US Coral Reef Monitoring

Data Summary 2018

NOAA Technical Memorandum CRCP 31

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

NOAA CORAL REEF CONSERVATION PROGRAM

SymbioSeas

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US Coral Reef Monitoring

Data Summary 2018

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Photography Credits

Photography credits are listed on pages 213–217.

Data Citations

Citations for data presented within the report and archived at the NOAA National Centers for Environmental Information can be found on pages 218–223.

Contents

Table of Contents

National Coral Reef Monitoring Program

The National Coral Reef Monitoring Program (NCRMP) supports conservation of the nation's coral reef ecosystems through documenting and understanding the status and trends of climate, fish, benthic, and socioeconomic variables. Since its inception in 2001, NOAA's Coral Reef Conservation Program (CRCP) has supported monitoring in US coral reef areas, and in 2013 these monitoring activities were consolidated within the framework of the NCRMP. The NCRMP is a cohesive NOAA-wide effort coordinating monitoring activities for biological, physical, and human dimensions of coral reefs. Through its implementation, NOAA can clearly and concisely communicate results of national-scale monitoring to national, state, and territorial policy makers, resource managers, and the public on a periodic basis.

The NCRMP is limited to shallow water (0-30 m) coral reef ecosystems in the following ten CRCP priority geographic areas: US Virgin Islands (USVI), Puerto Rico (PR), Florida (FL), Flower Garden Banks (FGB), American Sāmoa (AS), main Hawaiian Islands (MHI), northwestern Hawaiian islands (NWHI) – MHI and NWHI combined in this report as Hawai'i – Guam, Commonwealth of the Northern Mariana Islands (CNMI), and the Pacific Remote Island Areas (PRIA, including Wake, Johnston and Palmyra Atolls, Kingman Reef, and Howland, Baker and Jarvis Islands).

Report objectives and audience

The NCRMP is committed to making data and data products publically available in a timely and user-friendly format to a wide variety of audiences. This data summary report presents quantitative data for human, biological and physical variables. Data are summarized at the island and within-island scale ('georegions') for the priority areas of the Pacific and at the habitat scale ('strata') for the priority areas of the Atlantic/Caribbean. Georegion (Pacific) and habitat strata (Atlantic/Caribbean) represent the highest spatial resolution that summary data (often averages) can be reported at, given the stratified-random sampling design.

This US-wide data summary report is the first developed since the formal implementation of the NCRMP in 2013. The primary audience for this data summary report and the publically available summary data is the scientific and management community. Greater than 95% of the data presented in this report was collected between 2015 and 2017. All summary-level data presented within the report are available via the NOAA Coral Reef Information System (CoRIS), and raw data are available through the National Centers for Environmental Information (NCEI). The methods used to collect the data presented within this report can be found within data reports made available with this report on the NOAA CoRIS webpage.

This data summary report presents data in maps, graphs, charts, tables and other figures and clearly describes what the data are. The focus here is on compelling presentation of the data and making the data publically available in accompanying user-friendly data tables. The data are presented and described rather than interpreted. Ongoing and future research by the scientific and management community – the target audience – can help explain the data presented, and the drivers of data patterns. This and other NCRMP reporting products will evolve in future years to address feedback and meet needs. As examples, future reporting products will examine trends in the status of coral reef and reef fish communities, and integrate social, ecological, chemical, and physical data.

Report structure

The data summary report consists of a report for each of the priority geographic areas. The report for each area has three sections: Human Connections, Coral Reefs and Reef Fish, and Ocean Chemistry and Temperature.

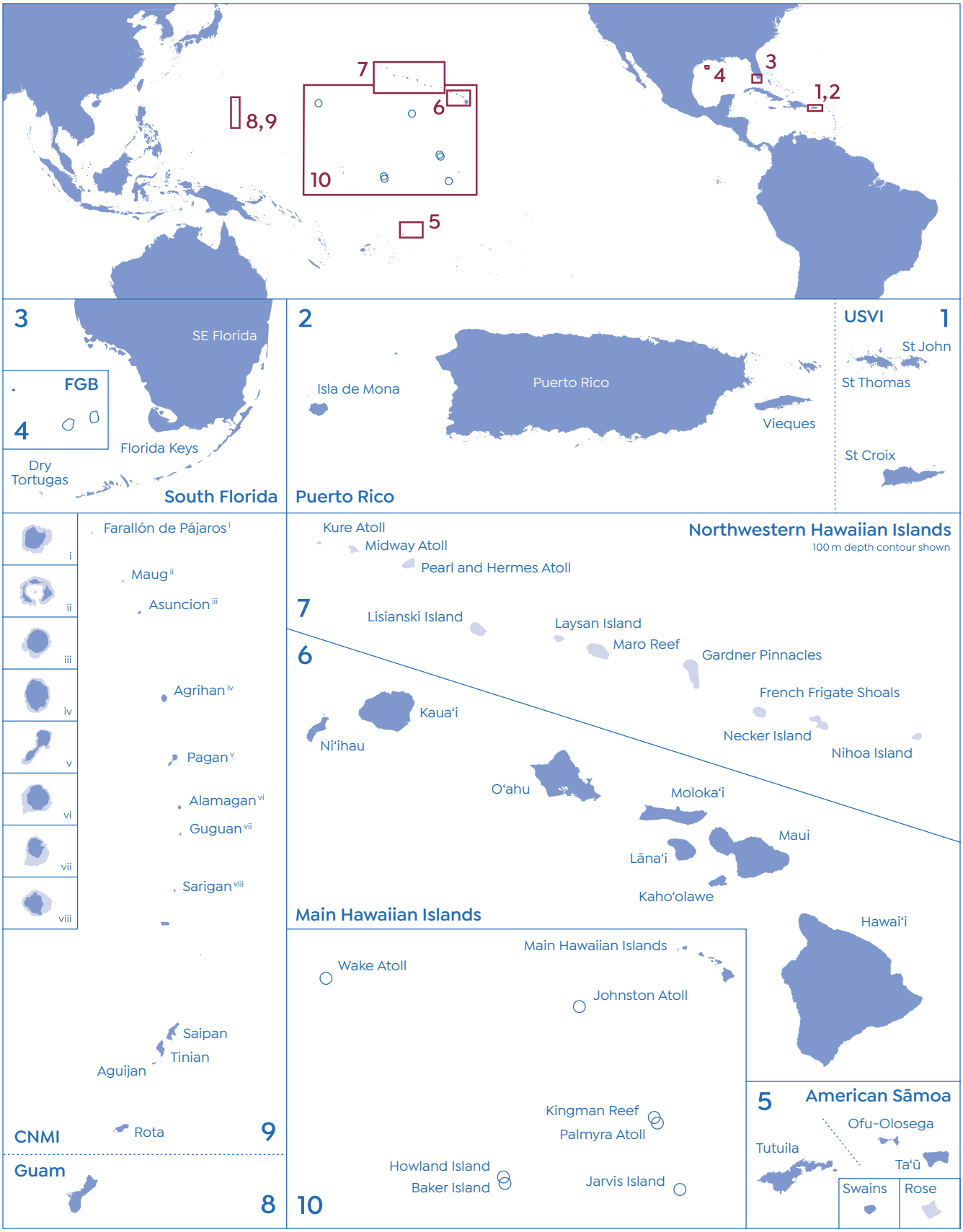
Human Connections: This section presents data from social surveys and secondary sources on demographics, values, resource use, and information sources; perceptions of resource condition, threats, and severity; and perceptions of reef management policies.

Coral Reefs and Reef Fish: This section presents data on benthic cover, adult and juvenile coral density, coral disease, coral mortality, the biomass and size-class distribution of reef fish, and the presence or absence of corals listed as Threatened under the Endangered Species Act (ESA-listed corals).

Ocean Chemistry and Temperature: This section presents data on aragonite saturation state, calcium carbonate accretion, pH, sub-surface temperature, and remotely sensed observations of temperature anomalies and heat stress.

The area reports can be seen as modules within the larger data summary report. Readers can navigate to each part of the report using the hyperlinks in the Table of Contents and can navigate from the area reports back to the Table of Contents.

Yellowmouth grouper (*Mycteroperca interstitialis*) at West Flower Garden Bank, Flower Garden Banks National Marine Sanctuary, Gulf of Mexico.



The NCRMP monitors coral reef ecosystems in these ten CRCP priority geographic areas: 1) US Virgin Islands (USVI), 2) Puerto Rico (PR), 3) Florida (FL), 4) Flower Garden Banks (FGB), 5) American Sāmoa (AS), 6) main Hawaiian Islands (MHI), 7) northwestern Hawaiian islands (NWHI), 8) Guam, 9) the Commonwealth of the Northern Mariana Islands (CNMI), and 10) the Pacific Remote Island Areas (PRIA, including Wake, Johnston and Palmyra Atolls, Kingman Reef, and Howland, Baker and Jarvis Islands).

United States Virgin Islands

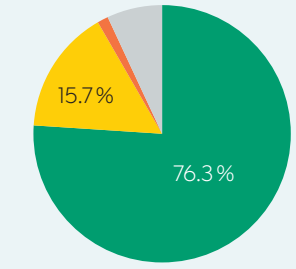
Demographics, values, resource use, and information sources

This Human Connections section presents findings from the United States Virgin Islands (USVI) NCRMP socioeconomic data collection and includes data never collected before in USVI. These are baseline data on social indicators from household surveys conducted in February to April, 2017, and from secondary sources.

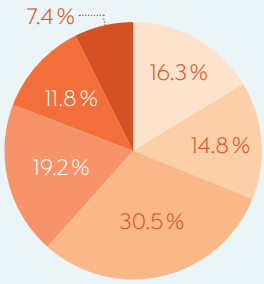
Highlights

- The great majority of residents agreed that coral reefs provide protection from erosion and natural disasters, attract tourists, and are culturally important.
- The dominant perception of the status of ocean water quality, amount of trash, amount and health of coral, and number of fish was that these were good. The dominant perception for trend was that the condition had worsened or remained the same over the past ten years.
- Of the potential threats to coral reefs, residents were least familiar with damage from SCUBA divers and snorkelers, and coral bleaching.
- Residents were generally very supportive of marine management policies.

Race



Educational attainment

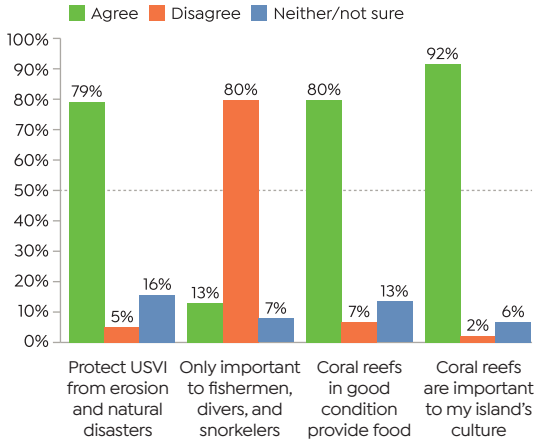


The population of USVI was predominantly composed of Black ethnicity (76%). Seventy percent of the population had at least completed high school, almost 40% had completed at least some college or an associate's degree, and ~19% a bachelor's degree or graduate degree.

Resource use

PERCENT OF POPULATION PARTICIPATING IN EACH ACTIVITY

Values and awareness

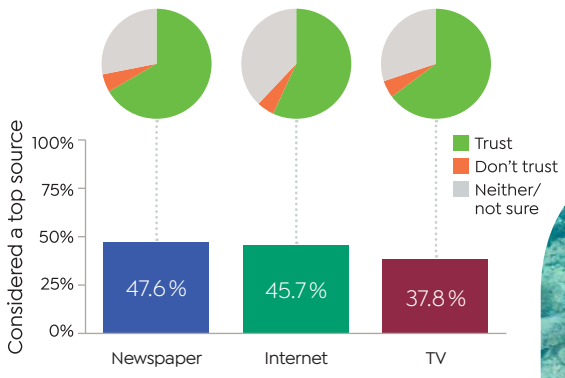


When asked about important services provided by reef resources, most residents agreed that coral reefs protect USVI from erosion and natural disasters (79%), that coral reefs provide food (80%), and that coral reefs are important to my island's culture (92%). The majority of residents (80%) disagreed with the statement that coral reefs are only important to fishermen, divers, and snorkelers.

2017 survey data (n = 1,188)

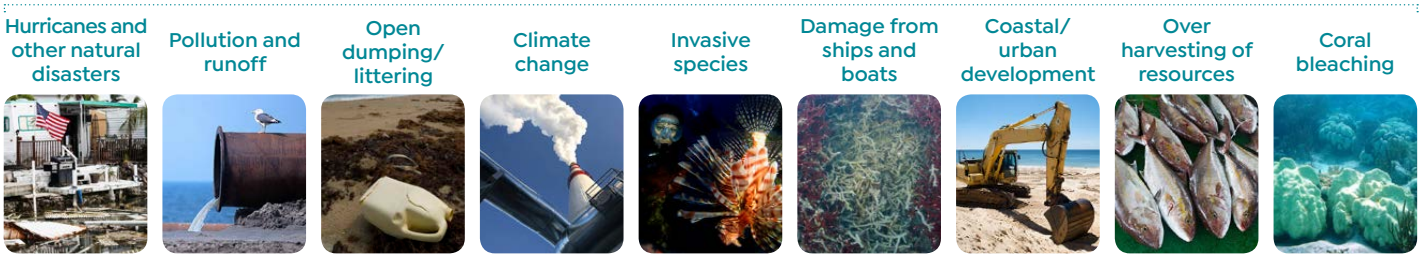
Information sources

Many residents considered newspapers (48%) and Internet (46%) to be a top source for information on the environment, including status of coral reefs and present and future threats. Greater than 60% of residents who claimed newspapers, Internet, and TV were top sources indicated these sources were trustworthy.



Perceptions of resource condition, threats, and severity

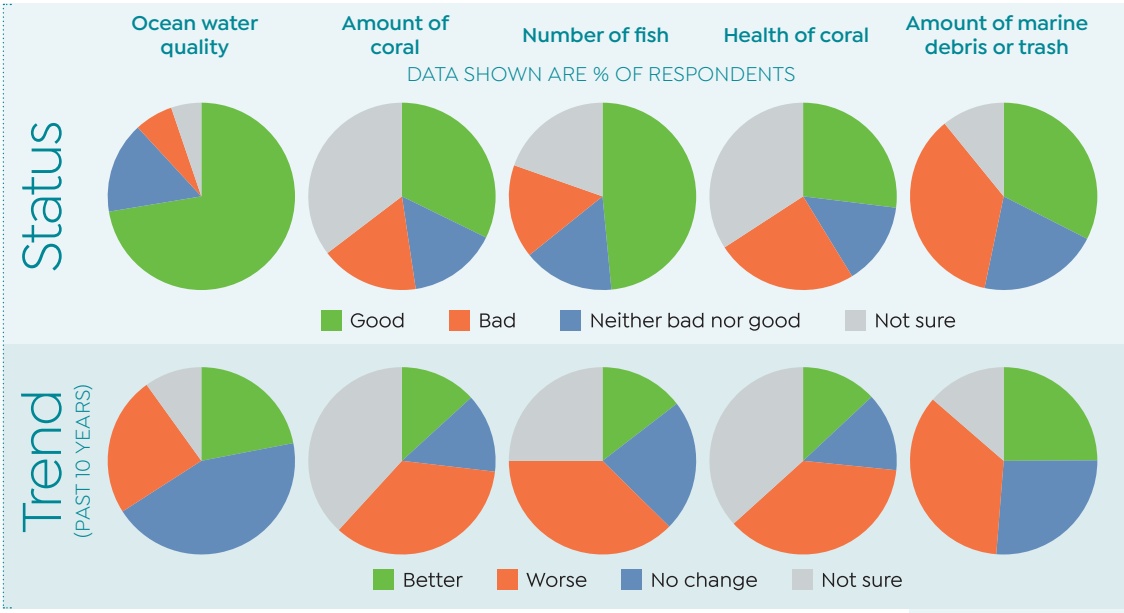
Threats

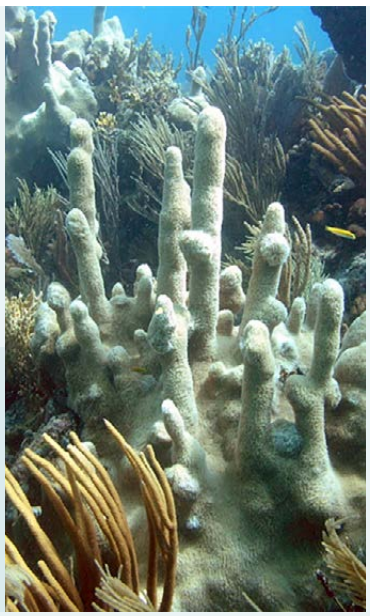


PERCENT OF THE POPULATION FAMILIAR WITH EACH THREAT

Threats not shown above: **Damage from SCUBA divers and snorkelers** (45 %).

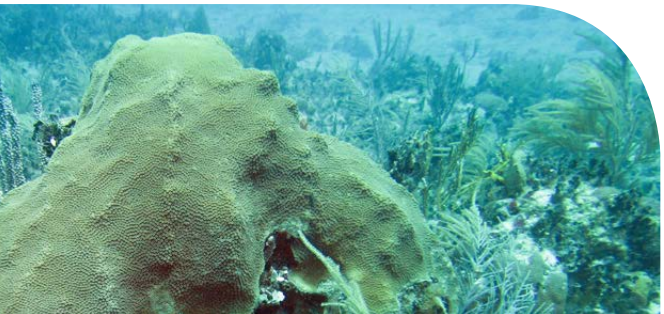
In general, residents were familiar with potential threats facing coral reefs in USVI, with at least half of residents stating they were familiar or very familiar with each potential threat shown above, except coral bleaching (47 %) and damage from SCUBA divers and snorkelers (45 %). Of the potential threats mentioned, residents were least familiar with threats caused by coral bleaching. Residents exhibited highest levels of familiarity with threats from pollution and hurricanes.



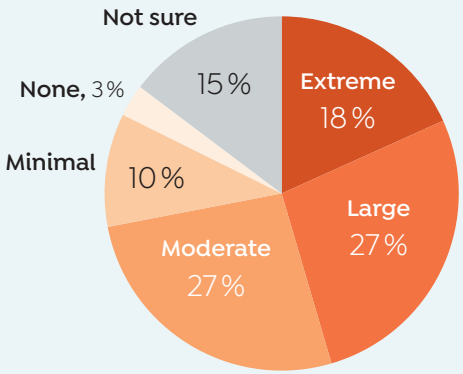


Status and trend

More residents felt confident in their perception of the status of ocean water quality and amount of marine debris or trash than for the amount and health of coral or number of fish (>20 % not sure). For those confident in their perception, roughly 35–75 % of residents felt the current status was good and roughly 5–40 % felt the current status was bad for all status variables. A different pattern was evident in the perceptions of trend. For those confident in their perception of the trends in these variables, roughly 70–80 % felt it had gotten worse or remained the same, and <30 % felt any of these had gotten better. The dominant perception of the status of ocean water quality, amount of trash, amount and health of coral, and number of fish was that these were good, however the dominant perception for trend was that the status had gotten worse or remained the same over the last ten years, rather than better.



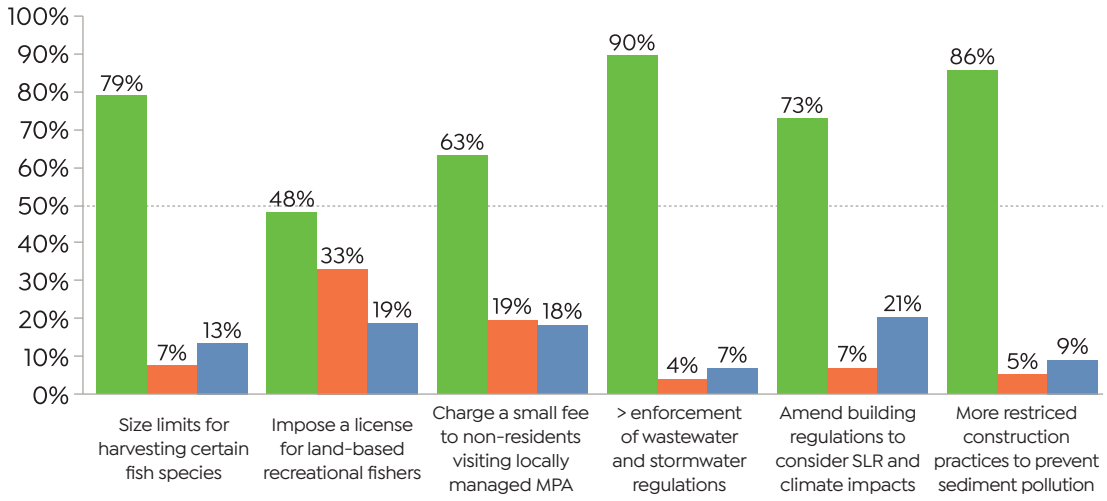
Severity of threats



Residents were generally concerned about threats to coral reefs in USVI. Eighteen percent of residents stated that they thought threats were extreme and 27 % thought threats were large. A small percentage (13 %) stated that threats were either minimal or believe there are no threats.

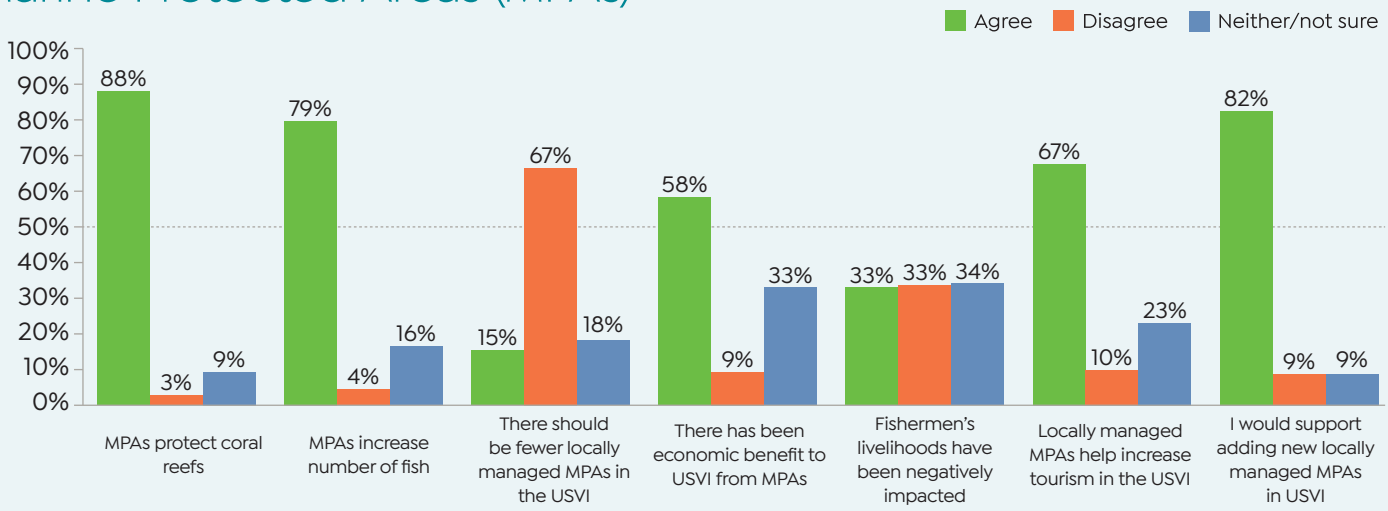
Perceptions of reef management policies

Management policies



Residents were generally supportive of current marine management policies. There was extremely high support for greater enforcement of wastewater regulations (90 %) and more restricted construction practices (86 %). There was less but still strong support for size limits for harvesting certain fish species (79 %) and amending building regulations to consider sea level rise (SLR) and climate impacts (73 %).

Marine Protected Areas (MPAs)



Respondents mostly agreed that MPAs provide benefits. Eighty percent or more of residents agreed or strongly agreed that MPAs protect coral reefs and would support adding new MPAs if evidence shows current ones are effective. Most also agree that MPAs increase number of fish (79 %), help increase tourism (67 %), and provide economic benefit (58 %). There was less certainty regarding whether or not fishermen's livelihoods had been negatively impacted by MPAs, with 33 % disagreeing with this statement, 33 % agreeing, and 34 % not sure. Most disagree with the statement that there should be fewer MPAs in USVI (67 %).

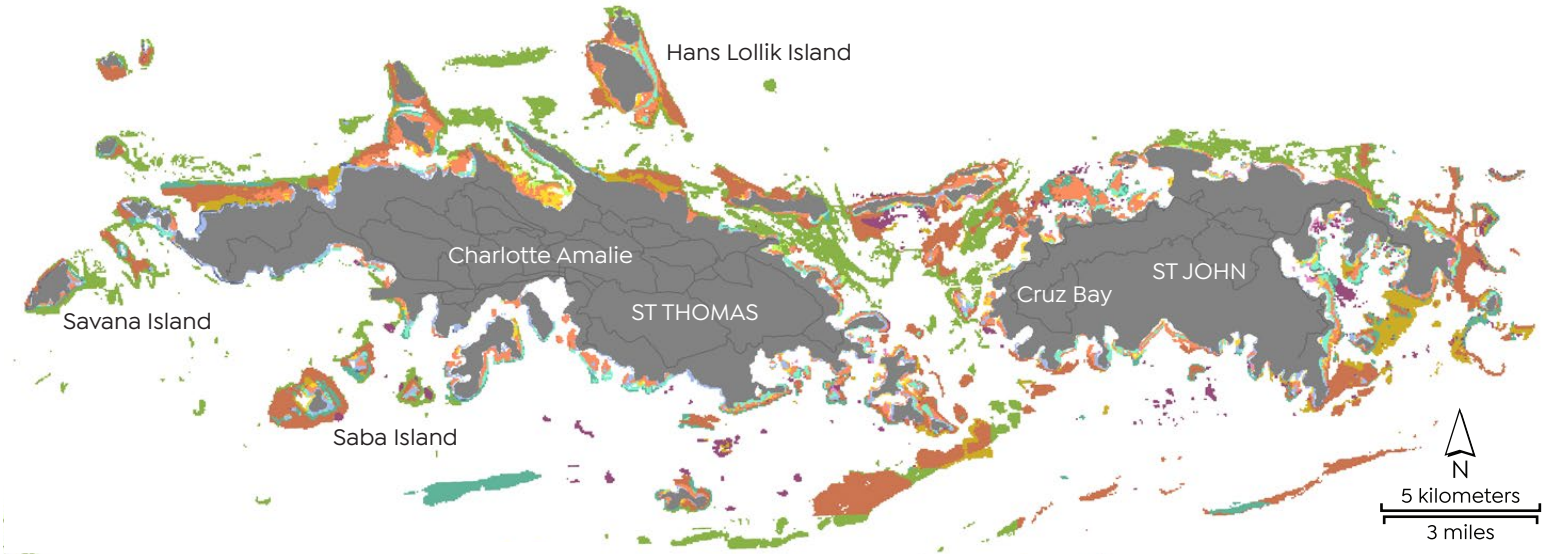
Coral reef, St Thomas, USVI

Divers monitoring coral reef condition in St Croix, US Virgin Islands.

Coral reefs – St Thomas and St John (2017)

Habitat strata

The coral reefs of St Thomas and St John were classified into five zones, as described below, plus an unknown hardbottom category. Within each zone, habitat strata were defined separately for deep areas (greater than 12m depth) and shallow areas (less than or equal to 12m depth).



Aggregate Reef

Linear coral formations that are oriented parallel to shore or the shelf edge. These features follow the contours of the shore/shelf edge.

This includes fore reef, fringing reef, shelf edge reef, and spur and groove reef.

Patch Reef

Coral formations that are isolated from other coral reef formations by sand, seagrass, or other habitats.

This includes individual patch reefs and/or aggregrated patch reefs.

Bedrock

Exposed bedrock contiguous with the shoreline that has coverage of macroalgae, hard coral, gorgonians, and/or other sessile invertebrates.

Colonized Pavement

Flat, low relief, solid carbonate rock with coverage of macroalgae, hard coral, gorgonians, contiguously or with sand channels.

Scattered Coral and Rock

Primarily sand or seagrass bottom with scattered rocks or small, isolated coral heads that are too small to be individual patch reefs.

Hard (unknown)

Habitat that has not yet been classified in detail, but is likely to be hardbottom based on spatial modeling of acoustic bathymetry survey data.

Habitat Strata (USVI)

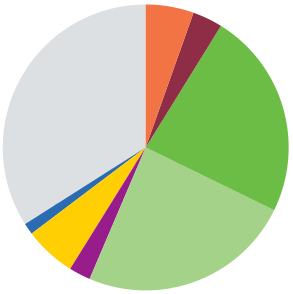
Deep (>12 m)	Shallow (≤ 12 m)	
		Aggregate Reef
		Patch Reef
		Bedrock
		Colonized Pavement
		Scattered Coral and Rock
		Hard (unknown)

Coral reefs – St Thomas and St John (2017)

Benthic cover

- Coral cover ranged from 0.1% in the Scattered Coral and Rock Deep to 17.5% in the Patch Reef Deep.
- Macroalgae cover ranged from 4.0% in the Hard (unknown) Shallow to 31.3% in the Aggregate Reef Deep.
- The region-wide average coral cover was 5.4% and macroalgae cover was 23.4%.

