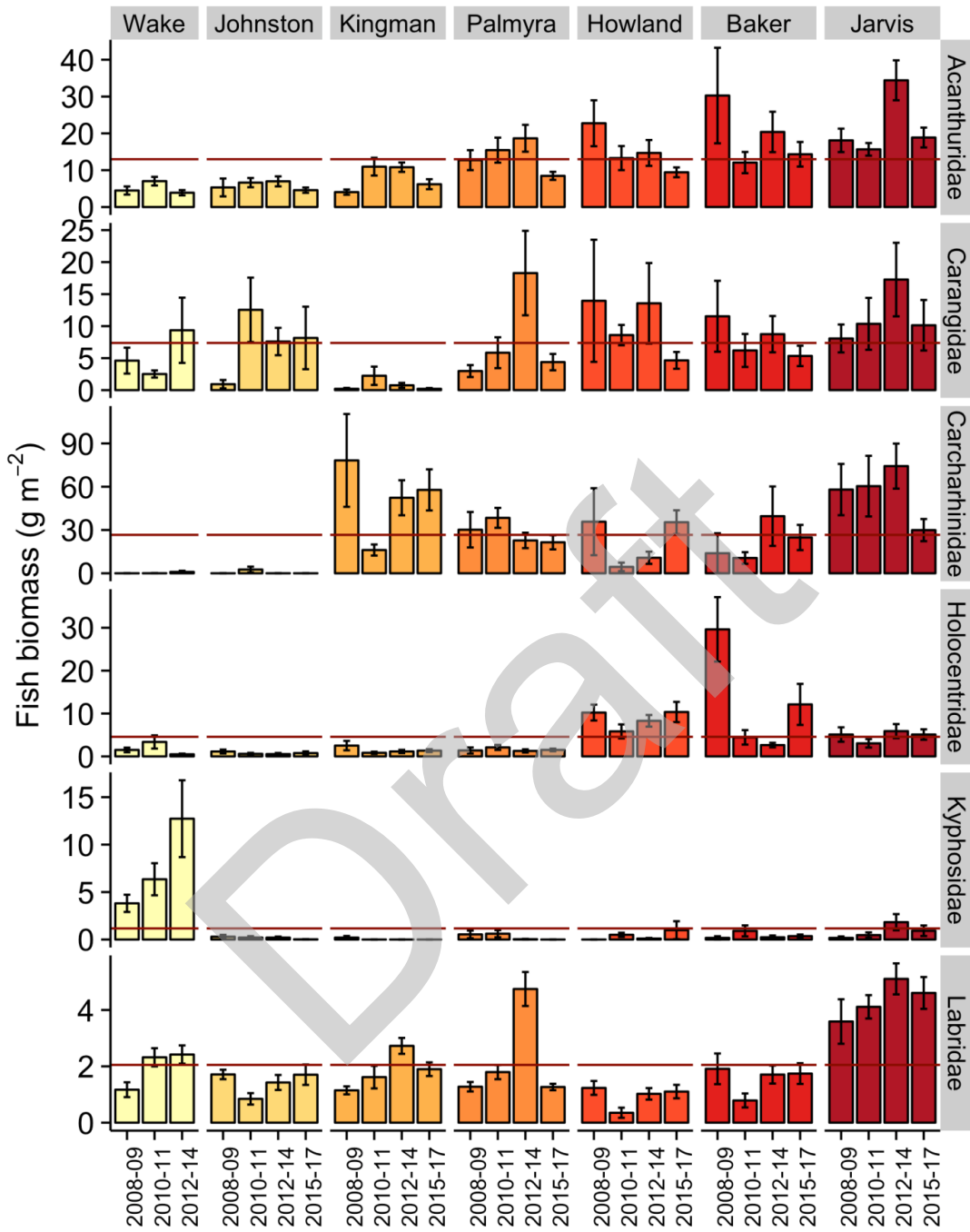
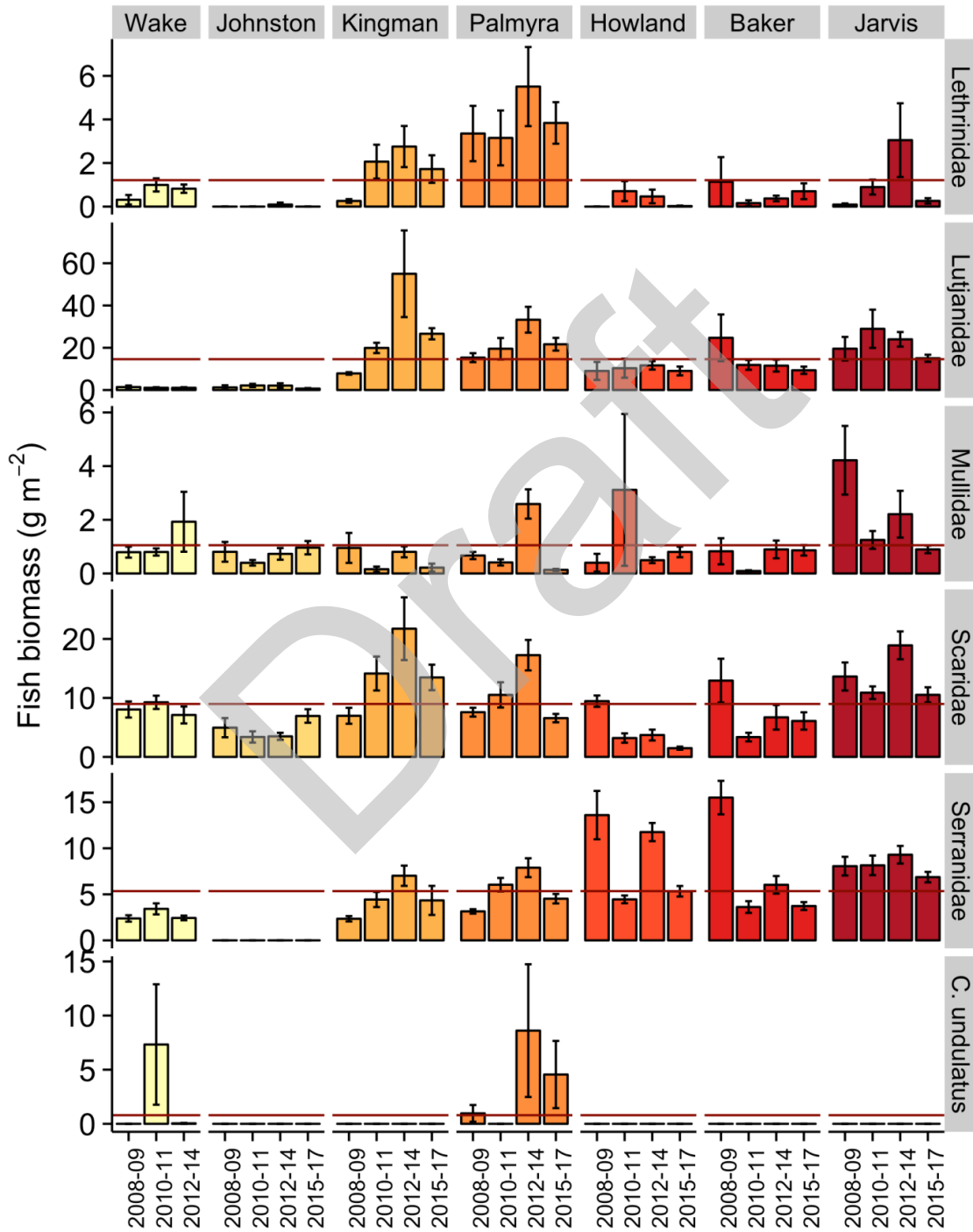


Figure 2. Mean fish biomass ($\text{g}/\text{m}^2 \pm$ standard error) of PRIA CREMUS from the years 2009-2015. The American Samoa archipelago mean estimates are represented by the red line. Figure continued from previous page.



2.1.3 Archipelagic Mean Fish Size

Description: ‘Mean fish size’ is mean size of reef fishes > 10 cm TL (i.e. excluding small fishes) derived from visual survey data (details of survey program below) between 2009 and 2015. These data are shown in Figure 3.

Category:

- Fishery independent
- Fishery dependent
- Biological

Timeframe: Triennial.

Jurisdiction:

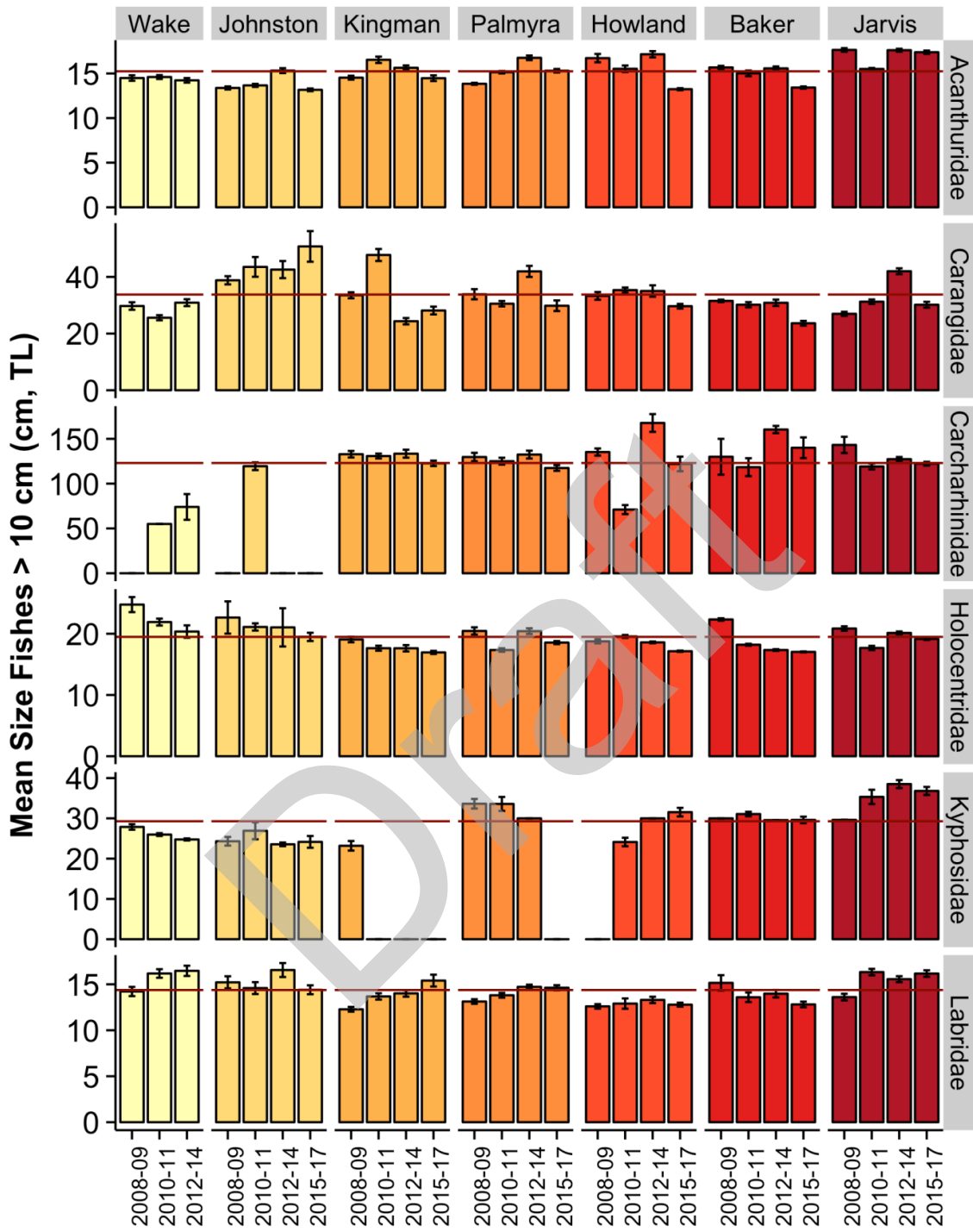
- Regional
- American Samoa
- Guam
- Commonwealth of Northern Mariana Islands
- Main Hawaiian Islands
- Northwest Hawaiian Islands
- Pacific Remote Island Areas

Spatial Scale:

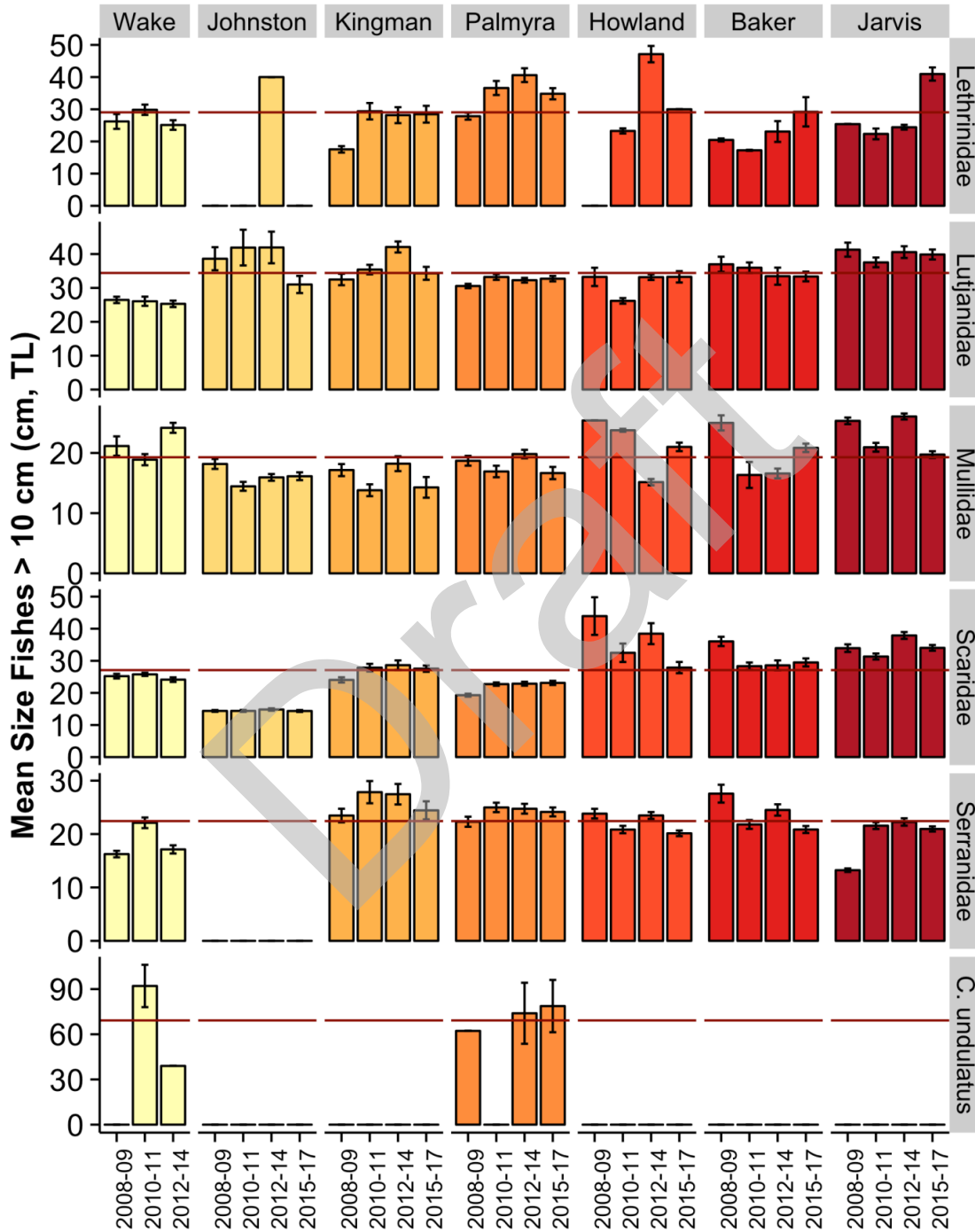
- Regional
- Archipelagic
- Island
- Site

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 and sampling design, and methods to generate reef fish biomass are described above (Section 2). Fishes smaller than 10 cm TL are excluded so that the fish assemblage measured more closely reflects fishes that are potentially fished, and so that mean sizes are not overly influenced by variability in space and time of recent recruitment.

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



**Figure 3. Mean fish size (cm, TL \pm standard error) of PRIA CREMUS from the years 2009-2015. The American Samoa archipelago mean estimates are plotted for reference (red line).
Figure continued from previous page.**



2.1.4 Reef Fish Population Estimates

Description: ‘Reef fish population estimates’ are calculated by multiplying mean biomass per unit area by estimated hardbottom area in a consistent habitat across all islands (specifically, the area of hardbottom forereef habitat in < 30 meters of water). These data are shown in Table 2.

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

Spatial Scale:

- Regional
- Archipelagic
- Island
- Site

Data Source: Data used to generate mean size estimates come from visual surveys conducted by NOAA PIFSC Coral Reef Ecosystem and partners, as part of the Pacific Reef Assessment and Monitoring Program (http://www.pifsc.noaa.gov/cred/pacific_ramp.php). Survey methods and sampling design, and methods to generate reef fish biomass are described above (Section 2). Those estimates are converted to population estimates by multiplying biomass (g/m²) per island by the estimated area of hardbottom habitat <30 meters deep at the island, which is the survey domain for the monitoring program that biomass data comes from. Measures of estimated habitat area per island are derived from GIS bathymetry and NOAA Coral Reef Ecosystems Program habitat maps. Many reef fish taxa are present in other habitats than is surveyed by the program, and some taxa likely have the majority of their populations in deeper water. Additionally, fish counts have the potential to be biased by the nature of fish response to divers. Curious fishes, particularly in locations where divers are not perceived as a threat, will tend to be overestimated by visual survey, while skittish fishes will tend to be undercounted. It is also likely that numbers of jacks and sharks in some locations, such as the NWHI are overestimated by visual survey. Nevertheless, the data shown here are consistently gathered across space and time.

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

Table 2. Reef fish population estimates for CREMUS in 0-30 m hardbottom habitat only of the PRIAs. *N* is number of sites surveyed per island/atoll.

Island/Atoll	Total area of reef (Ha)	<i>N</i>	Estimated population biomass (metric tons) in survey domain of < 30 m hard bottom					
			Acanthuridae	Carangidae	Carcharhinids	Holocentridae	Kyphosidae	Labridae
Wake	1,282.0	75	69.9	76.1	6.3	24.8	122.3	30.4
Johnston	9,410.2	104	570.1	887.6	81.2	60.1	13.5	124.7
Kingman	3,721.1	130	346.8	39.8	1,566.1	41.5	-	77.4
Palmyra	4,212.7	160	597.7	400.5	1,160.4	68.6	9.2	109.7
Howland	172.9	90	21.5	15.5	29.1	14.1	0.9	1.4
Baker	390.3	81	60.9	26.4	97.5	25.0	2.0	5.5
Jarvis	365.9	134	84.1	46.1	200.8	17.1	3.9	16.9
TOTAL	19,555.1	774	1,754.9	1,490.6	3,217.0	249.3	111.2	363.0
Island/Atoll	Total area of reef (Ha)	<i>N</i>	Lethrinidae	Lutjanidae	Mullidae	Scaridae	Serranidae	<i>C. undulatus</i>
Wake	1,282.0	75	11.6	13.5	17.5	104.9	37.5	47.2
Johnston	9,410.2	104	2.9	155.1	65.6	433.2	-	-
Kingman	3,721.1	130	81.1	1,259.5	14.7	611.9	195.9	-
Palmyra	4,212.7	160	175.5	1,045.6	44.0	482.1	259.2	184.8
Howland	172.9	90	0.7	17.9	2.5	4.8	12.4	-
Baker	390.3	81	1.6	42.6	2.4	21.0	17.4	-
Jarvis	365.9	134	5.1	82.9	5.3	49.2	29.7	-
TOTAL	19,555.1	774	280.1	2,661.1	148.8	1,707.2	549.1	220.8

Note: Note: No Siganidae or *Bolbometopon muricatum* were observed in the PRIAs during these surveys.

2.2 SOCIOECONOMICS

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

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



Figure 4. Settlement of the Pacific Islands, courtesy Wikimedia Commons. Found at https://commons.wikimedia.org/wiki/File:Polynesian_Migration.svg.

Polynesian voyagers relied on the ocean and marine resources on their long voyages in search of new islands, as well as in sustaining established island communities. Today, the population of the region also represents many Asian cultures from Pacific Rim countries, which have a similar reliance on marine resources. Thus, fishing and seafood are integral to local community ways of life. This is reflected in the amount of seafood eaten in the region relative to the rest of the United States, as well as in the language, customs, ceremonies, and community events. The amount of available seafood can also affect seasonality in prices of fish. Because fishing is such an integral part of the culture, it is difficult to discern commercial from non-commercial fishing where most trips involving multiple motivations and multiple uses of the fish caught. While the economic perspective is an important consideration, fishermen report other motivations, such as customary exchange, as being equally important. Due to changing economies and westernization, waning recruitment of younger fishermen is becoming a concern for the sustainability of fishing and fishing traditions in the region.

2.2.1 Response to Previous Council Recommendations

At its 166th meeting held in Tumon, Guam, the Council directed staff to develop a brief report identifying data sources, quality, and coverage for a range of socioeconomic parameters in the annual/SAFE reports, as resources permit. This report also identifies the quality and coverage of the socioeconomic data, including any data gaps. The data synthesis was conducted and used to guide the development of the socioeconomic section with further input and guidance from the Council Social Science Planning Committee and Archipelagic Plan Team.

For future Annual/SAFE reports, the Council also directed the Plan Team to consider including enhanced information on social, economic, and cultural impacts of climate change resulting in increased pressure on the ocean and its resources. PIFSC developed a Regional Action Plan and Climate Science Strategy as a first step in providing the information (Polovina *et al.*, 2016).

2.2.2 Background

Human habitation in the PRIA is limited. The FEP for the PRIA provides a description of the geography, history, and socioeconomic considerations of the archipelago (WPRFMC, 2016). Grace-McCaskey (2014) provided a brief review of the importance of these areas from a cultural perspective. She noted that although the PRIA were uninhabited when first visited by Westerners, Polynesians and Micronesians likely had been periodically visiting these islands for centuries. Many of the islands in the PRIA were altered during WWII, and many have subsequently become National Wildlife Refuges or part of the Pacific Remote Islands Marine National Monument. Only Wake, Johnston, and Palmyra have seasonal- and year-round residents, primarily related to the U.S. military and refuge management. The surrounding reef ecosystems are considered to be some of the healthiest in the world due to their distance to areas of high human population densities, though some are experiencing residual impacts from military activity nearby. There are no designated fishing communities residing in the PRIA. Most of the fishing effort has been concentrated around Johnston and Palmyra by members of the Hawaii fishing community.

2.2.3 Ongoing Research and Information Collection

There is currently no ongoing research specific to the PRIA. In 2017, an external review of the Economics and Human Dimensions Program was undertaken (PIFSC, 2017). Recommendations from this review will help focus and prioritize a strategic research agenda going forward.

2.2.4 Relevant PIFSC Economics and Human Dimensions Publications: 2017

Bennett, N.J., Teh, L., Ota, Y., Christie, P., Ayers, A., Day, J.C., Franks, P., Gill, D., Gruby, R.L., Kittinger, J.N., and Koehn, J.Z., 2017. An appeal for a code of conduct for marine conservation. *Marine Policy*, 81, pp. 411-418.

<https://doi.org/10.1016/j.marpol.2017.03.035>.

Pacific Islands Fisheries Science Center (PIFSC), 2017. Background and PIFSC Response: Panel Reports of the Economics and Human Dimensions Program Review. 18 p.

<https://go.usa.gov/xnDyP>.

2.2.5 References

Grace-McCaskey, C., 2014. Examining the potential of using secondary data to better understand human-reef relationships across the Pacific. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96818-5007. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-14-01, 69 p.

https://www.pifsc.noaa.gov/library/pubs/admin/PIFSC_Admin_Rep_14-01.pdf

Polovina, J. and Dreftak, K., (Chairs), Baker, J., Bloom, S., Brooke, S., Chan, V., Ellgen, S., Golden, D., Hospital, J., Van Houtan, K., Kolinski, S., Lumsden, B., Maison, K., Mansker, M., Oliver, T., Spalding, S., and Woodworth-Jefcoats, P., 2016. Pacific Islands Regional Action Plan: NOAA Fisheries climate science strategy. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-59, 33 p. doi:10.7289/V5/TM-PIFSC-59.