Regional

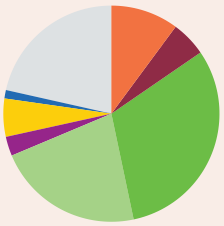


Coral 5.4±6.4%
Macroalgae 23.4±17.6%

- Coral cover was highest in the Patch Reef Deep.
- Macroalgae cover was highest in the Aggregate Reef Deep.
- Coral disease prevalence was lowest (0) in the Hard (unknown) Shallow, Pavement Shallow, and Scattered Coral and Rock Deep and highest (7.4% of colonies) in the Bedrock Deep.
- Seven species listed as Threatened under the Endangered Species Act were observed on reefs in St Thomas and St John in 2017. Six Threatened species were observed in the Aggregate Reef Shallow, Bedrock Shallow, and Hard (unknown) Deep.

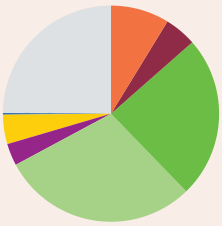
Aggregate Reef

Deep



Coral 10.1±6.4%
Macroalgae 31.3±17.6%

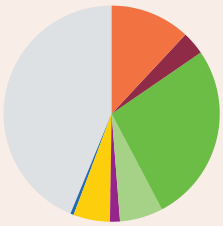
Shallow



Coral 8.8±7.4%
Macroalgae 24.3±15.6%

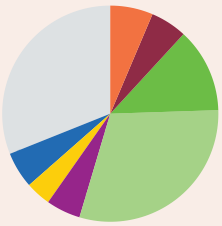
Bedrock

Deep



Coral 12.0±4.2%
Macroalgae 27.0±14.1%

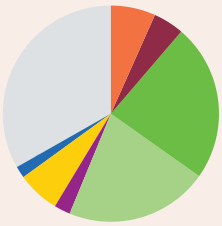
Shallow



Coral 6.4±6.6%
Macroalgae 12.6±9.9%

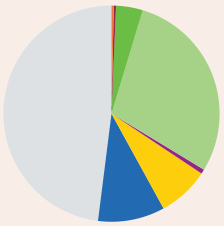
Hard (unknown)

Deep



Coral 6.7±9.0%
Macroalgae 23.5±19.2%

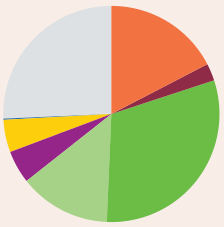
Shallow



Coral 0.3±0.6
Macroalgae 4.0±3.6

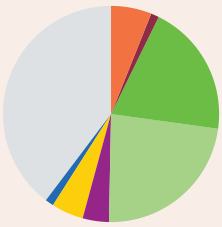
Patch Reef

Deep



Coral 17.5±13.2%
Macroalgae 30.9±17.9%

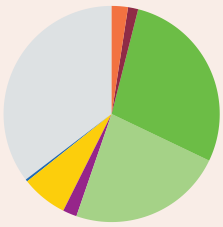
Shallow



Coral 6.1±6.1%
Macroalgae 19.9±15.4%

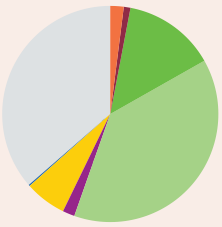
Pavement Reef

Deep



Coral 2.4±4.1%
Macroalgae 28.1±21.4%

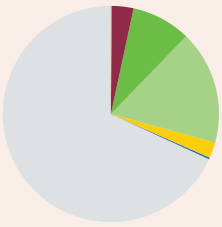
Shallow



Coral 2.0±3.9%
Macroalgae 13.8±13.4%

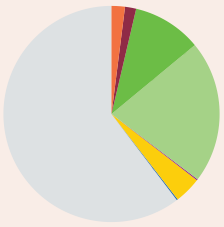
Scattered Coral and Rock

Deep



Coral 0.1±0.4%
Macroalgae 8.9±10.0%

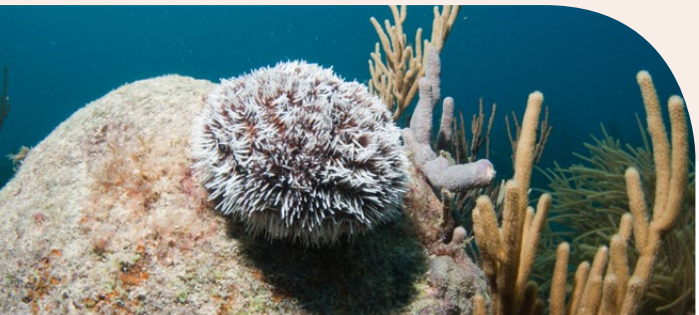
Shallow



Coral 2.0±1.9%
Macroalgae 10.3±3.5%

Benthic cover

- Hard coral
- Crustose coralline algae
- Macroalgae
- Turf algae
- Soft corals
- Sponges
- *Ramicrusta* spp.
- Other



Coral reefs – St Thomas and St John (2017)

Benthic communities

- Diadema (sea urchin) density ranged from absent in four strata to 0.42/m^2 in the Bedrock Shallow.
- Coral density (unweighted) ranged from 0.44/m^2 in the Scattered Coral and Rock Deep to 10.1/m^2 in the Bedrock Deep.
- Species richness (unweighted) was highest (13.5) in the Bedrock Deep and lowest (2.6) in the Scattered Coral and Rock Deep.
- Coral diversity was highest in the Aggregate Reef Deep and lowest in the Pavement Shallow.
- Disease prevalence ranged from 0 in the Hard (unknown) Shallow, the Pavement Shallow, and the Scattered Coral and Rock Deep, to 7.4% of colonies in the Bedrock Deep.
- Recent mortality (unweighted) was less than 1.5% in all habitat strata.
- Old mortality (unweighted) was highest (18.3%) in the Pavement Shallow and lowest (5.0%) in the Hard (unknown) Shallow.

Benthic data collected in 2017 for the habitat strata in St Thomas and St John. Transects (n) describes how sampling effort varied among the strata.

Habitat strata	Transects (n)	Diadema density (m^{-2})	Coral density (m^{-2})	Species richness	Coral diversity (Simpsons)	Disease prevalence (% colonies)	Recent mortality (%)	Old mortality (%)
Aggregate Reef Deep	35	0.00±0.00	5.73±2.91	11.79±3.09	8.84	2.0	0.43±0.71	15.39±7.87
Aggregate Reef Shallow	37	0.10±0.36	5.49±3.55	9.03±2.85	6.06	1.5	0.24±0.38	12.40±9.08
Bedrock Deep	2	0.00±0.00	10.10±4.10	13.50±0.71	5.55	7.4	0.93±0.77	14.34±11.22
Bedrock Shallow	21	0.42±0.81	4.88±2.78	9.38±3.07	5.49	0.6	0.13±0.30	13.07±7.97
Hard (unknown) Deep	65	0.00±0.01	3.88±3.33	7.85±3.99	7.35	1.9	0.60±1.53	10.40±8.57
Hard (unknown) Shallow	3	0.00±0.00	0.97±0.55	5.67±2.08	6.64	0.0	1.48±2.57	4.99±7.69
Patch Reef Deep	17	0.01±0.03	6.69±3.14	11.65±2.87	8.54	2.2	0.33±0.43	17.44±9.49
Patch Reef Shallow	15	0.04±0.09	6.02±6.46	9.13±4.26	6.35	2.9	0.23±0.37	16.71±16.41
Pavement Deep	21	0.00±0.00	1.57±1.64	5.76±2.53	5.99	1.6	0.55±1.76	14.10±12.37
Pavement Shallow	5	0.03±0.07	1.86±1.93	4.60±1.95	3.90	0.0	0.89±1.42	18.34±16.08
Scattered Coral and Rock Deep	8	0.00±0.01	0.44±0.32	2.63±1.06	4.45	0.0	0.19±0.33	12.30±23.82
Scattered Coral and Rock Shallow	6	0.06±0.11	1.60±0.80	5.50±2.51	4.38	1.1	0.21±0.45	10.68±7.12

Coral reefs – St Thomas and St John (2017)

Endangered coral species

» Seven species listed as Threatened under the Endangered Species Act (ESA) were observed on reefs in St Thomas and St John in 2017.

» *Acropora palmata* was only observed in the Aggregate Reef Shallow and the Bedrock Shallow. *Acropora cervicornis* was observed in all six strata, as was *Orbicella annularis*, *faveolata*, and *franksi*.

» Six of the seven ESA-listed coral species were observed in the Aggregate Reef Shallow, Bedrock Shallow, and Hard (unknown) Deep.

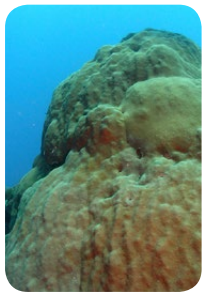
Acropora palmata

Acropora cervicornis

Dendrogyra cylindrus

Mycetophyllia ferox

Orbicella annularis



Orbicella faveolata

Orbicella franksi

Presence of coral species listed as Threatened under the Endangered Species Act (ESA).

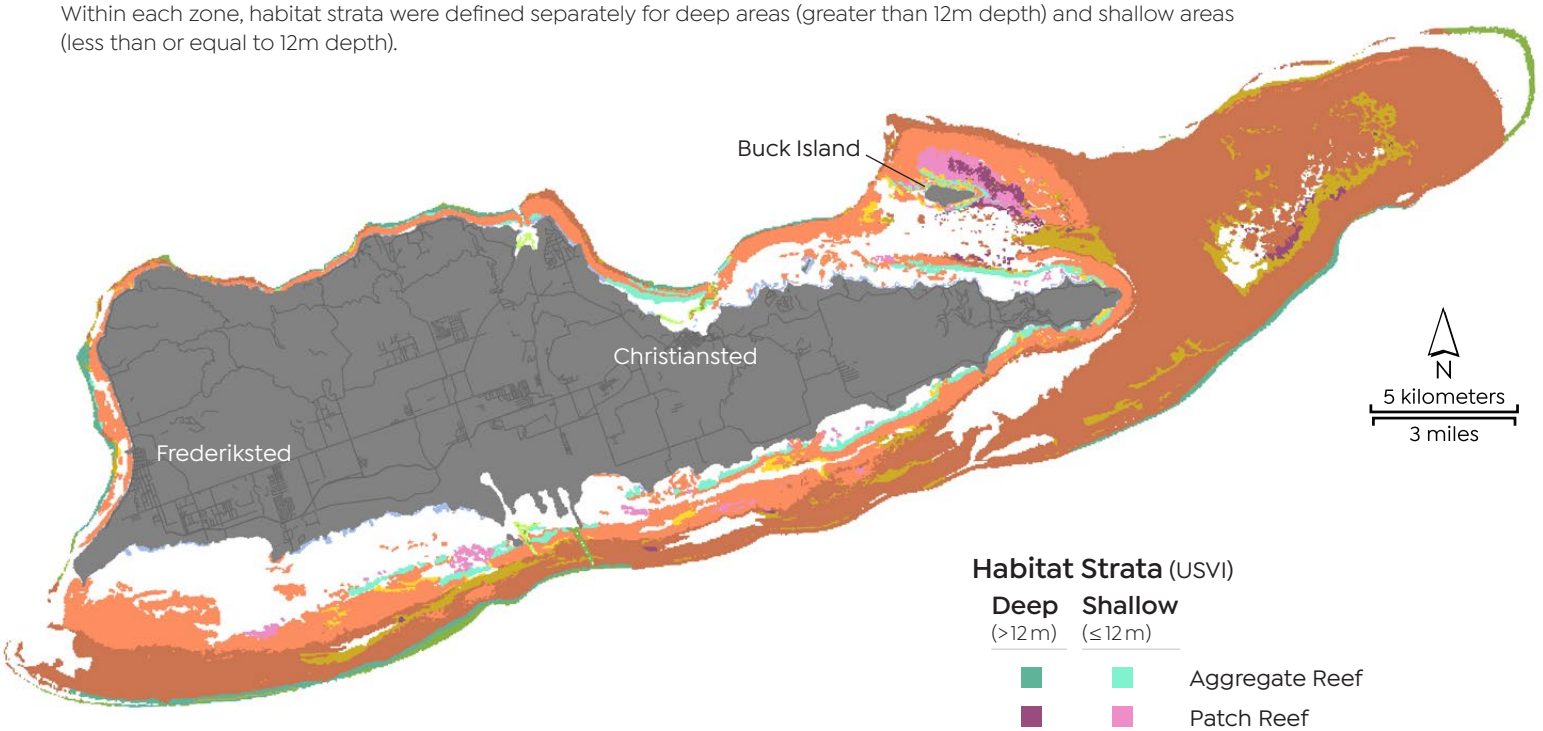
Habitat Strata	No. ESA coral species	*Acropora palmata*	*Acropora cervicornis*	*Dendrogyra cylindrus*	*Mycetophyllia ferox*	*Orbicella annularis*	*Orbicella faveolata*	*Orbicella franksi*
Aggregate Reef Deep	5	○	○	●	●	●	●	●
Aggregate Reef Shallow	6	●	●	●	○	●	●	●
Bedrock Deep	3	○	○	○	○	●	●	●
Bedrock Shallow	6	●	●	●	○	●	●	●
Hard (unknown) Deep	6	○	●	●	●	●	●	●
Hard (unknown) Shallow	1	○	○	○	○	○	○	●
Patch Reef Deep	5	○	●	●	○	●	●	●
Patch Reef Shallow	4	○	○	●	○	●	●	●
Pavement Deep	4	○	●	○	○	●	●	●
Pavement Shallow	3	○	○	○	○	●	●	●
Scattered Coral and Rock Deep	1	○	○	○	○	○	○	●
Scattered Coral and Rock Shallow	5	○	●	●	○	●	●	●

Dendrogyra cylindrus

Coral reefs – St Croix (2017)

Habitat strata

The coral reefs of St Croix were classified into five zones, as described below, plus an unknown hardbottom category. Within each zone, habitat strata were defined separately for deep areas (greater than 12m depth) and shallow areas (less than or equal to 12m depth).



Habitat Strata (USVI)

Deep (>12 m)	Shallow (≤ 12 m)	
		Aggregate Reef
		Patch Reef
		Bedrock
		Colonized Pavement
		Scattered Coral and Rock
		Hard (unknown)

Aggregate Reef

Linear coral formations that are oriented parallel to shore or the shelf edge. These features follow the contours of the shore/shelf edge.

This includes fore reef, fringing reef, shelf edge reef, and spur and groove reef.

Patch Reef

Coral formations that are isolated from other coral reef formations by sand, seagrass, or other habitats.

This includes individual patch reefs and/or aggregrated patch reefs.

Bedrock

Exposed bedrock contiguous with the shoreline that has coverage of macroalgae, hard coral, gorgonians, and/or other sessile invertebrates.

Colonized Pavement

Flat, low relief, solid carbonate rock with coverage of macroalgae, hard coral, gorgonians, contiguously or with sand channels.

Scattered Coral and Rock

Primarily sand or seagrass bottom with scattered rocks or small, isolated coral heads that are too small to be individual patch reefs.

Hard (unknown)

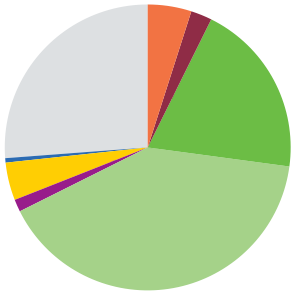
Habitat that has not yet been classified in detail, but is likely to be hardbottom based on spatial modeling of acoustic bathymetry survey data.

Coral reefs – St Croix (2017)

Benthic cover

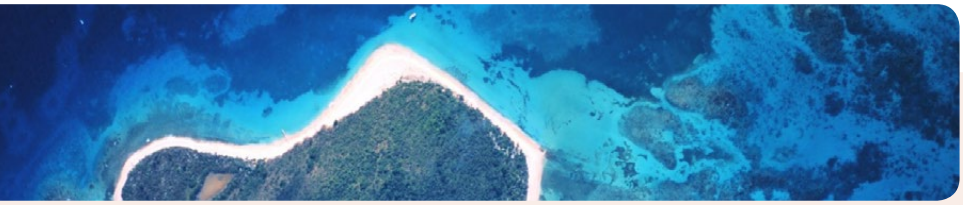
- Coral cover ranged from 0% in the Bedrock Shallow to 15.3% in the Patch Reef Deep.
- Macroalgae cover ranged from 8.6% in the Scattered Coral and Rock Shallow to 30.8% in the Aggregate Reef Shallow.
- The region-wide average coral cover was 4.9% and macroalgae cover was 19.8%.

Regional



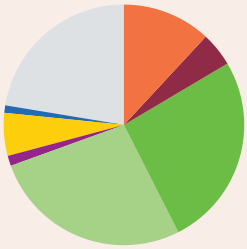
Coral 4.9±4.2%
Macroalgae 19.8±19.4%

- Coral cover was highest in the Patch Reef Deep
- Macroalgae cover was highest in the Aggregate Reef Shallow
- Coral disease prevalence was highest (3.5% of colonies) in the Pavement Shallow.
- Seven species listed as Threatened under the Endangered Species Act were observed on reefs in St Croix in 2017. Seven Threatened species were observed in the Patch Reef Deep and six species were observed in the Aggregate Reef, Deep and Shallow.



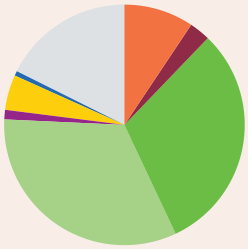
Aggregate Reef

Deep



Coral 11.9±8.0%
Macroalgae 26.0±21.3%

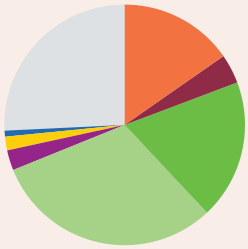
Shallow



Coral 9.4±6.5%
Macroalgae 30.8±18.0%

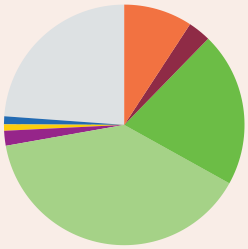
Patch Reef

Deep



Coral 15.3±9.7%
Macroalgae 18.7±17.9%

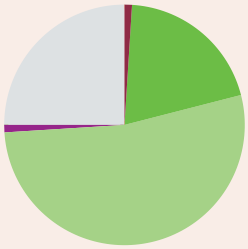
Shallow



Coral 9.2±7.4%
Macroalgae 20.8±20.1%

Bedrock

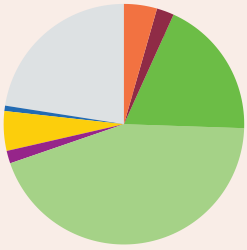
Shallow



Coral 0.0±NA%
Macroalgae 20.0±NA%

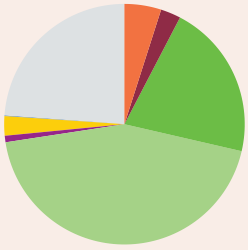
Pavement

Deep



Coral 4.4±3.6%
Macroalgae 18.8±19.5%

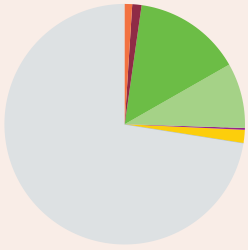
Shallow



Coral 4.9±5.0%
Macroalgae 21.0±18.2%

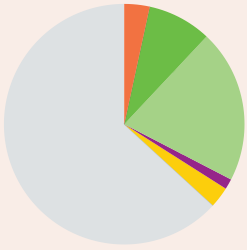
Scattered Coral and Rock

Deep



Coral 1.0±0.8%
Macroalgae 14.5±25.7%

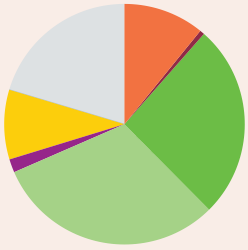
Shallow



Coral 3.4±7.6%
Macroalgae 8.6±8.5%

Hard (unknown)

Deep



Coral 10.9±7.9%
Macroalgae 26.1±30.3%

Benthic cover

- Hard coral
- Crustose coralline algae
- Macroalgae
- Turf algae
- Soft corals
- Sponges
- *Ramicrusta* spp.
- Other

Coral reefs – St Croix (2017)

Benthic communities

- Diadema (sea urchin) density (0.05/m^2) was highest in the Aggregate Reef Shallow.
- Coral density (unweighted) ranged from 0.9/m^2 in the Bedrock Shallow to 7.5/m^2 in the Patch Reef Deep.
- Species richness (unweighted) was highest (12.7) in the Patch Reef Deep and lowest (5.3) in the Scattered Coral and Rock Shallow.
- Coral diversity was highest in the Scattered Coral and Rock Shallow and lowest in the Bedrock Shallow.
- Disease prevalence ranged from absent in the Bedrock Shallow and the Scattered Coral and Rock Shallow to 3.5% of colonies in the Pavement Shallow.
- Recent mortality (unweighted) was less than 0.25% in all habitat strata.
- Old mortality (unweighted) was highest (16.7%) in the Patch Reef Shallow and lowest (5.6%) in a single transect in the Bedrock Shallow.

Benthic data collected in 2017 for the habitat strata in St Croix. Transects (n) describes how sampling effort varied among the strata.

Habitat strata	Transects (n)	Diadema density (m^{-2})	Coral density (m^{-2})	Species richness	Coral diversity (Simpsons)	Disease prevalence (% colonies)	Recent mortality (%)	Old mortality (%)
Aggregate Reef Deep	41	0.00±0.01	7.24±4.62	12.37±3.40	8.91	1.6	0.22±0.40	10.36±5.24
Aggregate Reef Shallow	11	0.05±0.17	5.61±2.97	10.64±4.43	7.37	1.6	0.20±0.26	12.86±6.55
Bedrock Shallow	1	0.00	0.90	6.00	5.40	0.0	0.00	5.56
Hard (unknown) Deep	8	0.00±0.00	5.81±3.06	11.00±3.21	9.30	2.4	0.22±0.31	13.04±7.30
Patch Reef Deep	17	0.00±0.00	7.49±3.76	12.71±3.39	9.57	2.4	0.23±0.36	12.81±8.04
Patch Reef Shallow	14	0.00±0.01	5.68±4.90	8.64±2.79	6.59	1.0	0.17±0.23	16.66±13.61
Pavement Deep	43	0.00±0.00	3.37±2.26	9.00±2.95	7.40	2.6	0.22±0.54	10.49±6.86
Pavement Shallow	29	0.01±0.03	3.70±2.62	7.14±2.85	5.55	3.5	0.19±0.36	12.59±7.77
Scattered Coral and Rock Deep	4	0.00±0.00	1.48±1.37	6.75±3.10	8.01	1.7	0.05±0.08	13.45±13.41
Scattered Coral and Rock Shallow	4	0.00±0.00	1.33±2.06	5.25±5.32	10.14	0.0	0.00±0.00	7.28±3.50

Coral reefs – St Croix (2017)

Endangered coral species

» Seven species listed as Threatened under the Endangered Species Act (ESA) were observed on reefs in St Croix in 2017.

» *Mycetophyllia ferox* was observed in only two of the six strata. *Orbicella annularis*, *faveolata*, and *franksi* were observed in five of the six strata.

» All seven of the ESA-listed corals present in St Croix during the 2017 surveys were observed in the Patch Reef Deep; six of the seven were observed in the Aggregate Reef Deep and Shallow.

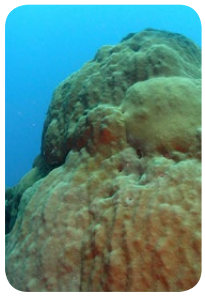
Acropora palmata

Acropora cervicornis

Dendrogyra cylindrus

Mycetophyllia ferox

Orbicella annularis

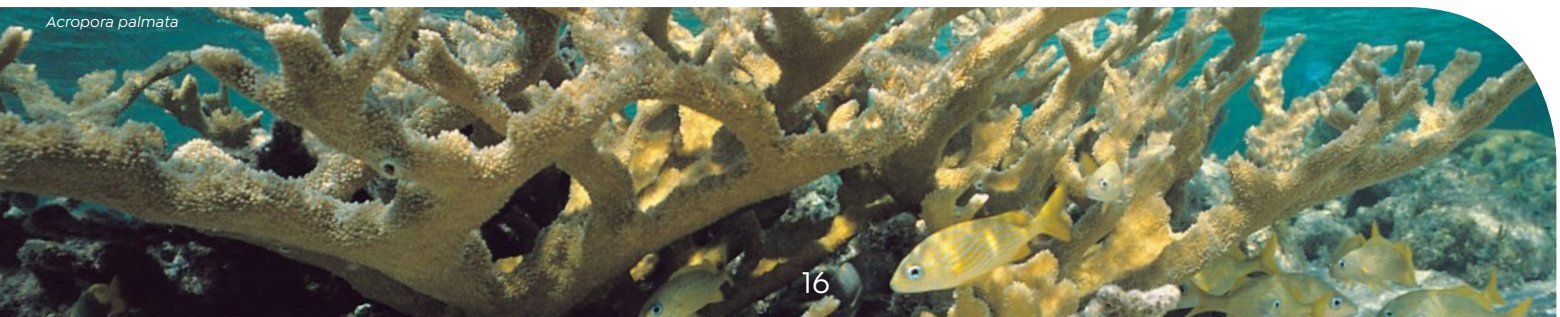


Orbicella faveolata

Orbicella franksi

Presence of coral species listed as Threatened under the Endangered Species Act (ESA).

Habitat Strata	No. ESA coral species	*Acropora palmata*	*Acropora cervicornis*	*Dendrogyra cylindrus*	*Mycetophyllia ferox*	*Orbicella annularis*	*Orbicella faveolata*	*Orbicella franksi*
Aggregate Reef Deep	6	○	●	●	●	●	●	●
Aggregate Reef Shallow	6	●	●	●	○	●	●	●
Bedrock Shallow	0	○	○	○	○	○	○	○
Hard (unknown) Deep	3	○	○	○	○	●	●	●
Hard (unknown) Shallow	5	○	●	●	○	●	●	●
Patch Reef Deep	7	●	●	●	●	●	●	●
Patch Reef Shallow	5	○	○	●	●	●	●	●
Pavement Deep	5	●	●	○	○	●	●	●
Pavement Shallow	2	○	○	○	○	○	●	●
Scattered Coral and Rock Deep	3	○	○	○	○	●	●	●



Acropora palmata

Coral Reef Fish – USVI (2017)

Relative abundance and length of reef fishes

Results are presented for 11 species surveyed in USVI in 2017. The diverse suite of species selected represent eight families of varying trophic levels (herbivores and piscivores) and fishing pressures (targeted and non-targeted), and together provide a perspective on the overall status of coral reef fishes. Relative abundance (density) and length-based indices (size-class distribution) are presented here to allow for comparison among sub-regions.



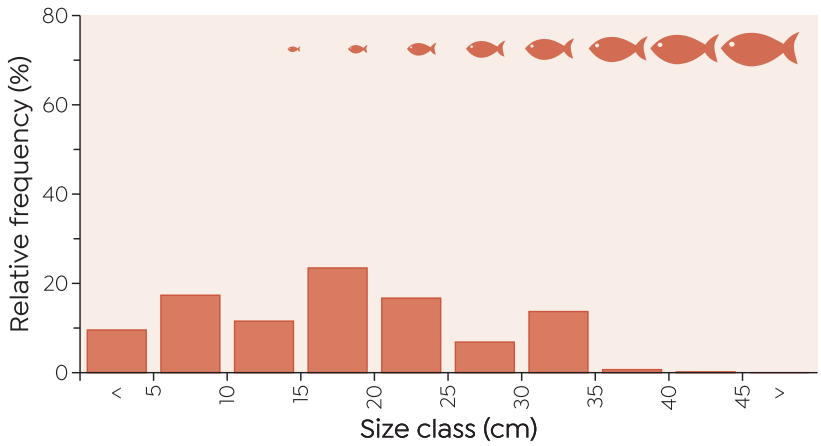


Stoplight Parrotfish (*Sparisoma viride*)

Family: **Scaridae**
Targeted: **No**

USVI – St Thomas and St John

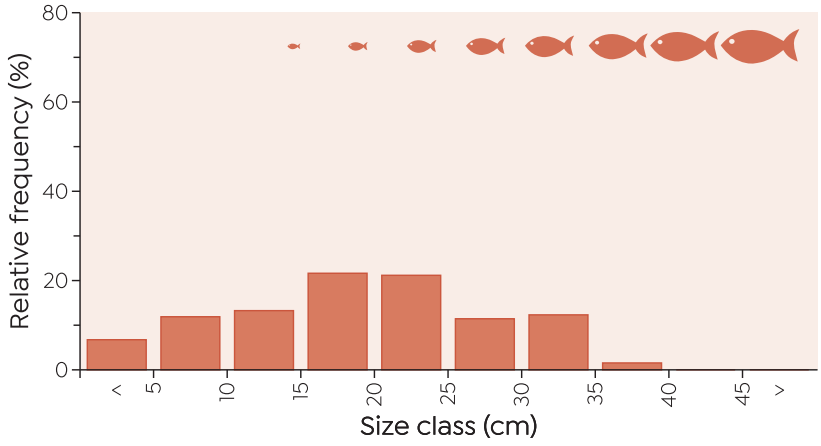
Mean density (/177m²) was 1.87±0.04 (n = 236 surveys).



Size-class distribution of *Sparisoma viride* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 1.50±0.06 (n = 181 surveys).