WPRFMC, 2016. Annual Stock Assessment and Fishery Evaluation Report: Pacific Remote Island Area Fishery Ecosystem Plan 2016. Sabater, M., Ishizaki, A., Walker, R., Spalding, S. (Eds.) Western Pacific Regional Fishery Management Council. Honolulu, Hawaii 96813 USA.

2.3 PROTECTED SPECIES

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

2.3.1 Indicators for Monitoring Protected Species Interactions in the PRIA FEP Fisheries

This report monitors the status of protected species interactions in the PRIA FEP fisheries using proxy indicators such as fishing effort and changes in gear types as these fisheries do not have observer coverage. Logbook programs are not expected to provide reliable data about protected species interactions due to the lack of active fisheries in these areas.

2.3.1.1 FEP Conservation Measures

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

2.3.1.2 ESA Consultations

ESA consultations were conducted by NMFS and the U.S. Fish and Wildlife Service (USFWS; for species under their jurisdiction) to ensure ongoing fisheries operations managed under the PRIA FEP are not jeopardizing the continued existence of any listed species or adversely modifying critical habitat. The results of these consultations, conducted under section 7 of the ESA, are briefly described below and summarized in Table 3.

NMFS concluded in an informal consultation dated February 20, 2015 that all fisheries managed under the PRIA FEP are not likely to adversely affect the Indo-West Pacific DPS of scalloped hammerhead shark. NMFS concluded on January 16, 2015 that all fisheries managed under the PRIA FEP have no effects on ESA-listed reef-building corals.

In January 2018, oceanic whitetip sharks and giant manta rays were listed under the ESA (83 FR 4153 and 83 FR 2916, respectively). If NMFS determines that the PRIA fisheries are likely to adversely affect these species, NMFS will initiate consultation for these two species for the applicable fisheries

Table 3. Summary of ESA consultations for PRIA FEP Fisheries.

Fishery	Consultation Date	Consultation Type^a	Outcome^b	Species
Bottomfish	3/8/2002	BiOp	NLAA	Loggerhead sea turtle, leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, sei whale, sperm whale
Coral reef ecosystem	3/7/2002	LOC	NLAA	Loggerhead sea turtle, leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, sei whale, sperm whale
	5/22/2002	LOC (USFWS)	NLAA	Green, hawksbill, leatherback, loggerhead and olive ridley turtles, Newell's shearwater, short-tailed albatross, Laysan duck, Laysan finch, Nihoa finch, Nihoa millerbird, Micronesian megapode, 6 terrestrial plants
Crustacean	9/28/2007	LOC	NLAA	Loggerhead sea turtle, leatherback sea turtle, olive ridley sea turtle, green sea turtle, hawksbill sea turtle, humpback whale, blue whale, fin whale, sei whale, sperm whale
Precious coral	10/4/1978	BiOp	Does not constitute threat	Sperm whale, leatherback sea turtle
	12/20/2000	LOC	NLAA	Humpback whale, green sea turtle, hawksbill sea turtle
All fisheries	1/16/2015	No effect memo	No effect	Reef-building corals
	2/20/2015	LOC	NLAA	Scalloped hammerhead shark (Indo-west Pacific DPS)

^a BiOp = Biological Opinion; LOC = Letter of Concurrence; BE = Biological Evaluation.

^b LAA = likely to adversely affect; NLAA = not likely to adversely affect.

Bottomfish Fishery

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

Crustacean Fishery

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

Coral Reef Fishery

An informal consultation completed by NMFS on March 7, 2002 concluded that fishing activities conducted under the Coral Reef Ecosystems FMP are not likely to adversely affect five sea turtle species (loggerhead, leatherback, olive ridley, green, and hawksbill turtles) and five marine mammal species (humpback, blue, fin, sei, and sperm whales).

On May 22, 2002, the USFWS concurred with the determination of NMFS that the activities conducted under the Coral Reef Ecosystems FMP are not likely to adversely affect listed species under USFWS's exclusive jurisdiction (i.e., seabirds and terrestrial plants) and listed species shared with NMFS (i.e., sea turtles).

Precious Coral Fishery

An informal consultation completed by NMFS on December 20, 2000 concluded that PRIA precious coral fisheries are not likely to adversely affect humpback whales, green turtles, or hawksbill turtles.

2.3.1.3 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. PRIA fisheries are not classified under the LOF due to the lack of active commercial fisheries.

2.3.2 Status of Protected Species Interactions in the PRIA FEP Fisheries

There are currently no bottomfish, crustacean, coral reef, or precious coral fisheries operating in the PRIA, and no historical observer data are available for fisheries under this FEP. No new fishing activity has been reported, and there is no other information to indicate that impacts to protected species from PRIA fisheries have changed in recent years.

2.3.3 Identification of Emerging Issues

Several ESA-listed species are being evaluated for critical habitat designation (

Table 4). If critical habitats are designated, they will be included in this SAFE report and impacts from FEP-managed fisheries will be evaluated under applicable mandates.

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Table 4. Candidate ESA species, and ESA-listed species being evaluated for critical habitat designation.

Species		Listing process			Post-listing activity	
Common name	Scientific name	90-day finding	12-month finding / Proposed rule	Final rule	Critical Habitat	Recovery Plan
Oceanic whitetip shark	<i>Carcharhinus longimanus</i>	Positive (81 FR 1376, 1/12/2016)	Positive, threatened (81 FR 96304, 12/29/2016)	Listed as Threatened (83 FR 4153, 1/30/18)	Not determinable because of insufficient data (83 FR 4153, 1/30/18)	TBA
Pacific bluefin tuna	<i>Thunnus orientalis</i>	Positive (81 FR 70074, 10/11/2016)	Not warranted (82 FR 37060, 8/8/17)	N/A	N/A	N/A
Giant manta ray	<i>Manta birostris</i>	Positive (81 FR 8874, 2/23/2016)	Positive, threatened (82 FRN 3694, 1/12/2017)	Listed as Threatened (83 FR 2916, 1/22/18)	N/A	N/A
Reef manta ray	<i>Manta alfredi</i>	Positive (81 FR 8874, 2/23/2016)	Not warranted (82 FRN 3694, 1/12/2017)	N/A	N/A	N/A
Corals	N/A	Positive for 82 species (75 FR 6616, 2/10/2010)	Positive for 66 species (77 FR 73219, 12/7/2012)	20 species listed as threatened (79 FR 53851, 9/10/2014)	In development, proposal expected TBA	In development, expected TBA, interim recovery outline in place
Green sea turtle	<i>Chelonia mydas</i>	Positive (77 FR 45571, 8/1/2012)	Identification of 11 DPSs, endangered and threatened (80 FR 15271, 3/23/2015)	11 DPSs listed as endangered and threatened (81 FR 20057, 4/6/2016)	In development, proposal expected TBA ^a	TBA

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

2.3.4 Identification of Research, Data, and Assessment Needs

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

- Improve the precision of commercial and non-commercial fisheries data to improve understanding of potential protected species impacts.
- Define and evaluate innovative approaches to derive robust estimates of protected species interactions in insular fisheries.

2.4 CLIMATE AND OCEANIC INDICATORS

2.4.1 Introduction

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

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

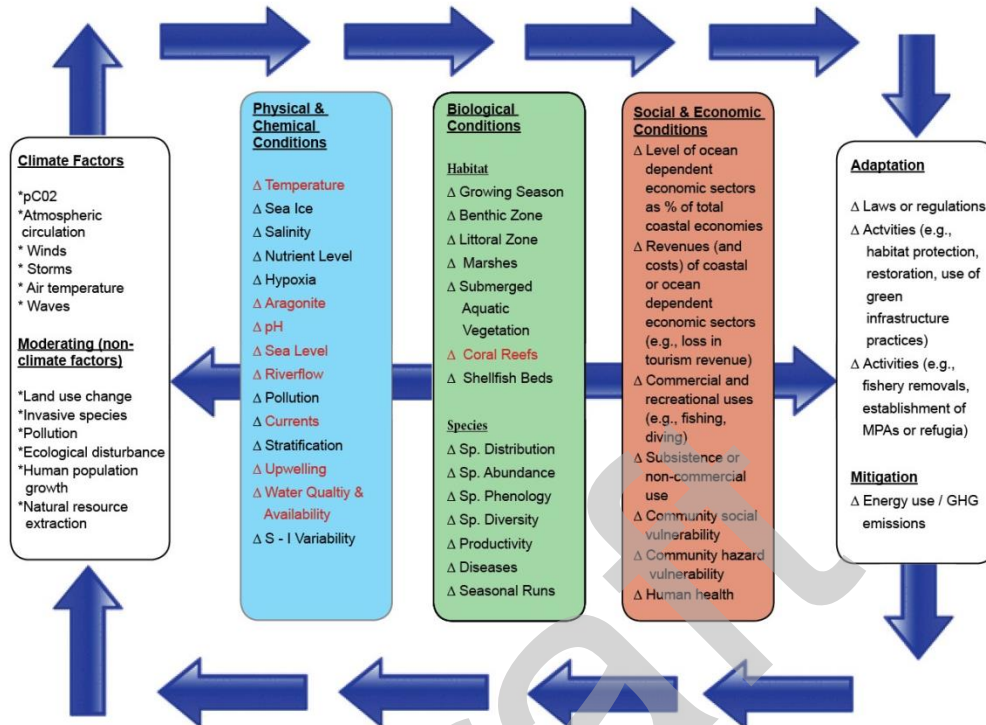
Starting with the 2015 Report, the Council and its partners have provided continuing descriptions of changes in a series of climate and oceanic indicators that will grow and evolve over time as they become available and their relevance to Western Pacific fishery resources becomes clear.

2.4.2 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:

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



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

Figure 5. 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 Annual Report; the specific indicators used in the Report are listed in Section 2.4.3. 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.

2.4.3 Selected Indicators

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

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

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

Atmospheric Carbon Dioxide (at Mauna Loa Observatory) – Increasing atmospheric CO₂ is a primary measure of anthropogenic climate change.

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

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

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

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

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

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

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

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

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

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

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

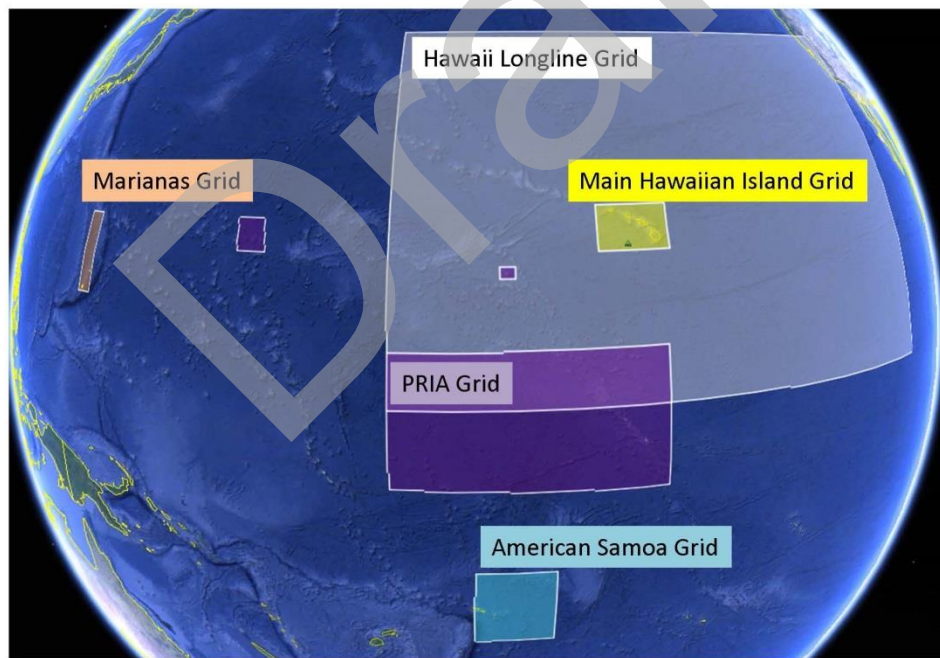


Figure 6. Regional spatial grids representing the scale of the climate change indicators being monitored.

Table 5. Climate and Ocean Indicator Summary.

Indicator	Definition and Rationale	Indicator Status
Atmospheric Concentration of Carbon Dioxide (CO ₂)	Atmospheric concentration CO ₂ at Mauna Loa Observatory. Increasing atmospheric CO ₂ is a primary measure of anthropogenic climate change.	Trend: increasing exponentially 2017: time series mean 406.53 ppm
Oceanic pH	Ocean surface pH at Station ALOHA. Ocean pH provides a measure of ocean acidification. Increasing ocean acidification limits the ability of marine organisms to build shells and other hard structures.	Trend: pH is decreasing at a rate of 0.039 pH units per year, equivalent to 0.4% increase in acidity per year
Oceanic Niño Index (ONI)	Sea surface temperature anomaly from Niño 3.4 region (5°N - 5°S, 120° - 170°W). This index is used to determine the phase of the El Niño – Southern Oscillation (ENSO), which has implications across the region, affecting migratory patterns of key commercial fish stocks which in turn affect the location, safety, and costs of commercial fishing.	2017: ENSO Neutral
Pacific Decadal Oscillation (PDO)	PDO can be thought of as a long-lived, multi-decadal ENSO cycle that has well-documented fishery implications related to ocean temperature and productivity.	2017: positive (warm) from Jan – June, negative (cool) from Jul – Dec
Sea Surface Temperature* (SST)	Satellite remotely-sensed sea surface temperature. SST is projected to rise, and impacts phenomena ranging from winds to fish distribution.	SST in waters surrounding most of PRIA ranged between 27-30° C with 2017 showing anomalies dependent on latitude: along the equator, 2017 showed a negative anomaly, while at ~4 deg N, the 2017 anomaly moves positive.
Coral Thermal Bleaching Exposure (DHW)	Satellite remotely-sensed metric of time and temperature above thresholds relevant for coral bleaching. Metric used is Degree Heating Weeks (DHW).	The equatorial PRIA showed prolonged, substantial DHW stress in 2015-2016, in which DHW values exceeded the range in which mass mortality is expected (DHW>8). Wake Atoll showed more regular, but less prolonged heating events ('14, '15, '17).
Chlorophyll-A (Chl-A)	Satellite remotely-sensed chlorophyll-a. Chl-A is projected to drop over much of the central Pacific, and is directly linked ecosystem productivity.	The Chl-A around the PRIA ranges from 0.08 to 0.35 mg/m ³ , with 2017 showing a near-zero and spatially variable anomaly.

Tropical Cyclones	Measures of tropical cyclone occurrence, strength, and energy. Tropical cyclones have the potential to significantly impact fishing operations.	Eastern Pacific, 2017: 31 storms, a level slightly lower than average.
		South Pacific, 2017: 6 storms, low – lowest since 2012.
		Central Pacific, 2017: 0 storms. Very low.
Rainfall/Precipitation	CMAP re-analysis of CPC Precipitation Data	2017 showed negative anomalies in rainfall.
Sea Level/Sea Surface Height	Monthly mean sea level time series, including extremes. Data from satellite altimetry & in situ tide gauges. Rising sea levels can result in a number of coastal impacts, including inundation of infrastructure, increased damage resulting from storm-driven waves and flooding, and saltwater intrusion into freshwater supplies.	Although varying over time the monthly mean sea level trend is increasing.

2.4.3.1 Atmospheric Concentration of Carbon Dioxide (CO₂) at Mauna Loa

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

Status: Atmospheric CO₂ is increasing exponentially. In 2017, the annual mean concentration of CO₂ was 406.53 ppm. In 1959, the first year of the time series, it was 315.97 ppm. The annual mean passed 350 ppm in 1988 and 400 ppm in 2015.

Description: Monthly mean atmospheric carbon dioxide (CO₂) at Mauna Loa Observatory, Hawai`i in parts per million (ppm) from March 1958 to present.

The observed increase in monthly average carbon dioxide concentration is primarily due to CO₂ emissions from fossil fuel burning. Carbon dioxide remains in the atmosphere for a very long time, and emissions from any location mix throughout the atmosphere in about one year. The annual oscillations at Mauna Loa, Hawai`i are due to the seasonal imbalance between the photosynthesis and respiration of plants on land. During the summer growing season photosynthesis exceeds respiration and CO₂ is removed from the atmosphere, whereas outside the growing season respiration exceeds photosynthesis and CO₂ is returned to the atmosphere. The seasonal cycle is strongest in the northern hemisphere because of this hemisphere's larger land mass.

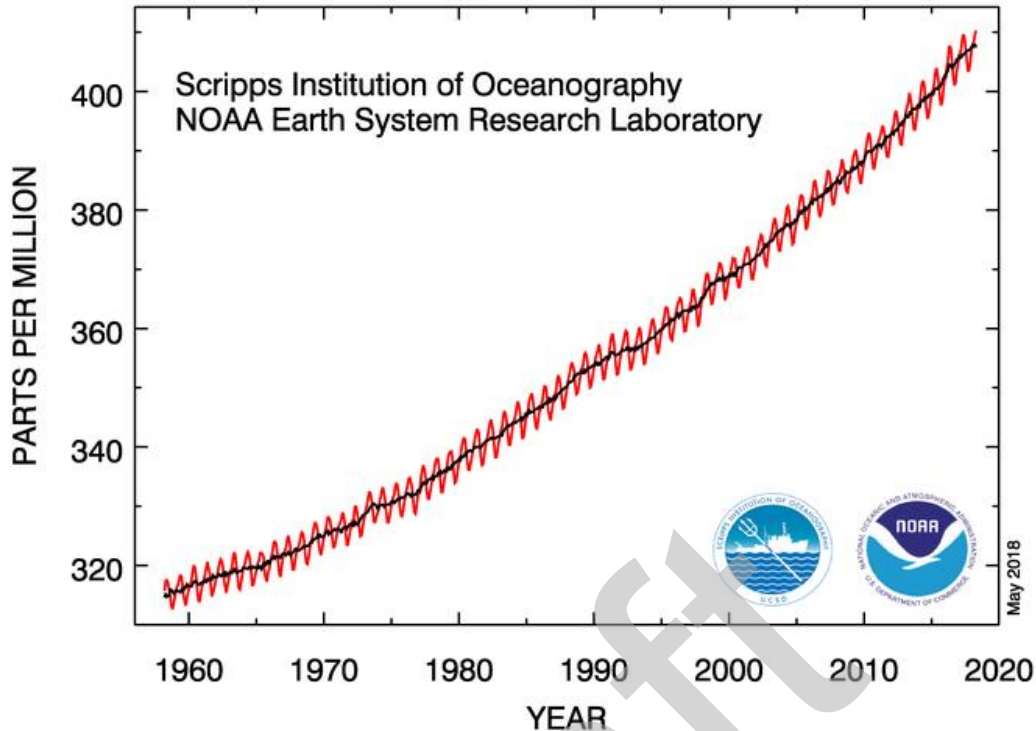


Figure 7. Monthly mean atmospheric carbon dioxide at Mauna Loa Observatory, Hawai`i. The red line shows monthly averages and the black line shows seasonally corrected data.

Timeframe: Annual, monthly

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

Data Source: “Full Mauna Loa CO₂ record” available at <https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html>. Data from additional monitoring stations, including the Tutuila, American Samoa station are available at <https://www.esrl.noaa.gov/gmd/dv/iadv/>.

Measurement Platform: *In-situ* station

References:

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

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

2.4.3.2 Oceanic pH

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

Status: Oceanic pH has shown a significant linear decrease of 0.0369 pH units, or roughly an 8.9% increase in acidity, over the nearly 30 years spanned by this time series. Additionally, the highest pH value reported for the most recent year (8.0846) is roughly equal to the lowest pH value reported in the first year of the time series (8.0845).

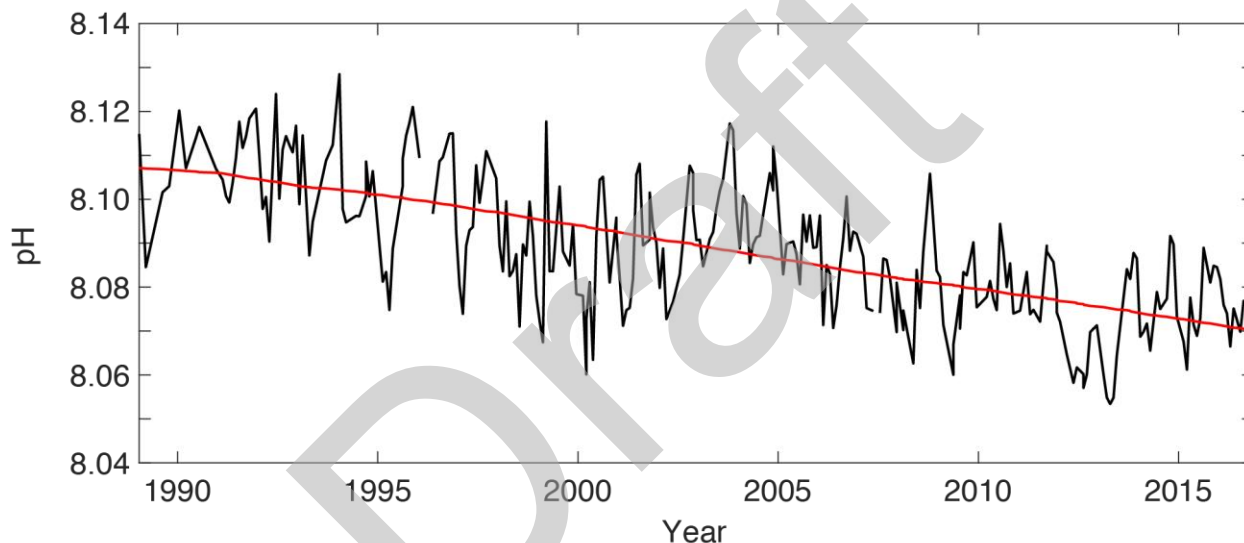


Figure 8. pH Trend at Station ALOHA, 1989 – 2016. Note: Measured pH values are plotted in black. The linear fit to this time series is shown in red.

Description: Trends in surface (5 m) pH at Station ALOHA, north of Oahu (22.75°N, 158°W), collected by the Hawai'i Ocean Time-series (HOT) from October 1988 to 2016 (2017 data are not yet available). Oceanic pH is a measure of ocean acidity, which increases as the ocean absorbs carbon dioxide from the atmosphere. Lower pH values represent greater acidity. The multi-decadal time series at Station ALOHA represents the best available documentation of the significant downward trend in oceanic pH since the time series began in 1988. Oceanic pH varies over both time and space, though the conditions at Station ALOHA are considered broadly representative of those across the Western and Central Pacific's pelagic fishing grounds.

Timeframe: Monthly

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

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

Measurement Platform: *In-situ* station

References:

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

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

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

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

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

2.4.3.3 Oceanic Niño Index

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

Status: The ONI was neutral in 2017.