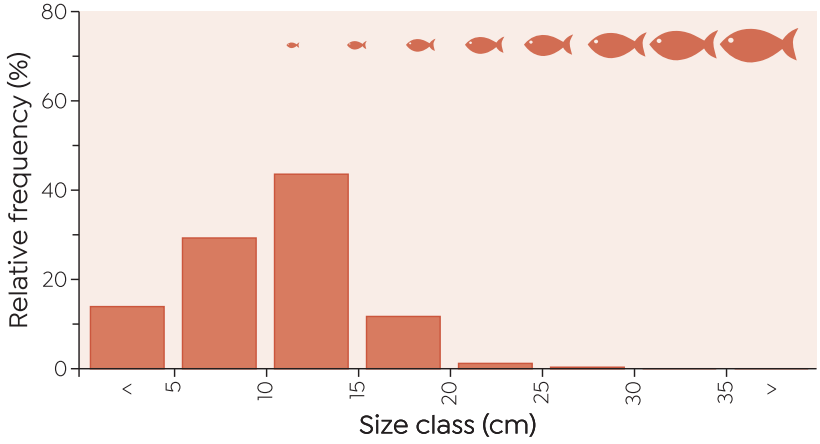
Size-class distribution of *Sparisoma viride* in St Croix.

Blue Tang (*Acanthurus coeruleus*)

Family: **Acanthuridae**
Targeted: **No**

USVI – St Thomas and St John

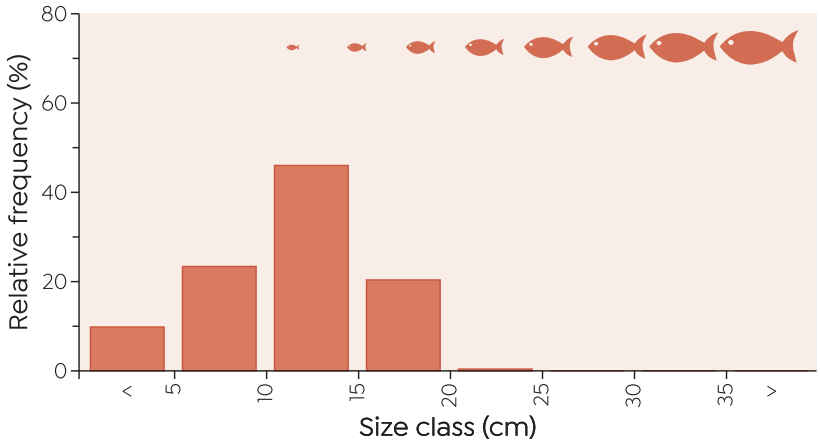
Mean density (/177m²) was 4.01±0.32 (n = 236 surveys).



Size-class distribution of *Acanthurus coeruleus* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 4.88±0.32 (n = 181 surveys).



Size-class distribution of *Acanthurus coeruleus* in St Croix.

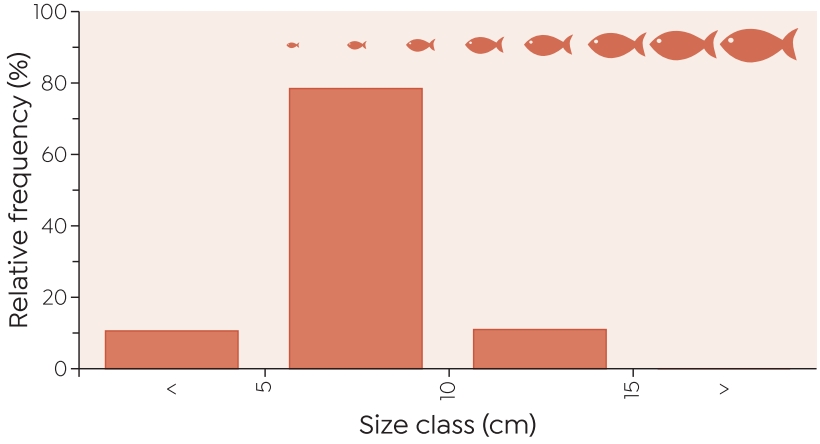
Acanthurus coeruleus

Foureye Butterflyfish (*Chaetodon capistratus*)

Family: **Chaetodontidae**
Targeted: **No**

USVI – St Thomas and St John

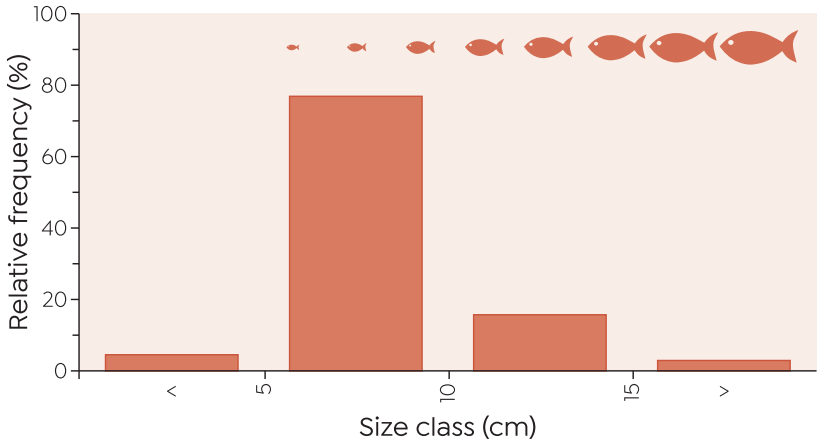
Mean density (/177m²) was 1.86±0.03 (n = 236 surveys).



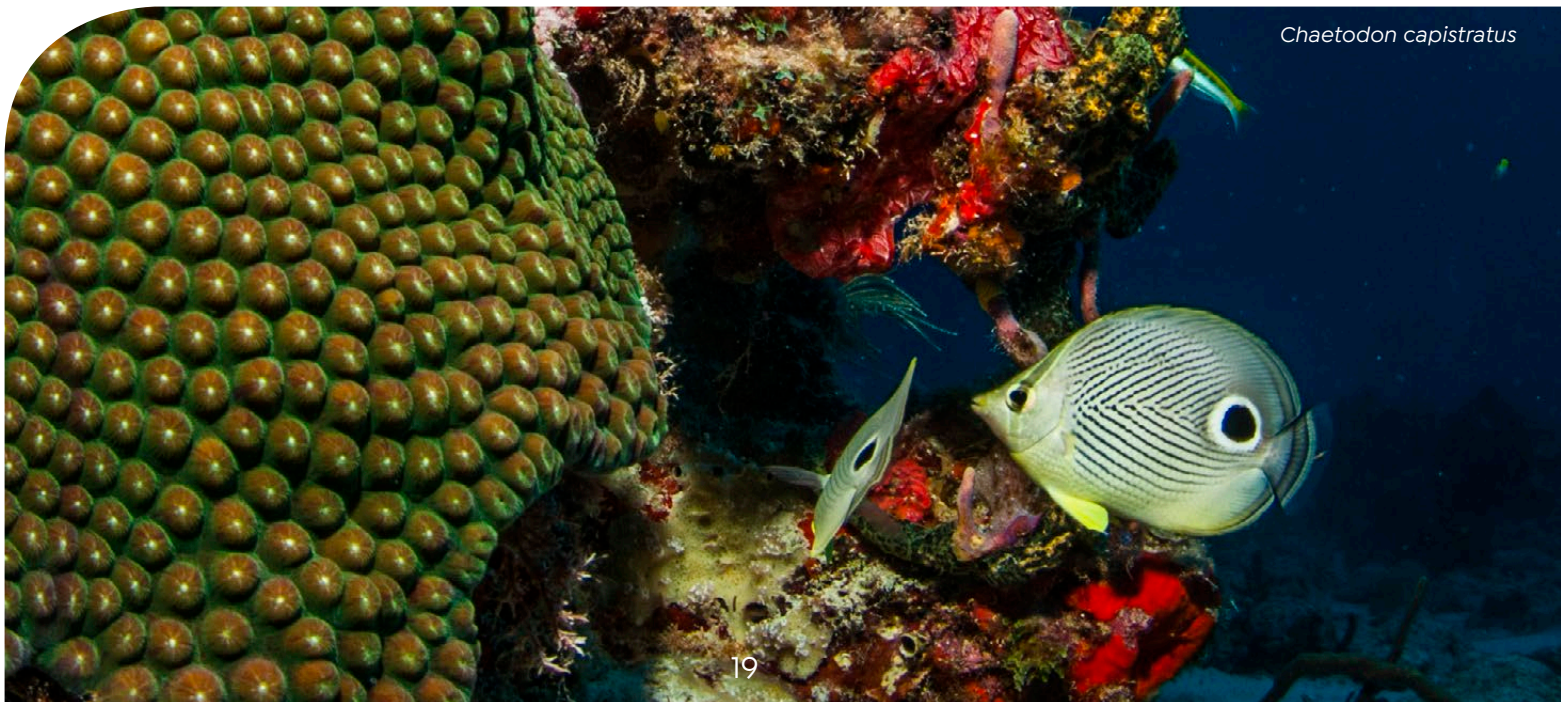
Size-class distribution of *Chaetodon capistratus* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 0.92±0.02 (n = 181 surveys).



Size-class distribution of *Chaetodon capistratus* in St Croix.



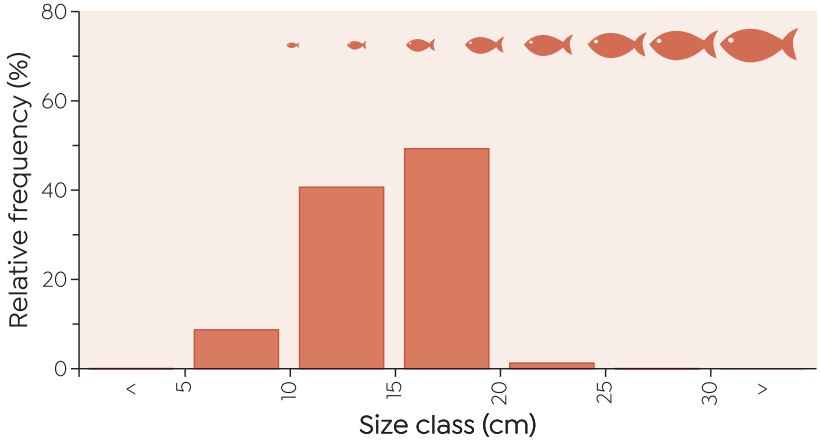
Chaetodon capistratus

French Grunt (*Haemulon flavolineatum*)

Family: **Haemulidae**
Targeted: **No**

USVI – St Thomas and St John

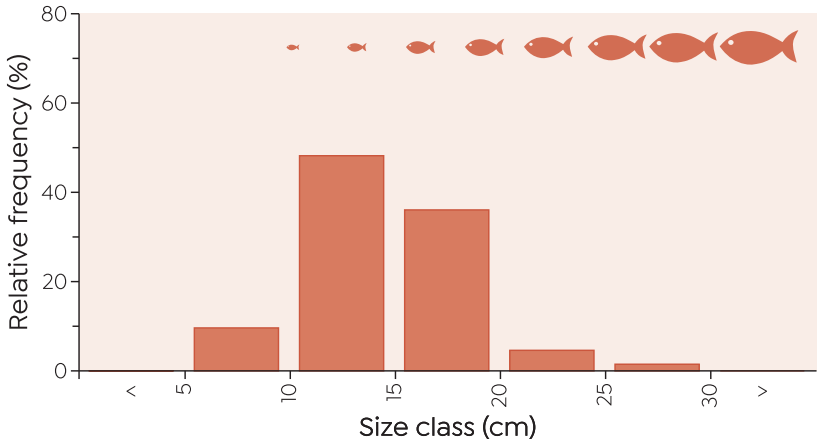
Mean density (/177m²) was 1.96±0.18 (n = 236 surveys).



Size-class distribution of *Haemulon flavolineatum* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 1.85±0.25 (n = 181 surveys).



Size-class distribution of *Haemulon flavolineatum* in St Croix.

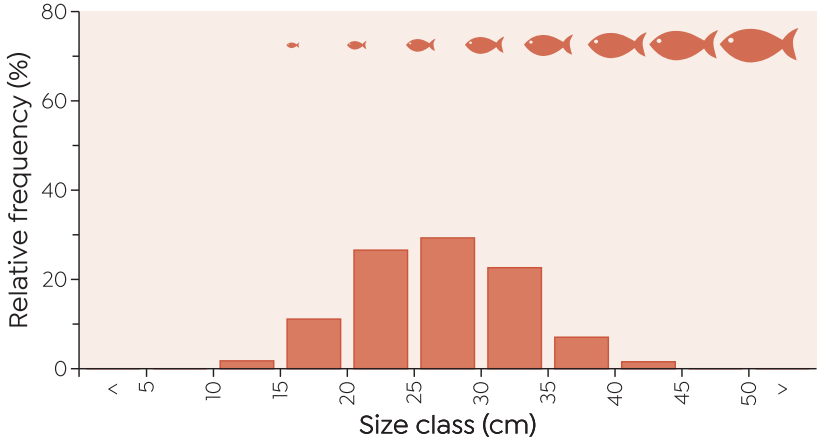
Haemulon flavolineatum

Queen Triggerfish (*Balistes vetula*)

Family: **Balistidae**
Targeted: **Yes**

USVI – St Thomas and St John

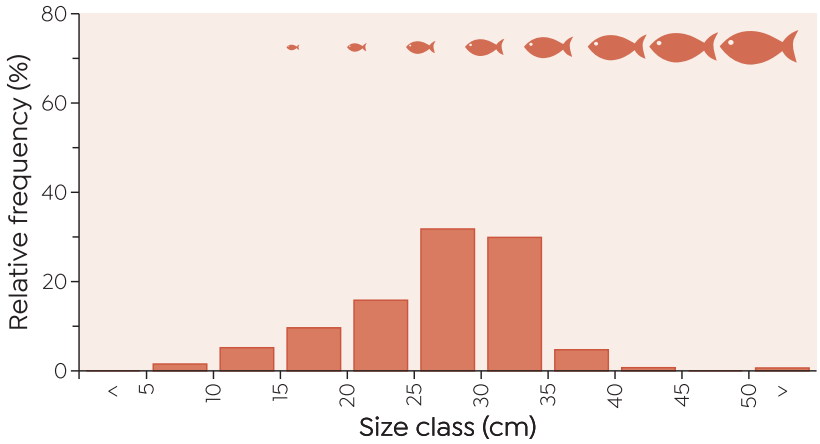
Mean density (/177m²) was 0.29±0.00 (n = 236 surveys).



Size-class distribution of *Balistes vetula* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 0.72±0.01 (n = 181 surveys).



Size-class distribution of *Balistes vetula* in St Croix.

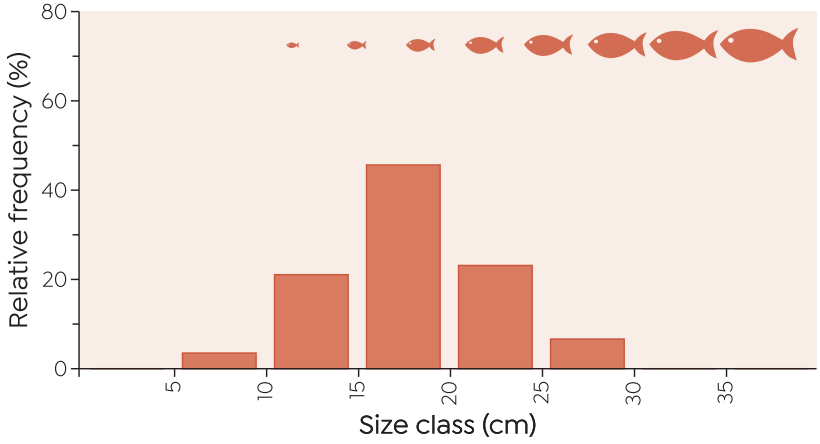
Balistes vetula

Coney (*Cephalopholis fulva*)

Family: **Serranidae**
Targeted: **Yes**

USVI – St Thomas and St John

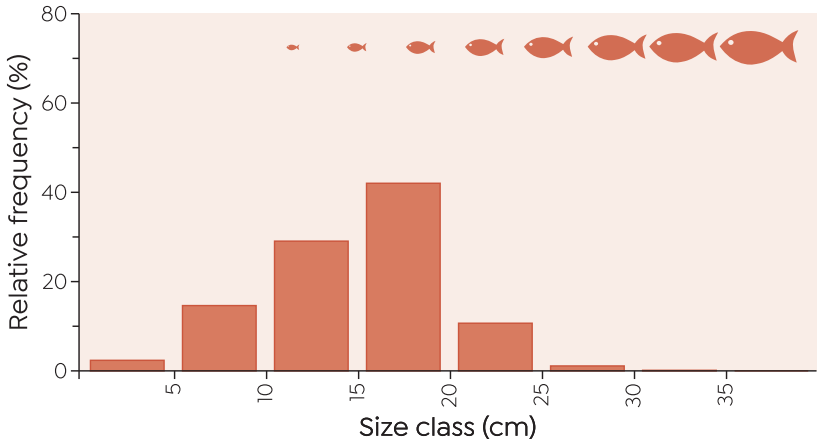
Mean density (/177m²) was 1.31±0.03 (n = 236 surveys).



Size-class distribution of *Cephalopholis fulva* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 4.29±0.12 (n = 181 surveys).



Size-class distribution of *Cephalopholis fulva* in St Croix.

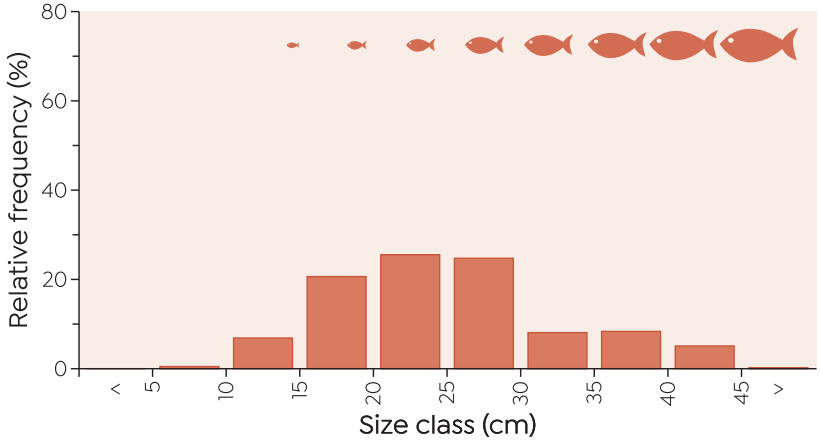
Cephalopholis fulva

Red Hind (*Epinephelus guttatus*)

Family: **Serranidae**
Targeted: **Yes**

USVI – St Thomas and St John

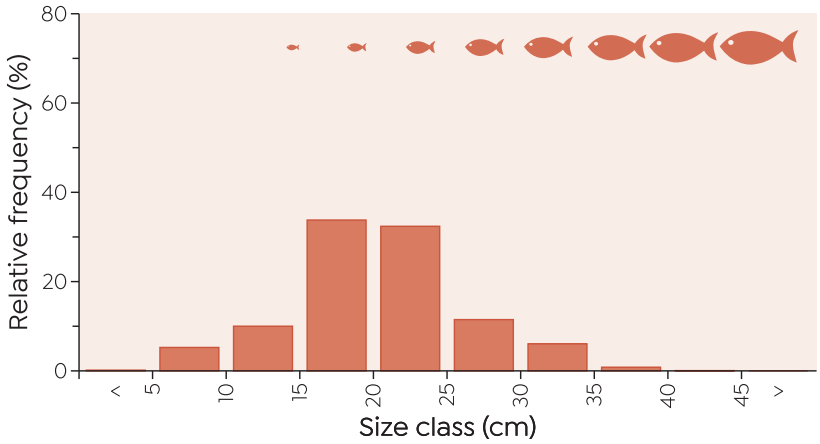
Mean density (/177m²) was 0.60±0.01 (n = 236 surveys).



Size-class distribution of *Epinephelus guttatus* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 0.28±0.00 (n = 181 surveys).



Size-class distribution of *Epinephelus guttatus* in St Croix.

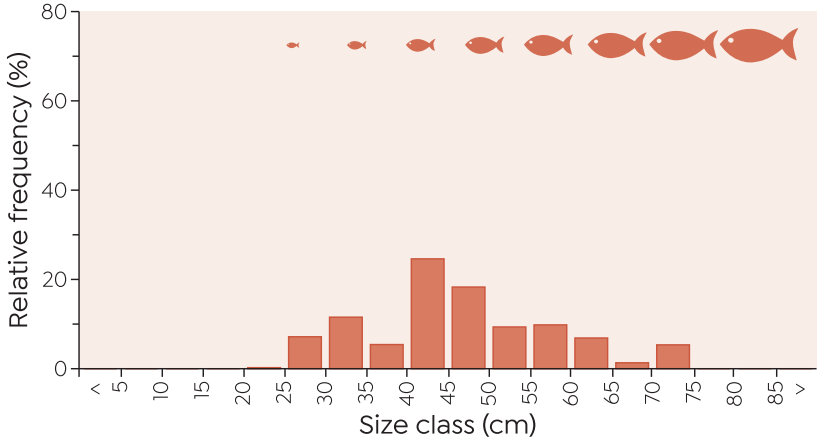

Epinephelus guttatus

Mutton Snapper (*Lutjanus analis*)

Family: **Lutjanidae**
Targeted: **Yes**

USVI – St Thomas and St John

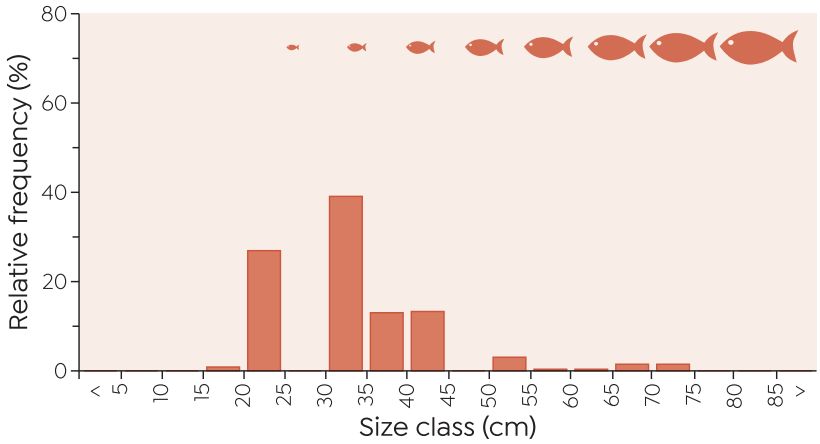
Mean density (/177m²) was 0.23±0.00 (n = 236 surveys).



Size-class distribution of *Lutjanus analis* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 0.07±0.00 (n = 181 surveys).



Size-class distribution of *Lutjanus analis* in St Croix.

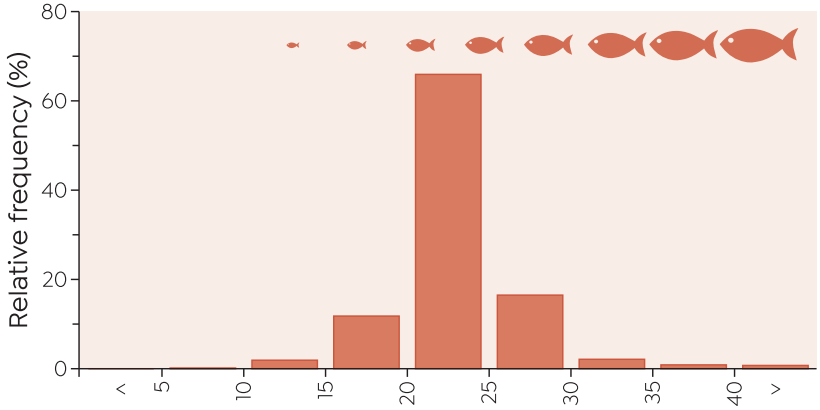
Lutjanus analis

Schoolmaster (*Lutjanus apodus*)

Family: **Lutjanidae**
Targeted: **Yes**

USVI – St Thomas and St John

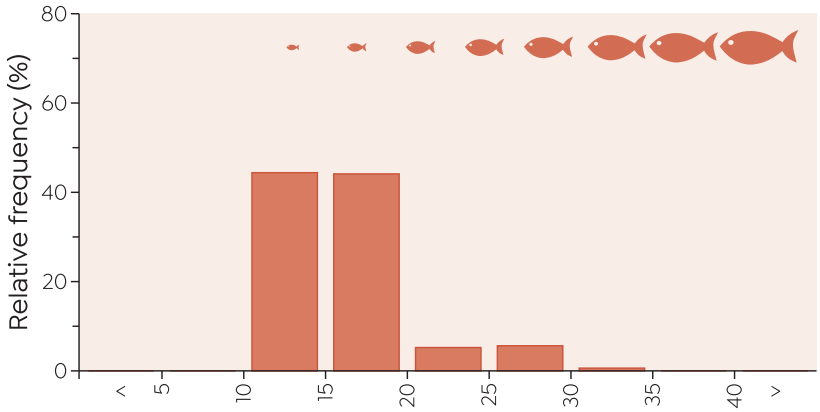
Mean density (/177m²) was 0.24±0.00 (n = 236 surveys).



Size-class distribution of *Lutjanus apodus* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 0.27±0.04 (n = 181 surveys).



Size-class distribution of *Lutjanus apodus* in St Croix.

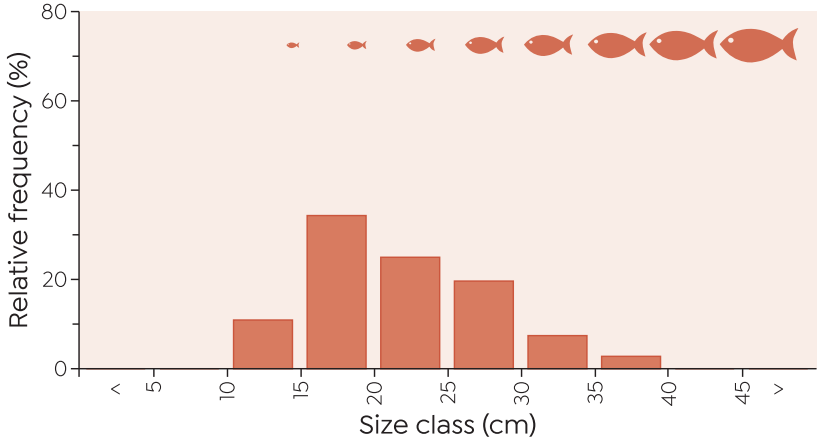
Lutjanus apodus

Gray Snapper (*Lutjanus griseus*)

Family: **Lutjanidae**
Targeted: **Yes**

USVI – St Thomas and St John

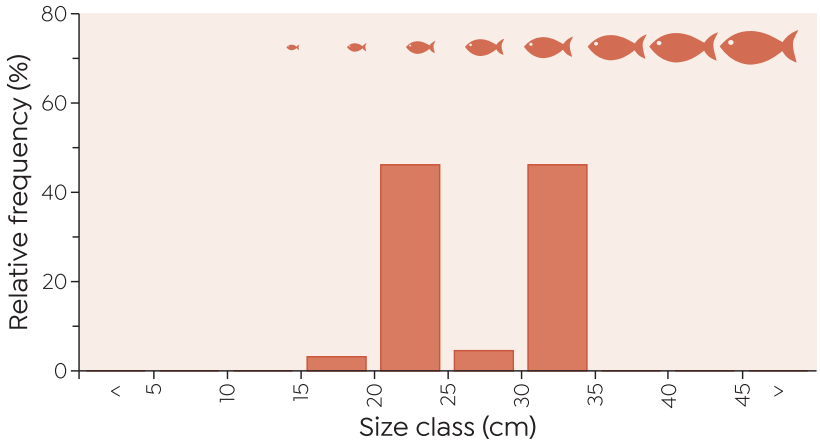
Mean density (/177m²) was 0.13±0.00 (n = 236 surveys).



Size-class distribution of *Lutjanus griseus* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 0.01±0.00 (n = 181 surveys).



Size-class distribution of *Lutjanus griseus* in St Croix.

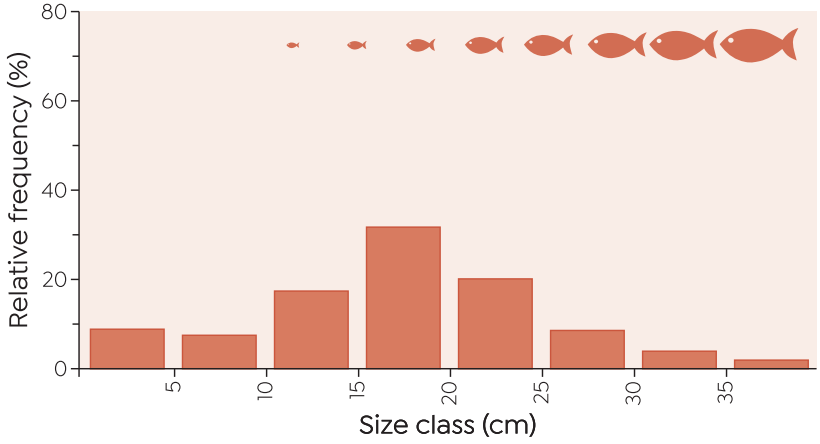
Lutjanus griseus

Yellowtail Snapper (*Ocyurus chrysurus*)

Family: **Lutjanidae**
Targeted: **Yes**

USVI – St Thomas and St John

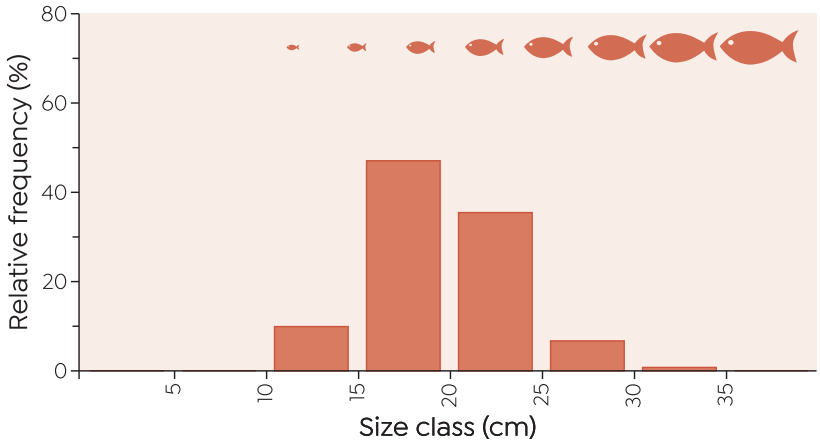
Mean density (/177m²) was 1.23±0.03 (n = 236 surveys).