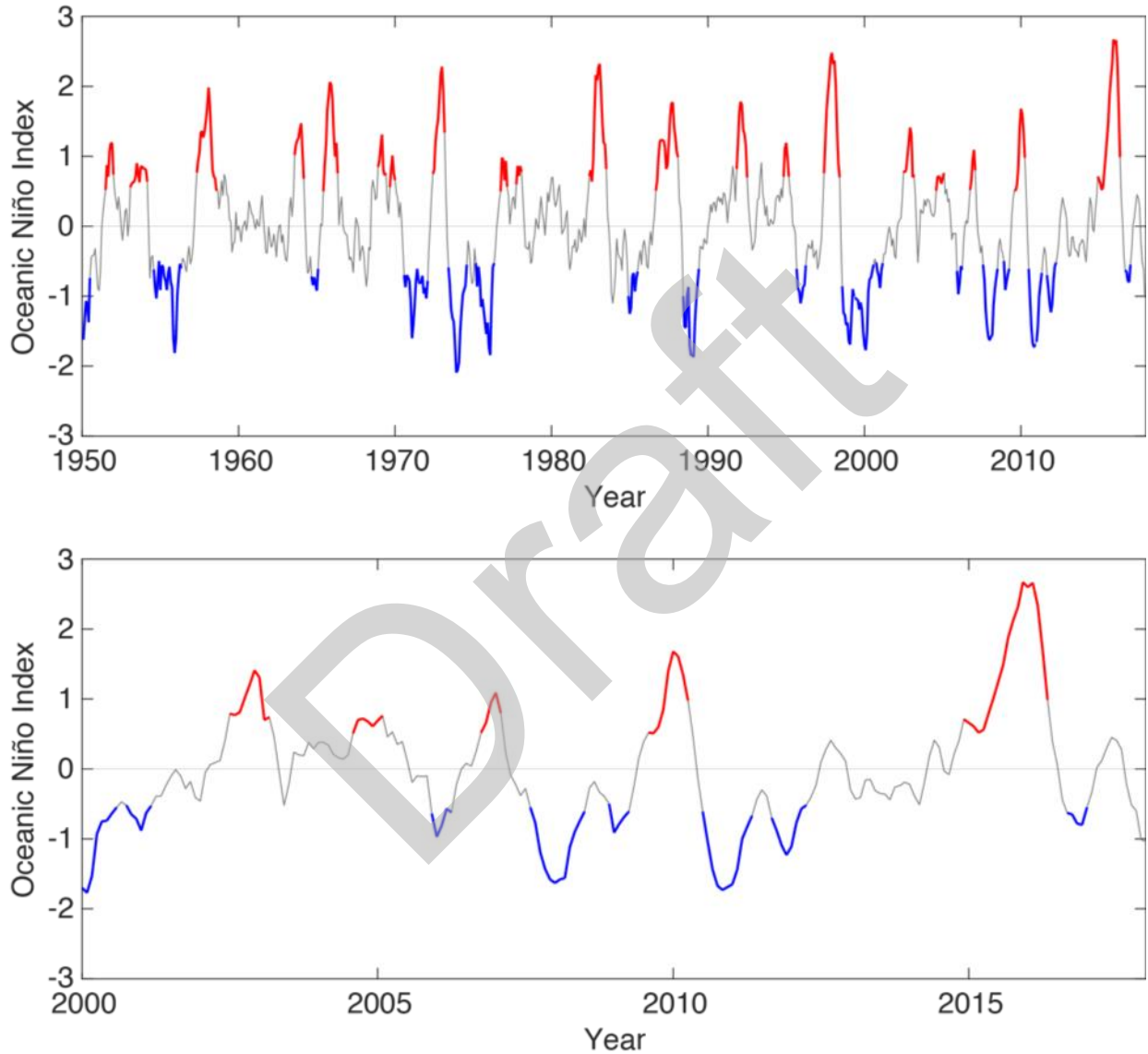


Figure 9. Oceanic Niño Index, 1950-2017 and 2000–2017. Note: Monthly time series of the Oceanic Niño Index for 1950 – 2017 (top) and 2000 – 2017 (bottom). El Niño periods are highlighted in red. La Niña periods are highlighted in blue.

Description: The three-month running mean of ERSST .v4 sea surface temperature (SST) anomalies in the Niño 3.4 region (5°S – 5°N, 120° – 170°W). The Oceanic Niño Index (ONI) is a measure of the El Niño – Southern Oscillation (ENSO) phase. Warm and cool phases, termed El Niño and La Niña respectively, are based in part on an ONI threshold of ± 0.5 °C being met for a minimum of five consecutive overlapping seasons. Additional atmospheric indices are needed to confirm an El Niño or La Niña event, as the ENSO is a coupled ocean-atmosphere phenomenon. The atmospheric half of this Pacific basin oscillation is measured using the Southern Oscillation Index.

Timeframe: Every three months

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

Data Source: NOAA NCEI at

<https://www.ncdc.noaa.gov/teleconnections/enso/indicators/sst.php>.

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

References:

A full description of ENSO and its global impacts can be found at:

<https://www.climate.gov/news-features/understanding-climate/el-ni%C3%B1o-and-la-ni%C3%B1a-frequently-asked-questions>

2.4.3.4 Pacific Decadal Oscillation

Rationale: The Pacific Decadal Oscillation (PDO) was initially named by a fisheries scientist, Steven Hare, in 1996 while researching connections between Alaska salmon production cycles and Pacific climate. Like ENSO, the PDO reflects changes between periods of persistently warm or persistently cool ocean temperatures, but over a period of 20 – 30 years versus 6 – 18 months for ENSO event. The climatic finger prints of the PDO are most visible in the Northeastern Pacific, but secondary signatures exist in the tropics.

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

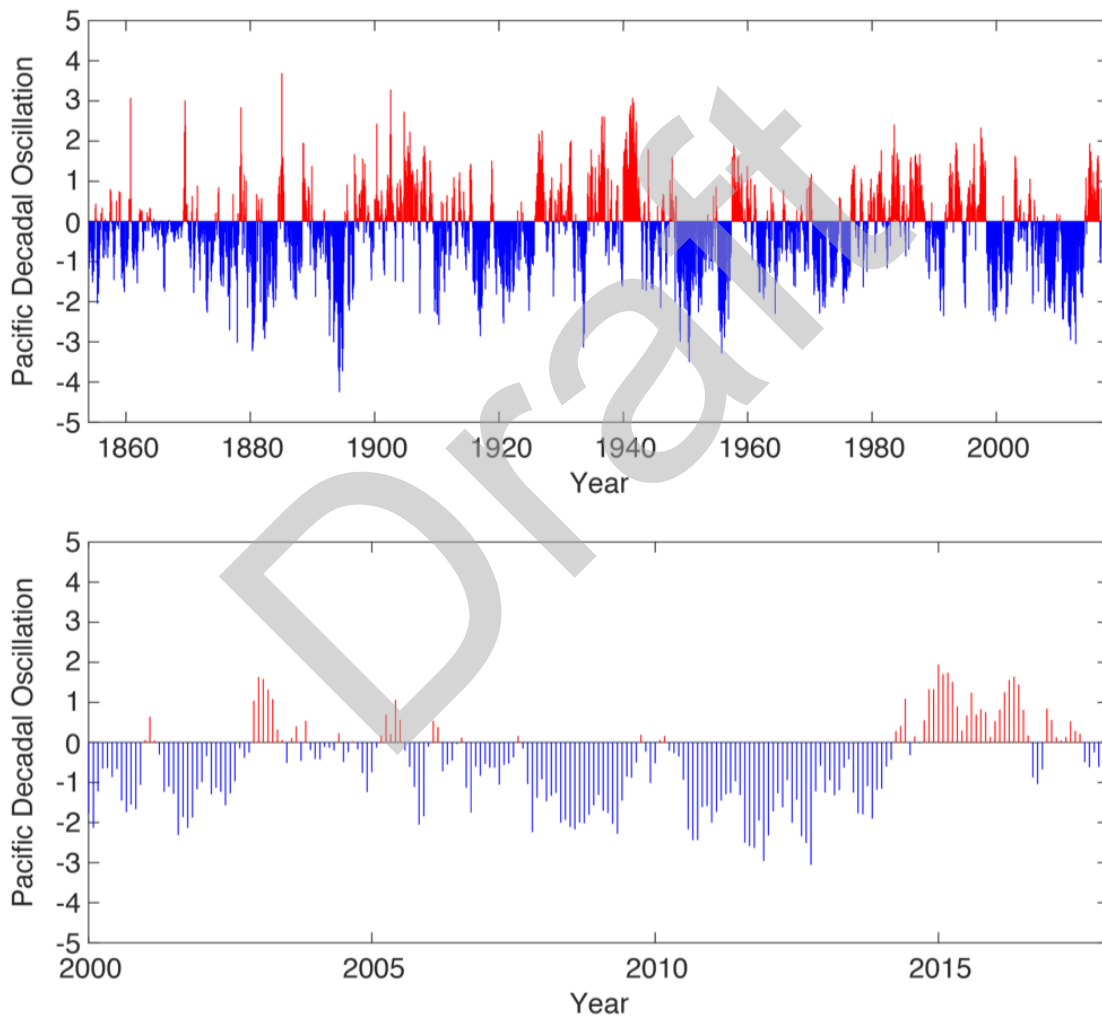


Figure 10. Pacific Decadal Oscillation, 1854–2017 (top) and 2000–2017 (bottom). Note: Positive, or warm, phases are plotted in red. Negative, or cool, phases are plotted in blue.

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

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

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

Timeframe: Annual, monthly

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

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

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

References:

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

2.4.3.5 Sea Surface Temperature & Anomaly

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

Short Descriptions:

Text from the OceanWatch Central Pacific Node:

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

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

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

Technical Summary:

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

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

Science (RSMAS) while distribution is a collaborative effort between the NASA Physical Oceanography Distributed Active Archive Center (PO.DAAC) and the NODC. From a historical perspective, the Pathfinder program was originally initiated in the 1990s as a joint NOAA/NASA research activity for reprocessing of satellite based data sets including SST.

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

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

GOES-POES dataset - Text from:

https://www.star.nesdis.noaa.gov/sod/mech/blended_validation/background.php

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

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

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

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

Region/Location: Global.

Data Source:

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

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

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

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

References:

- Li, X., Pichel, W.G., Clemente-Colón, P., and Sapper J.F., 2001a. Deriving the operational nonlinear multi-channel sea surface temperature algorithm coefficients for NOAA-15 AVHRR/3, *Int. J. Remote Sens.*, 22(4), pp. 699 - 704.
- Li, X., Pichel, W.G., Clemente-Colón, P., Krasnopolsky, V., and Sapper J.F., 2001b. Validation of coastal sea and lake surface temperature measurements derived from NOAA/AVHRR Data, *Int. J. Remote Sens.*, 22(7), pp. 1285-1303.
- Stowe, L.L., Davis, P.A., and McClain, E.P., 1999. Scientific basis and initial evaluation of the CLAVR-1 global clear/cloud classification algorithm for the advanced very high resolution radiometer. *J. Atmos. Oceanic Technol.*, 16, pp. 656-681.
- Walton C.C., Pichel, W.G., Sapper, J.F., May, D.A., 1998. The development and operational application of nonlinear algorithms for the measurement of sea surface temperatures with the NOAA polar-orbiting environmental satellites, *J. Geophys. Res.*, 103:(C12), pp. 27999-28012.

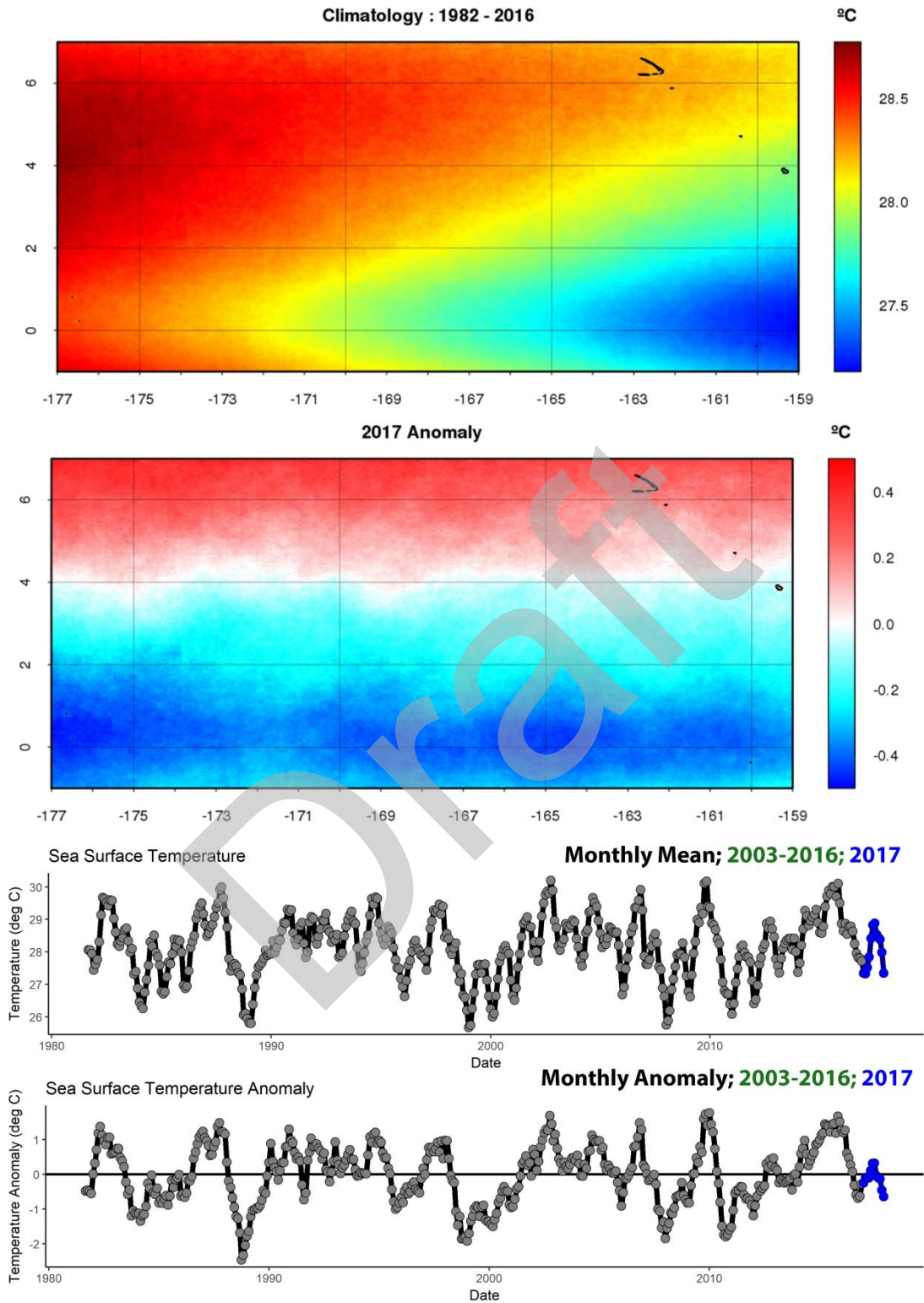


Figure 11. Sea surface temperature (SST) and SST Anomaly across the PRIA (excluding Wake Island and Johnston Atoll).

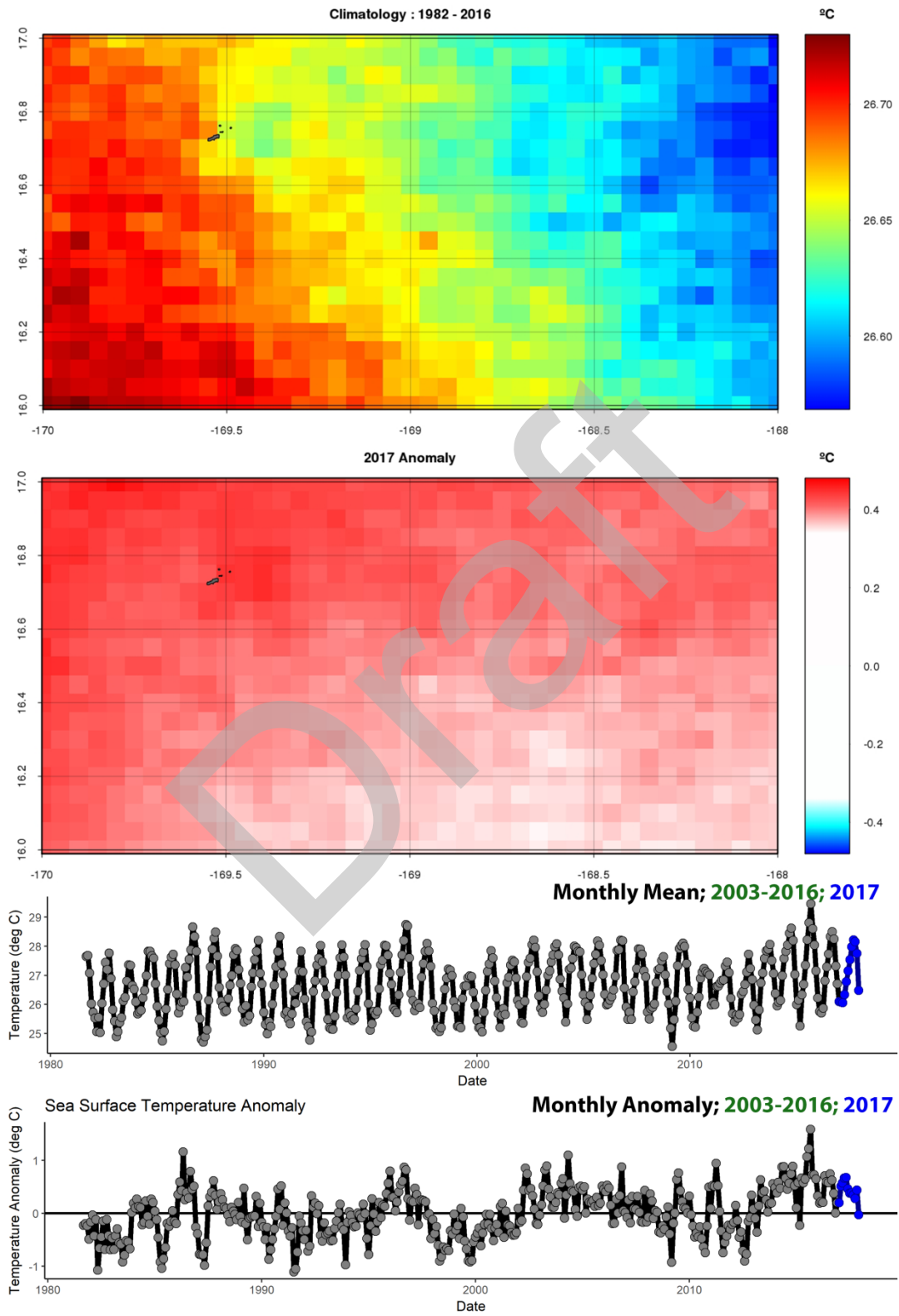


Figure 12. Sea surface temperature (SST) and SST Anomaly at Johnston Atoll.

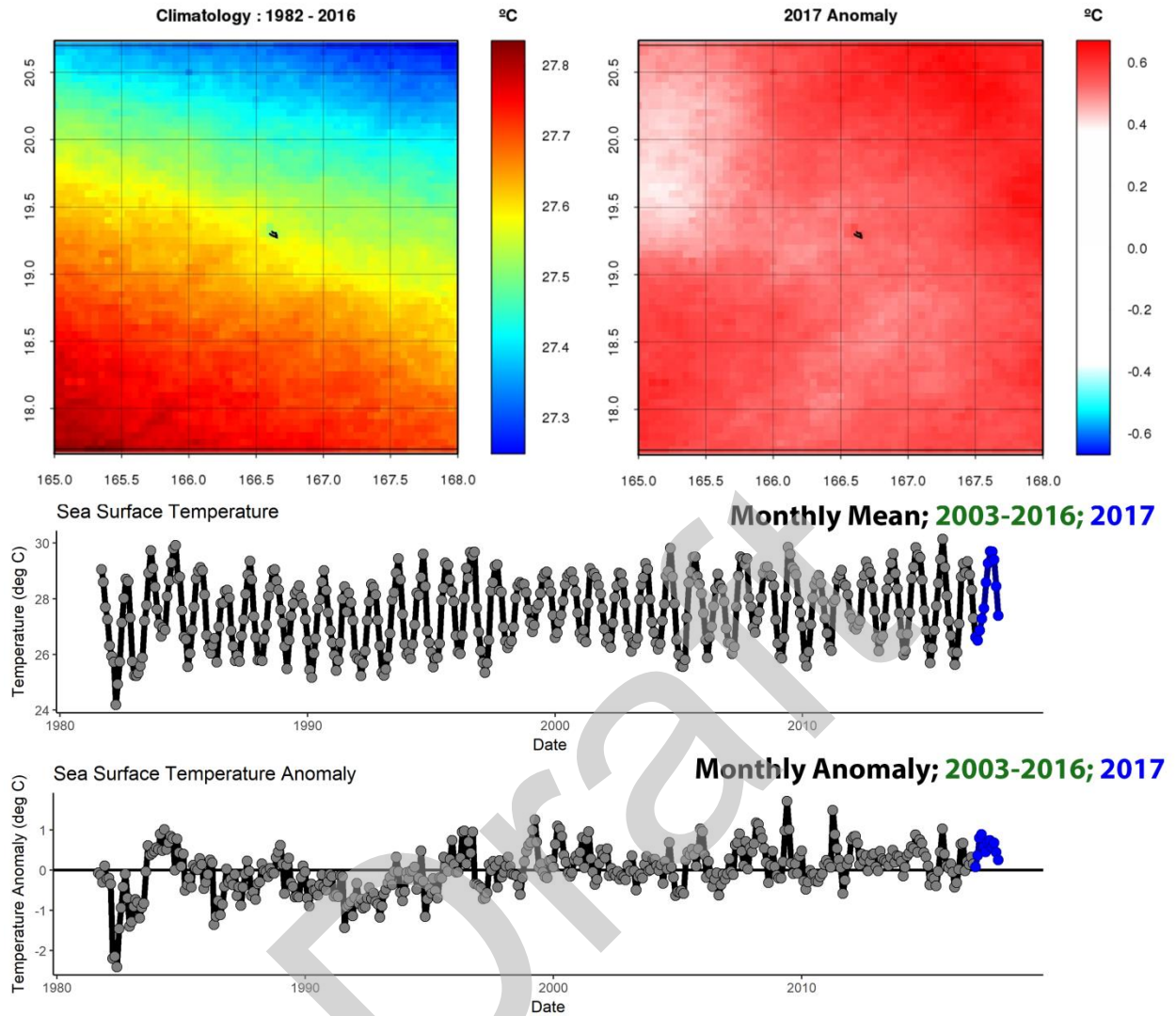


Figure 13. Sea surface temperature (SST) and SST Anomaly at Wake Atoll.

2.4.3.6 Coral Thermal Stress Exposure: Degree Heating Weeks

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

Short Description:

Text inserted from the NOAA [Coral Reef Watch](#) website.

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

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

Technical Summary:

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

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

A significantly improved climatology was introduced in the Version 3 products. It was derived from a combination of NOAA/NESDIS' 2002-2012 reprocessed daily global 5km Geo-Polar Blended Night-only SST Analysis and the 1985-2002 daily global 5km SST reanalysis, produced by the United Kingdom Met Office, on the Operational SST and Sea Ice Analysis (OSTIA) system. The near-real-time OSTIA SST was recently incorporated into the generation of NESDIS' operational daily 5km Blended SST that CRW's 5km coral bleaching heat stress monitoring product suite is based on. Hence, the 2002-2012 reprocessed 5km Geo-Polar Blended SST that has just become available, extended with the 1985-2002 portion of the 5km OSTIA

SST reanalysis, is the best historical 1985-2012 global SST dataset for deriving a climatology that is internally consistent and compatible with CRW's near-real-time 5km satellite coral bleaching heat stress monitoring products. Although the reprocessed 5km Geo-Polar Blended SST dataset is available to the end of 2016, to be consistent with the time period (1985-2012) of the climatology used in our Version 2 5km product suite, the Version 3 climatology is based on the same time period. It was then re-centered to the center of the baseline time period of 1985-1990 plus 1993, using the method described in [Heron *et al.*, \(2015\)](#) and [Liu *et al.*, \(2014\)](#), and was based on our monitoring algorithm (also described in these articles). More recent years may be incorporated in the climatology for future versions of CRW's 5 km products, but potential impacts on the products require further evaluation first.

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

Development of this next-generation 5 km product suite was accomplished through a collaboration of NOAA Coral Reef Watch, the University of South Florida, NASA-Ames, the UNEP World Conservation Monitoring Centre, and the Cooperative Institute for Research in Environmental Science, with funding support from the NASA Biodiversity and Ecological Forecasting program, the NOAA Coral Reef Conservation Program, and the NOAA/NESDIS Ocean Remote Sensing Program. Production of the Version 3 suite was made possible through funding from the NOAA Coral Reef Conservation Program. The 5km product suite, which was featured in the [NASA Applied Sciences Program's 2013 Annual Report](#), will undergo continuous improvements.

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

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

Timeframe: 2013-2017, Daily data.

Region/Location: Global.

Data Source: "NOAA Coral Reef Watch" <https://coralreefwatch.noaa.gov>

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

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

References:

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

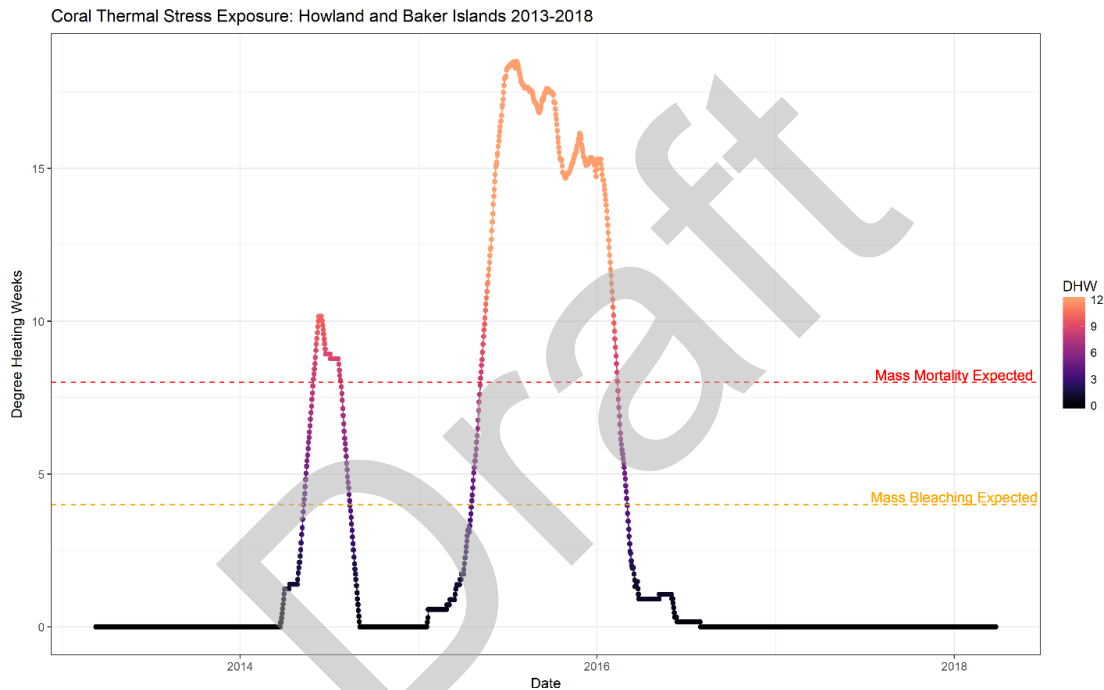


Figure 14. Coral Thermal Stress Exposure, Howland-Baker Virtual Station 2013-2017. Coral Reef Watch Degree Heating Weeks.

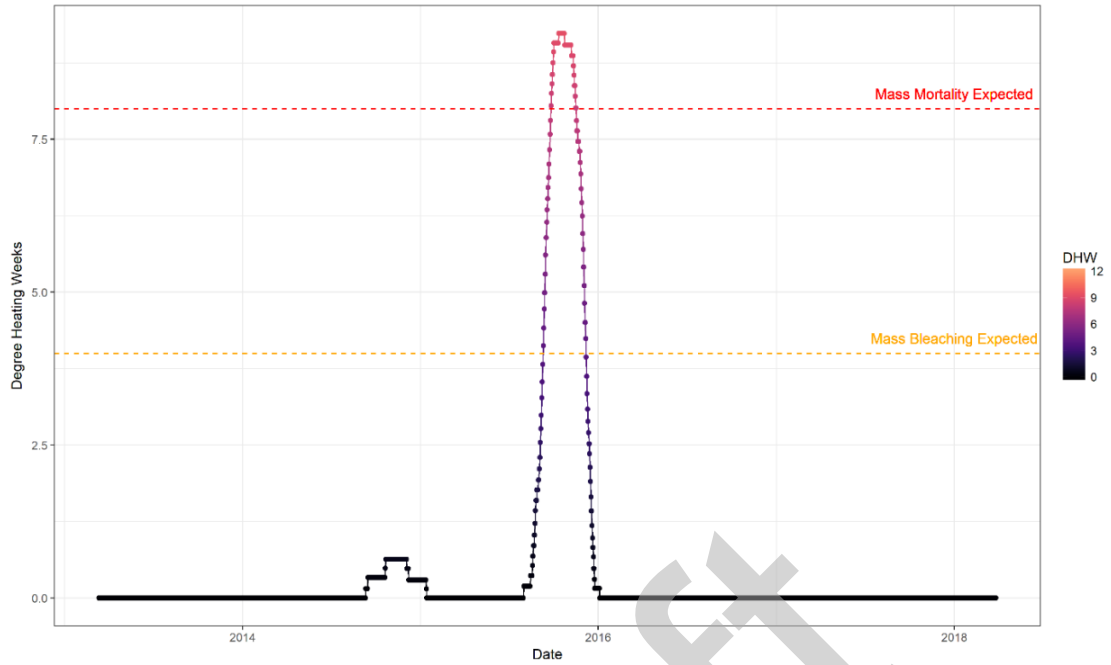


Figure 15. Coral Thermal Stress Exposure measured at Johnston Atoll Virtual Station 2013-2017 (Coral Reef Watch Degree Heating Weeks).

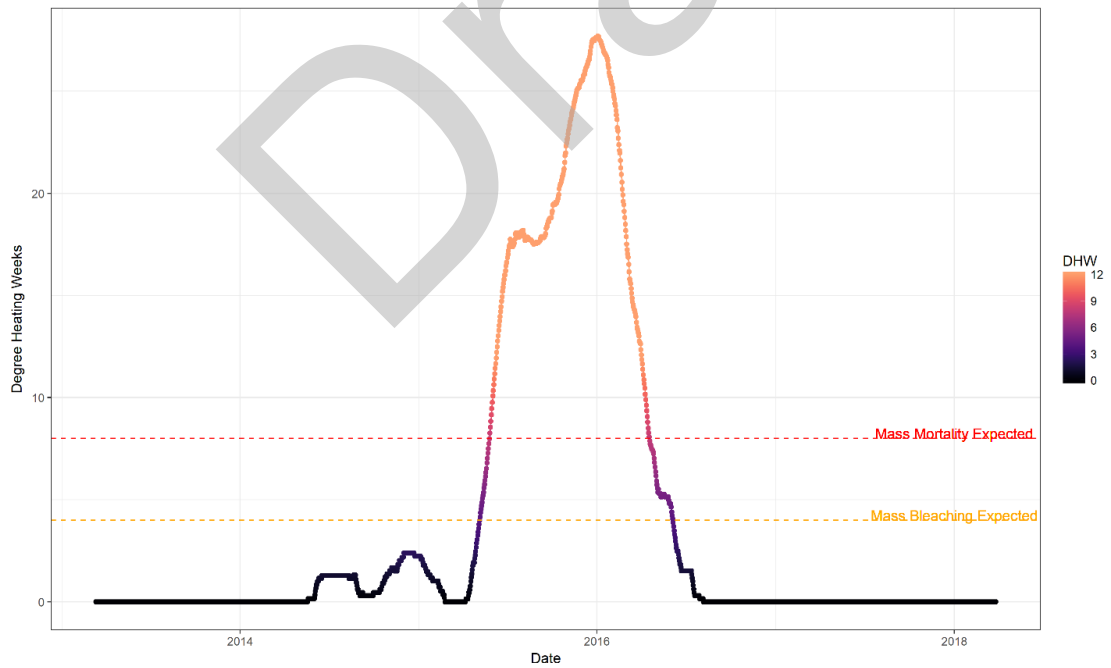


Figure 16. Coral Thermal Stress Exposure measured at Northern Line Islands Virtual Station 2013-2017 (Coral Reef Watch Degree Heating Weeks).

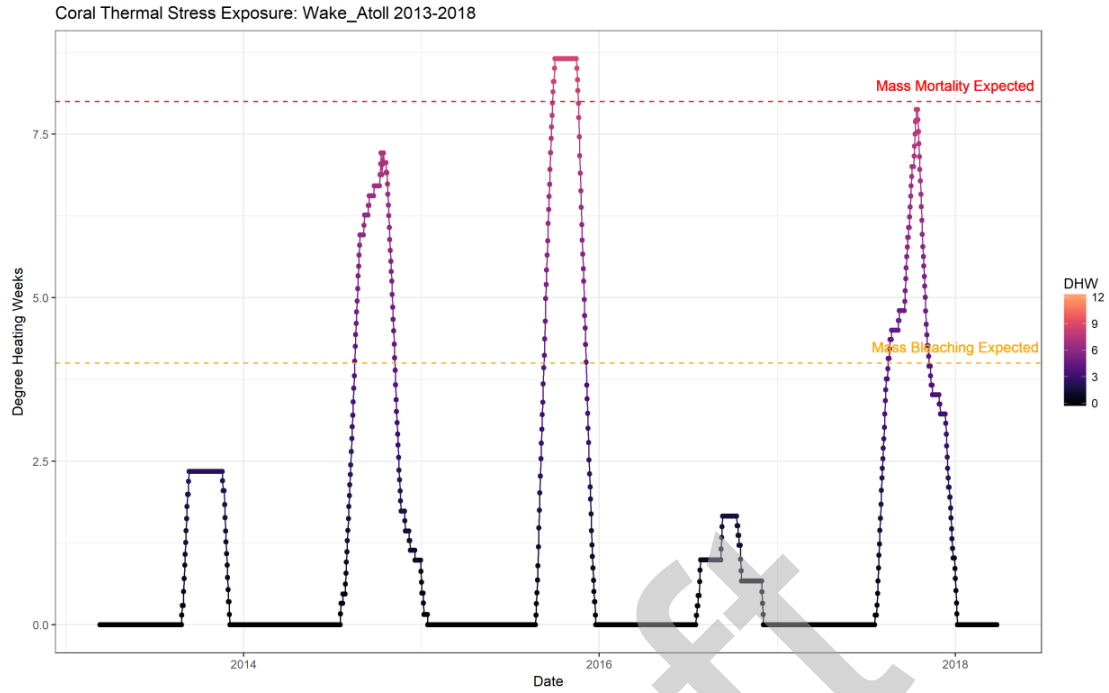


Figure 17. Coral Thermal Stress measured at Wake Atoll Virtual Station 2013-2017 (Coral Reef Watch Degree Heating Weeks).

2.4.3.7 Chlorophyll-A and Anomaly

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

Short Description:

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

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

Technical Summary:

Text inserted from:

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

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

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

Region/Location: Global.

Data Source:

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

Measurement Platform: *MODIS sensor on NASA Aqua Satellite*

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

References:

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

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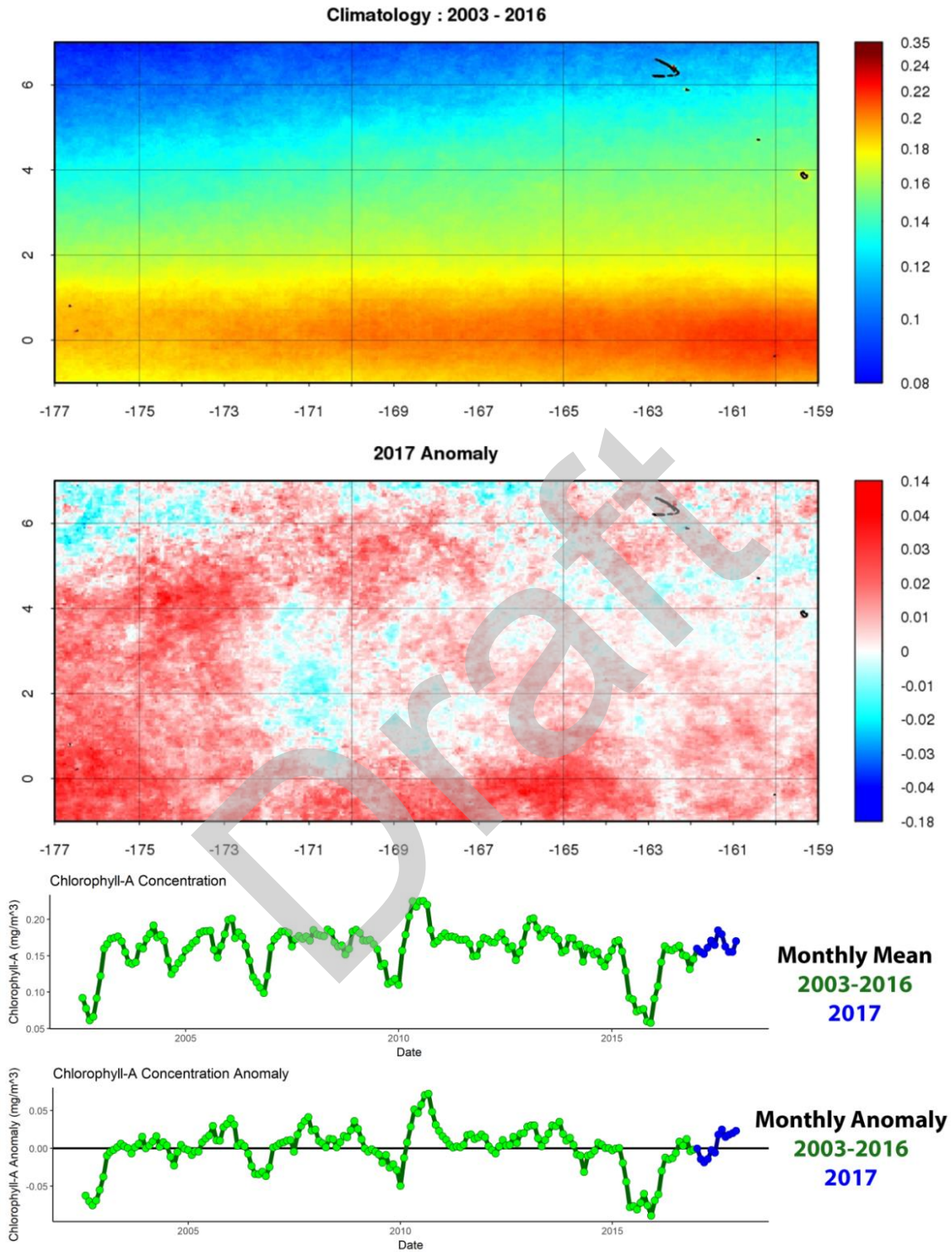


Figure 18. Chlorophyll-A (Chl-A) and Chl-A Anomaly across the PRIA (excluding Johnston Atoll and Wake Atoll) from 2003-2017.

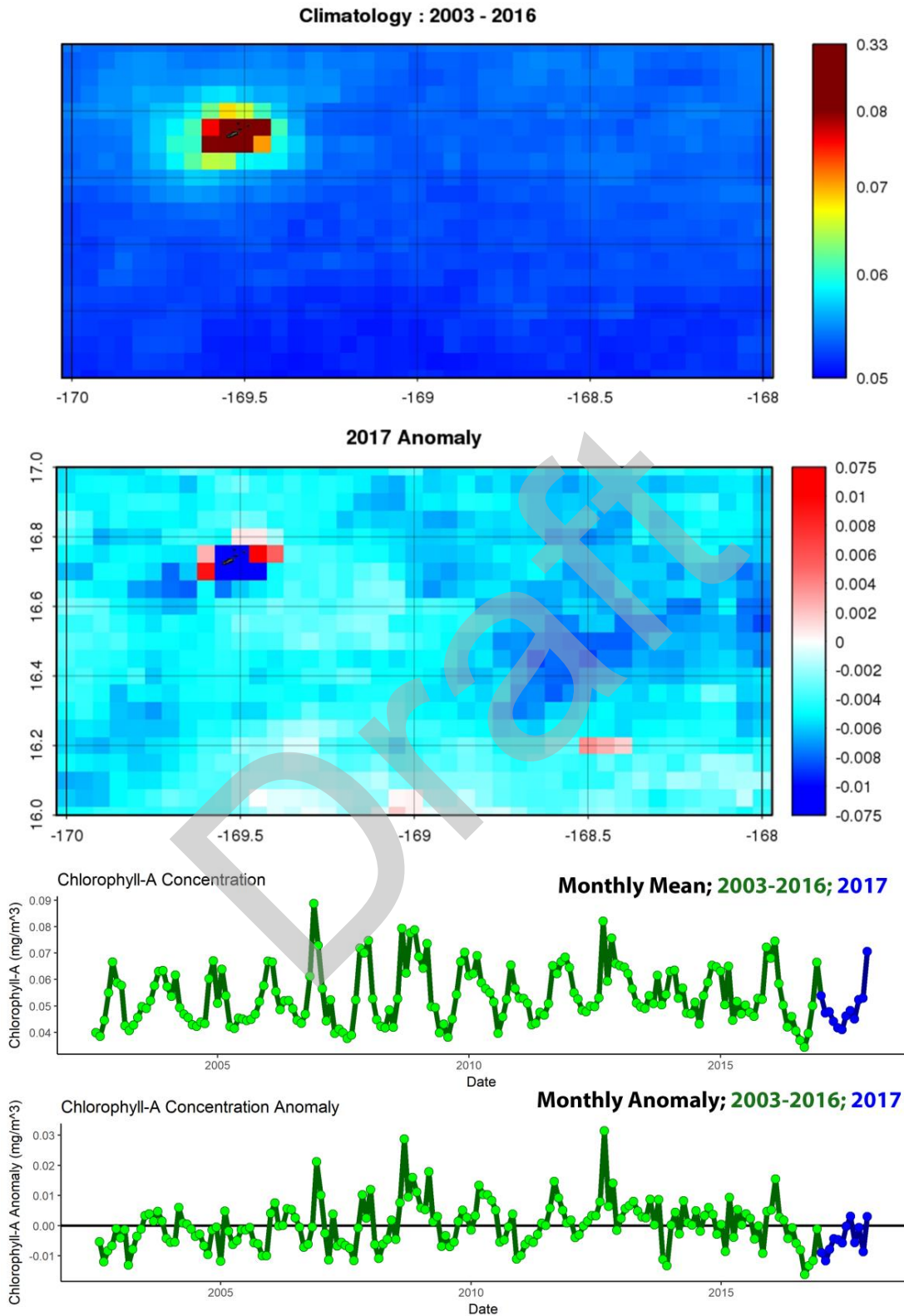


Figure 19. Chlorophyll-A (Chl-A) and Chl-A Anomaly at Johnston Atoll from 2003-2017.

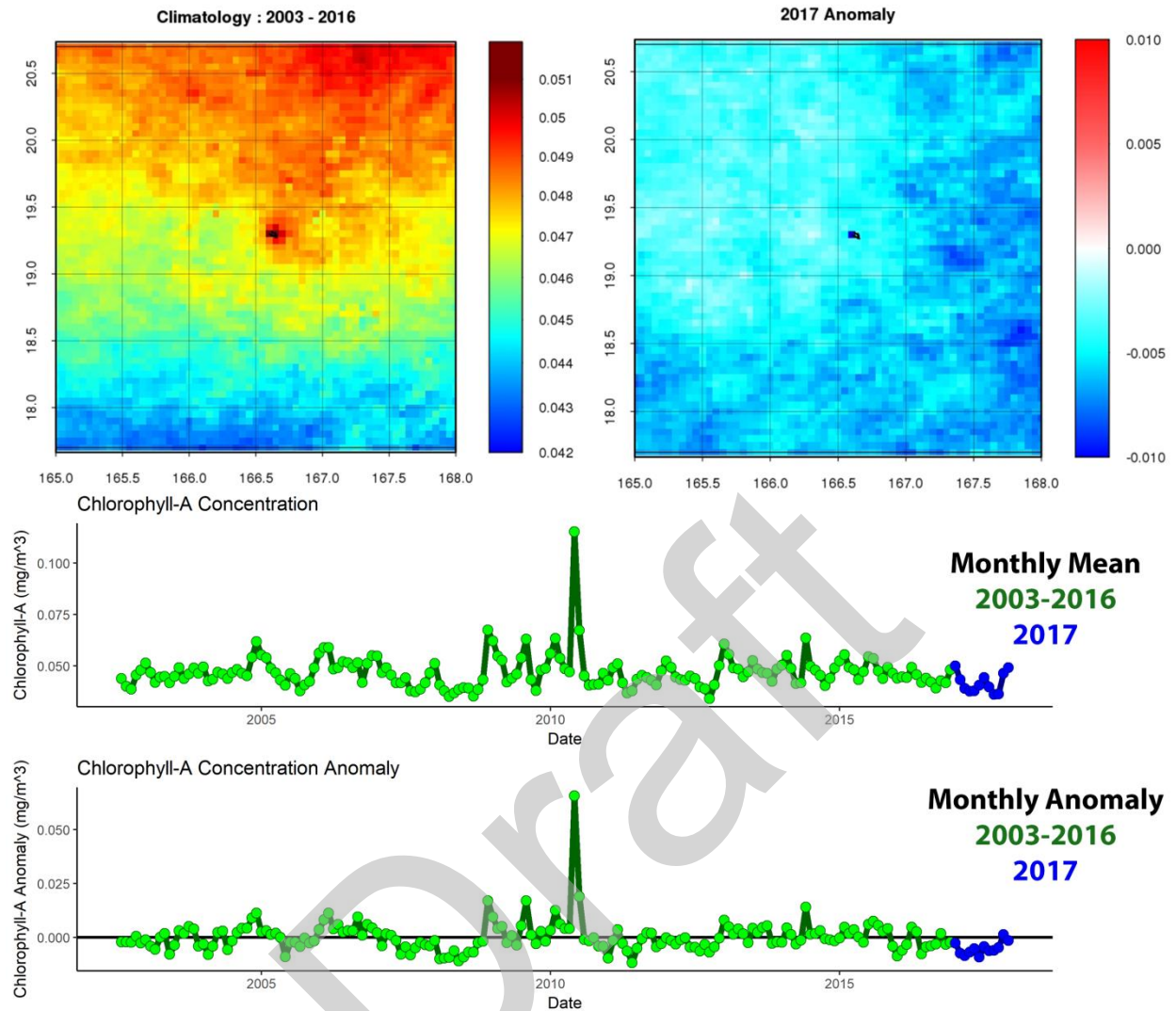


Figure 20. Chlorophyll-A (Chl-A) and Chl-A Anomaly at Wake Atoll from 2003-2017.

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

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

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

Every cyclone has an ACE Index value, which is a computed value based on the maximum wind speed measured at six-hourly intervals over the entire time that the cyclone is classified as at least a tropical storm (wind speed of at least 34 knot; 39 mph). Therefore, a storm's ACE Index value accounts for both strength and duration. This plot shows the historical ACE values for each typhoon season and has a solid line representing the 1981-2010 average ACE value.

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

Timeframe: Yearly

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

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

Measurement Platform: Satellite

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

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

While reports on activity during 2017 are not yet available for the south and central Pacific, the NOAA National Centers for Environmental Information, State of the Climate: Hurricanes and Tropical Storms for Annual 2017, published online January 2018, notes that “The 2017 East Pacific hurricane season had 18 named storms, including nine hurricanes, four of which became major.” The 1981-2010 average number of named storms in the East Pacific was 16.5, with 8.9 hurricanes, and 4.3 major hurricanes. Five Eastern Pacific tropical cyclones made landfall in 2017. Tropical Storm Selma made landfall in El Salvador and tropical storms Beatrix, Calvin, Lidia and Hurricane Max made landfall in Mexico. Tropical Storm Selma was the first named tropical cyclone on record to make landfall in El Salvador. Tropical Storm Adrian formed on May 9th, marking the earliest occurrence of a named storm in the East Pacific basin. The previous earliest occurrence was Tropical Storm Alma forming on May 12, 1990. For the first year since 2012 no tropical cyclones passed near the Hawaiian Islands. The ACE index for the East Pacific basin during 2016 was 98 ($\times 10^4$ knots²), which is below the 1981-2010 average of 132 ($\times 10^4$ knots²), and the lowest since 2013.” Inserted from <https://www.ncdc.noaa.gov/sotc/tropical-cyclones/201713>.