Size-class distribution of *Ocyurus chrysurus* in St Thomas and St John.

USVI – St Croix

Mean density (/177m²) was 0.43±0.07 (n = 181 surveys).



Size-class distribution of *Ocyurus chrysurus* in St Croix.

Ocyurus chrysurus

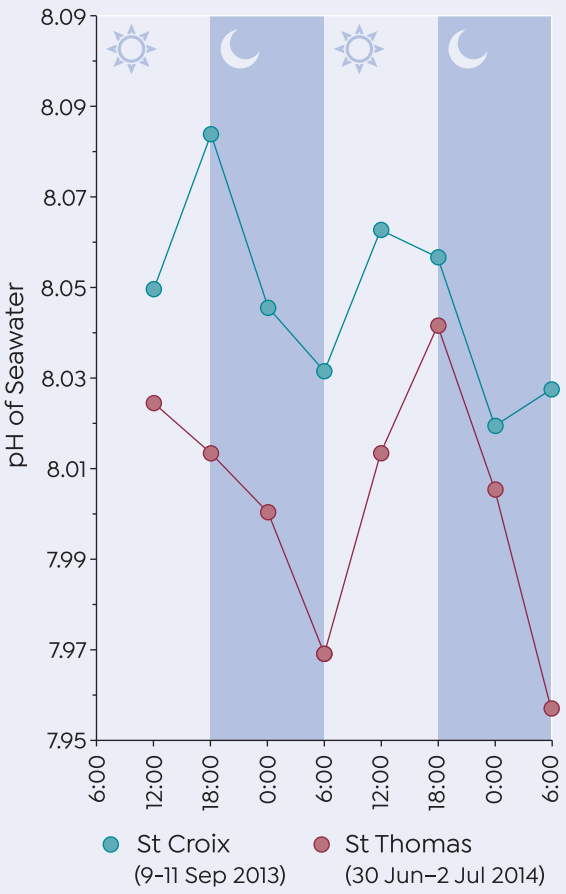
Loggerhead sea turtle swimming above the coral reef, St John, US Virgin Islands

Ocean Chemistry and Temperature

Chemistry (2013-2017) – USVI

This section represents the first US Virgin Islands (USVI) NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the NOAA Atlantic Oceanographic and Meteorological Laboratory and the NOAA Coral Reef Watch program.

Diurnal pH – USVI

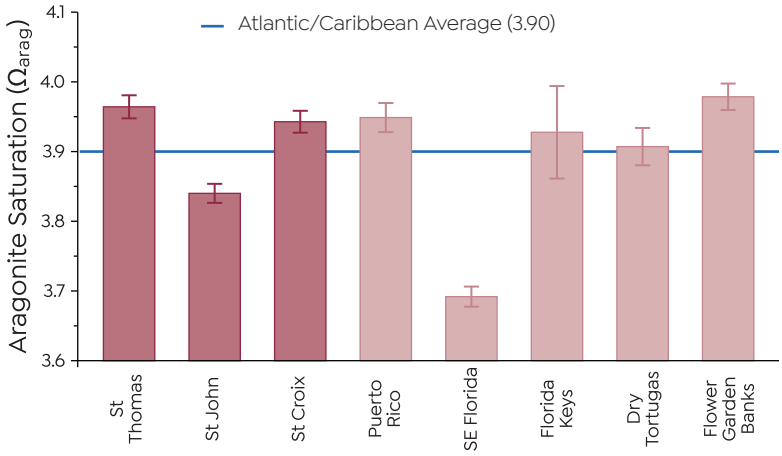


Processes driving local pH vary throughout the day. Photosynthesis drives up the pH during the day (meaning CO_2 concentrations, shown here, decrease) as organisms calcify. Lower pH (slightly higher CO_2 concentrations) returns at night as photosynthesis stops and respiration continues to release CO_2 into the water column. In addition to diurnal variability in seawater CO_2, there is also considerable seasonal variability. pH is higher after the cool season months (so CO_2 is lower) and pH is lower (so CO_2 is higher) after the warm season months.

Highlights

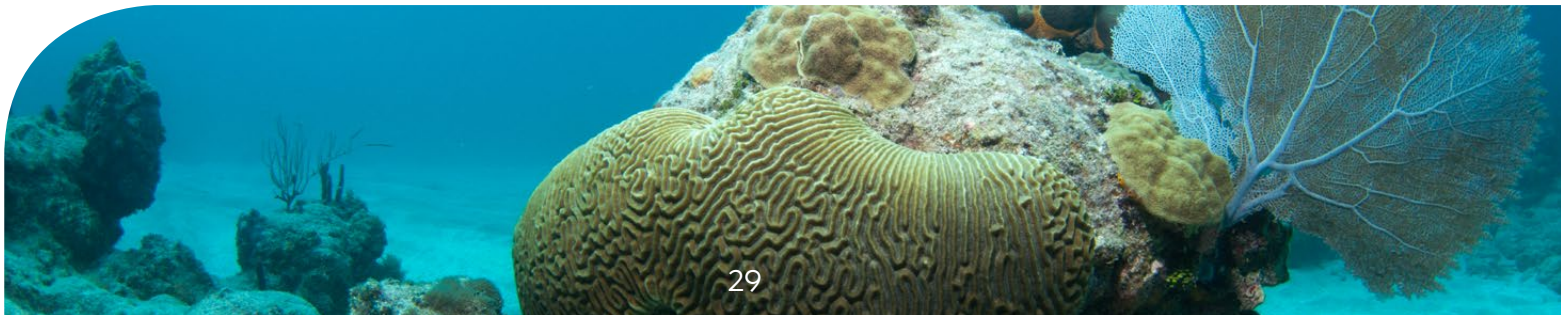
- Aragonite saturation state was higher than the Atlantic/Caribbean average for US coral reefs in St. Thomas and St. Croix and below average for St John.
- In St John and St. Thomas sub-surface temperature recorders showed that the shallow waters were typically much warmer and have greater diurnal variability than the water at 25 m.
- Heat stress accumulation triggered Alert Level 1 for the region in 2015 and bleaching was observed that year.

Aragonite saturation state



Mean (± std. error of mean) aragonite saturation Ω_{arag} values of US jurisdictions during summer months from 2013-2015. Data from SE FL and Florida Keys represent annual averages. Blue line is mean for Atlantic sites, excluding outlier sites of inshore Florida Keys and inlet sites of SE Florida Region.

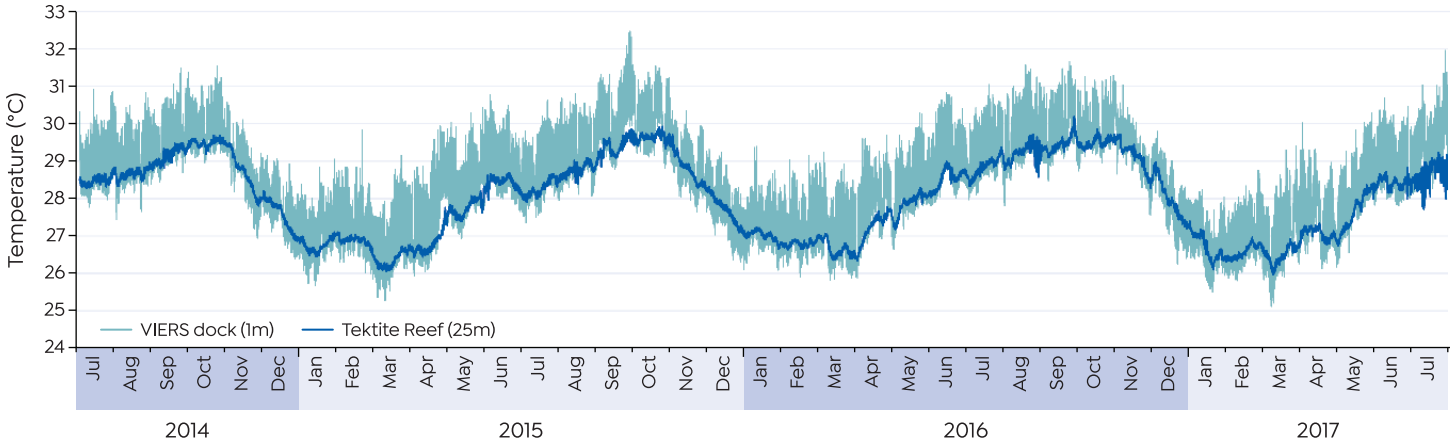
Ω_{arag} values around St. Croix and St. Thomas during the summer were, on average, slightly higher than the average for US coral reef jurisdictions in the Atlantic. Values in St. Croix and St. Thomas were very similar to nearby sites in Puerto Rico, due west. This likely creates a favorable environment for coral calcification. St John exhibited the second lowest Ω_{arag} values of all US jurisdictions when samples were taken in the summer of 2013. It is unclear what caused this deviation. Future sampling will determine if this is a persistent feature of St John, as well as help elucidate any potential causative factors. If these values are chronically lower than the rest of the USVI and Puerto Rico, this may mean St John could be more at risk to the impacts of ocean acidification.



Subsurface temperature

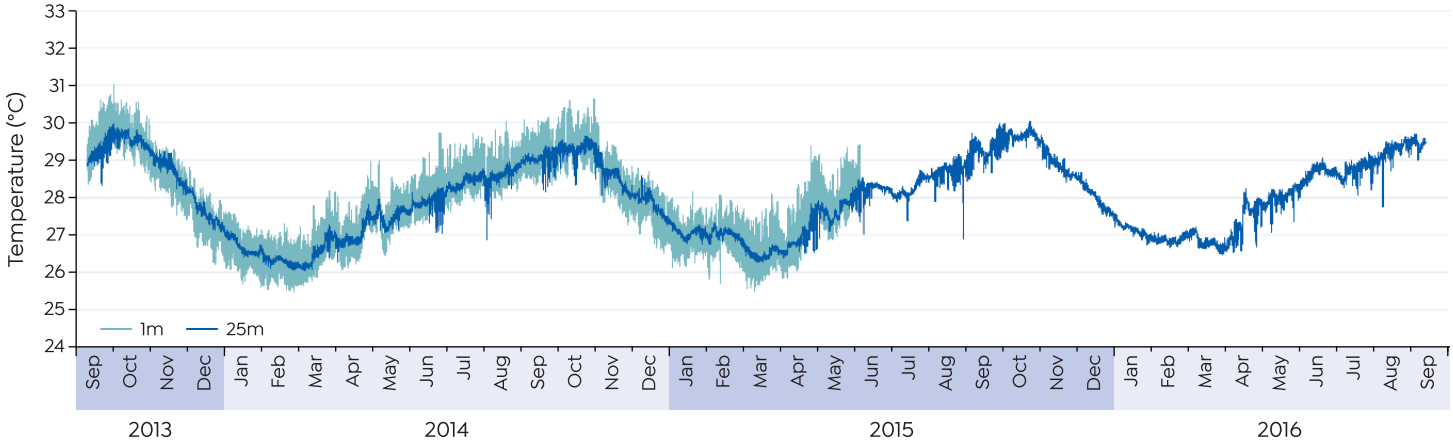
Subsurface temperature time series

Subsurface temperature recorders (STRs) are deployed across depth gradients (1, 5, 15, and 25 m) at all US jurisdictions with an overall impetus to understand temperature variability at depth. The reason for this interest is, in part, because of the Deep Reef Refugia Hypothesis (DRRH), which states that deeper coral reefs may be more resilient to elevated temperatures and coral bleaching because of cooler waters and lower light levels at depth.



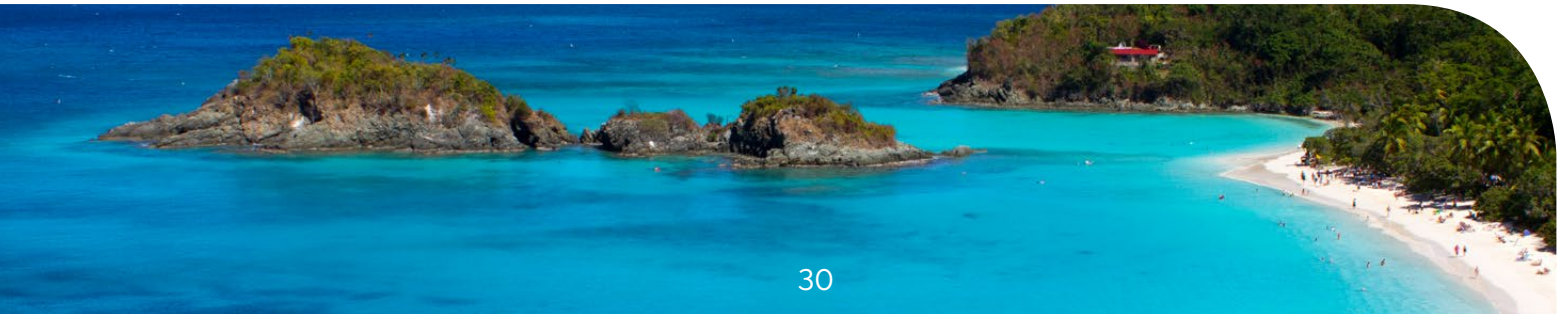
Sea temperatures off St John at 1 m (turquoise line, VIERS dock) and 25 m (blue line, Tektite Reef) from July 2014 thru July 2017.

In St John, the shallow sites had much greater diurnal variability, and were warmer than the deeper sites. There was no evidence of upwelling or thermocline shoaling with depth. Rather, deeper waters were slightly cooler (~0.5–2°C), but far less variable than the shallow sites. Thus, the potential for refugia from warmer waters with depths may be limited at the sites in the USVI where loggers were deployed.



Sea temperatures off the west end of St. Croix at 1 m (turquoise line) and 25 m (blue line) from Sept 2013 thru Sept 2016.

In St. Croix, much like Puerto Rico and St John, the shallow sites had much greater diurnal variability, and were slightly warmer than the deeper sites. There was no evidence of upwelling or thermocline shoaling with depth. Rather, deeper waters were slightly cooler (~0.5 °C), but far less variable than the shallow sites. Thus, the potential for refugia from warmer waters with depths may be limited at the sites in the USVI where loggers were deployed. There were occasional drops in temperature at the deep site, but it is unlikely this would be sufficient to ameliorate bleaching.

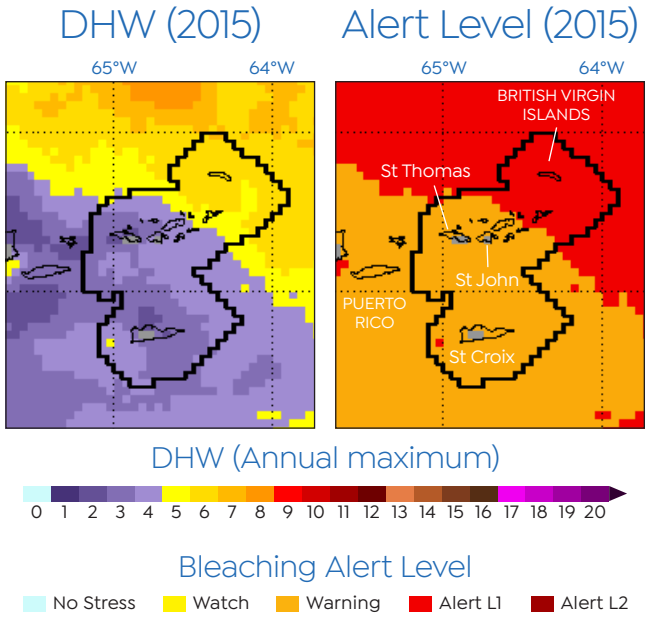


Ocean Chemistry and Temperature

Heat stress and coral bleaching

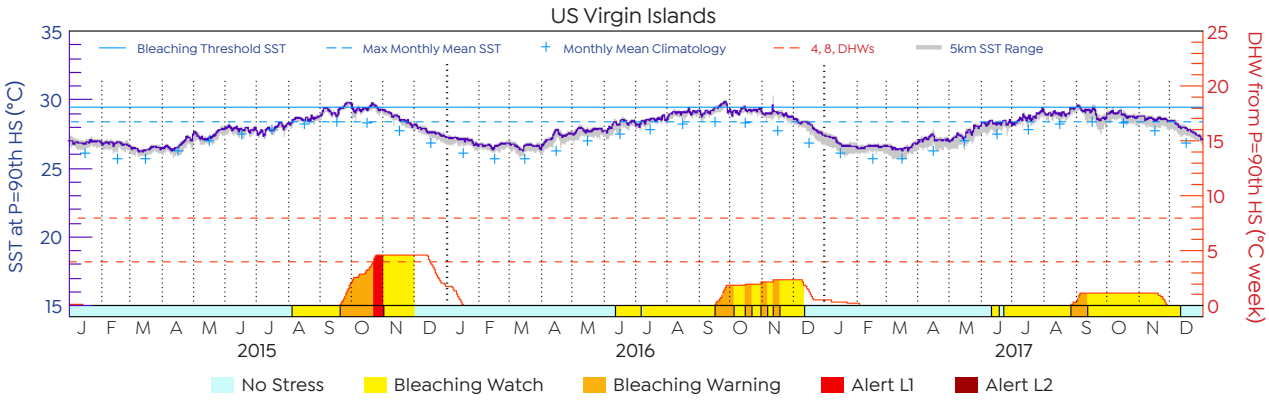
The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in the US Virgin Islands (USVI) in 1998, 2005, 2006, 2010, and 2015.

Bleached coral



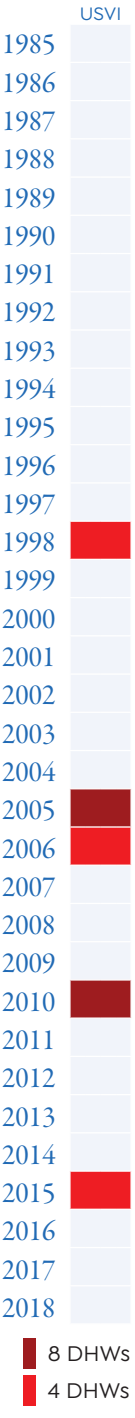
Annual maximum Degree Heating Weeks (DHWs) in 2015 (left panel) were as high as six in parts of the USVI when at least three DHWs accumulated at all islands in the region.

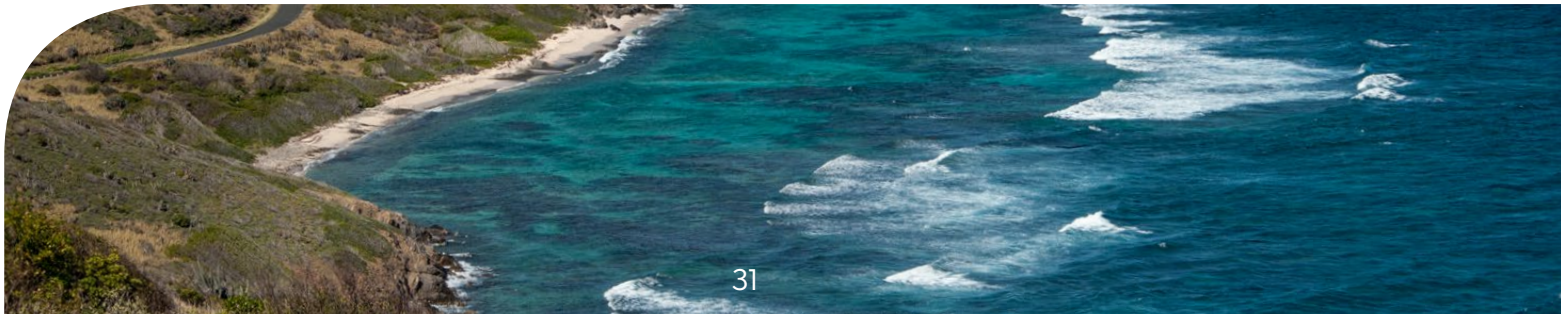
Heat stress accumulation triggered Alert Level 1 for the region in 2015 (right panel) and bleaching was observed that year.



Degree Heating Week (DHW) accumulation from 2015-2017 in the USVI. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in 2015 and bleaching was observed that year.

Thermal History





Puerto Rico

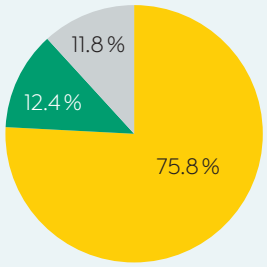
Demographics, values, resource use, and information sources

This Human Connections section presents findings from the Puerto Rico NCRMP socioeconomic data collection and includes data never collected before in Puerto Rico. These are baseline data on social indicators from household surveys conducted in December 2014 to February 2015, and from secondary sources.

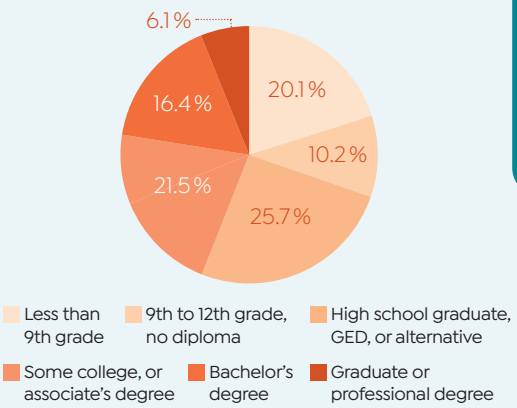
Highlights

- The great majority of residents agreed that coral reefs provide protection from erosion and natural disasters, attract tourists, and are culturally important.
- The dominant perception of the status of ocean water quality, amount and health of coral, and number of fish was that these were neither good or bad. The dominant perception for trend was that the condition had worsened or remained the same over the past ten years.
- Of the potential threats to coral reefs, residents were least familiar with coral diseases and bleaching.
- Residents were generally very supportive of marine management policies – roughly 90% agree that MPAs protect coral reefs and increase the number of fish, and would support adding new MPAs if there was evidence current ones are effective.

Race

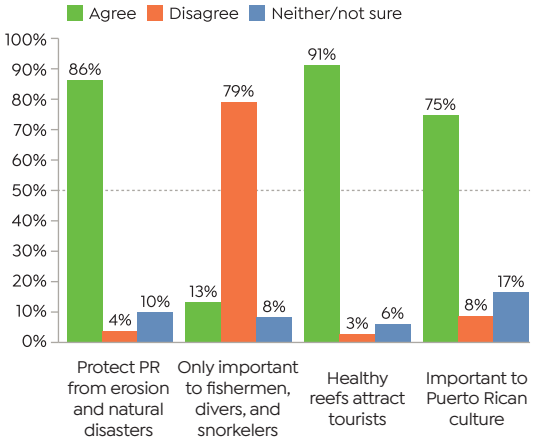


Educational attainment



The population of Puerto Rico was predominantly composed of White ethnicity (76%). Almost seventy percent of the population had at least completed high school, ~44% had completed at least some college or an associate's degree, and ~23% a bachelor's degree or graduate degree.

Values and awareness



When asked about important services provided by reef resources, most residents agreed that coral reefs protect Puerto Rico from erosion and natural disasters (86%), that healthy reefs attract tourists (91%), and that coral reefs are important to my island's culture (75%). The majority of residents (79%) disagreed with the statement that coral reefs are only important to fishermen, divers, and snorkelers.

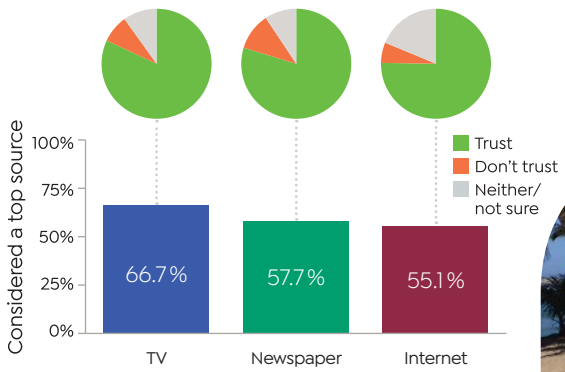
2014-15 survey data (n=2,494)

Resource use

PERCENT OF POPULATION PARTICIPATING IN EACH ACTIVITY

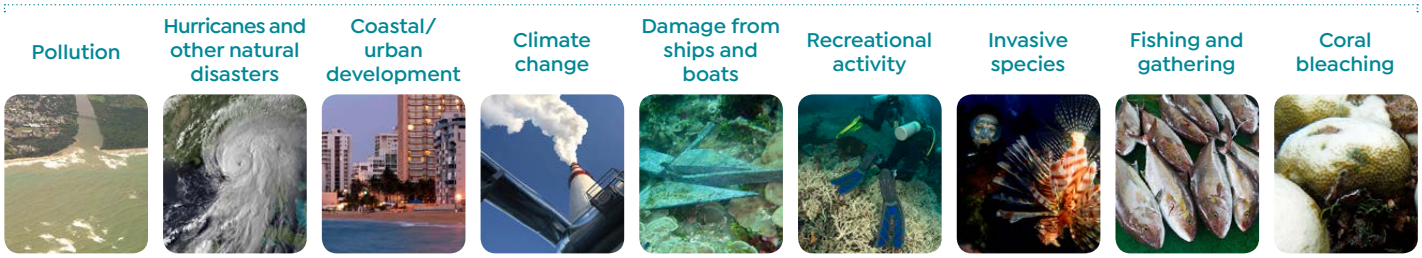
Information sources

Many residents considered TV (67%), newspapers (58%), and Internet (55%) to be a top source for information on the environment, including status of coral reefs and present and future threats. Greater than 75% of residents who claimed TV, newspapers and Internet are top sources indicated these sources were trustworthy.



Perceptions of resource condition, threats, and severity

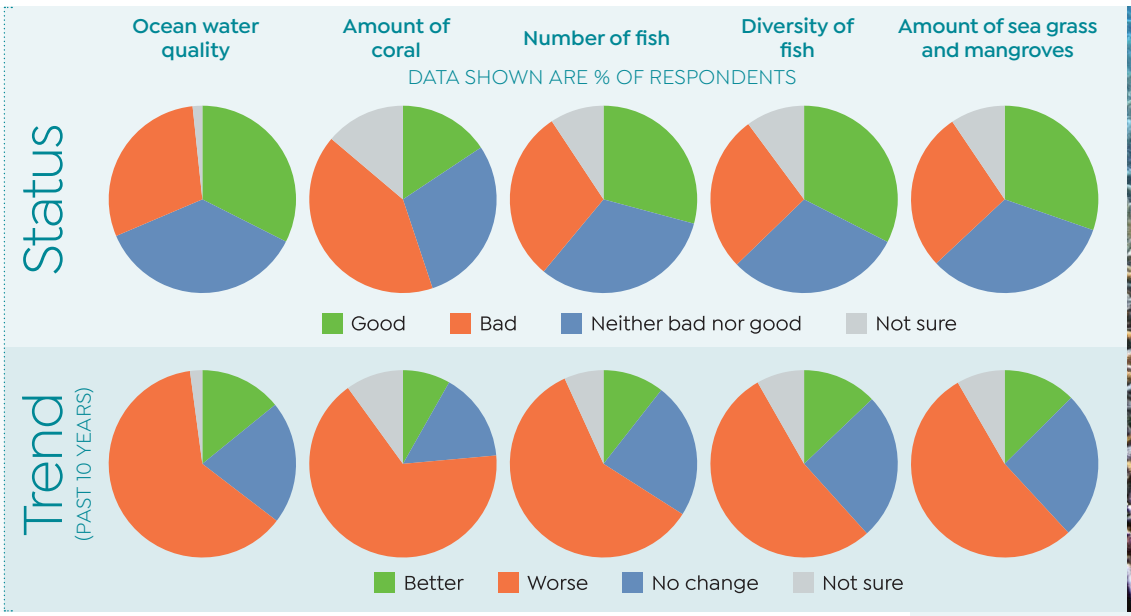
Threats



PERCENT OF THE POPULATION FAMILIAR WITH EACH THREAT

Threats not shown above: **Coral diseases** (30 %).

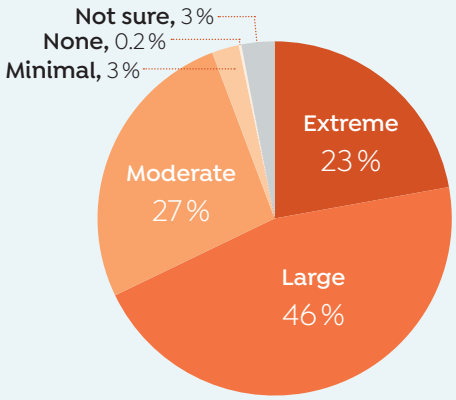
In general, residents were familiar with potential threats facing coral reefs in Puerto Rico. However, less than half of residents stated they were familiar with invasive species (49 %), fishing and gathering (44 %), coral bleaching (32 %), and coral diseases (30 %). Residents exhibited highest levels of familiarity with threats from pollution and hurricanes.



Status and trend

Respondents felt confident in their perception of the status of ocean water quality, amount of coral, number and diversity of fish and amount of seagrass and mangroves (<20 % not sure). For those confident in their perception, roughly 50–70 % felt the status was either good or neither good or bad and roughly 30–50 % felt the status was bad. A different pattern was shown in the perceptions of trend. For those confident in their perception of the trends in these variables, roughly 85–90 % felt it had gotten worse or remained the same, and roughly <15 % felt any of these had gotten better. The dominant perception of the status of ocean water quality, amount and health of coral, and number of fish was that the status was good or neutral. However, the dominant perception for trend was that the status had gotten worse or remained the same over the last ten years, rather than better.