References:

- NOAA National Centers for Environmental Information, State of the Climate: Hurricanes and Tropical Storms for Annual 2017, published online January 2018, retrieved on March 30, 2018. Accessed from <http://www.ncdc.noaa.gov/sotc/tropical-cyclones/201713>.
- Kanamitsu, M., Ebisuzaki, W., Woollen, J., Yang, S.K., Hnilo, J.J., Fiorino, M. and Potter, G.L., 2002. NCEP–DOE AMIP-II Reanalysis (R-2), *B. Am. Meteorol. Soc.*, 83, pp. 1631–1643, <https://doi.org/10.1175/BAMS-83-11-1631>.
- Knapp, K. R., M. C. Kruk, D. H. Levinson, H. J. Diamond, and C. J. Neumann, 2010: The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying tropical cyclone best track data. *Bulletin of the American Meteorological Society*, 91, 363-376. [doi:10.1175/2009BAMS2755.1](https://doi.org/10.1175/2009BAMS2755.1).
- State of Environmental Conditions in Hawaii and the U.S. Affiliated Pacific Islands under a Changing Climate, 2017. Coordinating Authors: J.J. Marra and M.C. Kruk. Contributing Authors: M. Abecassis; H. Diamond; A. Genz; S.F. Heron; M. Lander; G. Liu; J. T. Potemra; W.V. Sweet; P. Thompson; M.W. Widlansky; and P. Woodworth-Jefcoats. September, 2017. NOAA NCEI.

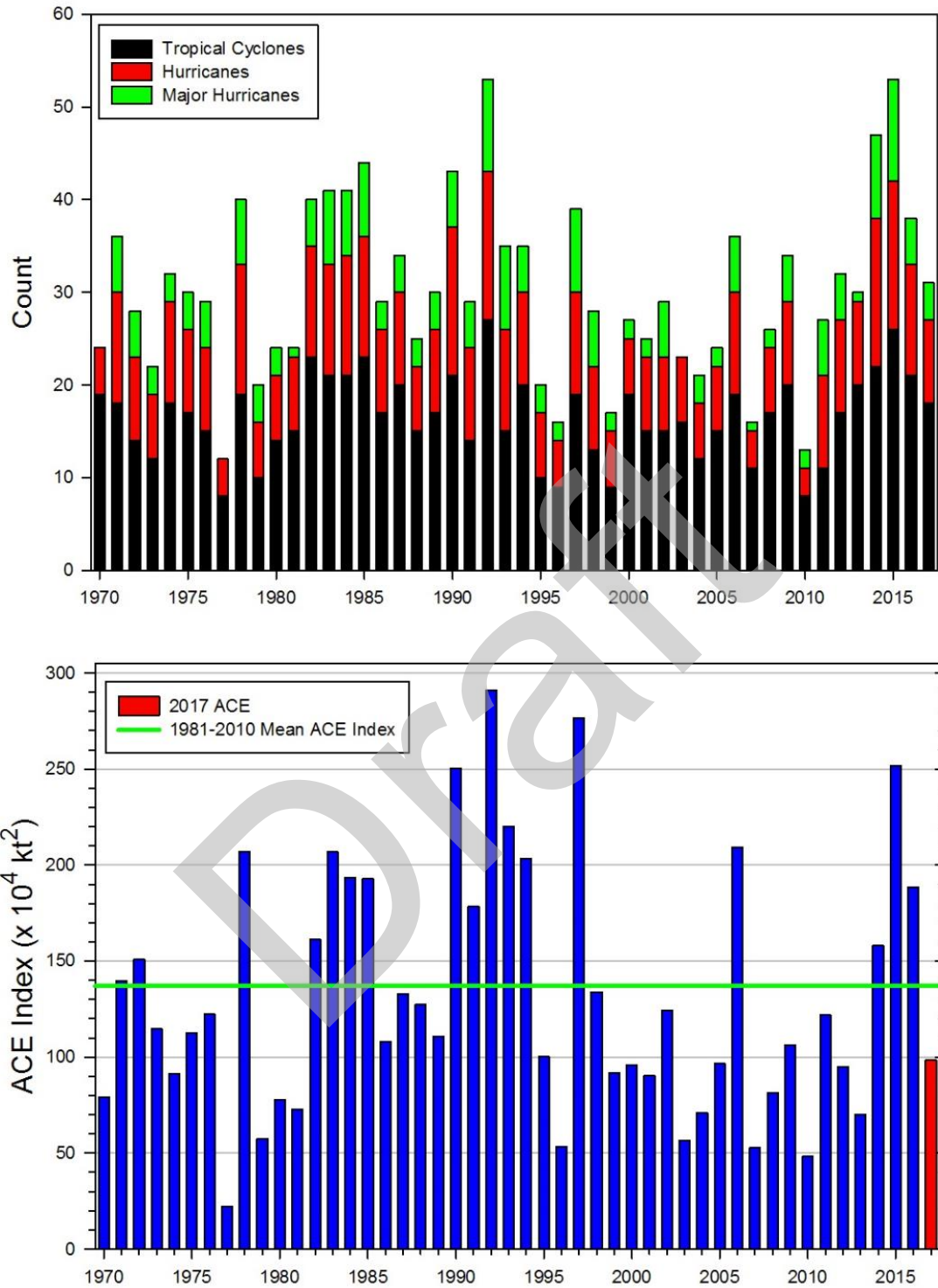


Figure 21. Annual Patterns of Tropical Cyclones in the Eastern Pacific, 1970-2017, with 1981-2010 mean superimposed. Source: NOAA's National Hurricane Center.

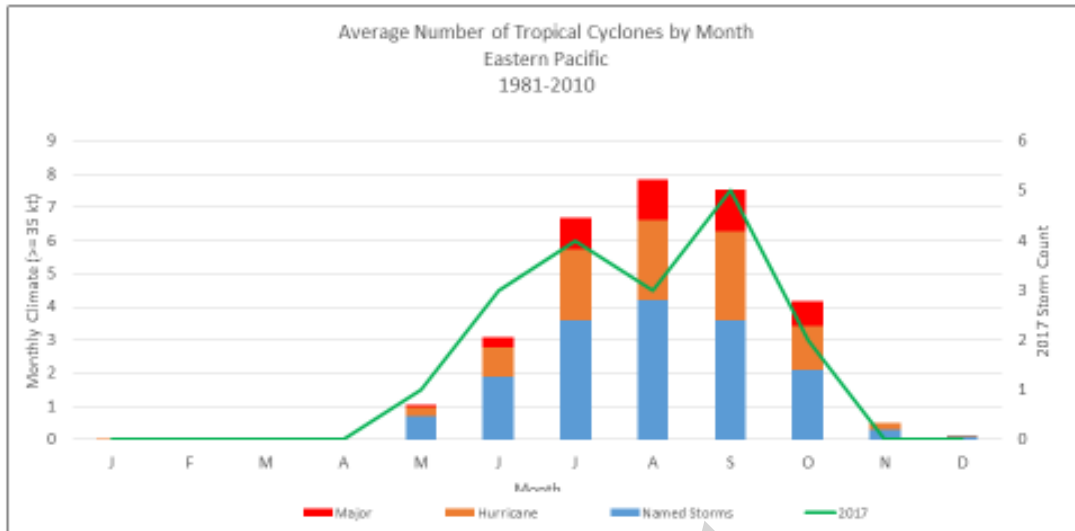


Figure 22. Seasonal Climatology of Tropical Cyclones in the Eastern Pacific, 1981-2010, with 2017 storms superimposed (sourced from NOAA's National Hurricane Center).

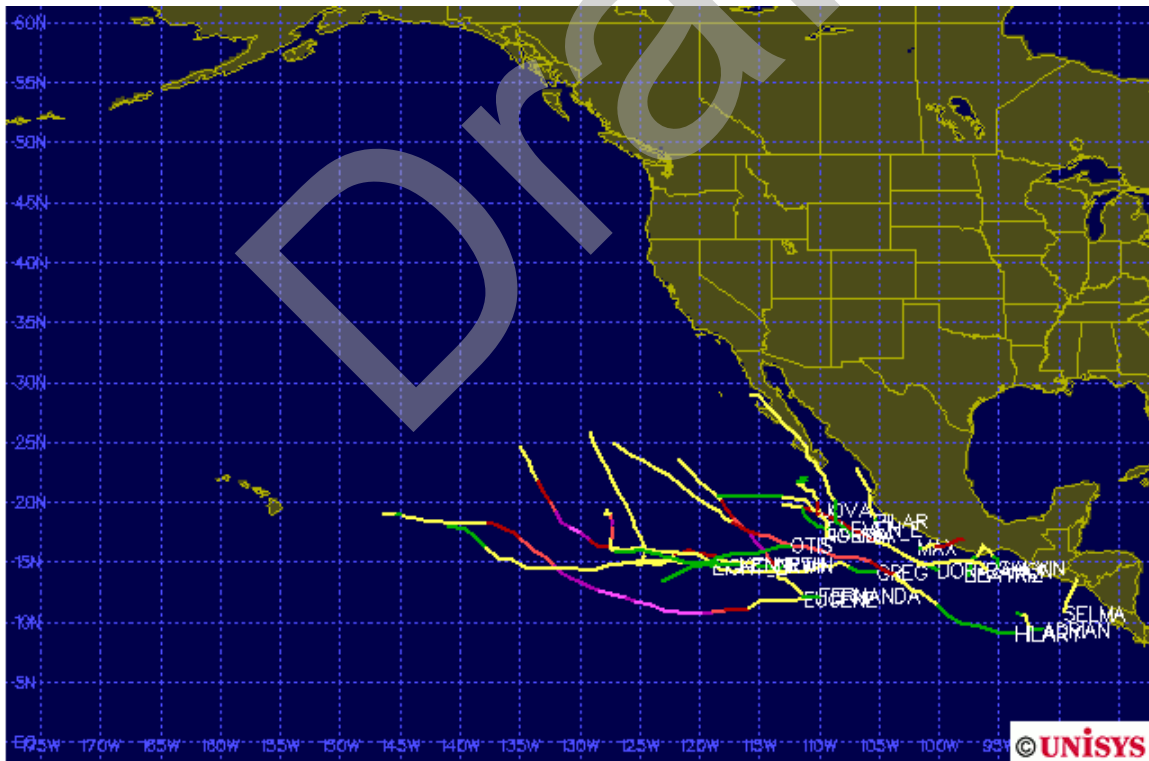


Figure 23. Eastern Pacific Cyclone Tracks in 2017.

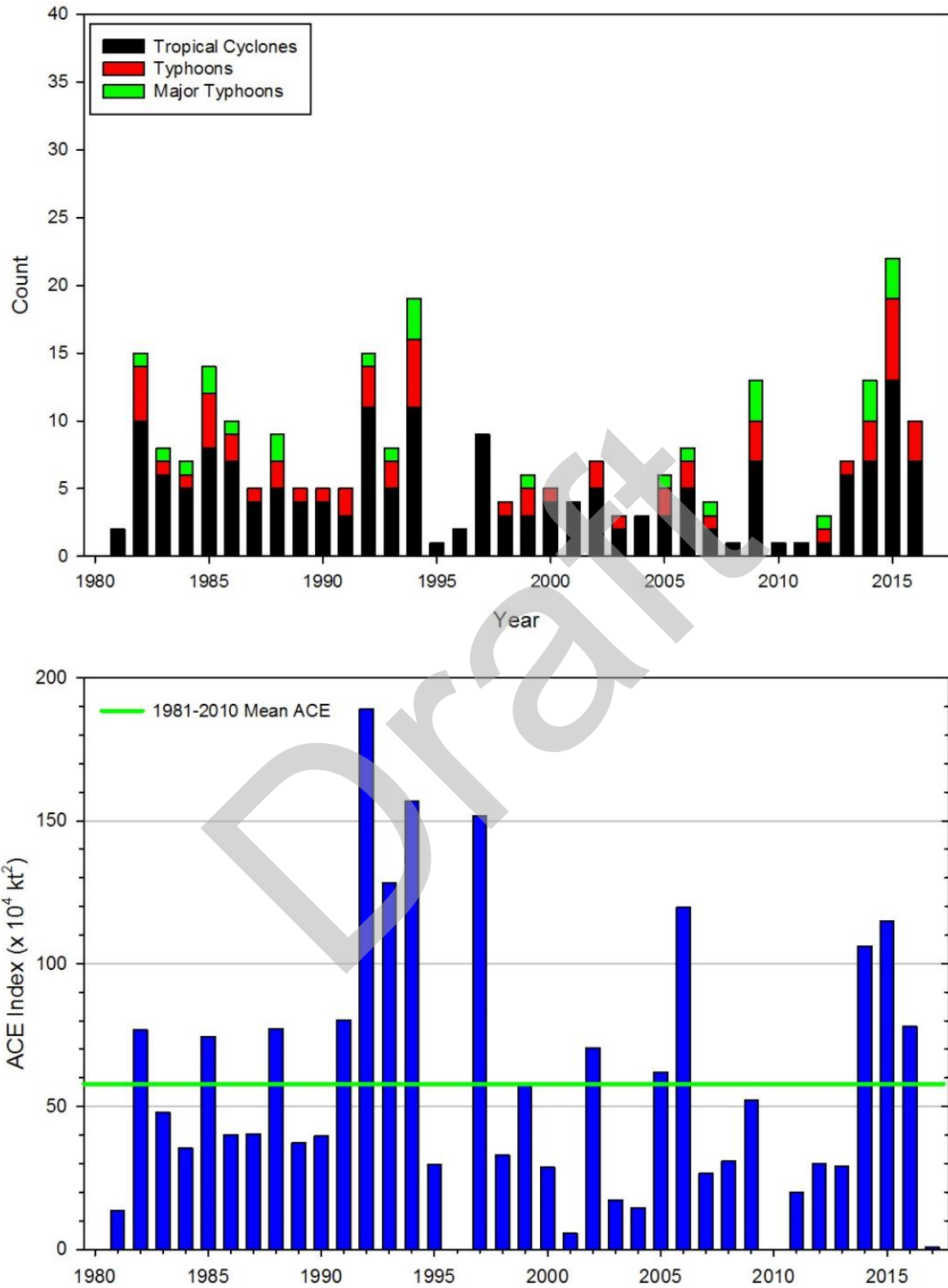


Figure 24. Annual Patterns of Tropical Cyclones in the Central Pacific, 1980-2017, with 1981-2010 mean superimposed (sourced from NOAA's National Hurricane Center).

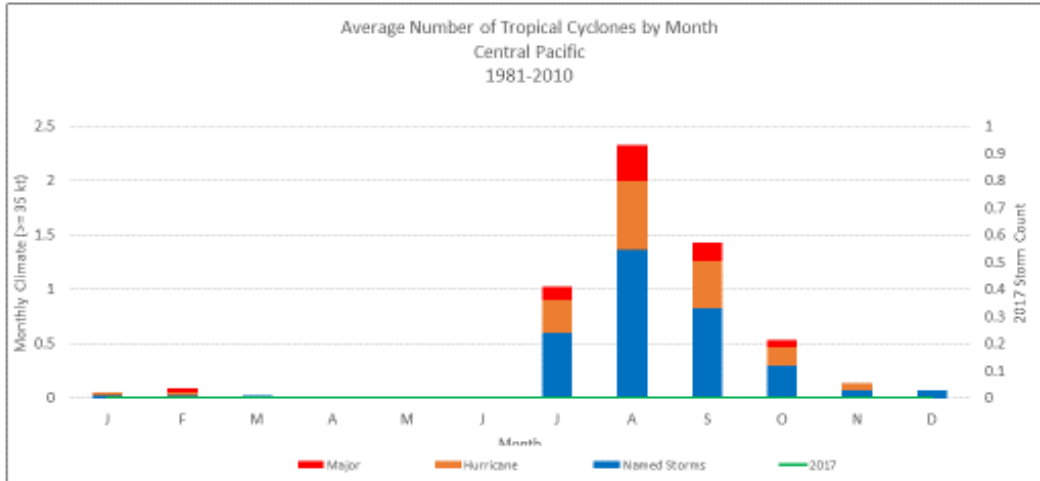


Figure 25. Seasonal Climatology of Tropical Cyclones in the Central Pacific, 1981-2010, with 2017 storms (zero) superimposed (sourced from NOAA's National Hurricane Center).

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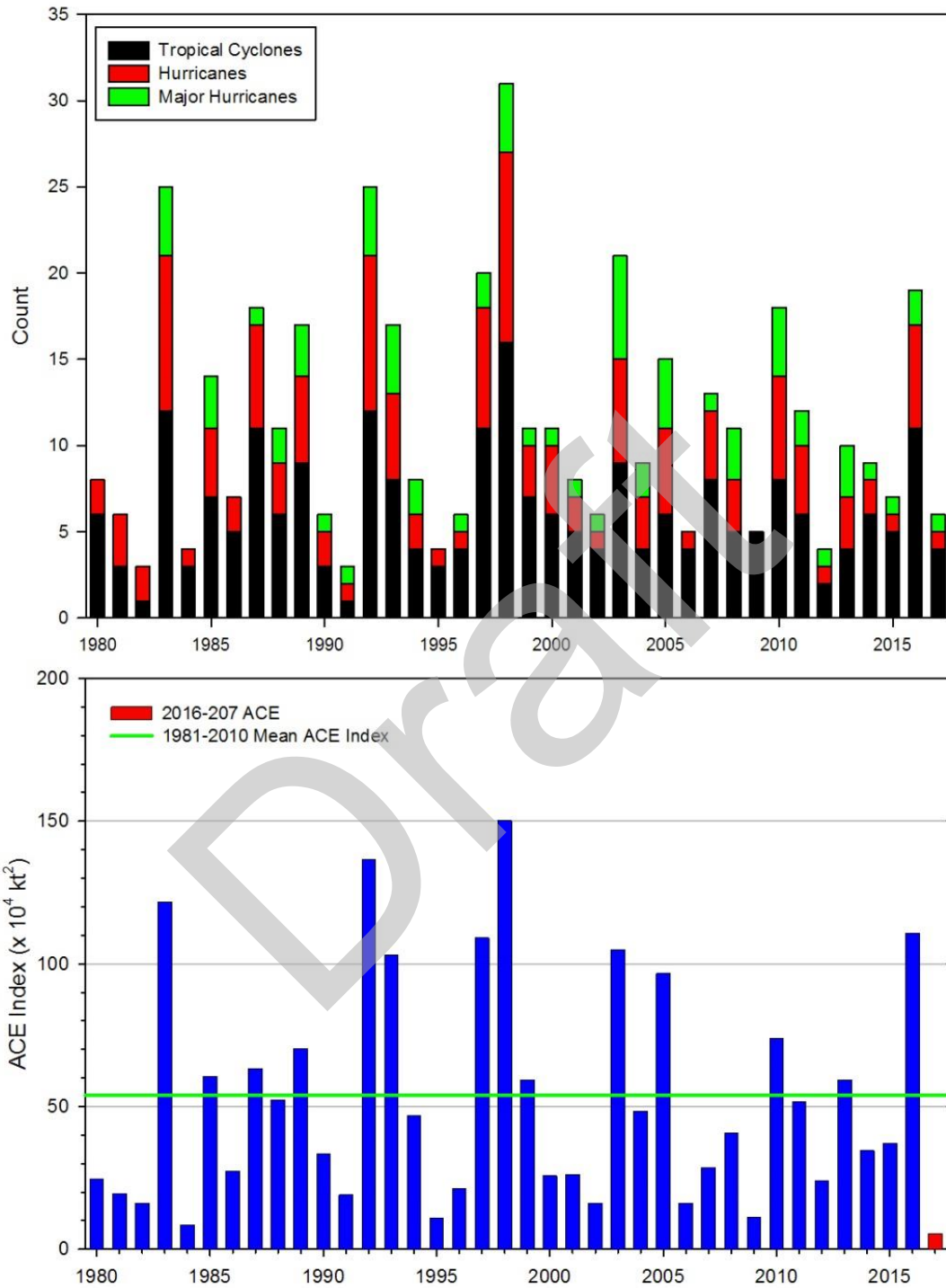


Figure 26. Annual Patterns of Tropical Cyclones in the South Pacific, 1980-2017, with 1981-2010 mean superimposed (sourced from NOAA's National Hurricane Center).

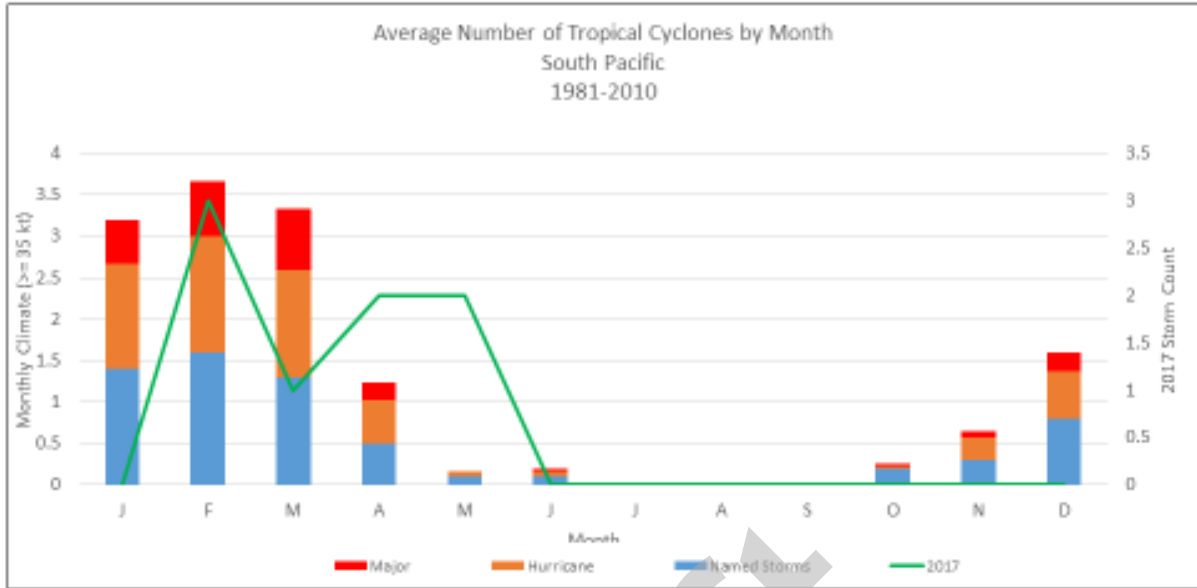


Figure 27. Seasonal Climatology of Tropical Cyclones in the South Pacific, 1981-2010, with 2017 storms (zero) superimposed (sourced from NOAA's National Hurricane Center).

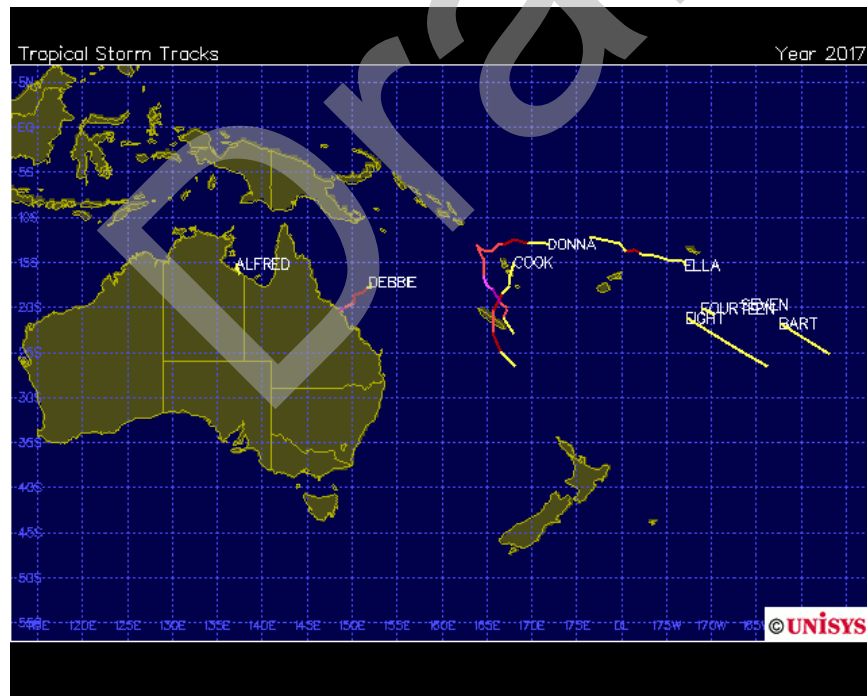


Figure 28. South Pacific Cyclone Tracks in 2017.