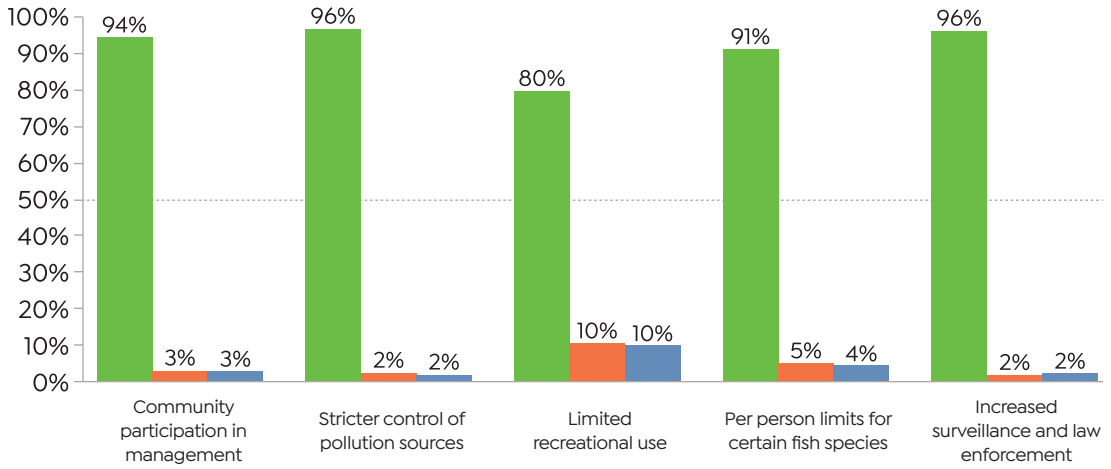
Severity of threats



Residents were generally concerned about threats to coral reefs in Puerto Rico. Twenty-three percent of residents stated that they thought threats were extreme and 46 % thought threats were large. A small percentage (3 %) stated that threats were either minimal or believe there are no threats.

Perceptions of reef management policies

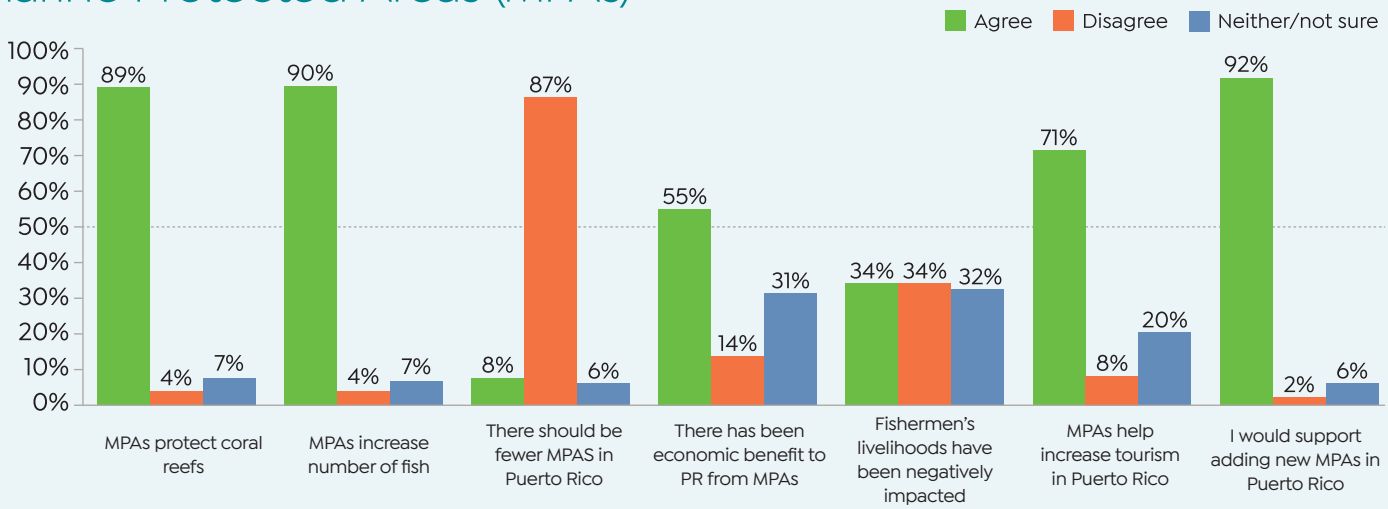
Management policies



Residents were generally supportive of current marine management policies. There was extremely high support for increased surveillance and law enforcement (96%), stricter control of pollution sources (96%), per person limits for certain fish species (91%), community participation in management (94%), and limited recreational use (80%).

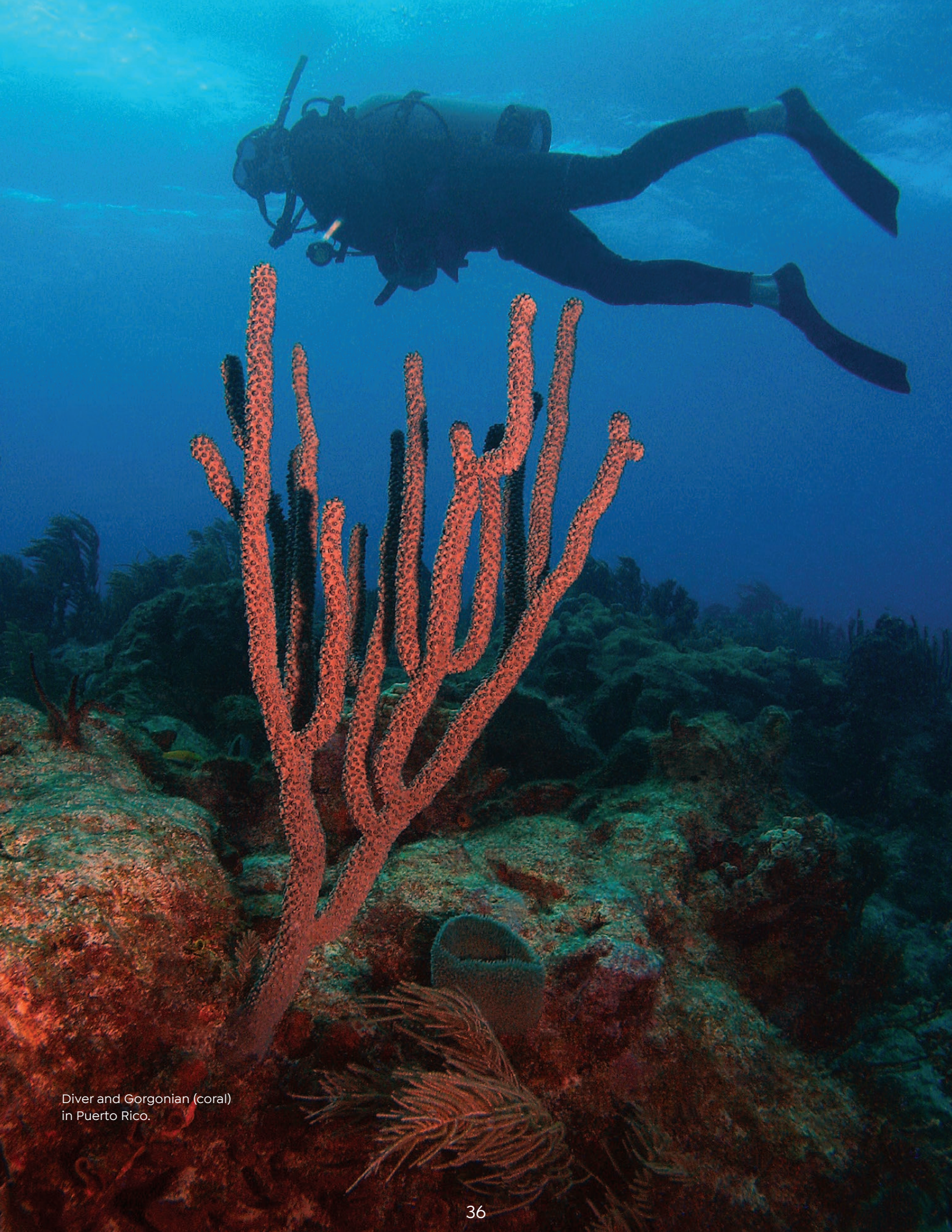
Human Connections

Marine Protected Areas (MPAs)



Respondents mostly agreed that MPAs provide benefits. Eighty percent or more of residents agreed or strongly agreed that MPAs protect coral reefs (89%), increase number of fish (90%), and 92% would support adding MPAs in Puerto Rico if evidence shows current ones are effective. Most also strongly agree that MPAs increase tourism to Puerto Rico (71%) and provide economic benefit (55%). There was less certainty regarding whether fishermen's livelihoods had been negatively impacted by MPAs, with 34% disagreeing with this statement, and 33% agreeing, and 32% not sure. Most disagree with the statement that there should be fewer MPAs in Puerto Rico (87%).

Beach sign that describes restricted activities.

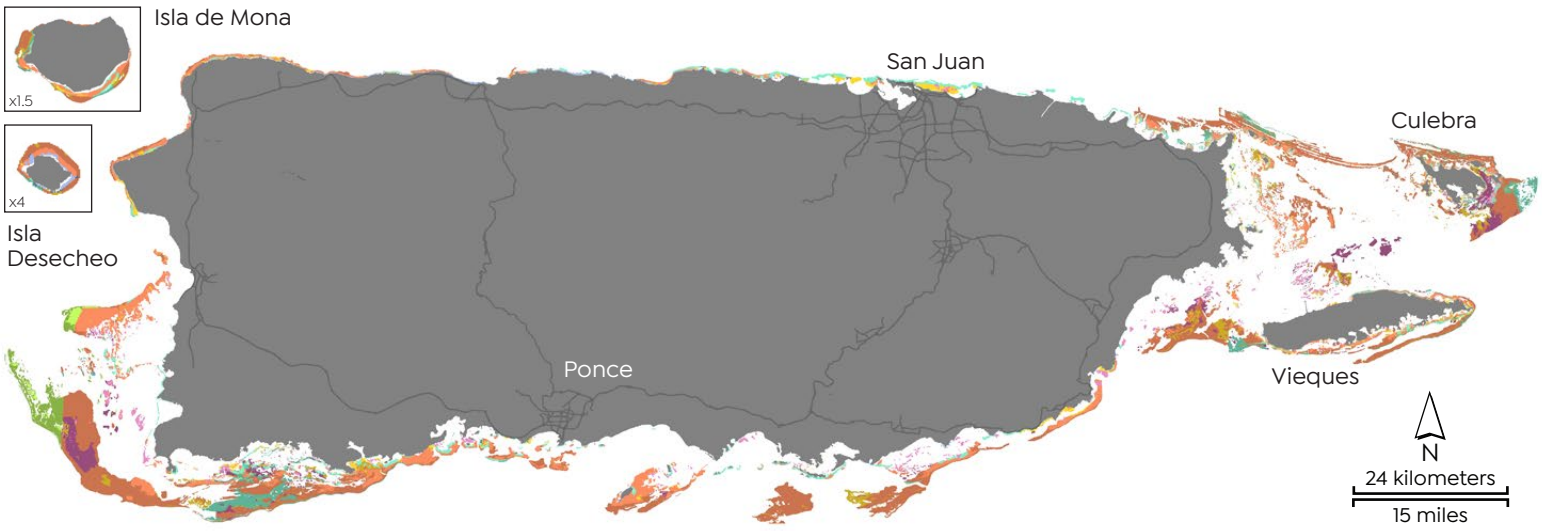


Diver and Gorgonian (coral) in Puerto Rico.

Coral reefs – Puerto Rico (2016)

Habitat strata

The coral reefs of Puerto Rico were classified into five zones, as described below, plus an unknown hardbottom category. Within each zone, habitat strata were defined separately for deep areas (greater than 12m depth) and shallow areas (less than or equal to 12m depth).



Aggregate Reef

Linear coral formations that are oriented parallel to shore or the shelf edge. These features follow the contours of the shore/shelf edge.

This includes fore reef, fringing reef, shelf edge reef, and spur and groove reef.

Patch Reef

Coral formations that are isolated from other coral reef formations by sand, seagrass, or other habitats.

This includes individual patch reefs and/or aggregrated patch reefs.

Bedrock

Exposed bedrock contiguous with the shoreline that has coverage of macroalgae, hard coral, gorgonians, and/or other sessile invertebrates.

Colonized Pavement

Flat, low relief, solid carbonate rock with coverage of macroalgae, hard coral, gorgonians, contiguously or with sand channels.

Scattered Coral and Rock

Primarily sand or seagrass bottom with scattered rocks or small, isolated coral heads that are too small to be individual patch reefs.

Hard (unknown)

Habitat that has not yet been classified in detail, but is likely to be hardbottom based on spatial modeling of acoustic bathymetry survey data.

Habitat Strata (Puerto Rico)

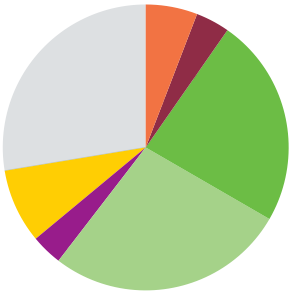
Deep (>12 m)	Shallow (≤ 12 m)	
		Aggregate Reef
		Patch Reef
		Bedrock
		Colonized Pavement
		Scattered Coral and Rock
		Hard (unknown)

Coral reefs – Puerto Rico (2016)

Benthic cover

- Coral cover ranged from 0.3% in the Scattered Coral and Rock Deep to 13.1% in the Aggregate Reef Deep.
- Macroalgae cover ranged from 7.8% in the Scattered Coral and Rock Shallow to 52% in the Bedrock Deep.
- The region-wide average coral cover was 5.9% and macroalgae cover was 23.7%.

Regional

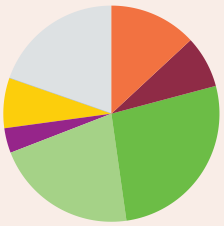


Coral 5.9±4.6%
Macroalgae 23.7±17.2%

- Coral cover was highest (13.1%) in the Aggregate Reef Deep
- Macroalgae cover (52%) was highest in the Bedrock Deep
- Coral disease prevalence was lowest (0) in the Bedrock Deep, Hard (unknown) Shallow, and Scattered Coral and Rock Deep, and highest (7.0% of colonies) in the Pavement Shallow.
- Seven species listed as Threatened under the Endangered Species Act were observed on reefs in Puerto Rico in 2016. At least five Threatened species were observed in the Patch Reef Deep, Bedrock Shallow, Aggregate Reef Shallow and Aggregate Reef Deep.

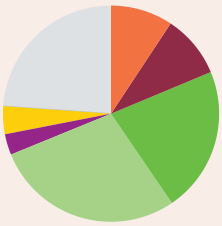
Aggregate Reef

Deep



Coral 13.1±7.1%
Macroalgae 26.9±15.7%

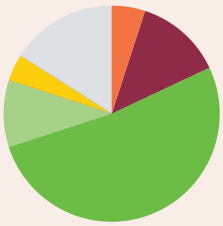
Shallow



Coral 9.3±7.2%
Macroalgae 21.8±16.4%

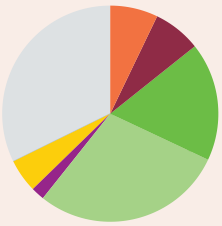
Bedrock

Deep



Coral 5.0±0.0%
Macroalgae 52.0±0.0%

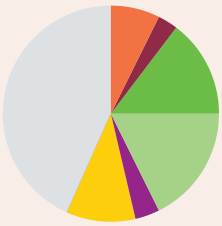
Shallow



Coral 7.1±5.1%
Macroalgae 17.7±16.2%

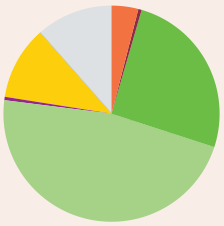
Hard (unknown)

Deep



Coral 7.3±8.7%
Macroalgae 14.7±16.3%

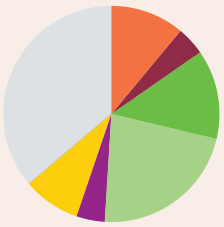
Shallow



Coral 4.0±2.8%
Macroalgae 25.5±36.1%

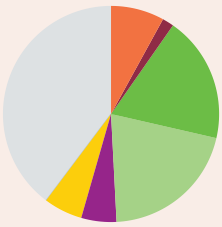
Patch Reef

Deep



Coral 11.1±7.8%
Macroalgae 13.4±11.7%

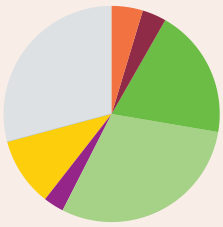
Shallow



Coral 8.0±6.2%
Macroalgae 18.9±16.5%

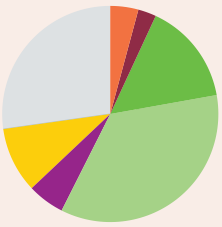
Pavement Reef

Deep



Coral 4.7±3.8%
Macroalgae 19.4±16.6%

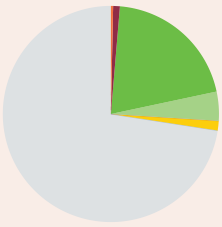
Shallow



Coral 4.2±3.5%
Macroalgae 15.3±12.3%

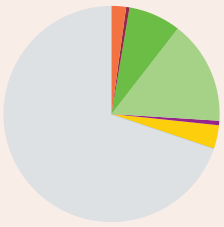
Scattered Coral and Rock

Deep



Coral 0.3±1.0%
Macroalgae 20.3±22.7%

Shallow



Coral 2.2±2.6%
Macroalgae 7.8±7.2%

Benthic cover

- Hard coral
- Crustose coralline algae
- Macroalgae
- Turf algae
- Soft corals
- Sponges
- *Ramicrusta* spp.
- Other

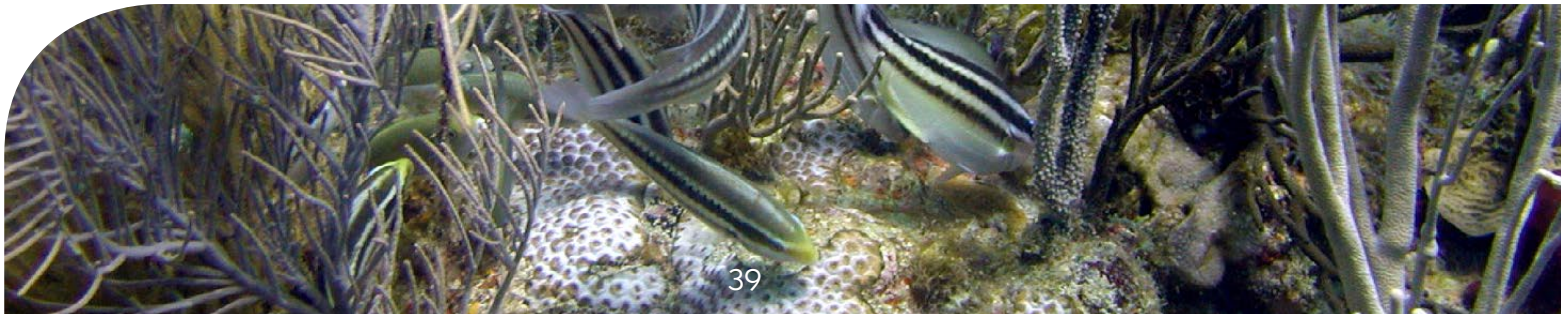
Coral reefs – Puerto Rico (2016)

Benthic communities

- Diadema (sea urchin) density was highest (0.12/m^2) in the Hard (unknown) Shallow and lowest (0) in the Bedrock Deep and Scattered Coral and Rock Deep.
- Coral density (unweighted) ranged from 0.35/m^2 in the Scattered Coral and Rock Deep to 4.8/m^2 in the Bedrock Deep.
- Species richness (unweighted) was highest (10.0) in the Bedrock Deep and lowest (2.3) in the Scattered Coral and Rock Deep.
- Coral diversity was highest in the Patch Reef Deep and lowest in the Scattered Coral and Rock Deep.
- Disease prevalence ranged from absent in three habitat strata to 7.0% of colonies in the Pavement Shallow.
- Recent mortality (mean weighted) was less than 0.65% in all habitat strata.
- Old mortality (unweighted) was highest (21.0%) in the Patch Reef Shallow and lowest (2.3%) in the Scattered Coral and Rock Deep.

Benthic data collected in 2016 for the habitat strata in Puerto Rico. Transects (n) describes how sampling effort varied among the strata.

Habitat strata	Transects (n)	Diadema density (m^{-2})	Coral density (m^{-2})	Species richness	Coral diversity (Simpsons)	Disease prevalence (% colonies)	Recent mortality (%)	Old mortality (%)
Aggregate Reef Deep	32	0.00±0.01	4.62±2.38	9.88±3.25	9.70	4.0	0.38±0.63	8.97±6.63
Aggregate Reef Shallow	17	0.03±0.07	3.81±2.68	7.76±3.78	5.60	5.3	0.64±1.02	9.32±6.90
Bedrock Deep	1	0.00	4.80	10.00	4.36	0.0	0.00	5.10
Bedrock Shallow	7	0.09±0.14	4.26±2.87	9.71±5.59	7.25	3.4	0.09±0.17	13.49±7.60
Hard (unknown) Deep	3	0.07±0.12	3.43±2.66	9.67±3.51	10.46	4.5	0.28±0.49	17.45±15.99
Hard (unknown) Shallow	2	0.12±0.16	3.25±0.92	8.50±0.71	4.87	0.0	0.00±0.00	18.88±5.12
Patch Reef Deep	20	0.01±0.04	4.05±2.72	9.45±3.73	11.59	3.5	0.34±0.87	14.23±7.14
Patch Reef Shallow	11	0.09±0.21	1.99±1.76	5.73±2.80	6.33	4.1	0.43±1.10	20.97±17.15
Pavement Deep	33	0.00±0.01	2.47±2.21	6.94±3.11	7.70	3.0	0.42±1.29	10.94±8.53
Pavement Shallow	21	0.01±0.03	1.91±1.03	6.05±1.91	5.58	7.0	0.29±0.67	16.46±13.22
Scattered Coral and Rock Deep	4	0.00±0.00	0.35±0.19	2.25±1.89	3.63	0.0	0.00±0.00	2.25±2.63
Scattered Coral and Rock Shallow	6	0.01±0.01	0.70±0.84	2.83±1.94	5.84	4.9	0.00±0.00	15.36±17.18



Coral reefs – Puerto Rico (2016)

Endangered coral species

» Seven species listed as Threatened under the Endangered Species Act (ESA) were observed on reefs in Puerto Rico in 2016.

» ESA corals were observed in all strata excepting Scattered Coral and Rock Deep. *Acropora palmata* and *Dendrogyra cylindrus* were observed in only two of the six strata. *Orbicella faveolata* and *Orbicella franksi* were observed in nearly all of the habitat strata.

» At least five ESA-listed coral species were observed in the Patch Reef Deep, Bedrock Shallow, Aggregate Reef Shallow, and Aggregate Reef Deep.

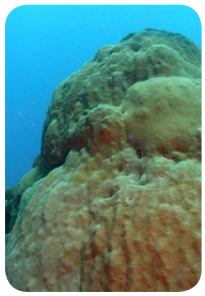
Acropora palmata

Acropora cervicornis

Dendrogyra cylindrus

Mycetophyllia ferox

Orbicella annularis

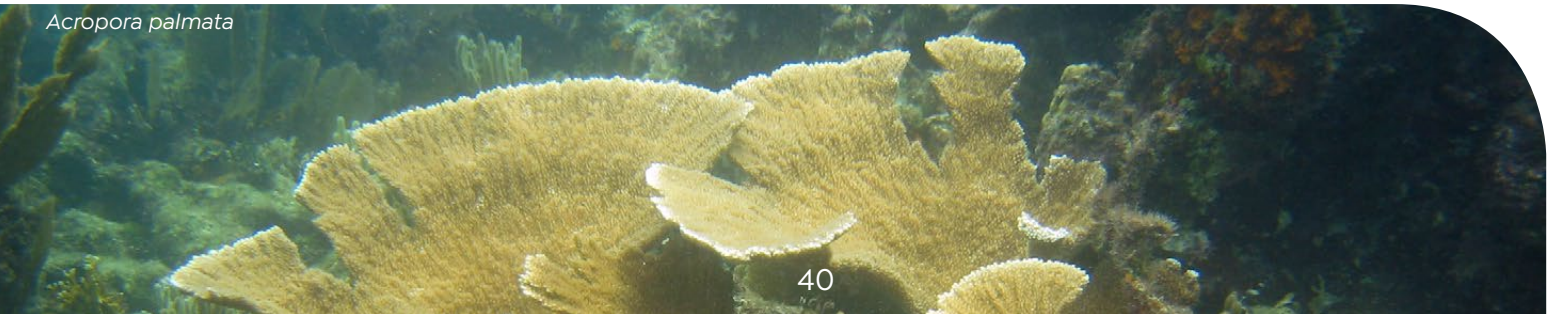


Orbicella faveolata

Orbicella franksi

Presence of coral species listed as Threatened under the Endangered Species Act (ESA).

Habitat strata	No. ESA coral species	*Acropora palmata*	*Acropora cervicornis*	*Dendrogyra cylindrus*	*Mycetophyllia ferox*	*Orbicella annularis*	*Orbicella faveolata*	*Orbicella franksi*
Aggregate Reef Deep	6	○	●	●	●	●	●	●
Aggregate Reef Shallow	5	●	○	○	●	●	●	●
Bedrock Deep	1	○	○	○	○	○	●	○
Bedrock Shallow	5	●	○	●	○	●	●	●
Hard (unknown) Deep	2	○	○	○	○	○	●	●
Hard (unknown) Shallow	2	○	●	○	○	○	●	○
Patch Reef Deep	5	○	●	○	●	●	●	●
Patch Reef Shallow	4	○	●	○	○	●	●	●
Pavement Deep	4	○	●	○	○	●	●	●
Pavement Shallow	4	○	●	○	○	●	●	●
Scattered Coral and Rock Deep	0	○	○	○	○	○	○	○
Scattered Coral and Rock Shallow	3	○	○	○	○	●	●	●



Acropora palmata

Coral Reef Fish – Puerto Rico (2016)

Relative abundance and length of reef fishes

Results are presented for 11 species surveyed in Puerto Rico in 2016. The diverse suite of species selected represent eight families of varying trophic levels (herbivores and piscivores) and fishing pressures (targeted and non-targeted), and together provide a perspective on the overall status of coral reef fishes. Relative abundance (density) and length-based indices (size-class distribution) are presented here to allow for comparison among sub-regions.



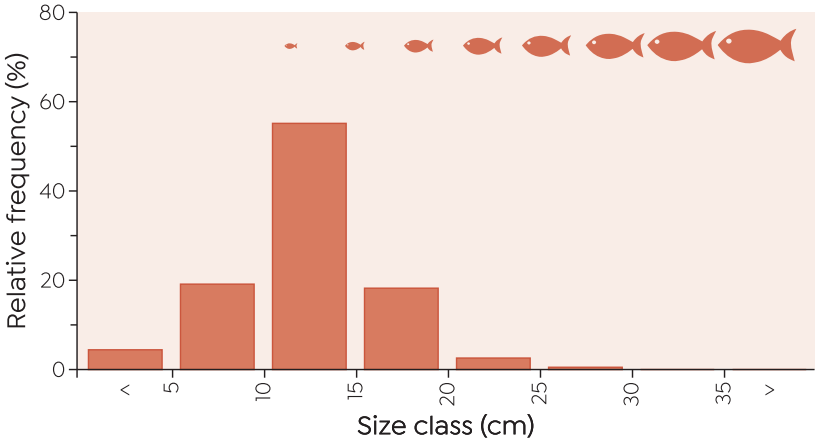


Blue Tang (*Acanthurus coeruleus*)

Puerto Rico

Mean density (/177m^2) was 3.78±0.13 (n = 240 surveys).

Family: **Acanthuridae**
Targeted: **No**



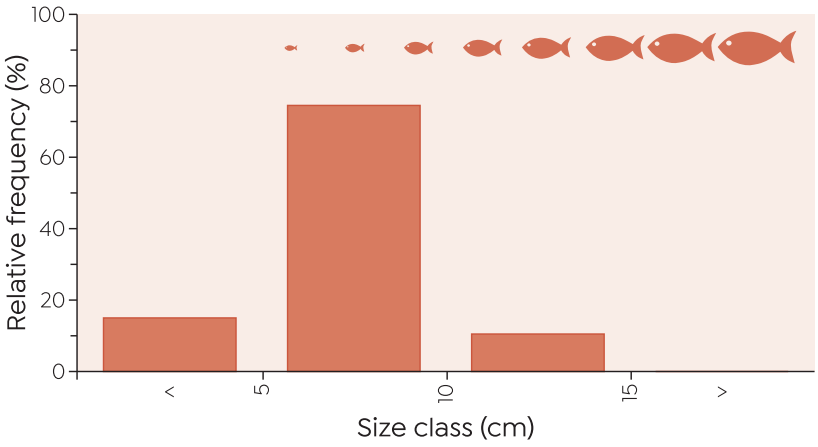
Size-class distribution of *Acanthurus coeruleus* in Puerto Rico.

Foureye Butterflyfish (*Chaetodon capistratus*)

Puerto Rico

Mean density (/177m^2) was 2.00±0.03 (n = 240 surveys).

Family: **Chaetodontidae**
Targeted: **No**



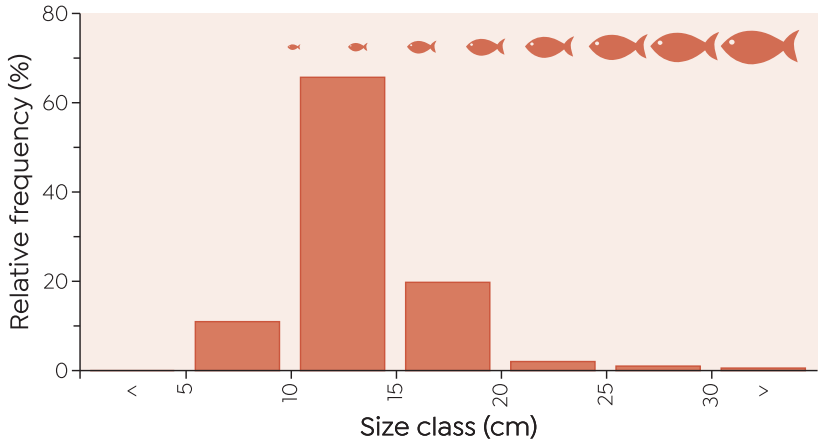
Size-class distribution of *Chaetodon capistratus* in Puerto Rico.

French Grunt (*Haemulon flavolineatum*)

Family: **Haemulidae**
Targeted: **No**

Puerto Rico

Mean density (/177m²) was 0.80±0.02 (n = 240 surveys).



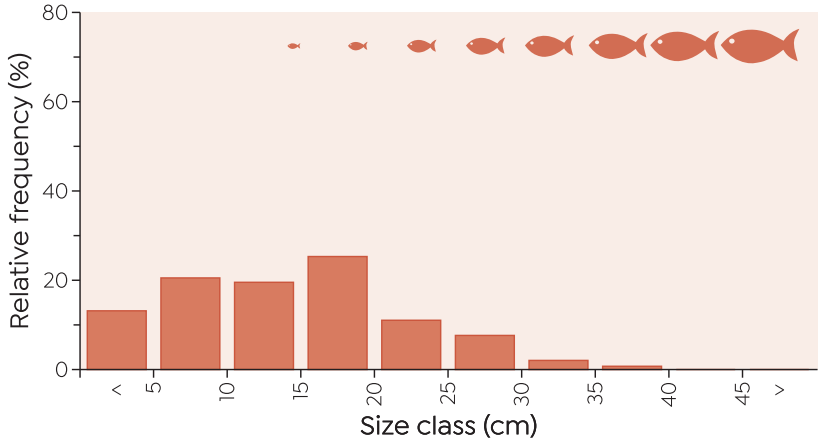
Size-class distribution of *Haemulon flavolineatum* in Puerto Rico.

Stoplight Parrotfish (*Sparisoma viride*)

Family: **Scaridae**
Targeted: **No**

Puerto Rico

Mean density (/177m²) was 1.69±0.03 (n = 240 surveys).



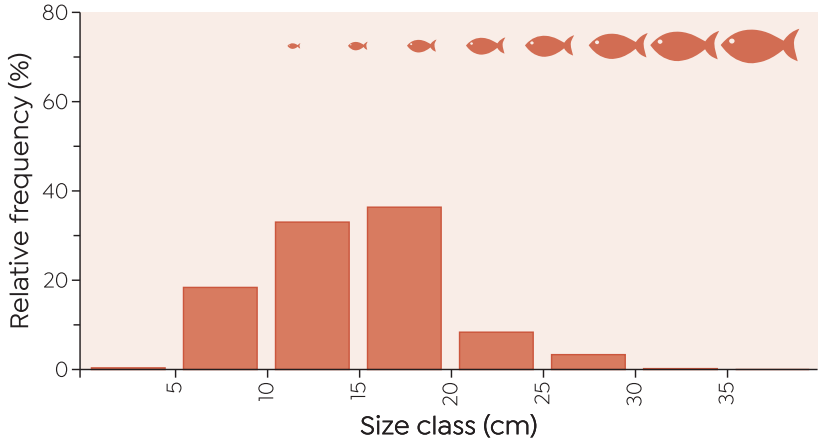
Size-class distribution of *Sparisoma viride* in Puerto Rico.

Coney (*Cephalopholis fulva*)

Family: **Serranidae**
Targeted: **Yes**

Puerto Rico

Mean density (/177m²) was 2.44±0.07 (n = 240 surveys).



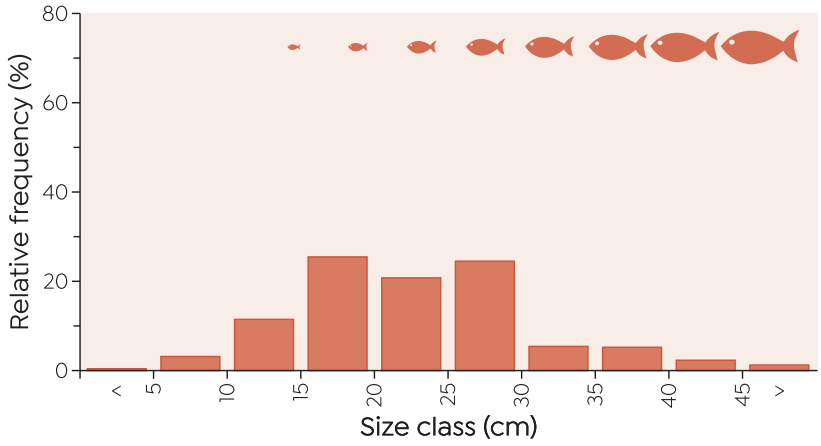
Size-class distribution of *Cephalopholis fulva* in Puerto Rico.

Red Hind (*Epinephelus guttatus*)

Family: **Serranidae**
Targeted: **Yes**

Puerto Rico

Mean density (/177m²) was 0.54±0.00 (n = 240 surveys).



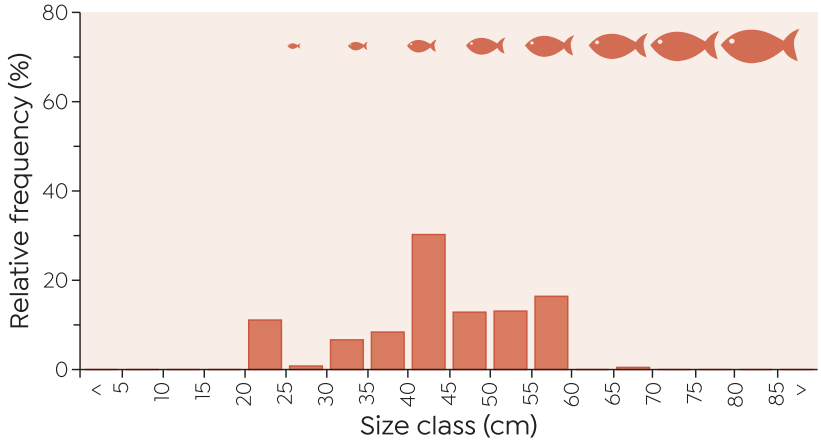
Size-class distribution of *Epinephelus guttatus* in Puerto Rico.

Mutton Snapper (*Lutjanus analis*)

Family: **Lutjanidae**
Targeted: **Yes**

Puerto Rico

Mean density (/177m²) was 0.09±0.00 (n = 240 surveys).



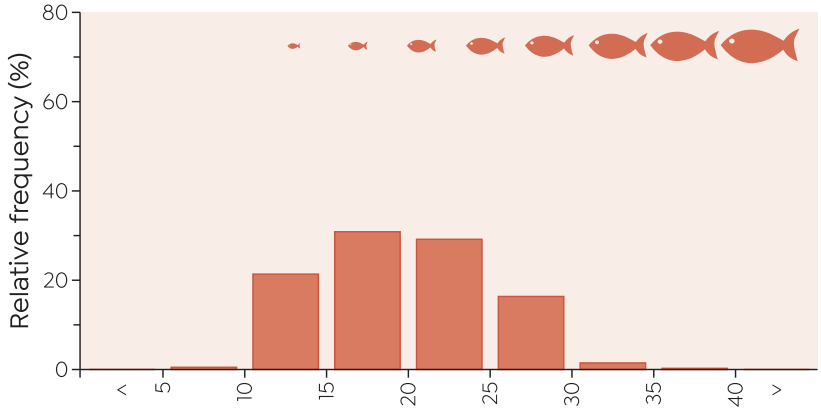
Size-class distribution of *Lutjanus analis* in Puerto Rico.

Schoolmaster (*Lutjanus apodus*)

Family: **Lutjanidae**
Targeted: **Yes**

Puerto Rico

Mean density (/177m²) was 0.40±0.01 (n = 240 surveys).



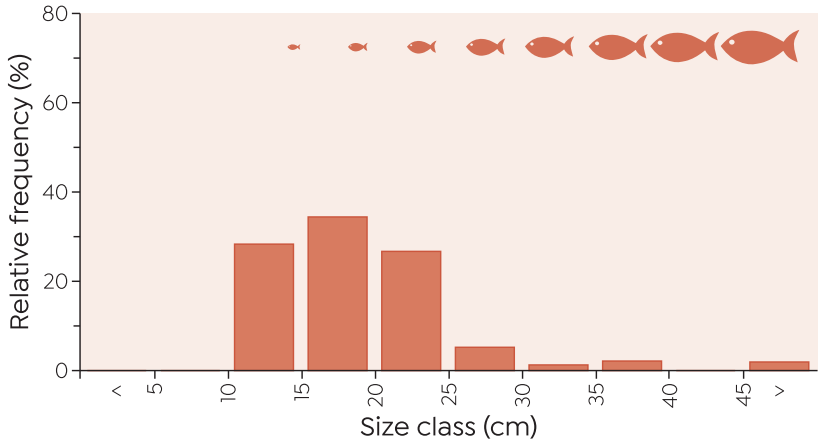
Size-class distribution of *Lutjanus apodus* in Puerto Rico.

Gray Snapper (*Lutjanus griseus*)

Family: **Lutjanidae**
Targeted: **Yes**

Puerto Rico

Mean density (/177m²) was 0.32±0.05 (n = 240 surveys).



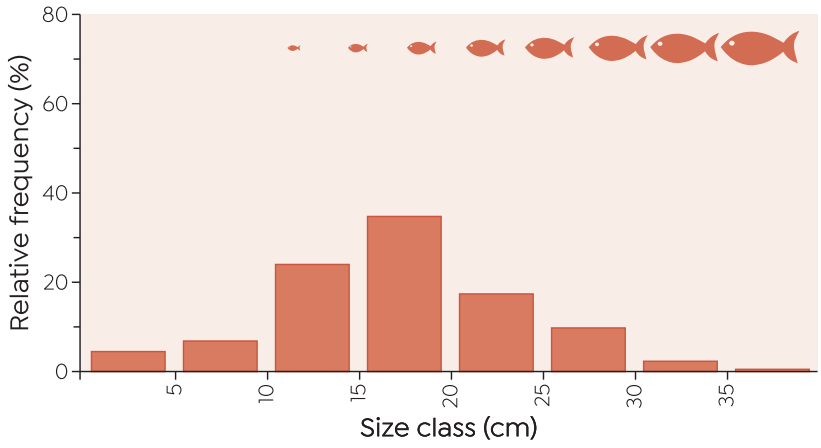
Size-class distribution of *Lutjanus griseus* in Puerto Rico.

Yellowtail Snapper (*Ocyurus chrysurus*)

Family: **Lutjanidae**
Targeted: **Yes**

Puerto Rico

Mean density (/177m²) was 2.08±0.08 (n = 240 surveys).



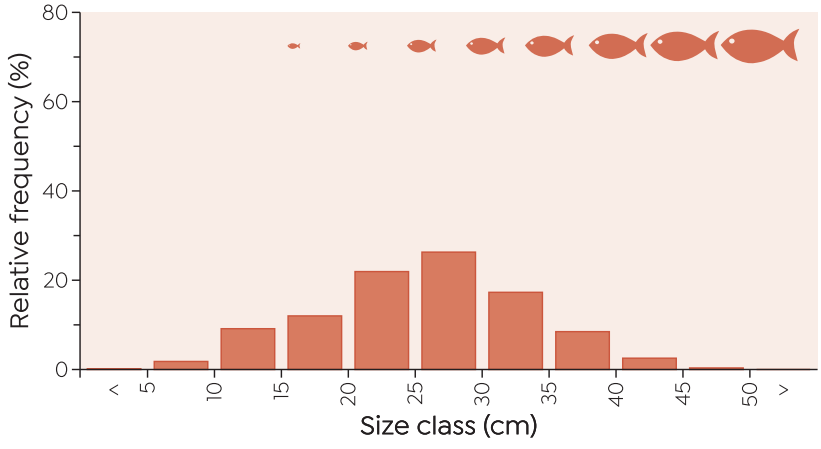
Size-class distribution of *Ocyurus chrysurus* in Puerto Rico.

Queen Triggerfish (*Balistes vetula*)

Family: **Balistidae**
Targeted: **Yes**

Puerto Rico

Mean density (/177m²) was 0.49±0.01 (n = 240 surveys).



Size-class distribution of *Balistes vetula* in Puerto Rico.

Chemistry (2015-2017) – Puerto Rico

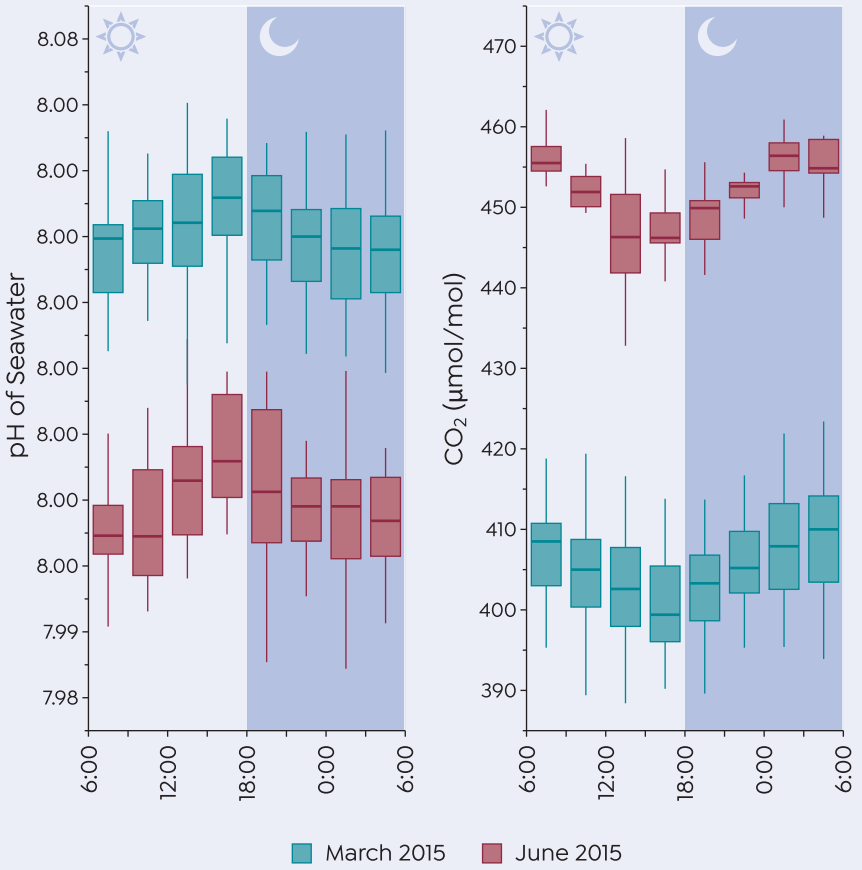
This section represents the first Puerto Rico NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the NOAA Atlantic Oceanographic and Meteorological Laboratory and the NOAA Coral Reef Watch program.

Highlights

- Aragonite saturation state in Puerto Rico was slightly higher than the average for US coral reef areas in the Atlantic/Caribbean.
- Coral Reef Watch Bleaching Alert Levels were not triggered in Puerto Rico between 2015 and 2017.

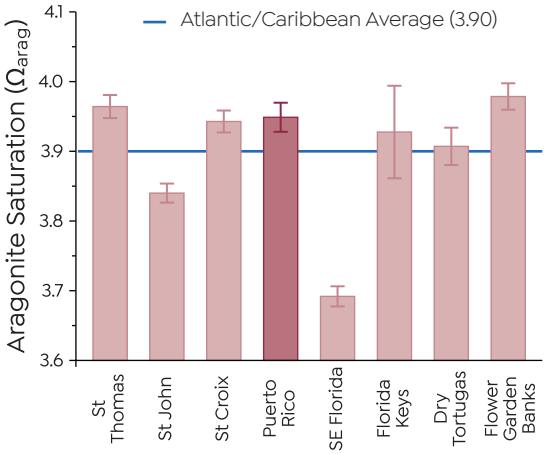
Diurnal pH – La Parguera

Diurnal CO_2



Processes driving local pH vary throughout the day. Photosynthesis drives up the pH during the day (meaning CO_2 concentrations, shown here, decrease) as organisms calcify. Lower pH (slightly higher CO_2 concentrations) returns at night as photosynthesis stops and respiration continues to release CO_2 into the water column. In addition to diurnal variability in seawater CO_2, there is also considerable seasonal variability. pH is higher after the cool season months (so CO_2 is lower) and pH is lower (so CO_2 is higher) after the warm season months.

Aragonite saturation state

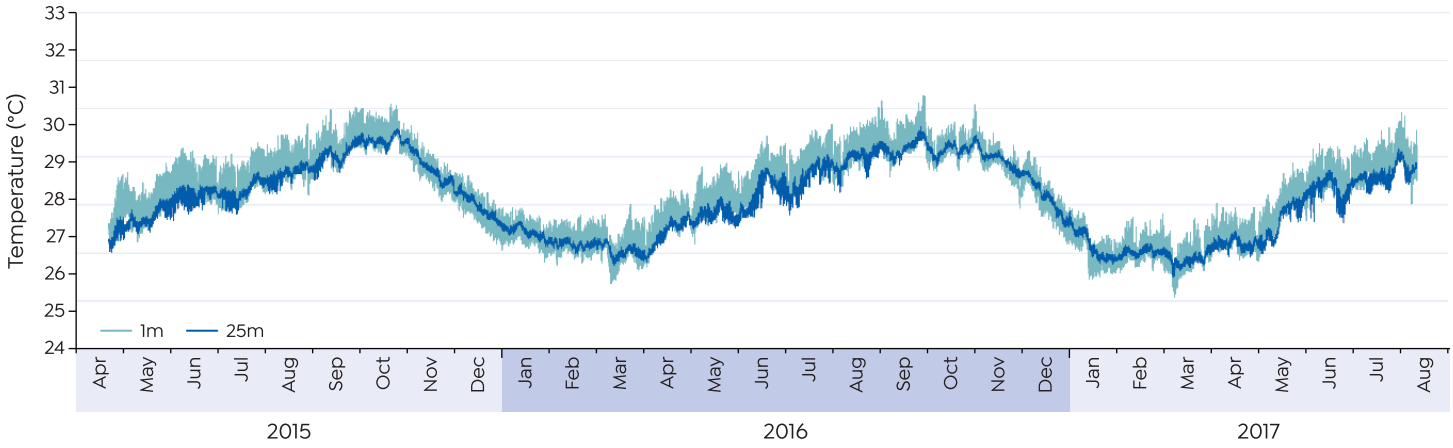


Mean (± std. error of mean) aragonite saturation Ω_{arag} values of US jurisdictions during summer months from 2013–2015. Data from Southeast Florida and Florida Keys represent annual averages. Blue line is mean for Atlantic sites, excluding outlier sites of inshore Florida Keys and inlet sites of Southeast Florida Region.

Ω_{arag} values around Puerto Rico during the summer are, on average, slightly higher than the average for US coral reef jurisdictions in the Atlantic. Values in Puerto Rico were very similar to nearby sites in St. Croix and St. Thomas, due east. This likely creates a favorable environment for coral calcification.

Subsurface temperature

Subsurface temperature time series



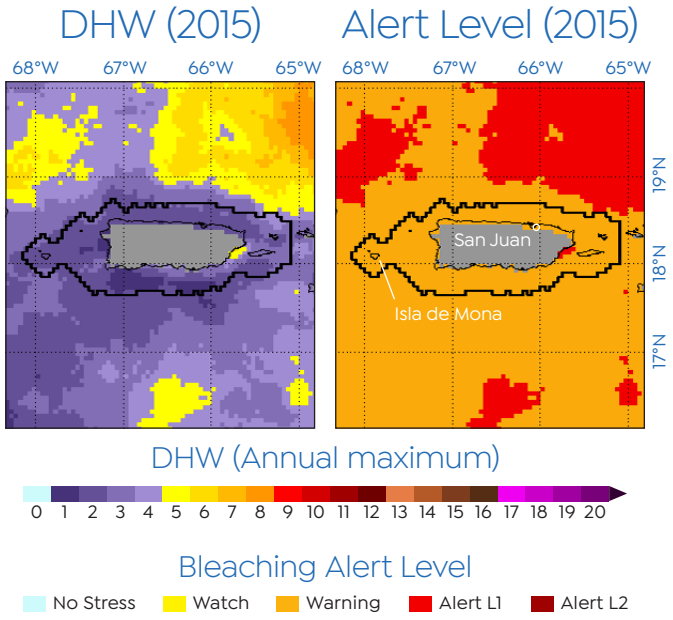
Sea temperatures off Culebra, Puerto Rico at 1 m (turquoise line) and 25 m (blue line) from April 2015 thru August 2017.

In Puerto Rico, the shallow sites had much greater diurnal variability, and were warmer than the deeper sites. There was no evidence of upwelling or thermocline shoaling with depth. Rather, deeper waters were slightly cooler (~0.5°C), but far less variable than the shallow sites. Thus, the potential for refugia from warmer waters with depths may be limited at the sites in Puerto Rico where loggers were deployed.

Heat stress and coral bleaching

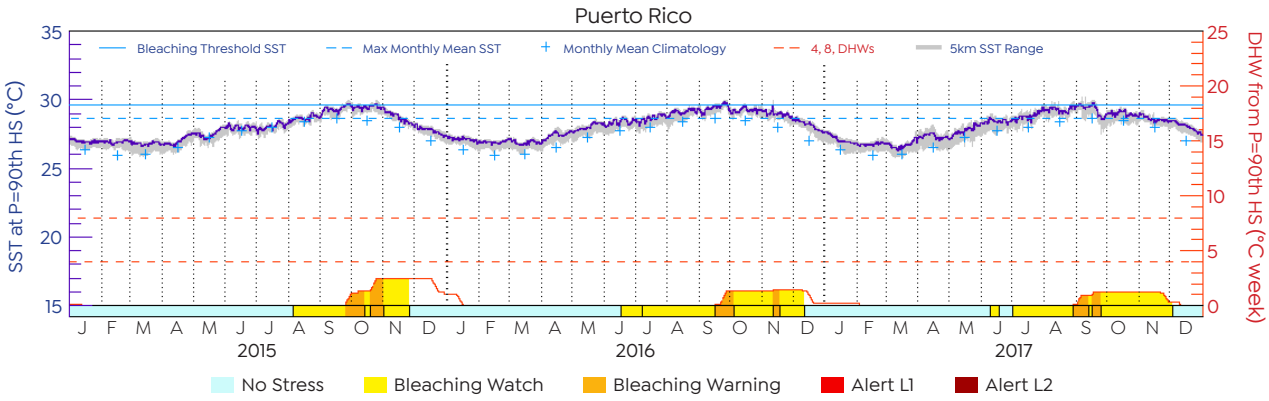
The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in Puerto Rico in 2005, 2006, and 2010.

Bleached coral in Puerto Rico



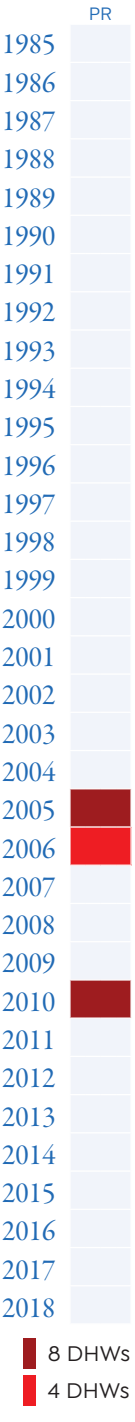
Annual maximum Degree Heating Weeks (DHWs) never reached four Puerto Rico in 2015 (left panel), 2016, or 2017, except for some isolated locations.

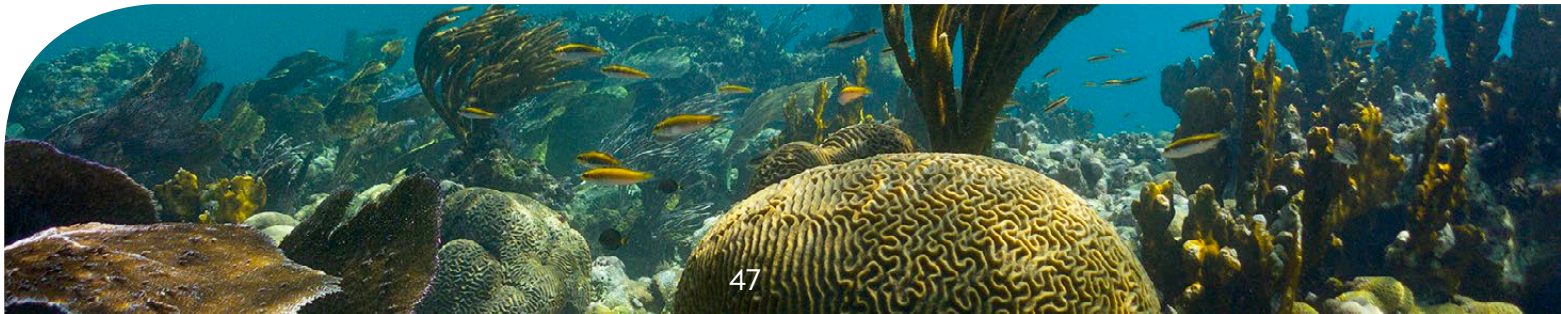
Heat stress accumulation triggered a Warning in 2015 (right panel) and only the typical seasonal minor bleaching occurred that year.



Degree Heating Week (DHW) accumulation from 2015-2017 in Puerto Rico. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Levels 1 and 2 were not triggered between 2015 and 2017.

Thermal History





South Florida

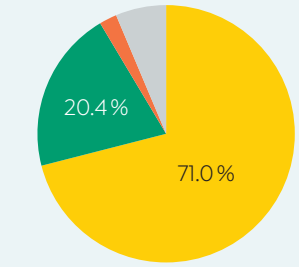
Demographics, values, resource use, and information sources

This Human Connections section presents findings from the Florida NCRMP socioeconomic data collection and includes data never collected before in Florida. These are baseline data on social indicators from household surveys conducted in January to July of 2014, and from secondary sources.

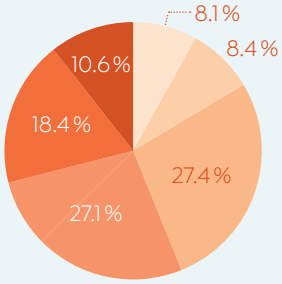
Highlights

- The great majority of residents agreed that coral reefs provide protection from erosion and natural disasters, attract tourists, and are culturally important.
- The dominant perception of the status of ocean water quality and beach quality, mangroves, and the amount of coral and number of fish was that the current status was good; however the dominant perception for trend was that the status had gotten worse over the last ten years.
- Of the potential threats to coral reefs, residents were least familiar with coral bleaching and beach nourishment.
- Residents were generally very supportive of marine management policies – roughly 90% supported protected areas and would support stricter controls on pollution and development.

Race

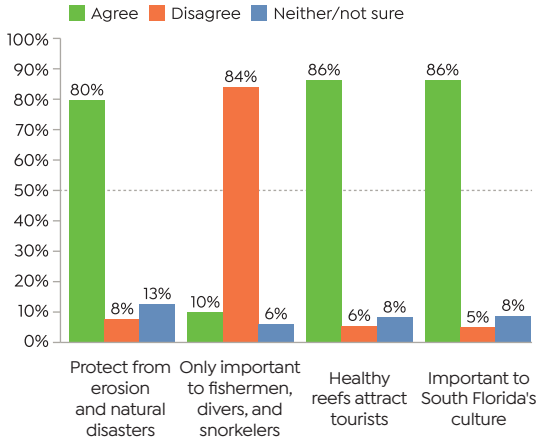


Educational attainment



The population of South Florida was predominantly composed of White (71%) and Black ethnicity (20%). Over 80% of the population had at least completed high school, 56% had completed at least some college or an associate's degree, and almost 30% a bachelor's degree or graduate degree.

Values and awareness



When asked about important services provided by reef resources, most residents agreed that coral reefs protect South Florida from erosion and natural disasters (80%), that healthy reefs attract tourists (86%), and that coral reefs are important to South Florida's culture (86%). The majority of residents (84%) disagreed with the statement that coral reefs are only important to fishermen, divers, and snorkelers.

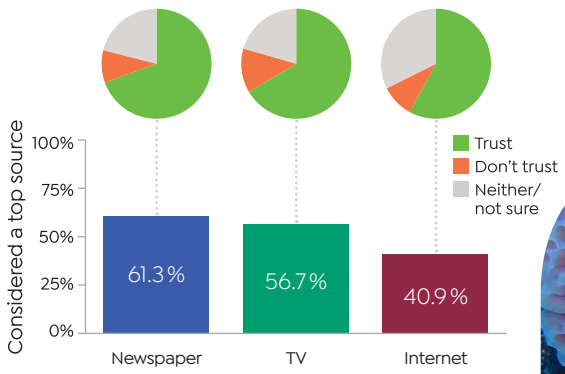
2014 survey data (n = 1,210)

Resource use

PERCENT OF POPULATION PARTICIPATING IN EACH ACTIVITY

Information sources

The majority (>50%) of residents considered newspapers and TV to be a top source for information on the environment, including status of coral reefs and present and future threats. Greater than 60% of residents who claimed newspapers, TV and Internet are top sources indicated these sources were trustworthy.