Further, we present the occurrence of “storm-force” winds, i.e. wind speeds greater than 34 knots.

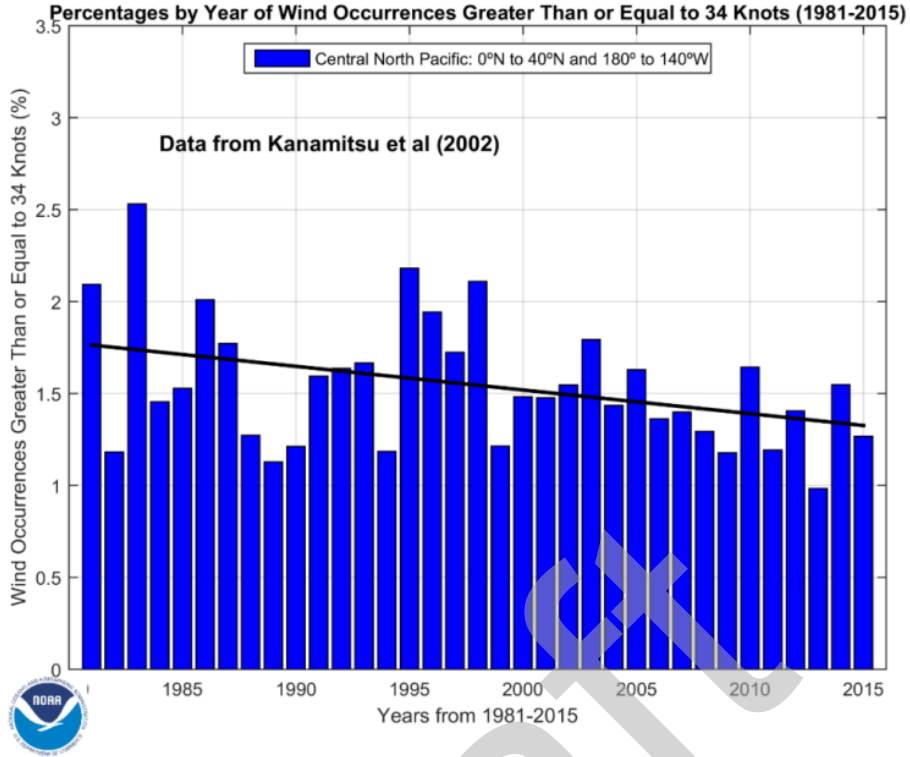


Figure 29. Storm-Force Wind in the Central North Pacific from 1981-2015.

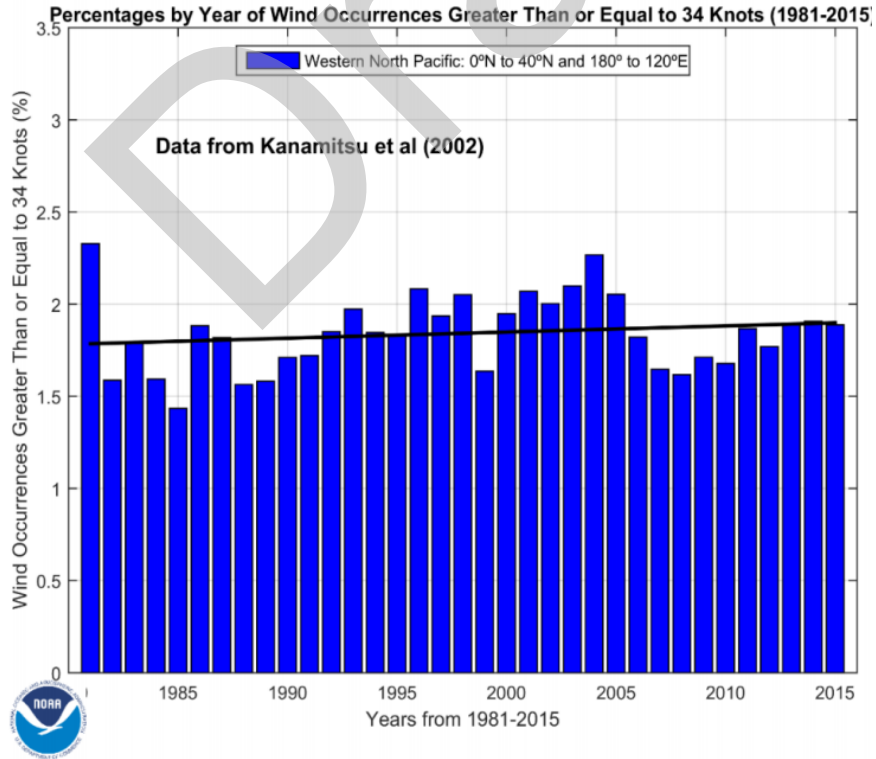


Figure 30. Storm-Force Wind in the Western North Pacific from 1981-2015.

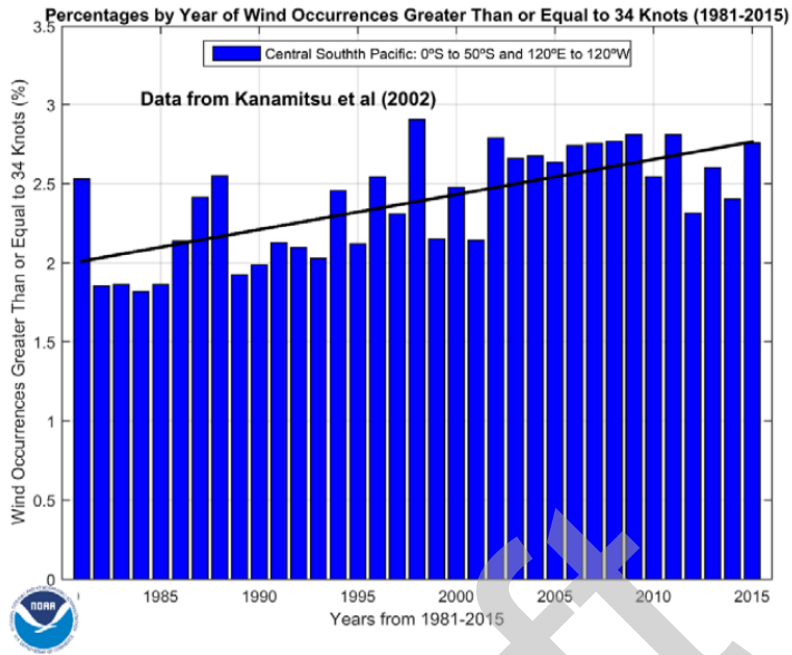


Figure 31. Storm-Force Wind in the Central South Pacific from 1981-2015.

2.4.3.9 Rainfall (CMAP Precipitation)

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

Description: The CPC Merged Analysis of Precipitation ("CMAP") is a technique which produces pentad and monthly analyses of global precipitation in which observations from rain gauges are merged with precipitation estimates from several satellite-based algorithms (infrared and microwave). The analyses are on a 2.5 x 2.5 degree latitude/longitude grid and extend back to 1979. These data are comparable (but should not be confused with) similarly combined analyses by the Project, which are described in Huffman *et al.* (1997).

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

The merging technique is thoroughly described in Xie and Arkin (1997). Briefly, the methodology is a two-step process. First, the random error is reduced by linearly combining the satellite estimates using the maximum likelihood method, in which case the linear combination coefficients are inversely proportional to the square of the local random error of the individual data sources. Over global land areas the random error is defined for each time period and grid location by comparing the data source with the rain gauge analysis over the surrounding area. Over oceans, the random error is defined by comparing the data sources with the rain gauge observations over the Pacific atolls. Bias is reduced when the data sources are blended in the second step using the blending technique of Reynolds (1988). Here the data output from step 1 is used to define the "shape" of the precipitation field and the rain gauge data are used to constrain the amplitude.

Monthly and pentad CMAP estimates back to the 1979 are available from [CPC ftp server](#).

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

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

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

Timeframe: Monthly

Region/Location: Global

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

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

References:

Huffman, G.J., Adler, R.F., Arkin, P., Chang, A., Ferraro, R., Gruber, A., Janowiak, J., McNab, A., Rudolf, B. and Schneider, U., 1997. The global precipitation climatology project (GPCP) combined precipitation dataset. *Bulletin of the American Meteorological Society*, 78(1), pp.5-20.

Reynolds, R.W., 1988. A real-time global sea surface temperature analysis. *Journal of Climate*, 1(1), pp. 75-87.

Spencer, R.W., 1993. Global oceanic precipitation from the MSU during 1979—91 and comparisons to other climatologies. *Journal of Climate*, 6(7), pp.1301-1326.

Xie, P. and Arkin, P.A., 1997. Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bulletin of the American Meteorological Society*, 78(11), pp. 2539-2558.

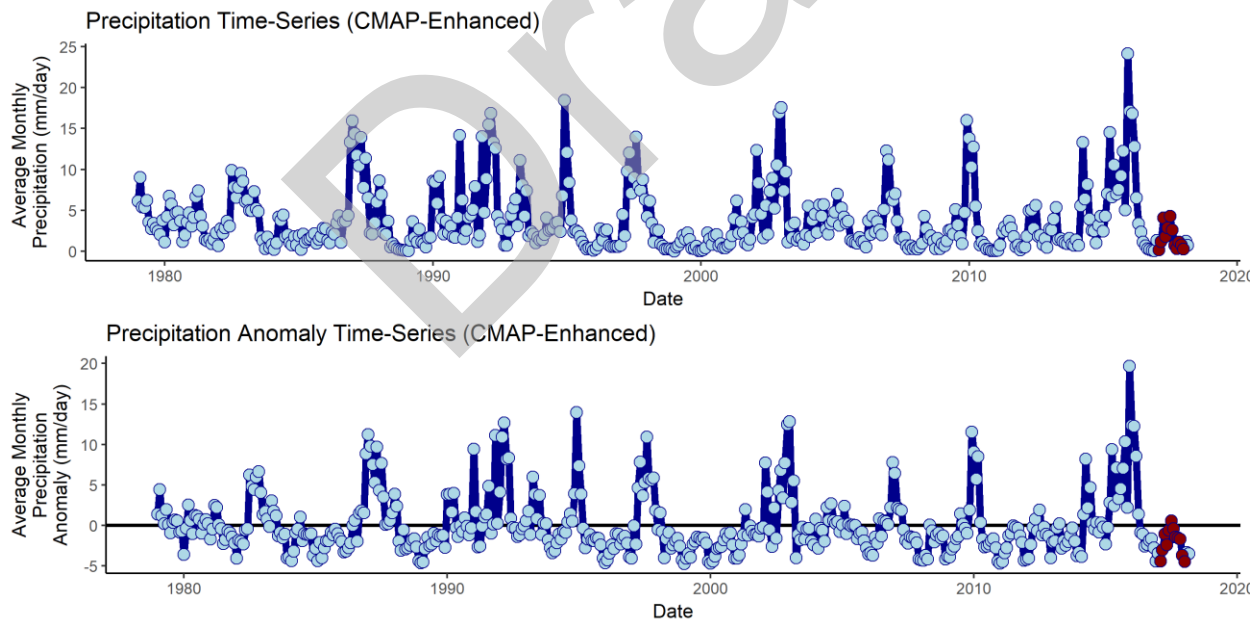


Figure 32. CMAP precipitation across the Howland-Baker Grid. 2017 values are in red.

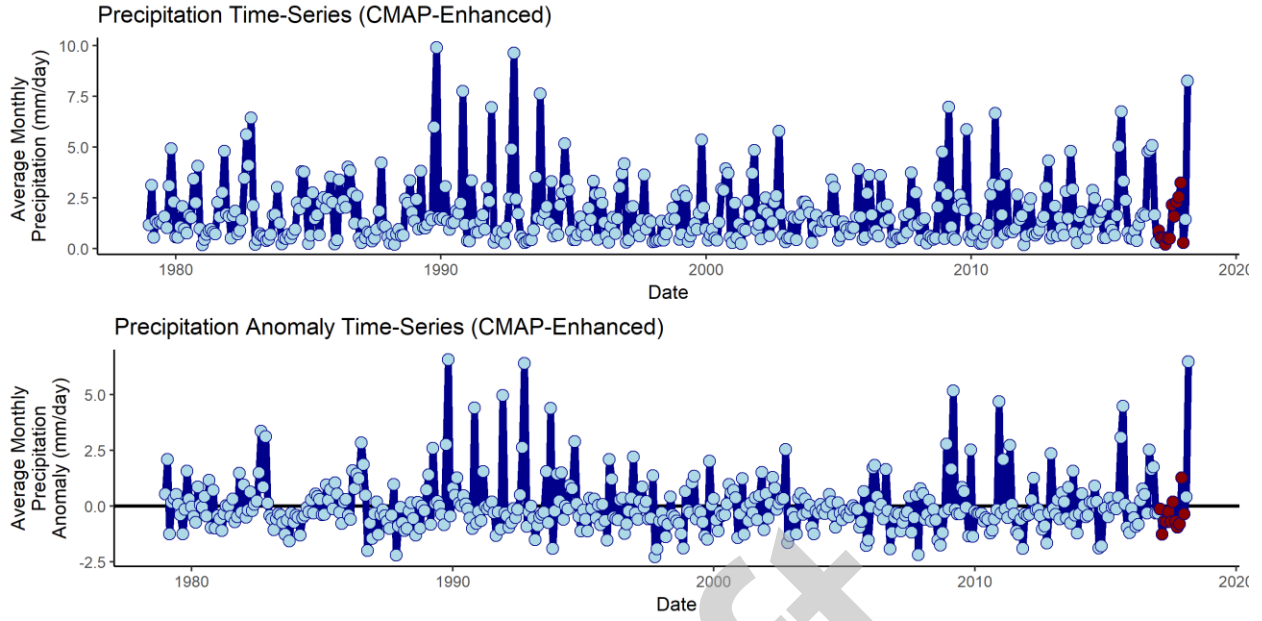


Figure 33. CMAP precipitation across the Johnston Atoll Grid. 2017 values are in red.

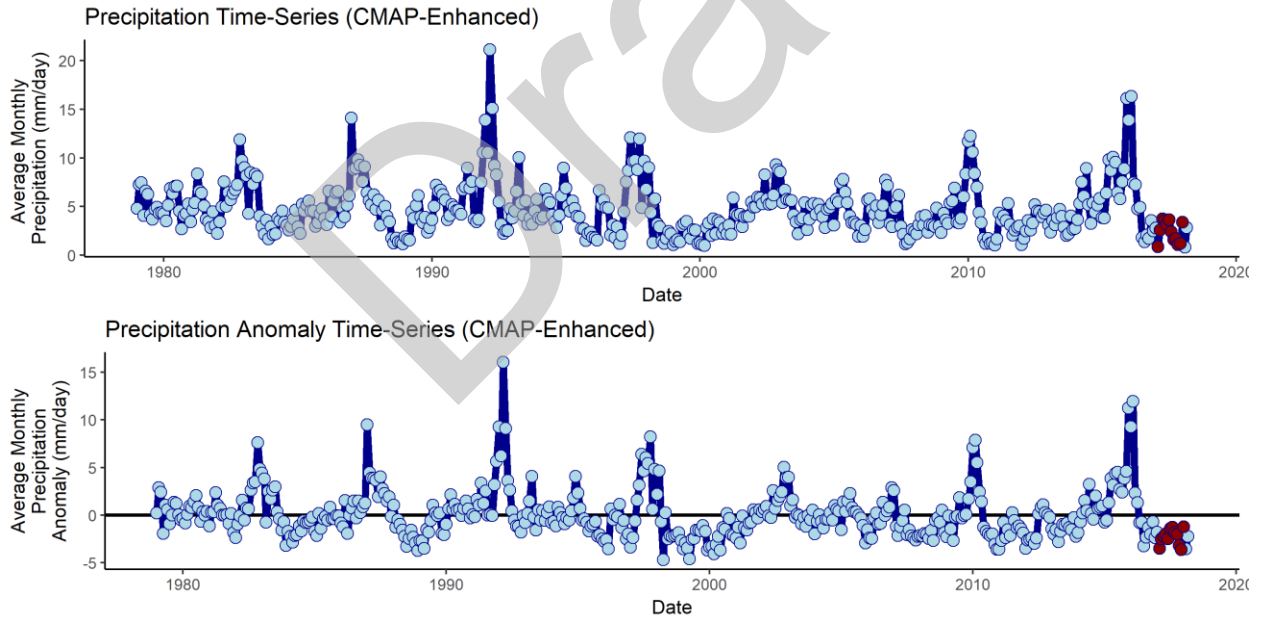


Figure 34. CMAP precipitation across the Line Islands Grid. 2017 values are in red.

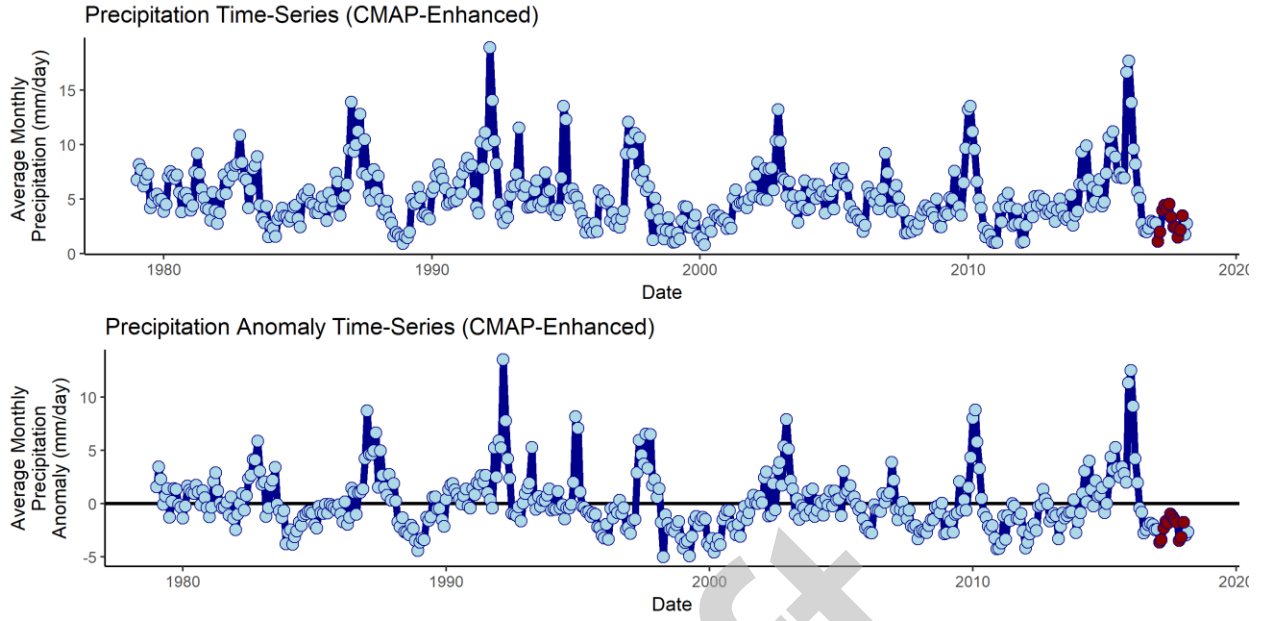


Figure 35. CMAP precipitation across the PRIA Grid. 2017 values are in red.

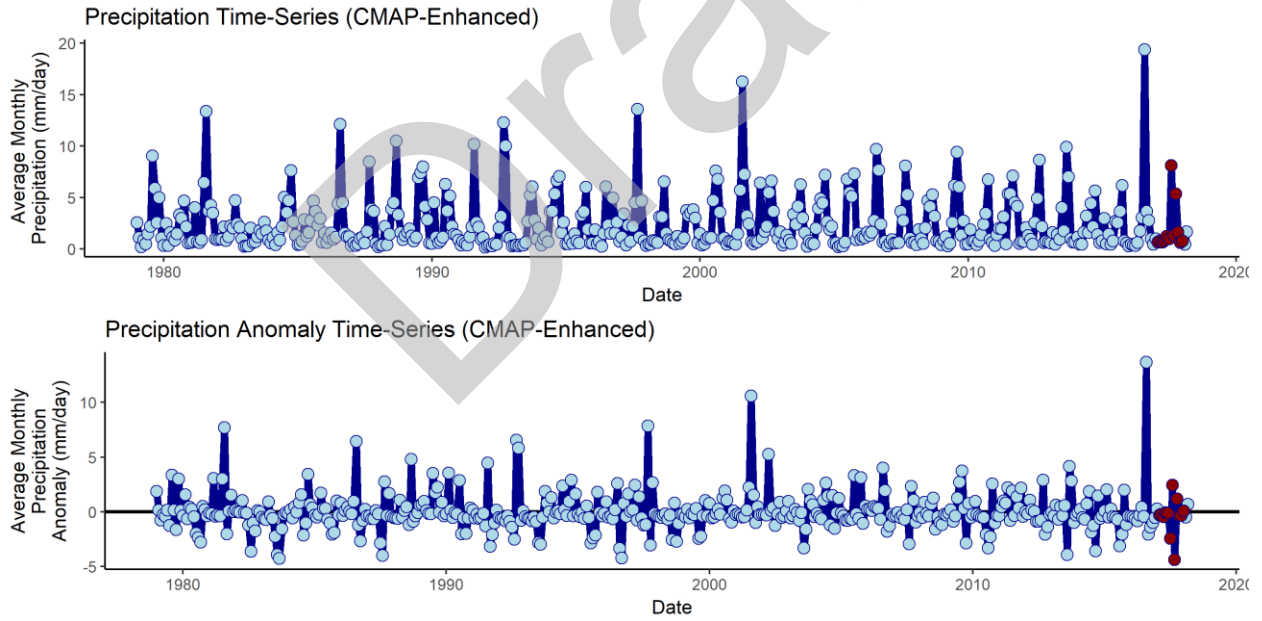


Figure 36. CMAP precipitation across the Wake Atoll Grid. 2017 values are in red.

2.4.3.10 Sea Level (Sea Surface Height and Anomaly)

Description: Monthly mean sea level time series, including extremes

Timeframe: Monthly

Region/Location: Observations from selected sites within the 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/elniнопdo/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.

2.4.3.10.1 Basin-Wide Perspective

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

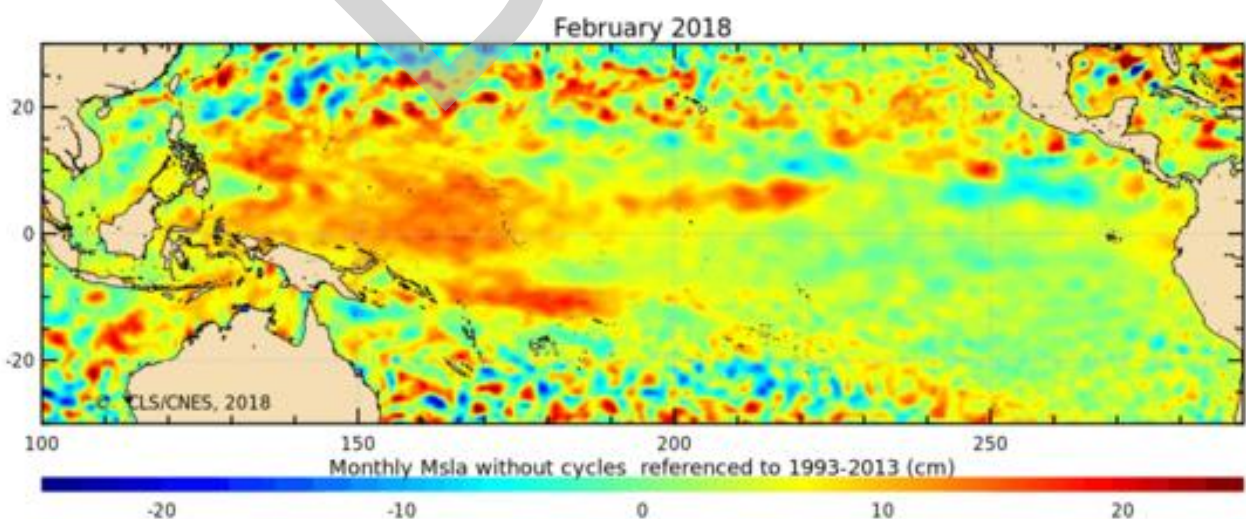


Figure 37a. Sea surface height and anomaly.