Perceptions of resource condition, threats, and severity

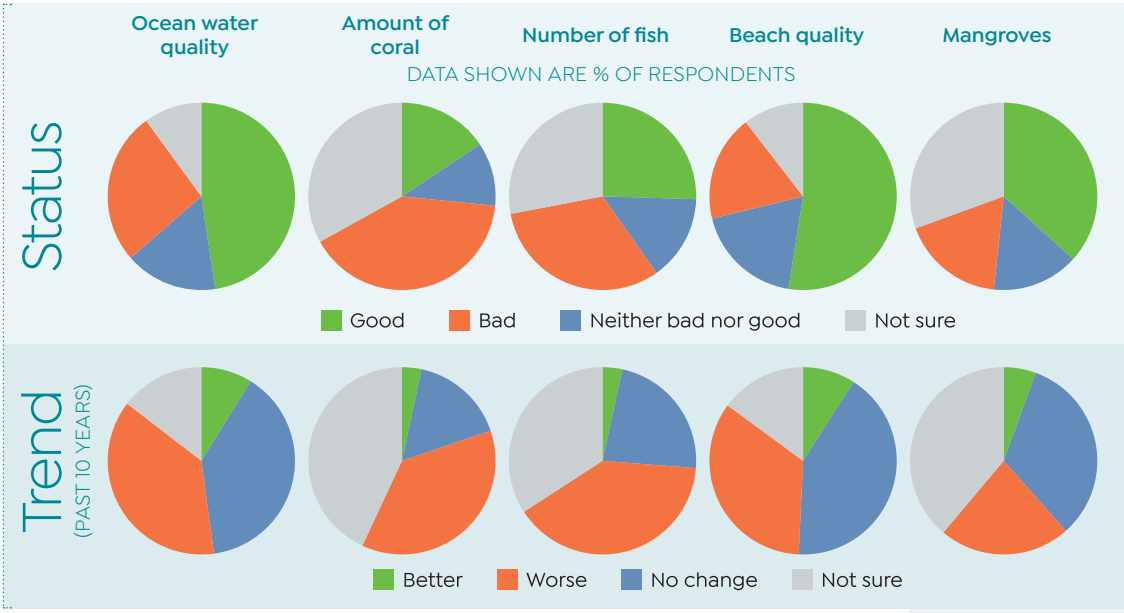
Threats

PERCENT OF THE POPULATION FAMILIAR WITH EACH THREAT

Threats not shown above: **Coral bleaching** (44 %).

In general, residents were familiar with potential threats facing coral reefs in South Florida, with at least half of residents stating they were familiar or very familiar with each potential threat shown above. Of the potential threats mentioned, residents were least familiar with threats caused by coral bleaching (44 %), snorkeling and diving (56 %), and beach nourishment (56 %). Residents exhibited highest levels of familiarity with threats from pollution and hurricanes.

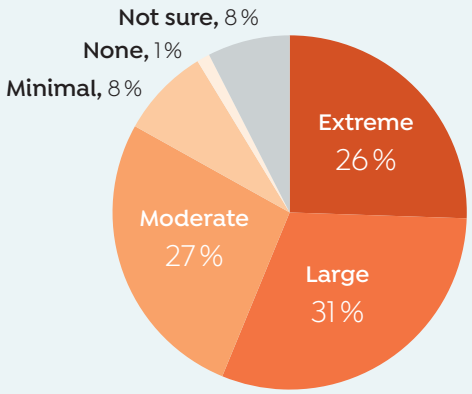
PERCEPTIONS OF



Status and trend

More residents felt confident in their perception of the status of ocean water quality and beach quality (<15 % not sure) than for the amount of coral, number of fish, and mangroves (>20 % not sure). For those confident in their perception, roughly 25–60 % of residents felt the current status was good and roughly 20–60 % felt the current status was bad for all status variables. A different pattern was shown in the perceptions of trend. For those confident in their perception of the trends in these variables, roughly 90–95 % felt it had gotten worse or remained the same, and roughly 5–10 % felt any of these had gotten better. Overall, there was no dominant perception of the status of ocean water and beach quality, amount of coral, number of fish, and mangroves – residents were split on whether status was good or bad. The dominant perception for trend was that the status had gotten worse or remained the same over the last ten years.

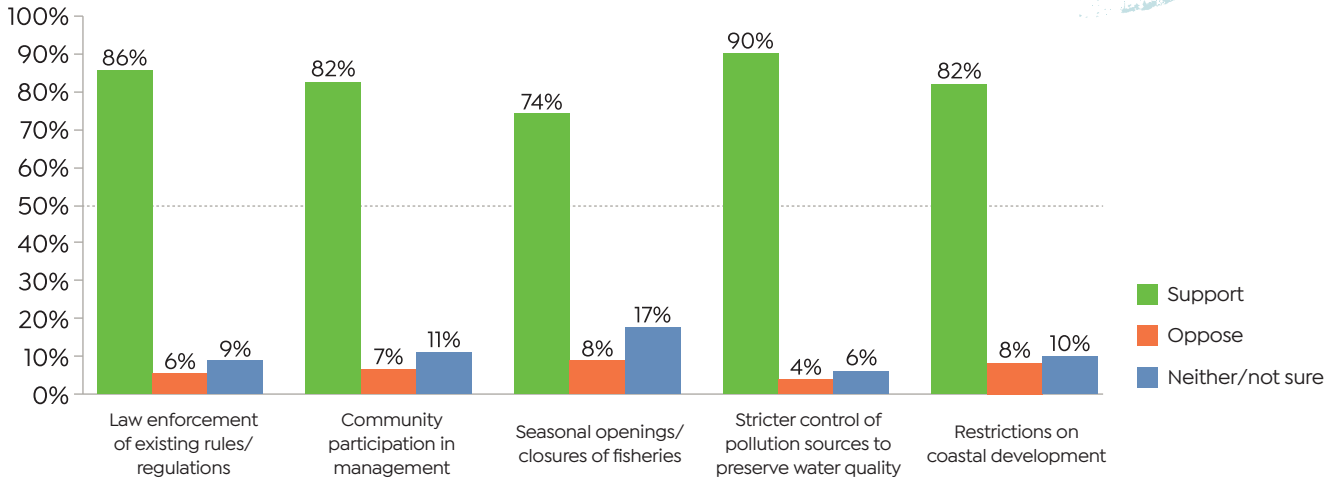
Severity of threats

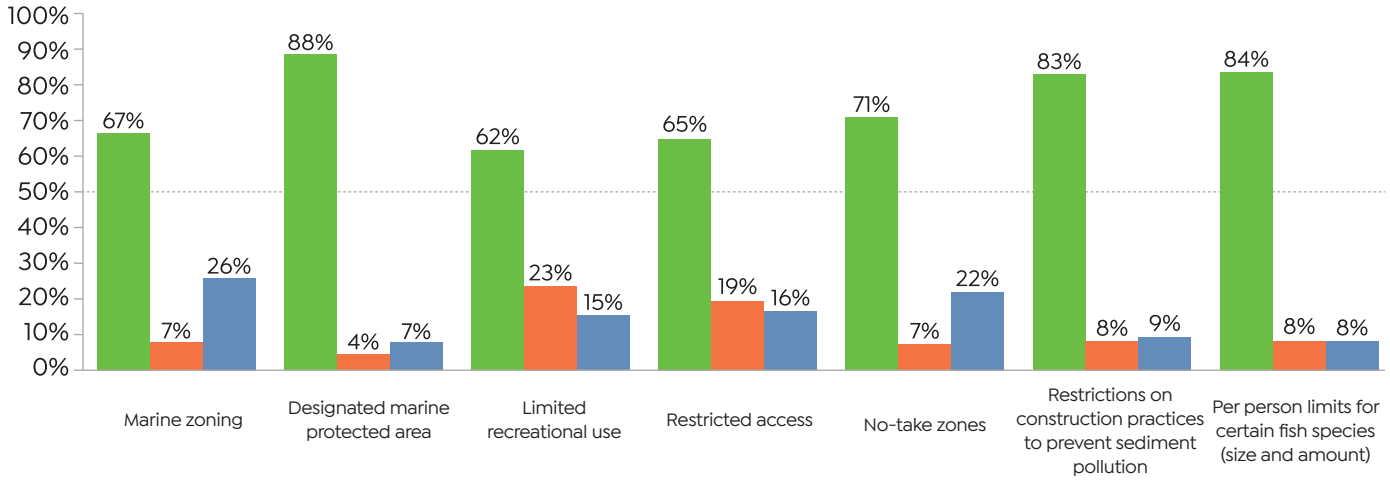


Residents were generally concerned about threats to coral reefs in South Florida. Twenty-six percent of residents stated that they thought threats were extreme and 31 % thought threats were large. A small percentage (9 %) stated that threats were either minimal or believe there are no threats.

Perceptions of reef management policies

Management policies





Residents were generally supportive of current marine management policies. There was extremely high support for stricter controls of pollution sources (90%), designated marine protected areas (88%), enforcing extisting rules/regulations (86%), per person limits for certain fish species (84%), restrictions on construction practices to prevent sediment pollution (83%), and restricting coastal development (82%). There was less but still strong support for seasonal openings and closures of fisheries (74%) and no-take zones (71%).

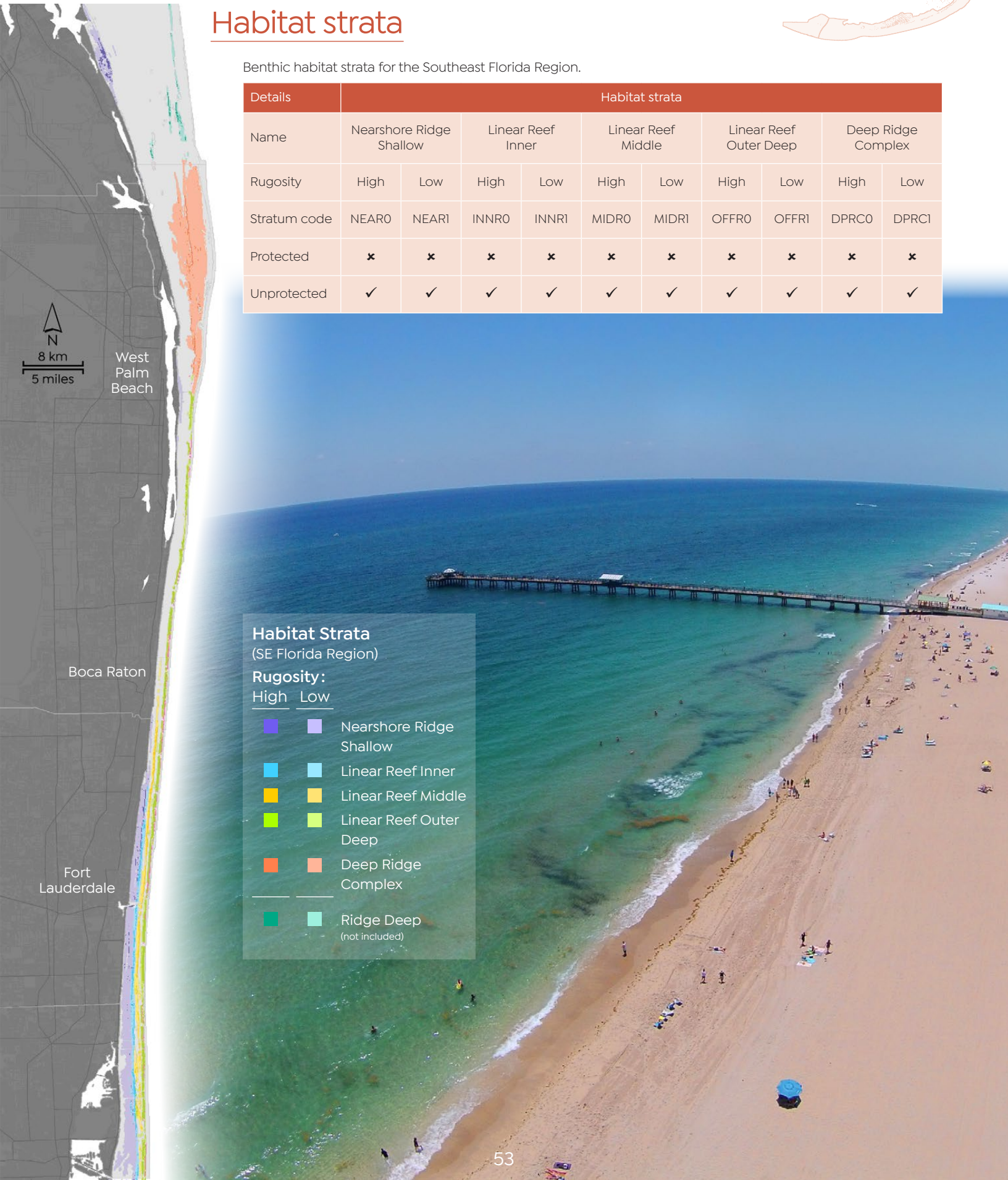
NOAA diver monitoring coral reef condition in Florida.

Coral reefs – Southeast Florida Region (2016)

Habitat strata

Benthic habitat strata for the Southeast Florida Region.

Details	Habitat strata									
Name	Nearshore Ridge Shallow		Linear Reef Inner		Linear Reef Middle		Linear Reef Outer Deep		Deep Ridge Complex	
Rugosity	High	Low	High	Low	High	Low	High	Low	High	Low
Stratum code	NEAR0	NEAR1	INNR0	INNR1	MIDR0	MIDR1	OFFR0	OFFR1	DPRC0	DPRC1
Protected	×	×	×	×	×	×	×	×	×	×
Unprotected	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

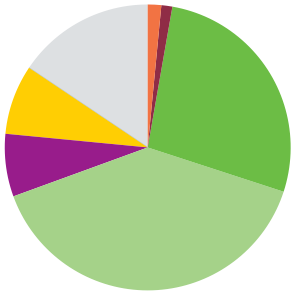


Coral reefs – Southeast Florida Region (2016)

Benthic cover

- Coral cover was <3%, except in the Nearshore Ridge Shallow, High Rugosity (7%) and in the Linear Reef Outer Deep, Low Rugosity (3.5%). Coral cover was lowest in the Deep Ridge Complex, Low Rugosity (0.2%).
- Macroalgae cover ranged from 13.5% in the Linear Reef Outer Deep, Low Rugosity to 42.5% in the Deep Ridge Complex, Low Rugosity.
- The region-wide average coral cover was 1.5% and macroalgae cover was 27.2%.

Regional



Coral 1.5±2.5%
Macroalgae 27.2±19.5%

- Coral cover was highest in the Nearshore Ridge Shallow, High Rugosity.
- Macroalgae cover was highest in the Linear Reef Outer Deep, Low Rugosity.
- Coral disease prevalence was lowest (1.3% of colonies) in the Linear Reef Middle, High Rugosity and highest (21.6% of colonies) in the Linear Reef Inner, Low Rugosity.
- Three species listed as Threatened under the Endangered Species Act were observed on reefs in Southast Florida in 2016. The greatest number of different Threatened species were observed in the Linear Reef Middle, Low Rugosity and High Rugosity (2 species).

Nearshore Ridge Shallow, High Rugosity

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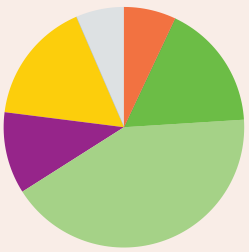

Coral 7.0±4.2%
Macroalgae 17.0±2.8%

Nearshore Ridge Shallow, Low Rugosity

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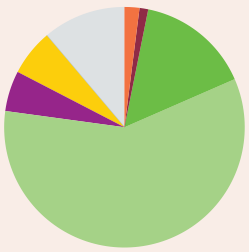

Coral 2.0±4.6%
Macroalgae 15.3±16.0%

Linear Reef Inner, High Rugosity

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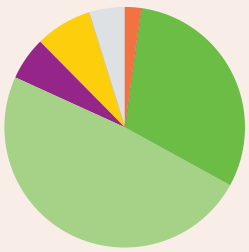

Coral 2.2±2.5%
Macroalgae 30.8±7.9%

Linear Reef Inner, Low Rugosity

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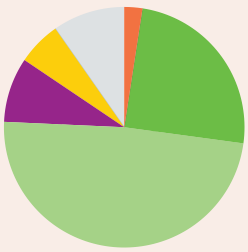

Coral 2.4±4.0%
Macroalgae 24.7±13.8%

Linear Reef Middle, High Rugosity

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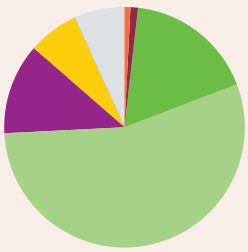

Coral 0.8±0.8%
Macroalgae 17.4±11.3%

Linear Reef Middle, Low Rugosity

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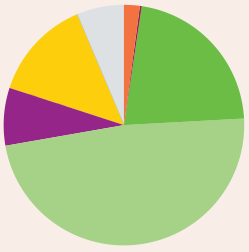

Coral 2.1±2.2%
Macroalgae 21.8±24.9%

Linear Reef Outer Deep, High Rugosity

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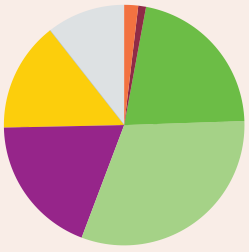

Coral 1.9±2.0%
Macroalgae 21.5±20.3%

Linear Reef Outer Deep, Low Rugosity

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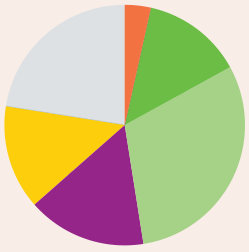

Coral 3.5±5.1%
Macroalgae 13.5±18.3%

Deep Ridge Complex, High Rugosity

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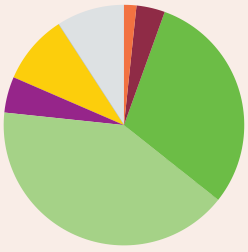

Coral 1.7±2.7%
Macroalgae 30.2±15.0%

Deep Ridge Complex, Low Rugosity

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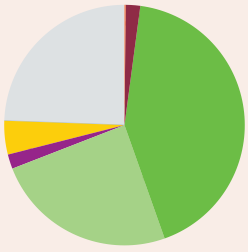


Coral 0.2±0.4%
Macroalgae 42.5±24.1%

Benthic cover

- Hard coral
- Crustose coralline algae
- Macroalgae
- Turf algae
- Soft corals
- Sponges
- *Ramicrusta* spp.
- Other

Coral reefs – Southeast Florida Region (2016)

Benthic communities

- Diadema (sea urchin) density was highest (0.01/m^2) in the Nearshore Ridge Shallow, Low Rugosity.
- Coral density (unweighted) ranged from 0.4/m^2 in the Deep Ridge Complex, Low Rugosity to 1.6/m^2 in the Nearshore Ridge Shallow, High Rugosity.
- Species richness (unweighted) was highest (4.9) in the Linear Reef Middle, Low Rugosity and lowest (1.9) in the Deep Ridge Complex, Low Rugosity.
- Coral diversity was highest in the Nearshore Ridge Shallow, Low Rugosity and lowest in the Deep Ridge Complex, Low Rugosity.
- Disease prevalence was highest (21.6% of colonies) in the Linear Reef Inner, Low Rugosity and lowest (1.3% of colonies) in the Linear Reef Middle, High Rugosity.
- Recent mortality (unweighted) ranged from 0.5% in the Deep Ridge Complex, Low Rugosity to 6.2% in the Deep Ridge Complex, High Rugosity.
- Old mortality (unweighted) was highest (19.0%) in the Linear Reef Inner, Low Rugosity and lowest (2.8%) in the Linear Reef Inner, High Rugosity.

Benthic data collected in 2016 for the habitat strata in the SE Florida region. Transects (n) describes how sampling effort varied among the strata.

Habitat strata		Transects (n)	Diadema density (m^{-2})	Coral density (m^{-2})	Species richness	Coral diversity (Simpsons)	Disease prevalence (% colonies)	Recent mortality (%)	Old mortality (%)
Prefix	Protection								
Nearshore Ridge Shallow, High Rugosity	No	2	0.00±0.00	1.55±1.63	4.00±1.41	4.05	16.1	0.67±0.94	7.13±10.08
Nearshore Ridge Shallow, Low Rugosity	No	19	0.01±0.04	0.61±0.62	2.28±0.89	6.76	16.2	2.58±4.87	9.64±14.56
Linear Reef Inner, High Rugosity	No	5	0.00±0.00	1.18±0.58	4.60±0.89	4.43	7.3	2.61±5.53	2.77±3.30
Linear Reef Inner, Low Rugosity	No	7	0.00±0.00	0.60±0.33	2.86±1.57	4.13	21.6	3.94±4.91	19.03±23.88
Linear Reef Middle, High Rugosity	No	7	0.00±0.00	0.50±0.42	3.20±1.79	4.16	1.3	4.00±5.48	18.21±24.70
Linear Reef Middle, Low Rugosity	No	9	0.00±0.00	1.20±0.60	4.88±1.46	5.04	18.2	3.52±5.19	6.47±7.79
Linear Reef Outer Deep, High Rugosity	No	27	0.00±0.00	0.98±0.55	4.26±1.89	6.57	15.6	2.99±4.18	4.36±6.04
Linear Reef Outer Deep, Low Rugosity	No	5	0.00±0.00	0.60±0.54	3.25±3.20	3.16	9.8	1.64±2.28	3.54±7.08
Deep Ridge Complex, High Rugosity	No	8	0.00±0.00	1.05±1.45	3.17±2.14	5.77	12.8	6.15±6.10	13.12±11.42
Deep Ridge Complex, Low Rugosity	No	19	0.00±0.01	0.44±0.28	1.94±1.11	2.48	8.1	0.50±1.27	4.60±11.41

Coral reefs – Southeast Florida Region (2016)

Endangered coral species

» Of the seven species listed as Threatened under the Endangered Species Act (ESA) that were surveyed in the Florida Reef Tract, three were observed on reefs in the Southeast Florida Region in 2016. *Acropora palmata*, *Dendrogyra cylindrus*, *Mycetophyllia ferox*, and *Orbicella annularis* were not observed in SE Florida during the 2016 surveys.

» *Acropora cervicornis* was observed in only one of the five habitat strata. *Orbicella faveolata* and *Orbicella franksi* were each observed in two of the habitat strata. The greatest number of different Threatened species were observed in the Linear Reef Middle, Low Rugosity and High Rugosity (two species).

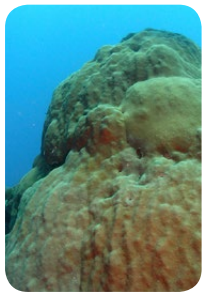
Acropora palmata

Acropora cervicornis

Dendrogyra cylindrus

Mycetophyllia ferox

Orbicella annularis

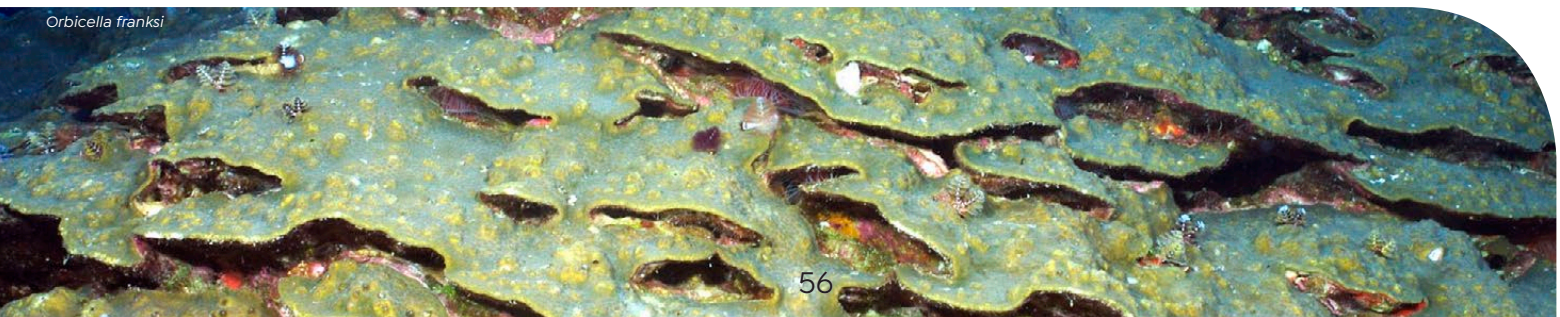


Orbicella faveolata

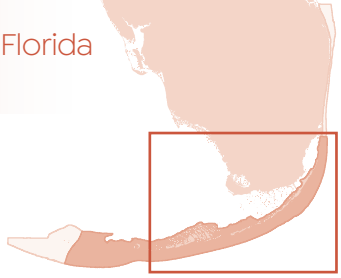
Orbicella franksi

Presence of coral species listed as Threatened under the Endangered Species Act (ESA).

Habitat Strata	Protected	No. ESA coral species	*Acropora palmata*	*Acropora cervicornis*	*Dendrogyra cylindrus*	*Mycetophyllia ferox*	*Orbicella annularis*	*Orbicella faveolata*	*Orbicella franksi*
Nearshore Ridge Shallow, High Rugosity	No	1	○	○	○	○	○	○	●
Nearshore Ridge Shallow, Low Rugosity	No	1	○	●	○	○	○	○	○
Linear Reef Inner, High Rugosity	No	0	○	○	○	○	○	○	○
Linear Reef Inner, Low Rugosity	No	1	○	○	○	○	○	●	○
Linear Reef Middle, High Rugosity	No	2	○	○	○	○	○	●	●
Linear Reef Middle, Low Rugosity	No	2	○	○	○	○	○	●	●
Linear Reef Outer Deep, High Rugosity	No	1	○	○	○	○	○	○	●
Linear Reef Outer Deep, Low Rugosity	No	0	○	○	○	○	○	○	○
Deep Ridge Complex, High Rugosity	No	0	○	○	○	○	○	○	○
Deep Ridge Complex, Low Rugosity	No	0	○	○	○	○	○	○	○



Orbicella franksi



Coral reefs – Florida Keys Region (2016)

Habitat strata

Benthic habitat strata for the Florida Keys Region.

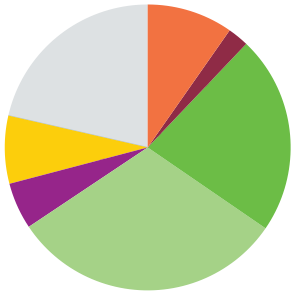
Details	Habitat strata						
Name	Forereef Deep Linear Reef	Forereef Medium Depth Linear Reef	Forereef Shallow Linear Reef	High Relief Reef	Inshore Patch Reef	Mid Channel Patch Reef	Offshore Patch Reef
Stratum code	FDLR	FMLR	FSLR	HRRF	INPR	MCPR	OFPR
Protected	✖	✓	✓	✓	✓	✓	✓
Unprotected	✓	✓	✓	✓	✓	✓	✓

Coral reefs – Florida Keys Region (2016)

Benthic cover

- Coral cover ranged from 0.5% in the protected Offshore Patch Reef to 19% in the unprotected Inshore Patch Reef and unprotected Mid Channel Patch Reef.
- Macroalgae cover ranged from 6.7% in the unprotected Offshore Patch Reef to 43.6% in the protected Forereef Medium Depth Linear Reef.
- The region-wide average coral cover was 9.7% and macroalgae cover was 22.5%.

Regional

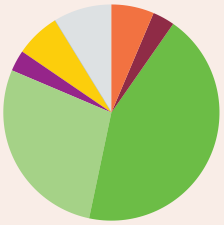


Coral 9.7±8.0%
Macroalgae 22.5±12.6%

- Coral cover was highest in the unprotected Inshore Patch Reef.
- Macroalgae cover was highest in the protected Forereef Medium Depth Linear Reef
- Coral disease prevalence was lowest (0) in the Forereef Deep Linear Reef and in the protected Inshore Patch Reef and highest (6.8% of colonies) in the unprotected Offshore Patch Reef.
- Five species listed as Threatened under the Endangered Species Act were observed on reefs in the Florida Keys in 2016. The greatest number of different Threatened species were observed in the protected Forereef Medium Depth Linear Reef (5 species).