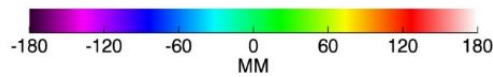
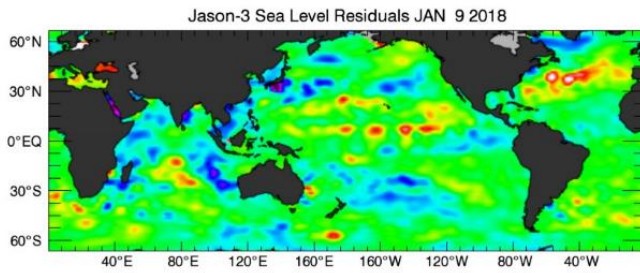
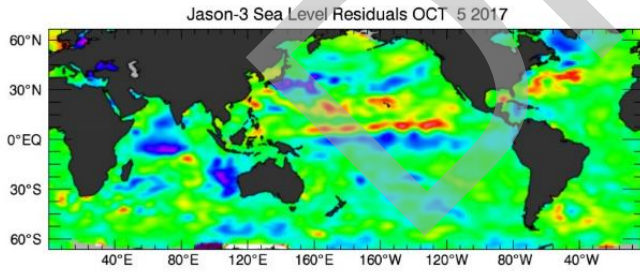
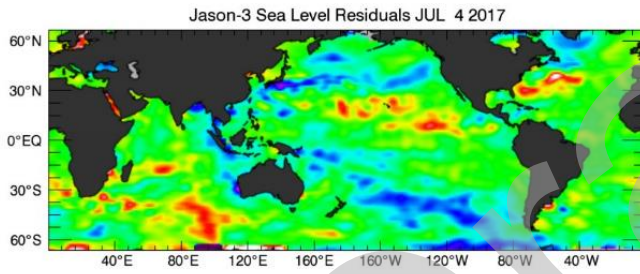
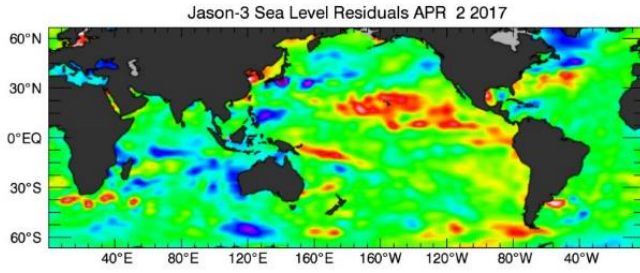
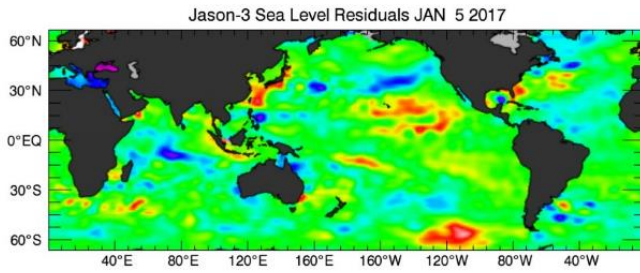
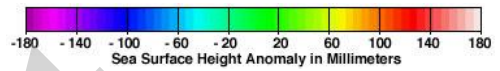


Figure 37b. Quarterly time series of mean sea level anomalies during 2017 show no pattern of El Niño throughout the year according to satellite altimetry measurements of sea level height (unlike 2015).

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



2.4.3.10.2 Local Sea Level

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

The following figures and descriptive paragraphs were inserted from https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=1619000, & https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=1890000.

Figure 38 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.

At Johnston Atoll, water levels include a Mean Sea Level (MSL) trend of 0.75 millimeters/year with a 95% confidence interval of +/- 0.56 millimeters/year based on monthly MSL data from 1947 to 2003 which is equivalent to a change of 0.25 feet in 100 years.

At Wake Island, water levels include a Mean Sea Level (MSL) trend of 2.07 millimeters/year with a 95% confidence interval of +/- 0.43 millimeters/year based on monthly MSL data from 1950 to 2017 which is equivalent to a change of 0.68 feet in 100 years.

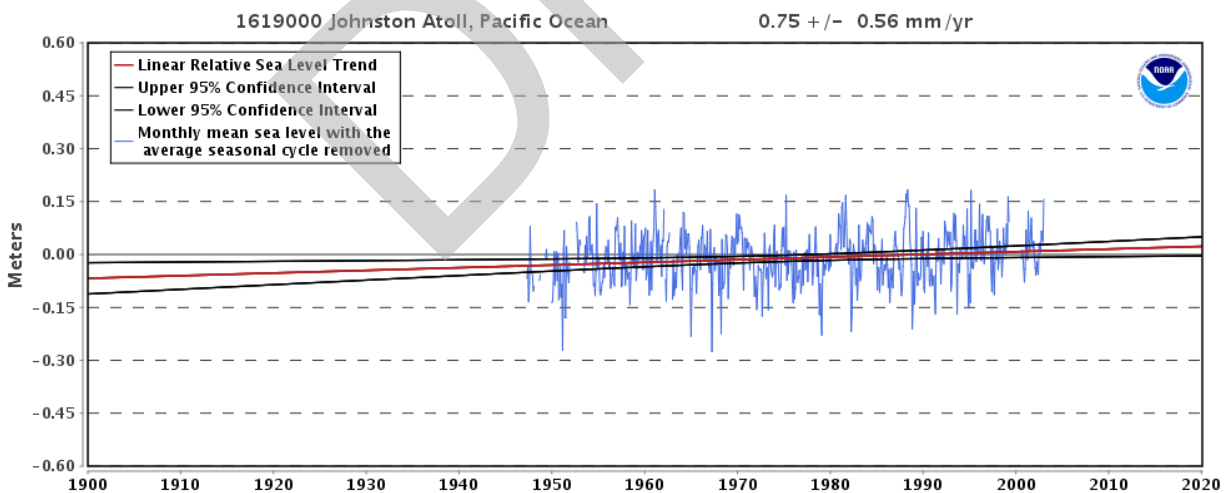


Figure 38. Monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents.

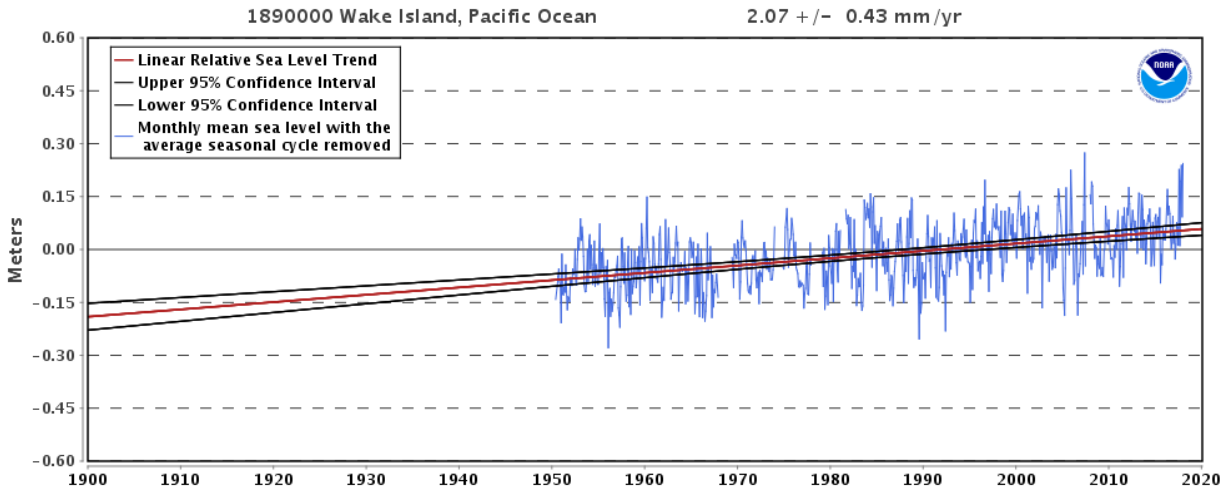


Figure 39. Monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents.

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2.5 ESSENTIAL FISH HABITAT

2.5.1 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.

2.5.2 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 Pacific Remote Island Area (PRIA) FEP describes EFH for the BMUS, CMUS, CREMUS, and PCMUS.

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

- Updated species descriptions, which can be found appended to the SAFE report. These can be used to directly update the FEP.
- Updated EFH levels of information tables, which can be found in Section 2.5.5.
- Updated research and information needs, which can be found in Section 2.5.6. These can be used to directly update the FEP.
- An analysis that distinguishes EFH from all potential habitats used by the species, which is the basis for an options paper for the Council. This part is developed if enough information exists to refine EFH.

2.5.2.1 Habitat Objectives of FEP

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

- a. Review EFH and HAPC designations every five years based on the best available scientific information and update such designations based on the best available scientific information, when available
- b. Identify and prioritize research to: assess adverse impacts to EFH and HAPC from fishing (including aquaculture) and non-fishing activities, including, but not limited to, activities that introduce land-based pollution into the marine environment.

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

2.5.2.2 Response to Previous Council Recommendations

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

At its 170th meeting, the Council directed staff to scope the non-fishing impacts review, from the 2016 SAFE reports, through its advisory bodies. The Plan Team met January 26, 2018 and provided comments on the review.

2.5.3 Habitat Use by MUS and Trends in Habitat Condition

The Pacific Remote Island Areas comprise the U.S. possessions of Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Wake Island, Palmyra Atoll, and Midway

Atoll (Figure 40). However, because Midway is located in the Hawaiian archipelago, it is included in the Hawaii Archipelago FEP¹. Therefore, neither the “Pacific Remote Islands” nor “PRIA” include Midway Atoll, for the purpose of federal fisheries management.

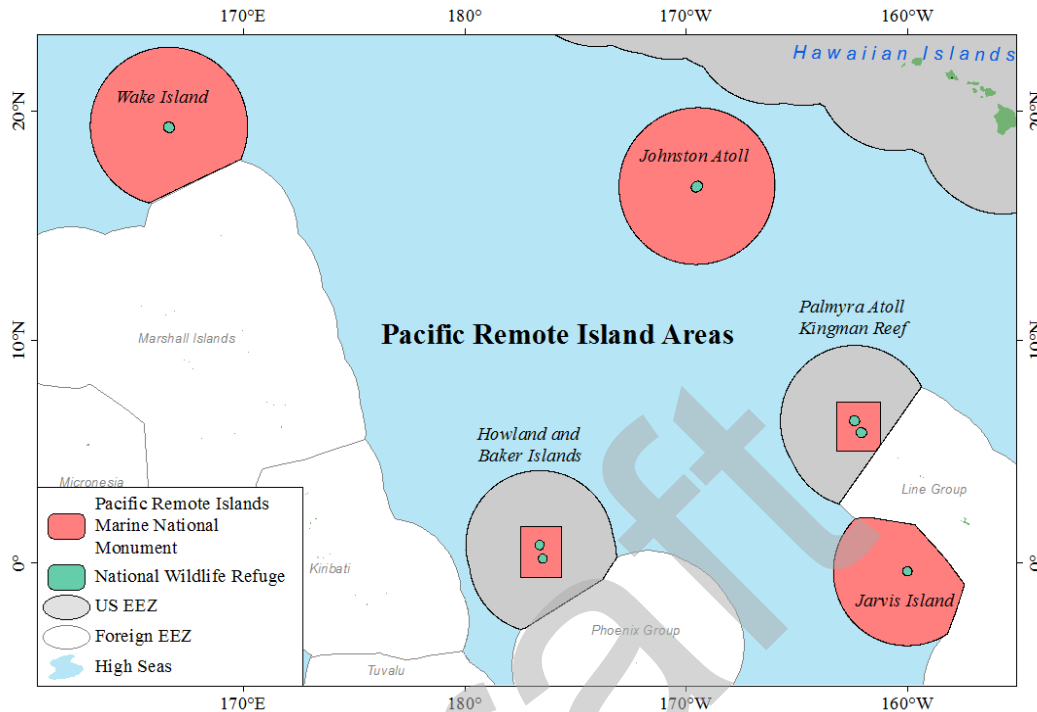


Figure 40. Pacific Remote Island Areas.

Baker Island is part of the Phoenix Islands archipelago. It is located approximately 1,600 nautical miles to the southwest of Honolulu at 0° 13' N and 176° 38' W. Baker is a coral-topped seamount surrounded by a narrow-fringing reef that drops steeply very close to the shore. The total amount of emergent land area of Baker Island is 1.4 square kilometers.

Howland Island lies approximately 35 miles due north of Baker Island and is also part of the Phoenix Islands archipelago. The island, which is the emergent top of a seamount, is fringed by a relatively flat coral reef that drops off sharply. Howland Island is approximately 1.5 miles long and 0.5 miles wide. The island is flat and supports some grasses and small shrubs. The total land area is 1.6 square kilometers.

Jarvis Island, which is part of the Line Island archipelago, is located approximately 1,300 miles south of Honolulu and 1,000 miles east of Baker Island. It sits 23 miles south of the Equator at 160° 01' W. Jarvis Island is a relatively flat, sandy coral island with a 15–20-ft beach rise. Its total land area is 4.5 square kilometers. It experiences a very dry climate.

¹ Midway is not administered civilly by the State of Hawaii.

Palmyra Atoll is a low-lying coral atoll system comprised of approximately 52 islets surrounding three central lagoons. It is approximately 1,050 nautical miles south of Honolulu and is located at 5° 53' N and 162° 05' W. It is situated about halfway between Hawaii and American Samoa. Palmyra Atoll is located in the intertropical convergence zone, an area of high rainfall.

Kingman Reef is located 33 nautical miles northwest of Palmyra Atoll at 6° 23' N and 162° 24' W. Along with Palmyra, it is at the northern end of the Line Island archipelago. Kingman is actually a series of fringing reefs around a central lagoon with no emergent islets that support vegetation.

Wake Island is located at 19° 18' N and 166° 35' E, and is the northernmost atoll of the Marshall Islands group, located approximately 2,100 miles west of Hawaii. Wake Island has a total land area of 6.5 square kilometers and comprises three islets: Wake, Peale, and Wilkes.

Johnston Atoll is located at 16° 44' N and 169° 31' W and is approximately 720 nautical miles southwest of Honolulu. French Frigate Shoals in the NWHI, about 450 nautical miles to the northwest, is the nearest land mass. Johnston Atoll is an egg-shaped coral reef and lagoon complex comprised of four small islands totaling 2.8 square kilometers. The complex resides on a relatively flat, shallow platform approximately 34 kilometers in circumference. Johnston Island, the largest and main island, is natural, but has been enlarged by dredge-and-fill operations. Sand Island is composed of a naturally-formed island on its eastern portion and is connected by a narrow, man-made causeway to a dredged coral island at its western portion. The remaining two islands, North Island and East Island, are completely man-made from dredged coral.

All commercial activity is prohibited within the Pacific Remote Island Area Marine National Monument, which is 50 nautical miles surrounding Palmyra Atoll and Kingman Reef and Howland and Baker Islands, and the entire US EEZ surrounding Johnston Atoll, Wake, and Jarvis Island.

Essential fish habitat in the PRIA for the four MUS comprises all substrate from the shoreline to the 700 m isobath (Figure 41). The entire water column is described as EFH from the shoreline to the 700 m isobath, and the water column to a depth of 400 m is described as EFH from the 700 m isobath to the limit or boundary of the exclusive economic zone (EEZ). While the coral reef ecosystems surrounding the islands in the PRIA have been the subject of a comprehensive monitoring program through the PIFSC Coral Reef Ecosystem Division (CRED) biennially since 2002, surveys are focused on the nearshore environments surrounding the islands, atolls, and reefs (PIBHMC).

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 islands, atolls, 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.

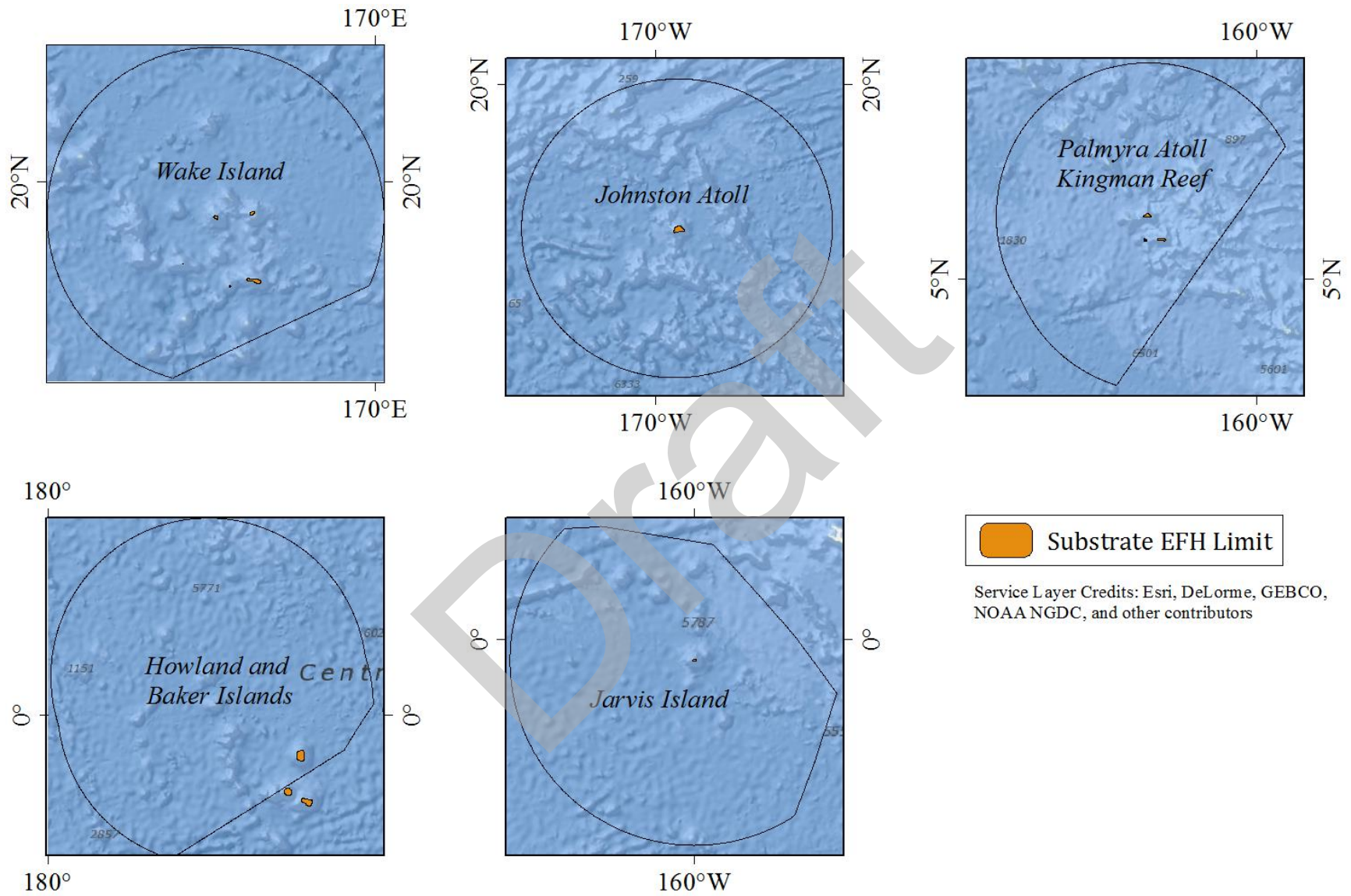


Figure 41. Substrate EFH Limit of 700 meter isobath around the PRIA (from GMRT).

2.5.3.1 Habitat Mapping

Mapping products for the PRIA are available from the Pacific Islands Benthic Habitat Mapping Center and are listed in Table 6.

Table 6. Summary of habitat mapping in the PRIA.

Depth Range	Timeline/Mapping Product	Progress	Source
0-30 m	IKONOS Benthic Habitat Maps	Palmyra only	CRCP 2011
	2000-2010 Bathymetry	67%	DesRochers 2016
	2011-2015 Multibeam Bathymetry		DesRochers 2016
	2011-2015 Satellite Worldview 2 Bathymetry	Wake, Baker, and Howland Islands, Johnston and Palmyra Atolls, and Kingman Reef	Pers. Comm. DesRochers, March 19, 2018
30-150 m	2000-2010 Bathymetry	79%	DesRochers 2016
	2011-2015 Multibeam Bathymetry	Howland and Baker updated with data collected in a few small areas in 2015	Pers. Comm, DesRochers, March 19, 2018
15 to 2500 m	Multibeam bathymetry	Complete at Jarvis, Howland, and Baker Islands	Pacific Islands Benthic Habitat Mapping Center
	Derived Products	Backscatter available for all Geomorphology products for Johnston, Howland, Baker, Wake	Pacific Islands Benthic Habitat Mapping Center

The land and seafloor area surrounding the islands and atolls of the PRIA are reproduced from CRCP (2011) and shown in Figure 42 alongside other physical data.

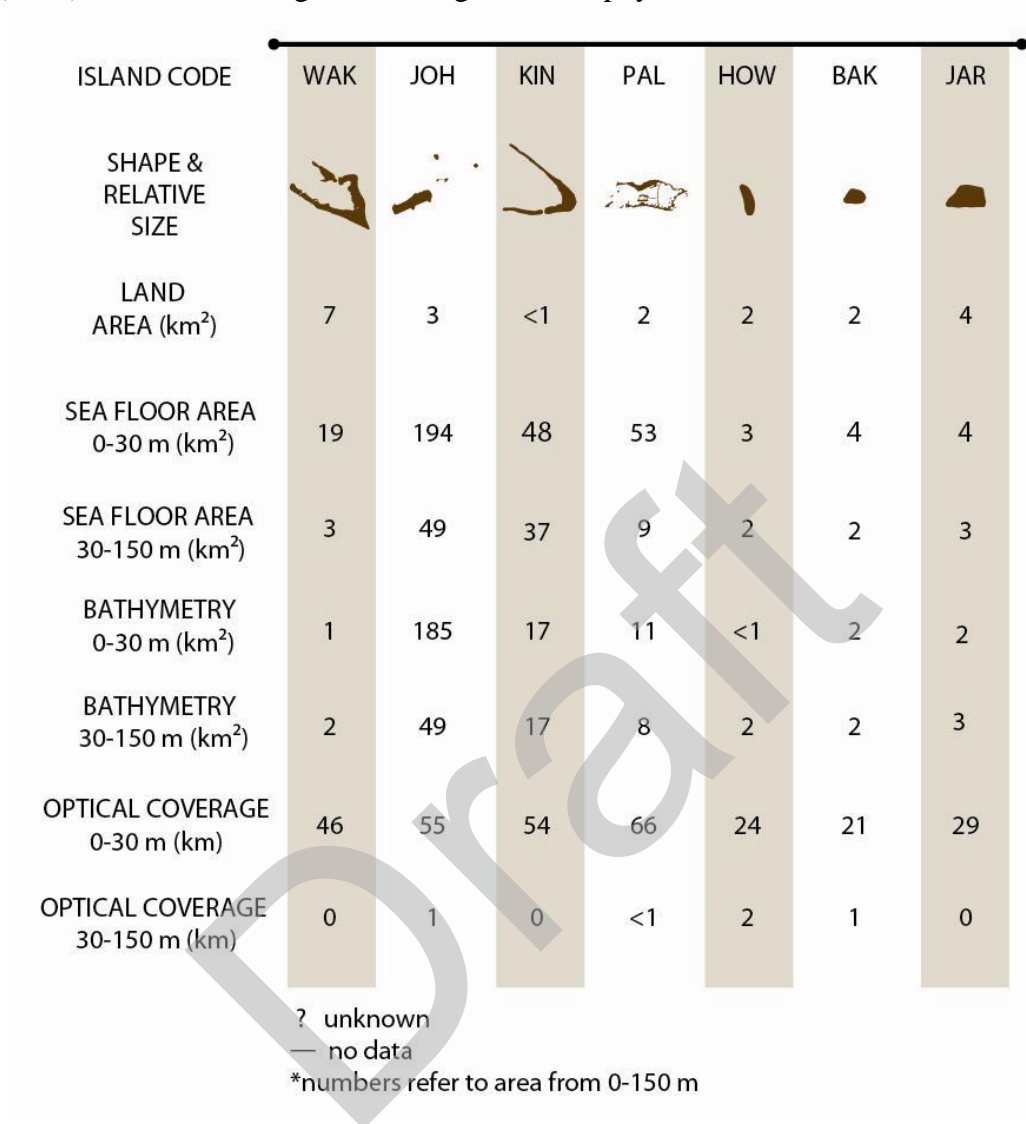


Figure 42. PRIA Land and Seafloor Area and Primary Data Coverage from CRCP (2011).

2.5.3.2 Benthic Habitat

Juvenile and adult life stages of coral reef MUS and crustaceans including spiny and slipper lobsters and Kona crab extends from the shoreline to the 100 m isobath (64 FR 19067, April 19, 1999). All benthic habitat is considered EFH for 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 7 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 7. Occurrence of EFH by feature in the PRIA.

Feature	Summit Minimum Depth	Coral Reef/Crustaceans (w/o Deepwater Shrimp)	Bottomfish	Deepwater Shrimp	CRED Long Term Monitoring
Johnston Atoll	Emergent	✓	✓	✓	✓
Palmyra	Emergent	✓	✓	✓	✓
Kingman Reef	Emergent	✓	✓	✓	✓
Extensive banks 80 km SW of Kingman		?	?	?	
Jarvis Island	Emergent	✓	✓	✓	✓
Howland Island	Emergent	✓	✓	✓	✓
Baker Island	Emergent	✓	✓	✓	✓
Southeast of Baker	?	?	?	✓	
Wake Island	Emergent	✓	✓	✓	✓
South of Wake	?	?	?	✓	

2.5.3.3 Oceanography and Water Quality

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

2.5.3.3.1 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 m above the reef roughly 60 m behind a small boat at a constant speed of about 1.5 kt. Each diver maneuvers a tow board platform, which is connected to the boat by a bridle and towline and outfitted with a communications telegraph and various survey equipment, including a downward-facing digital SLR camera (Canon EOS 50D, Canon Inc., Tokyo). The benthic towed diver records general habitat complexity and type (e.g., spur and groove, pavement), percent cover by functional-group (hard corals, stressed corals, soft corals, macroalgae, crustose coralline algae, sand, and rubble) and for macroinvertebrates (crown-of-thorns sea stars, sea cucumbers, free and boring urchins, and giant clams).

Towed-diver surveys are typically 50 min long and cover about two to three km of habitat. Each survey is divided into five-minute segments, with data recorded separately per segment to allow for later location of observations within the ~ 200-300 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 8. Mean percent cover of live coral from RAMP sites collected from towed-diver surveys in the PRIA.

Year	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015
Baker	35.37	49.47	38.78		32.95		41.20		47.44		42.10		34.48
Howland	29.06	42.53	36.75		34.69		44.47		50.74		43.26		23.20
Jarvis	24.22	26.19	30.63		28.54		27.70		26.92		25.38		39.75
Johnston			5.01		22.95		18.38		7.94		10.89		7.46
Kingman	39.77	49.51	38.35		24.59		33.13		35.56		37.11		41.92
Palmyra	24.95	31.99	35.07		22.66		25.02		35.35		31.11		42.77
Wake				31.98		19.29		22.56		31.40		32.34	

Table 9. Mean percent cover of macroalgae from RAMP sites collected from towed-diver surveys in the PRIA.

Year	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015
Baker	12.33	2.11	12.63		9.29		8.09		1.60		8.05		2.15
Howland	2.58	5.34	13.01		3.57		6.14		0.64		6.07		1.08
Jarvis	28.75	10.88	25.03		38.14		24.01		7.35		7.58		3.94
Johnston			25.06		6.90		8.82		1.57		8.49		2.49
Kingman	4.36	5.36	27.04		7.81		7.31		3.97		5.05		2.04
Palmyra	13.28	10.45	23.14		15.17		11.98		4.76		8.94		4.35
Wake				22.88		18.74		12.00		8.30		6.80	

Table 10. Mean percent cover of crustose coralline algae from RAMP sites collected from towed-diver surveys in the PRIA.

Year	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2014	2015
Baker	31.66	37.57	39.61		33.43		23.09		23.40		24.03		32.80
Howland	36.60	27.40	34.26		22.60		22.59		15.73		18.12		21.25
Jarvis	29.11	29.56	34.76		24.23		11.82		30.29		24.20		27.48
Johnston			30.54		19.50		16.07		17.13		17.49		17.45
Kingman	33.04	16.4	17.49		23.50		13.45		9.20		8.45		9.64
Palmyra	38.46	24.46	27.26		26.30		18.02		13.87		17.09		10.28
Wake				1.01		6.43		3.87		4.15		1.13	

2.5.4 Report on Review of EFH Information

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

2.5.5 EFH Levels

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

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

The Council adopted a fifth level, denoted Level 0, for situations in which there is no information available about the geographic extent of a particular managed species' life stage. The existing level of data for individual MUS in each fishery are presented in tables per fishery. Each fishery section also includes the description of EFH, the 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.

2.5.5.1 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 11. Level of EFH information available for the Western Pacific precious corals management unit species complex. All observations are from the Hawaiian Islands.

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

Species	Pelagic phase (larval stage)	Benthic phase	Source(s)
<i>ulex</i>)			HURL Database

2.5.5.2 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 12. Level of EFH information available for the Western Pacific BMUS and seamount groundfish MUS complex.

Life History Stage	Eggs	Larvae	Juvenile	Adult
Bottomfish: (scientific/english common)				
<i>Aphareus rutilans</i> (red snapper/silvermouth)	0	0	0	2
<i>Aprion virescens</i> (gray snapper/jobfish)	0	0	1	2
<i>Caranx ignobilis</i> (giant trevally/jack)	0	0	1	2
<i>C. lugubris</i> (black trevally/jack)	0	0	0	2
<i>Epinephelus faciatus</i> (blacktip grouper)	0	0	0	1
<i>E. quernus</i> (sea bass)	0	0	1	2
<i>Etelis carbunculus</i> (red snapper)	0	0	1	2
<i>E. coruscans</i> (red snapper)	0	0	1	2
<i>Lethrinus amboinensis</i> (ambon emperor)	0	0	0	1
<i>L. rubrioperculatus</i> (redgill emperor)	0	0	0	1
<i>Lutjanus kasmira</i> (blueline snapper)	0	0	1	1
<i>Pristipomoides auricilla</i> (yellowtail snapper)	0	0	0	2
<i>P. filamentosus</i> (pink snapper)	0	0	1	2
<i>P. flavipinnis</i> (yelloweye snapper)	0	0	0	2
<i>P. seiboldi</i> (pink snapper)	0	0	1	2
<i>P. zonatus</i> (snapper)	0	0	0	2
<i>Pseudocaranx dentex</i> (thicklip trevally)	0	0	1	2
<i>Seriola dumerili</i> (amberjack)	0	0	0	2
<i>Variola louti</i> (lunartail grouper)	0	0	0	2
Seamount Groundfish:				
<i>Beryx splendens</i> (alfonsin)	0	1	2	2
<i>Hyperoglyphe japonica</i> (ratfish/butterfish)	0	0	0	1
<i>Pseudopentaceros richardsoni</i> (armorhead)	0	1	1	3

2.5.5.3 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 13. Level of EFH information available for the Western Pacific CMUS complex.

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

2.5.5.4 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 has not been undertaken, as the Council only recently completed its process of re-designating certain CREMUS into the ecosystem component classification. Ecosystem component species do not require EFH designations, as they are not a managed species.

2.5.6 Research and Information Needs

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

2.5.6.1 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.

2.5.6.2 Bottomfish Fishery

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

- High resolution maps of bottom topography/currents/water masses/primary productivity.
- Habitat utilization patterns for different life history stages and species.

2.5.6.3 Crustaceans Fishery

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

2.5.6.4 Precious Corals Fishery

- Distribution, abundance, and status of precious corals in the PRIA.

2.5.7 References

DesRochers, A., 2016. “Benthic Habitat Mapping.” NOAA Fisheries Center, Honolulu, HI. Presentation. April 6, 2016.

Miller, J., Battista, T., Pritchett, A, Rohmann, S, Rooney, J., 2011. Coral Reef Conservation Program Mapping Achievements and Unmet Needs. 68 p.

PIFSC, 2016. Ecosystem Sciences. Coral Reef Ecosystem Survey Methods. Benthic Monitoring. http://www.pifsc.noaa.gov/cred/survey_methods.php. Updated April 1, 2016. Accessed April 5, 2016.

PIFSC, 2011. Coral reef ecosystems of American Samoa: a 2002-2010 overview. NOAA Fisheries Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-11-02, 48 p.

PIFSC CREP, 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.

2.6 MARINE PLANNING

2.6.5 Introduction

Marine planning is a science-based tool being utilized regionally, nationally and globally to identify and address issues of multiple human uses, ecosystem health and cumulative impacts in the coastal and ocean environment. The Council's efforts to formalize incorporation of marine planning in its actions began in response to Executive Order 13547, Stewardship of the Ocean, Our Coasts, and the Great Lakes. Executive Order 13158, Marine Protected Areas (MPAs), proposes that agencies strengthen the management, protection, and conservation of existing MPAs, develop a national system of MPAs representing diverse ecosystems, and avoid causing harm to MPAs through federal activities. MPAs, or marine managed areas (MMAs) are one tool used in fisheries management and marine planning.

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

- a. Identify and prioritize research that examines the positive and negative consequences of areas that restrict or prohibit fishing to fisheries, fishery ecosystems, and fishermen, such as the Bottomfish Fishing Restricted Areas, military installations, NWHI restrictions, and Marine Life Conservation Districts.
- b. Establish effective spatially-based fishing zones.
- c. Consider modifying or removing spatial-based fishing restrictions that are no longer necessary or effective in meeting their management objectives.
- d. As needed, periodically evaluate the management effectiveness of existing spatial-based fishing zones in Federal waters.

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

In order to meet the EFH and National Environmental Policy Act (NEPA) mandates, this annual report tracks activities that occur in the ocean that are of interest to the Council, and incidents or facilities that may contribute to cumulative impact. The National Marine Fisheries Service (NMFS) is responsible for NEPA compliance, and the Council must assess the environmental effects of ocean activities for the FEP's EFH cumulative impacts section. These are redundant efforts; therefore, this report can provide material or suggest resources to meet both mandates.

2.6.5.1 Response to Previous Council Recommendations

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

2.6.5.2 MMAs established under FMPs

Council-established marine managed areas (MMAs) were compiled in Figure 43 from 50 CFR § 665, Western Pacific Fisheries, the Federal Register, and Council amendment documents.

Geodesic areas were calculated in square kilometers in ArcGIS 10.2. All regulated fishing areas and large MMAs, including the Pacific Remote Islands Marine National Monument, are shown in Figure 43.

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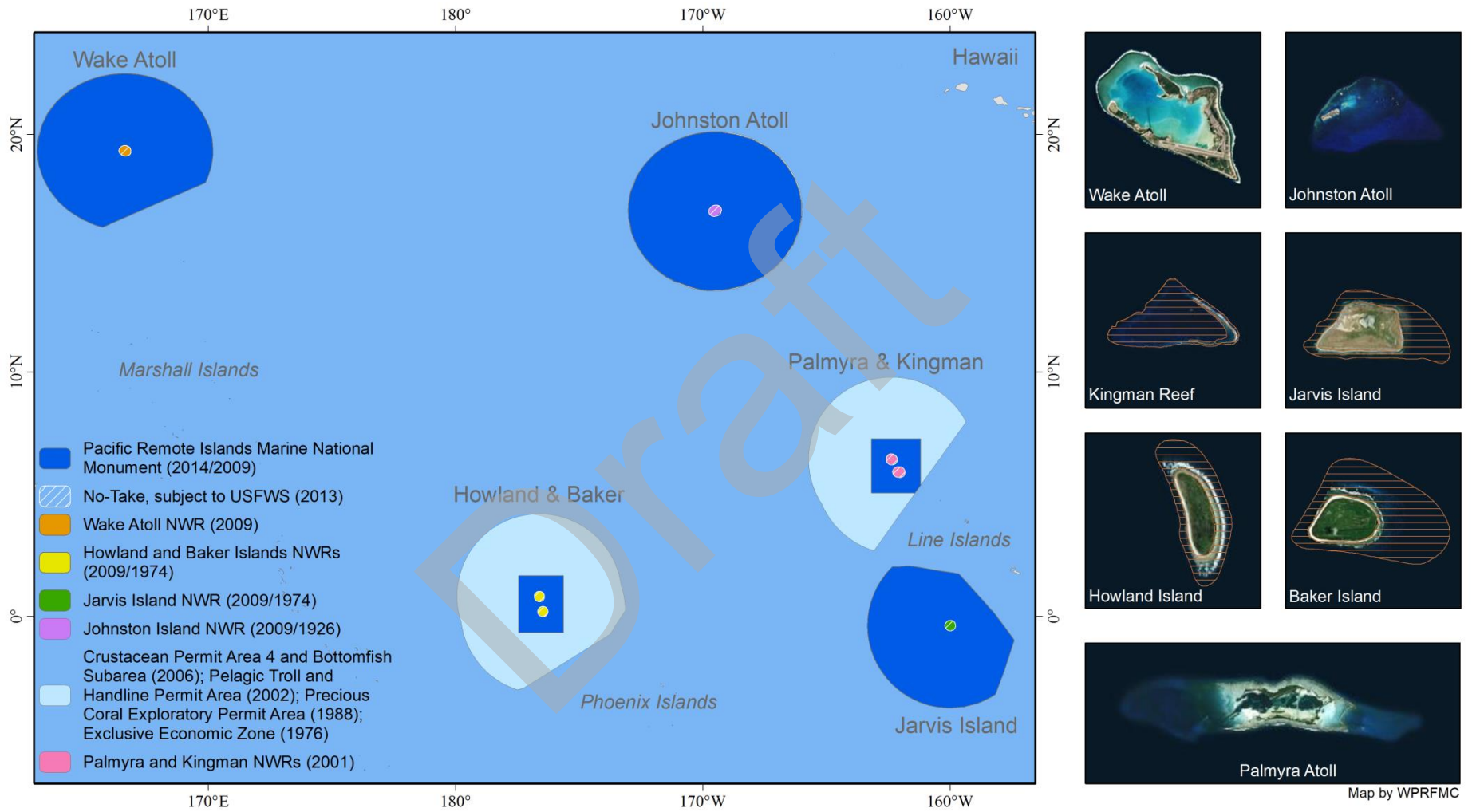


Figure 43. Regulated fishing areas of the PRIA.

Table 14. 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
Other Restrictions								
Howland Island No-Take MPA/PRI Marine National Monument	PRIA/Pelagic	Howland Island	665.599 and 665.799(a)(1) 69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 PRIA FEP Am. 2	-	All Take Prohibited	Minimize adverse human impacts on coral reef resources; commercial fishing prohibited within 12 nm	2013	-
Jarvis Island No-Take MPA/PRI Marine National Monument	PRIA/Pelagic	Jarvis Island	665.599 and 665.799(a)(1) 69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 PRIA FEP Am. 2	-	All Take Prohibited	Minimize adverse human impacts on coral reef resources; commercial fishing prohibited within 12 nm	2013	-
Baker Island No-Take MPA/PRI Marine National Monument	PRIA/Pelagic	Baker Island	665.599 and 665.799(a)(1) 69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 PRIA FEP Am. 2	-	All Take Prohibited	Minimize adverse human impacts on coral reef resources; commercial fishing prohibited within 12 nm	2013	-

Name	FEP	Island	50 CFR /FR /Amendment Reference	Marine Area (km ²)	Fishing Restriction	Goals	Most Recent Evaluation	Review Deadline
Kingman Reef No-Take MPA/PRI Marine National Monument	PRIA/Pelagic	Kingman Reef	665.599 and 665.799(a)(1) 69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 PRIA FEP Am. 2	-	All Take Prohibited	Minimize adverse human impacts on coral reef resources; all fishing prohibited within 12 nm	2013	-
Johnston Atoll Low-Use MPA/PRI Marine National Monument	PRIA/Pelagic	Johnston Atoll	69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 PRIA FEP Am. 2	-	Special Permit Only	Minimize adverse human impacts on coral reef resources; superseded by prohibiting fishing within 12 nm in Am. 2	2013	-
Palmyra Atoll Low-Use MPAs/PRI Marine National Monument	PRIA/Pelagic	Palmyra Atoll	69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 PRIA FEP Am. 2	-	Special Permit Only	Minimize adverse human impacts on coral reef resources; superseded by prohibiting fishing within 12 nm in Am. 2	2013	-
Wake Island Low-Use MPA/PRI Marine National Monument	PRIA/Pelagic	Wake Island	69 FR 8336 Coral Reef Ecosystem FEP 78 FR 32996 PRIA FEP Am. 2	-	Special Permit Only	Minimize adverse human impacts on coral reef resources; superseded by prohibiting fishing within 12 nm in Am. 2	2013	-

2.6.6 Activities and Facilities

There are no aquaculture, alternative energy facilities, or military training and testing activities occurring in the US EEZ around the PRIAs at this time. The Plan Team will add to this section as new facilities are proposed and/or built.

2.6.7 Pacific Islands Regional Planning Body Report

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

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

2.6.8 References

- 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>.
- Pelagic Fisheries of the Western Pacific Region, Final Rule. *Federal Register* 56 (18 October 1991): 52214-52217. Downloaded from <http://www.wpcouncil.org/pelagic/Documents/FMP/Amendment3-FR-FinalRule.pdf>.
- Pelagic Fisheries of the Western Pacific Region, Final Rule. *Federal Register* 57 (4 March 1992): 7661-7665. Downloaded from <http://www.wpcouncil.org/pelagic/Documents/FMP/Amendment5-FR-FinalRule.pdf>.
- 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/>.

3 DATA INTEGRATION

At the 2016 joint meeting of the Archipelagic and Pelagic Fishery Ecosystem Plan Team, the teams recommended that the Council, in coordination with NMFS, organize a workshop in developing the Data Integration Chapter of the annual SAFE Report. The workshop was convened on November 30 and December 1, 2016. The goal of the workshop was to identify policy-relevant fishery ecosystem relationships, as well as analytical procedures that can be utilized to examine those relationships, to be used as the foundation of the data integration chapter (“Chapter 3”) of the western Pacific region’s (WPR) four archipelagic annual Stock Assessment and Fishery Evaluation (SAFE) reports. Such variables include, for example, catch, number of fishing trips, primary productivity, and climate and weather attributes.

The Western Pacific Regional Fishery Management Council (Council) hosted the workshop. Participants included staff from the National Marine Fisheries Service (NMFS) Pacific Islands Fisheries Science Center (PIFSC) and Pacific Islands Regional Office (PIRO), the Council, and Triton Aquatics, a Hawaii-based consulting company.

Table 15. Participants of the Data Integration Workshop held on November 30th and December 1st, 2016.

Name	Affiliation	Name	Affiliation
Keith Bigelow	PIFSC	Kevin Kelley	Consultant/PIRO
Chris Boggs	PIFSC	Eric Kingma	Council
Rusty Brainard	PIFSC	Don Kobayashi	PIFSC
Paul Dalzell	Council	Tom Oliver	PIFSC
Joshua DeMello	Council	Michael Parke	PIFSC
Stefanie Dukes	PIFSC	Frank Parrish	PIFSC
Sarah Ellgen	PIRO	Marlowe Sabater	Council
Jamison Gove	PIFSC	Sylvia Spalding	Council
Justin Hospital	PIFSC	Rebecca Walker	Council
Asuka Ishizaki	Council	Mariska Weijerman	PIFSC
Ariel Jacobs	PIRO	Ivor Williams	PIFSC

Several background presentations were given to contextualize the discussions:

1. EBFM and adaptive management in the SAFE report process

2. Examples of fishery ecosystem integration efforts from other regions
3. FEP Objectives and Management Measures
4. Past attempts at Data Integration: Environmental, Social, and Economic Variables Known to Influence Fisheries

Following these background presentations and discussions, participants were segregated into two smaller working groups to brainstorm island and pelagic fishery and environmental/ecological relationships that may be of use in the context of Chapter 3. These relationships could be bivariate or multivariate. Several guided questions were provided for every combination of variables:

1. What can we reasonably expect to learn from or monitor with the results?
2. How does it inform Council decision-making, consistent with the purposes of the FEP?
3. Is it part of an ongoing research initiative?

The archipelagic fisheries group developed nearly 30 relationships to examine across bottomfish, coral reef, and crustacean fisheries (Table 16), while the pelagic breakout group developed 11 relationships for pelagic fisheries, including protected species.

Table 16. List of brainstormed potential archipelagic island fishery relationships – scored and ranked. Rank denotes priority level from 3 (highest) to 1 (lowest).

Relationships	FEP	Score	Rank
Bottomfish catch/effort/CPUE/species composition and benthos/substrate (i.e. depth, structure)	All	22	3
Bottomfish catch/effort/ CPUE /species composition and Pacific Decadal Oscillation	All	20	3
Coral reef fish/fishery/biomass and temperature-derived variable	All	20	3
Akule/opelu and precipitation (MHI and Guam)	HI	20	3
Bottomfish catchability and wind speed	All	19	3
Coral reef fish/fishery/biomass and chlorophyll- <i>a</i> (with phase lag)	All	19	3
Bottomfish Catch /CPUE and lunar cycle/moon phase	All	19	3
Bottomfish catch/effort/ CPUE /species composition and sea-level height (eddy feature)	All	18	2
Coral reef fish/fishery/biomass and Pacific Decadal Oscillation	All	18	2
Green/red spiny lobster catch/CPUE and vertical relief	HI	18	2
Green/red spiny lobster catch/CPUE and Pacific Decadal Oscillation	HI	18	2
Bottomfish catchability and fishing conditions (i.e. surface, subsurface current, speed, and direction)	All	17	2
Coral reef fish/fishery/biomass and moon phase	All	17	2

Coral reef fish/fishery/biomass and Oceanic Niño Index	All	17	2
Coral reef fish/fishery/biomass and sea-level height	All	17	2
Coral reef fish/fishery/biomass and pH	All	17	2
Bottomfish catch/effort/ CPUE /species composition and temperature-derived variable (e.g. temperature at depth)	All	16	2
Bottomfish catch/effort/ CPUE /species composition and chlorophyll- <i>a</i> (with phase lag)	All	16	2
Bottomfish catch/effort/ CPUE /species composition and precipitation	All	16	2
Coral reef fish/fishery/biomass and structural complexity /benthic habitat	All	16	2
Bottomfish catch/effort/ CPUE /species composition and dissolved oxygen	All	15	2
Coral reef fish/fishery/biomass and precipitation	All	14	2
Bottomfish catch/effort/ CPUE /species composition and pH	All	13	2
Bottomfish catch/effort/ CPUE /species composition and predator abundance	All	12	2
Coral reef fish/fishery/biomass and salinity	All	12	2
Coral reef fish/fishery/biomass and dissolved oxygen	All	12	2
Bottomfish catch/effort/ CPUE /species composition and salinity	All	10	1

The continued development of the data integration chapter is work in progress that has a 2-3 year timeline. The workshop produced a long list of fishery and ecosystem variable combinations that comprise a significant workload that the participants could not currently take on. The Council hired a contractor in 2017 that began exploratory data analysis on different variable combinations to determine which relationships are worth using in the Data Integration chapter. Though the contractor delivered preliminary results for evaluations including data from the MHI, Guam, CNMI, and American Samoa, no explicit analyses were conducted for the PRIA.