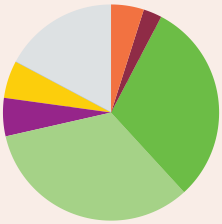
Forereef Medium Depth Linear Reef

Protected



Coral 6.4±4.1%
Macroalgae 43.6±10.0%

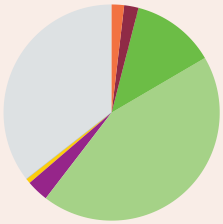
Unprotected



Coral 4.9±4.1%
Macroalgae 30.5±13.7%

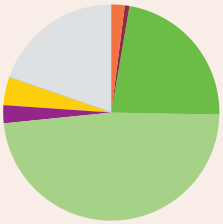
Forereef Shallow Linear Reef

Protected



Coral 1.9±2.5%
Macroalgae 12.6±8.1%

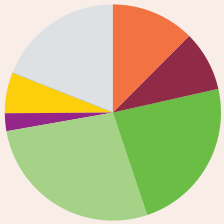
Unprotected



Coral 2.0±1.9%
Macroalgae 22.6±14.0%

High Relief Reef

Protected



Coral 12.5±10.8%
Macroalgae 23.4±12.0%

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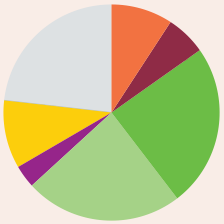
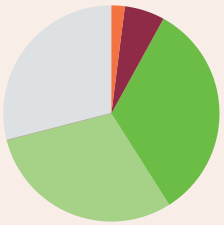


Coral 9.2±5.6%
Macroalgae 24.4±8.3%

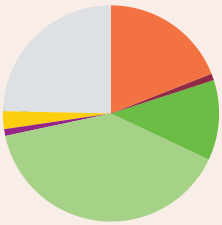
Inshore Patch Reef

Protected



Coral 2.0±NA%
Macroalgae 33.0±NA%

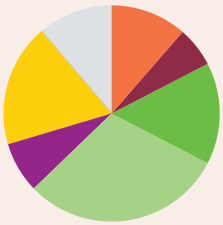
Unprotected



Coral 19.0±23.6%
Macroalgae 12.0±10.5%

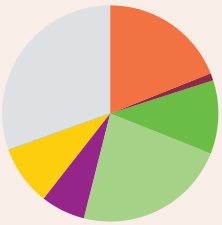
Mid Channel Patch Reef

Protected



Coral 11.4±5.8%
Macroalgae 15.2±11.6%

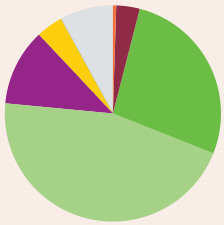
Unprotected



Coral 18.9±14.9%
Macroalgae 11.0±13.2%

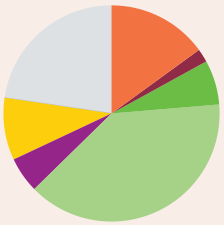
Offshore Patch Reef

Protected



Coral 0.5±0.7%
Macroalgae 27.0±32.5%

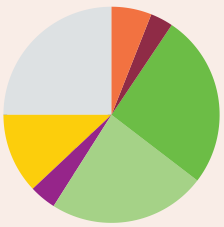
Unprotected



Coral 15.0±12.5%
Macroalgae 6.7±4.9%

Forereef Deep Linear Reef

Unprotected



Coral 6.0±4.4%
Macroalgae 26.0±12.7%

Benthic cover

- Hard coral
- Crustose coralline algae
- Macroalgae
- Turf algae
- Soft corals
- Sponges
- *Ramicrusta* spp.
- Other

TABLE OF CONTENTS

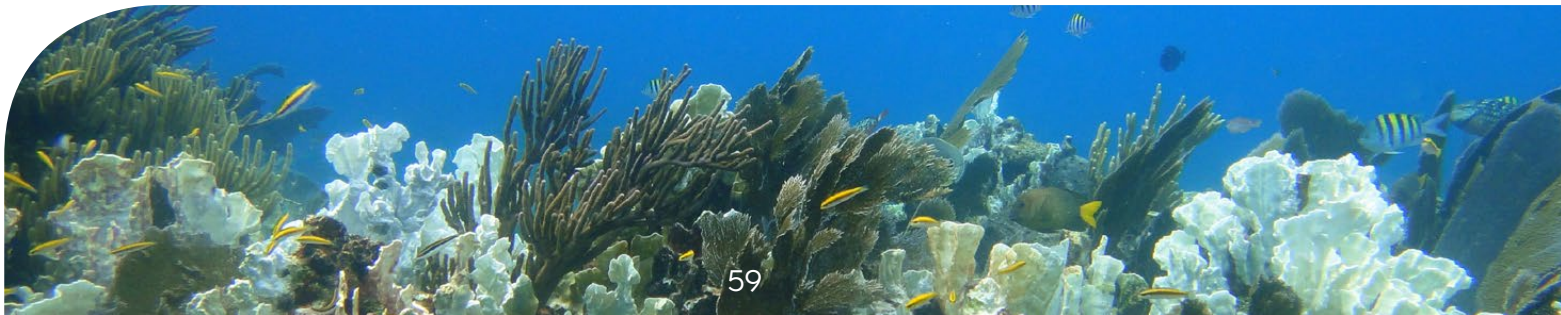
Coral reefs – Florida Keys Region (2016)

Benthic communities

- Diadema (sea urchin) density ranged from absent in nine of thirteen habitat strata to 0.07/m^2 in the protected Mid Channel Patch Reef.
- Coral density (unweighted) was highest (10.4/m^2) in the unprotected Offshore Patch Reef and lowest (1.3/m^2) in the protected Forereef Shallow Linear Reef.
- Species richness (unweighted) was highest (9.4) in the unprotected High Relief Reef and lowest (3.0) in the protected Inshore Patch Reef.
- Coral diversity was highest in the protected High Relief Reef and lowest in the protected Inshore Patch Reef.
- Disease prevalence was lowest (0) in the Forereef Deep Linear Reef and in the protected Inshore Patch Reef and highest (6.8 % of colonies) in the unprotected Offshore Patch Reef.
- Recent mortality (unweighted) was less than 2% in all habitat strata.
- Old mortality (unweighted) ranged from 9.5% in the protected Forereef Shallow Linear Reef to 42% in the unprotected Inshore Patch Reef.

Benthic data collected in 2016 for the habitat strata in the Florida Keys. Transects (n) describes how sampling effort varied among the strata.

Habitat strata		Transects (n)	Diadema density (m^{-2})	Coral density (m^{-2})	Species richness	Coral diversity (Simpsons)	Disease prevalence (% colonies)	Recent mortality (%)	Old mortality (%)
Prefix	Protection								
Forereef Deep Linear Reef	No	5	0.00±0.00	3.47±2.58	7.80±2.17	5.31	0.0	0.00±0.00	20.35±3.54
Forereef Medium Depth Linear Reef	No	22	0.00±0.01	3.39±1.69	8.36±2.11	4.95	1.5	0.96±2.13	12.82±10.08
	Yes	13	0.00±0.00	4.30±1.68	9.38±2.33	5.12	5.0	1.37±1.29	13.15±6.84
Forereef Shallow Linear Reef	No	10	0.00±0.00	1.62±1.07	5.40±2.67	5.75	2.8	1.90±2.93	10.70±10.00
	Yes	7	0.01±0.02	1.27±1.18	3.86±2.27	3.94	1.3	0.32±0.39	9.51±10.09
High Relief Reef	No	5	0.00±0.00	4.84±2.82	9.40±2.70	6.61	1.7	0.71±1.03	12.86±7.59
	Yes	6	0.00±0.00	4.42±2.57	8.00±3.41	7.07	4.2	1.04±1.17	21.13±10.94
Inshore Patch Reef	No	3	0.00±0.00	2.17±1.72	4.67±2.52	4.86	1.5	0.06±0.10	42.05±10.97
	Yes	1	0.00	2.00	3.00	1.23	0.0	0.00	36.60
Mid Channel Patch Reef	No	11	0.01±0.01	6.06±4.81	7.82±3.82	4.36	2.2	1.04±1.98	16.29±8.21
	Yes	5	0.07±0.10	5.30±1.80	8.40±1.95	5.46	0.8	0.24±0.31	28.95±8.06
Offshore Patch Reef	No	3	0.00±0.00	10.43±7.65	9.00±2.65	2.28	6.8	0.02±0.03	10.55±4.22
	Yes	2	0.00±0.00	3.00±0.71	7.50±0.71	5.25	1.7	1.15±1.62	29.74±19.81



Coral reefs – Florida Keys Region (2016)

Endangered coral species

» Of the seven species listed as Threatened under the Endangered Species Act (ESA) that were surveyed in the Florida Reef Tract, five were observed on reefs in the Florida Keys Region in 2016.

» *Acropora palmata* and *Dendrogyra cylindrus* were not observed in the Florida Keys during the 2016 surveys. *Acropora cervicornis* was observed in only two of the seven habitat strata. *Orbicella faveolata* was observed in all of the habitat strata.

» The most different Threatened species were observed in the protected Forereef Medium Depth Linear Reef (five species).

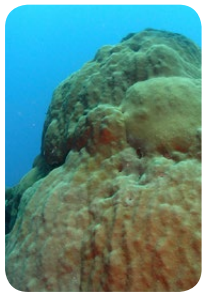
Acropora palmata

Acropora cervicornis

Dendrogyra cylindrus

Mycetophyllia ferox

Orbicella annularis



Orbicella faveolata

Orbicella franksi

Presence of coral species listed as Threatened under the Endangered Species Act (ESA).

Habitat Strata	Protected	No. ESA coral species	*Acropora palmata*	*Acropora cervicornis*	*Dendrogyra cylindrus*	*Mycetophyllia ferox*	*Orbicella annularis*	*Orbicella faveolata*	*Orbicella franksi*
Forereef Deep Linear Reef	No	2	○	○	○	●	○	●	○
Forereef Medium Depth Linear Reef	No	3	○	●	○	○	○	●	●
	Yes	5	○	●	○	●	●	●	●
Forereef Shallow Linear Reef	No	1	○	○	○	○	○	●	○
	Yes	0	○	○	○	○	○	○	○
High Relief Reef	No	2	○	○	○	○	○	●	●
	Yes	2	○	●	○	○	○	●	○
Inshore Patch Reef	No	2	○	○	○	○	●	●	○
	Yes	2	○	○	○	○	●	●	○
Mid Channel Patch Reef	No	4	○	○	○	●	●	●	●
	Yes	4	○	○	○	●	●	●	●
Offshore Patch Reef	No	2	○	○	○	●	○	●	○
	Yes	1	○	○	○	○	○	●	○

Orbicella faveolata

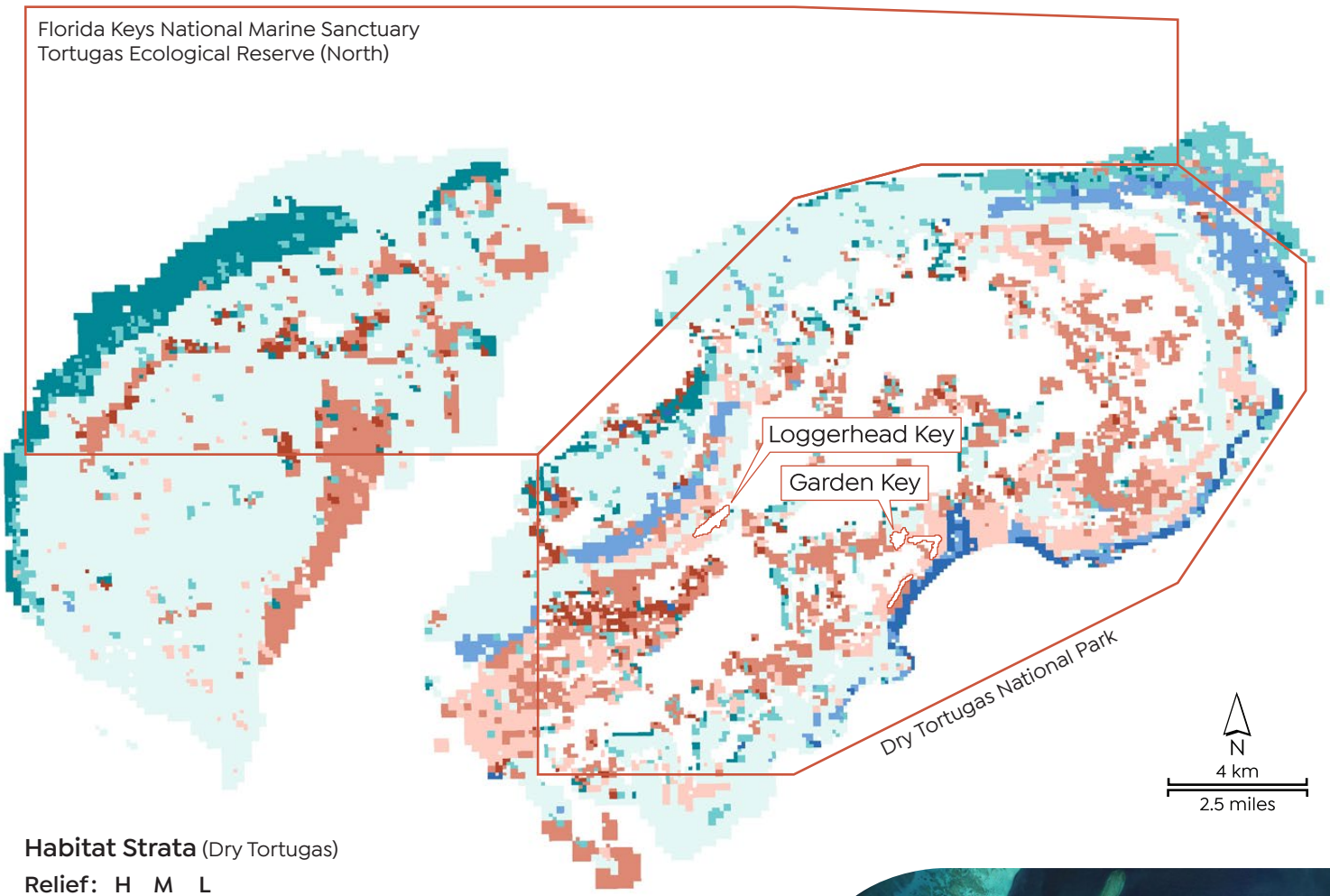
Coral reefs – Dry Tortugas Region (2016)

Habitat strata

Benthic habitat strata for the Dry Tortugas Region.

Details	Habitat strata							
Name	Contiguous Reef, High Relief	Contiguous Reef, Low Relief	Contiguous Reef, Medium Relief	Isolated Patch Reef, High Relief	Isolated Patch Reef, Low Relief	Isolated Patch Reef, Medium Relief	Spur and Groove Reef, High Relief	Spur and Groove Reef, Low Relief
Stratum code	CONT_HR	CONT_LR	CONT_MR	ISOL_HR	ISOL_LR	ISOL_MR	SPGR_HR	SPGR_LR
Protected – FKNMS TER[1]	✓	✓	×	✓	✓	✓	×	×
Protected – DTNP[2]	✓	✓	✓	✓	✓	✓	✓	✓
Unprotected	✓	✓	×	×	×	✓	×	×

[1] Florida Keys National Marine Sanctuary – Tortugas Ecological Reserve
[2] Dry Tortugas National Park



Habitat Strata (Dry Tortugas)

Relief: H M L

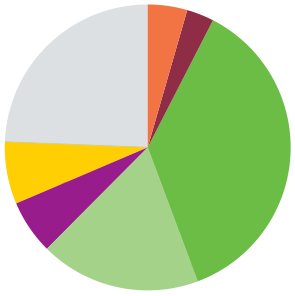
- Contiguous Reef
- Isolated Patch Reef
- Spur and Groove Reef

Coral reefs – Dry Tortugas Region (2016)

Benthic cover

- Coral cover ranged from 0 in parts of the Contiguous Reef Low Relief to 17.5% in the unprotected Isolated Patch Reef Medium Relief.
- Macroalgae cover ranged from 6.6% in the Isolated Patch Reef Medium Relief in the FKNMS TER to 53% in the unprotected Contiguous Reef Low Relief.
- The region-wide average coral cover was 4.4% and macroalgae cover was 36.6%.

Regional

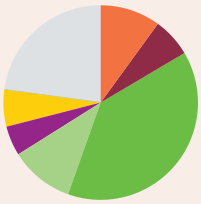


Coral 4.4±3.5%
Macroalgae 36.6±14.3%

- Coral cover was highest in the unprotected Isolated Patch Reef Medium Relief.
- Macroalgae cover was highest in the unprotected Contiguous Reef Low Relief.
- Coral disease prevalence was less than 2.5% of colonies in all habitats.
- Five species listed as Threatened under the Endangered Species Act were observed on reefs in the Dry Tortugas in 2016. The greatest number of different Threatened species was observed in the Isolated Patch Reef High Relief (4 species).

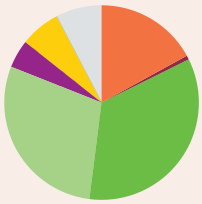
Contiguous Reef High Relief

FKNMS TER[1]



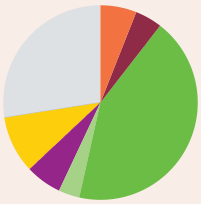
Coral 10.0±9.7%
Macroalgae 38.9±16.3%

DTNP[2]



Coral 17.0±13.0%
Macroalgae 34.3±22.2%

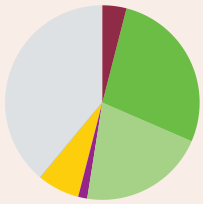
Unprotected



Coral 6.0±4.2%
Macroalgae 43.0±21.2%

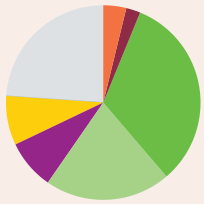
Contiguous Reef Low Relief

FKNMS TER



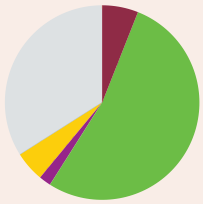
Coral 0.0±0.0%
Macroalgae 27.5±19.1%

DTNP



Coral 3.8±3.9%
Macroalgae 32.5±11.8%

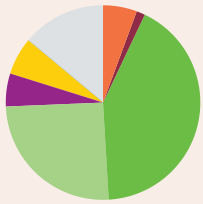
Unprotected



Coral 0.0±NA%
Macroalgae 53.0±NA%

C.R. Med Relief

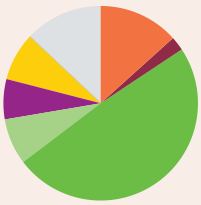
DTNP



Coral 5.6±4.0%
Macroalgae 42.0±16.0%

Isolated Patch Reef High Relief

FKNMS TER



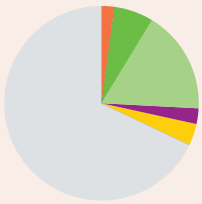
Coral 13.3±13.5%
Macroalgae 49.0±11.5%

DTNP

Coral 11.1±6.3%
Macroalgae 19.1±17.2%

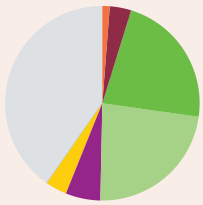
Isolated Patch Reef Low Relief

FKNMS TER



Coral 2.1±1.3%
Macroalgae 6.6±7.6%

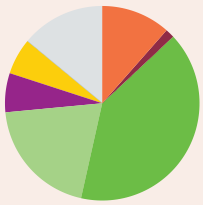
DTNP



Coral 1.2±1.1%
Macroalgae 22.4±26.0%

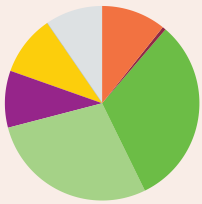
Isolated Patch Reef Medium Relief

FKNMS TER



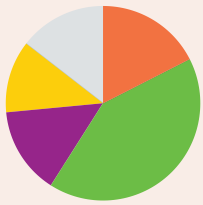
Coral 11.5±4.9%
Macroalgae 40.5±10.6%

DTNP



Coral 10.7±8.0%
Macroalgae 31.5±19.6%

Unprotected



Coral 17.5±7.8%
Macroalgae 41.5±16.3%

[1] Florida Keys National Marine Sanctuary – Tortugas Ecological Reserve
[2] Dry Tortugas National Park

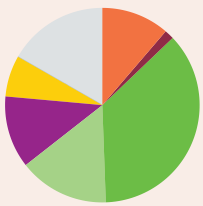
Benthic cover

- Hard coral
- Crustose coralline algae
- Macroalgae
- Turf algae
- Soft corals
- Sponges
- *Ramicrusta* spp.
- Other

Spur and Groove Reef

High Relief

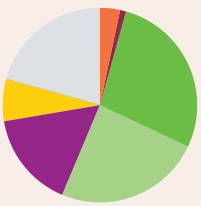
DTNP



Coral 11.3±8.7%
Macroalgae 36.6±11.0%

Low Relief

DTNP



Coral 3.3±3.1%
Macroalgae 27.7±5.8%

TABLE OF CONTENTS

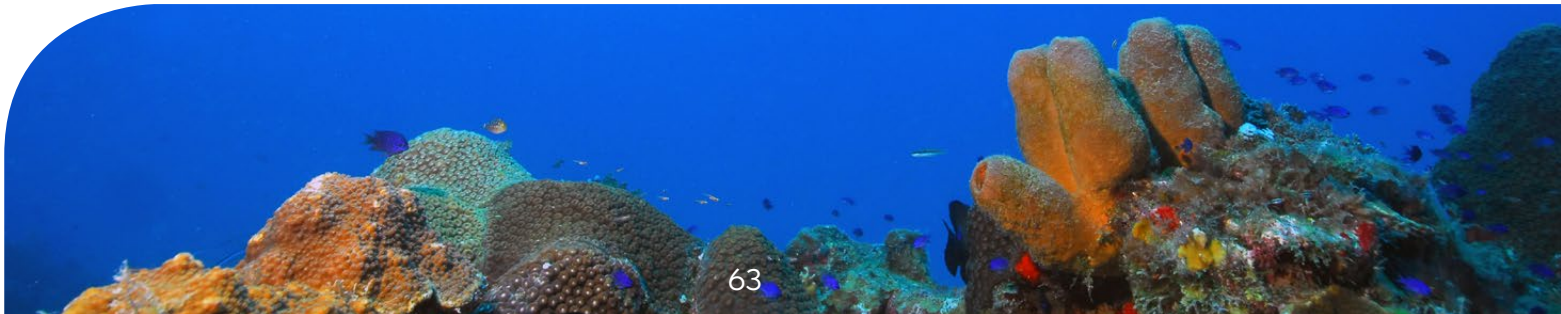
Coral reefs – Dry Tortugas Region (2016)

Benthic communities

- Diadema (sea urchin) density ranged from absent in nine habitat strata to 0.11/m^2 in the Isolated Patch Reef Low Relief in the DTNP.
- Coral density (unweighted) was highest (4.8/m^2) in the unprotected Isolated Patch Reef Medium Relief and lowest (0.6/m^2) in the unprotected Contiguous Reef Low Relief.
- Species richness (unweighted) was highest (9.7) in the Isolated Patch Reef High Relief in the FKNMS TER.
- Coral diversity was highest in the Contiguous Reef High Relief in the FKNMS TER.
- Disease prevalence ranged from 0 in eight of sixteen habitat strata to 2.8% of colonies in the Contiguous Reef High Relief in the FKNMS TER.
- Recent mortality (unweighted) was less than 1.5% in all habitat strata.
- Old mortality (unweighted) was highest (42.5%) in the Isolated Patch Reef Low Relief in the FKNMS TER and lowest (8.2%) in the Isolated Patch Reef Medium Relief in the FKNMS TER.

Benthic data collected in 2016 for the habitats of the Dry Tortugas. Transects (n) describes how sampling effort varied in 2016 among the habitats.

Habitat strata		Transects (n)	Diadema density (m^{-2})	Coral density (m^{-2})	Species richness	Coral diversity (Simpsons)	Disease prevalence (% colonies)	Recent mortality (%)	Old mortality (%)
Prefix	Protection								
Contiguous Reef High Relief	FKNMS TER	14	0.00±0.00	3.30±1.24	8.50±2.56	8.25	2.8	0.07±0.15	18.31±10.08
	DTNP	3	0.00±0.00	3.26±0.83	7.67±1.15	8.06	0.0	0.42±0.41	10.00±5.05
	No	2	0.02±0.02	2.10±0.14	8.50±3.54	5.92	0.0	0.68±0.96	31.08±6.83
Contiguous Reef Low Relief	FKNMS TER	2	0.00±0.00	1.40±0.28	6.50±0.71	3.21	0.0	0.00±0.00	16.36±12.21
	DTNP	11	0.02±0.05	1.63±0.84	6.55±2.34	7.45	1.2	1.31±2.36	11.17±8.98
	No	1	0.00	0.60	4.00	3.00	0.0	0.50	39.50
Contiguous Reef Medium Relief	DTNP	19	0.05±0.10	2.92±1.34	7.74±1.91	7.22	2.2	0.53±1.27	17.89±10.20
Isolated Patch Reef High Relief	FKNMS TER	3	0.00±0.00	3.00±1.31	9.67±0.58	6.66	0.0	0.00±0.00	18.55±10.29
	DTNP	11	0.05±0.06	3.55±1.32	8.82±2.71	6.82	0.8	0.16±0.27	13.74±8.12
Isolated Patch Reef Low Relief	FKNMS TER	2	0.00±0.00	1.00±1.27	4.50±4.95	4.88	0.0	0.00±0.00	42.50±60.10
	DTNP	9	0.11±0.27	1.27±1.03	5.22±2.49	7.01	1.0	0.31±0.65	16.54±8.38
Isolated Patch Reef Medium Relief	FKNMS TER	2	0.00±0.00	3.15±1.48	7.50±0.71	4.63	0.0	0.00±0.00	8.24±4.06
	DTNP	7	0.08±0.09	3.64±1.19	9.57±2.37	6.24	2.4	0.21±0.30	14.51±6.77
	No	2	0.00±0.00	4.75±1.48	9.00±0.00	6.53	0.0	0.04±0.06	13.55±0.52
Spur and Groove Reef High Relief	DTNP	7	0.00±0.01	3.61±1.19	8.86±2.54	5.64	2.1	0.18±0.32	11.35±7.17
Spur and Groove Reef Low Relief	DTNP	3	0.00±0.00	1.67±1.25	6.00±3.00	5.58	2.0	0.00±0.00	15.45±4.95



Coral reefs – Dry Tortugas Region (2016)

Endangered coral species

» Of the seven species listed as Threatened under the Endangered Species Act (ESA) that were surveyed in the Florida Reef Tract, five were observed on reefs in the Dry Tortugas Region in 2016.

» *Acropora palmata* and *Dendrogyra cylindrus* were not observed in the Dry Tortugas during the 2016 surveys.

» *Acropora cervicornis* was observed in only two of the eight habitat strata, and *Orbicella annularis* was only observed in the Contiguous Reef Medium Relief habitat. *Orbicella franksi* was observed in nearly all habitat strata during the 2016 surveys.

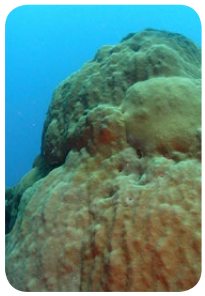
Acropora palmata

Acropora cervicornis

Dendrogyra cylindrus

Mycetophyllia ferox

Orbicella annularis



Orbicella faveolata

Orbicella franksi

Presence of coral species listed as Threatened under the Endangered Species Act (ESA).

Habitat Strata	Protected	No. ESA coral species	*Acropora palmata*	*Acropora cervicornis*	*Dendrogyra cylindrus*	*Mycetophyllia ferox*	*Orbicella annularis*	*Orbicella faveolata*	*Orbicella franksi*
Contiguous Reef High Relief	FKNMS TER	3	○	○	○	●	○	●	●
	DTNP	3	○	○	○	●	○	●	●
	No	2	○	○	○	○	○	●	●
Contiguous Reef Low Relief	FKNMS TER	1	○	○	○	○	○	○	●
	DTNP	3	○	●	○	○	○	●	●
	No	0	○	○	○	○	○	○	○
Contiguous RF MR	DTNP	4	○	●	○	○	●	●	●
Isolated Patch Reef High Relief	FKNMS TER	3	○	○	○	●	○	●	●
	DTNP	3	○	○	○	●	○	●	●
Isolated Patch Reef Low Relief	FKNMS TER	2	○	○	○	○	○	●	●
	DTNP	2	○	○	○	○	○	●	●
Isolated Patch Reef Medium Relief	FKNMS TER	2	○	○	○	●	○	○	●
	DTNP	2	○	○	○	○	○	●	●
	No	3	○	○	○	●	○	●	●
Spur & Groove Rf HR	DTNP	3	○	○	○	●	○	●	●
Spur & Groove Rf LR	DTNP	2	○	○	○	●	○	●	○

Acropora cervicornis

Coral Reef Fish – South Florida (2016)

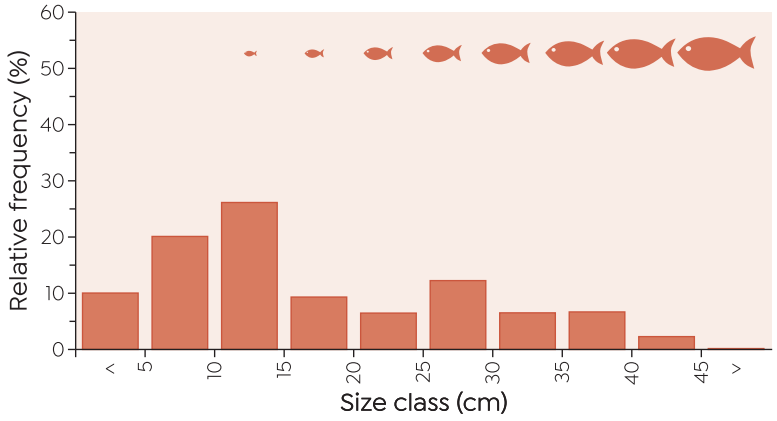
Results are presented for ten species surveyed in South Florida in 2016. The diverse suite of species selected represent seven families of varying trophic levels (herbivores and piscivores) and fishing pressures (targeted and non-targeted), and together provide a perspective on the overall status of coral reef fishes. Relative abundance (density) and length-based indices (size-class distribution) are presented here to allow for comparison among sub-regions.

Stoplight Parrotfish (*Sparisoma viride*)

Family: **Scaridae**
Targeted: **No**

S.E. Florida

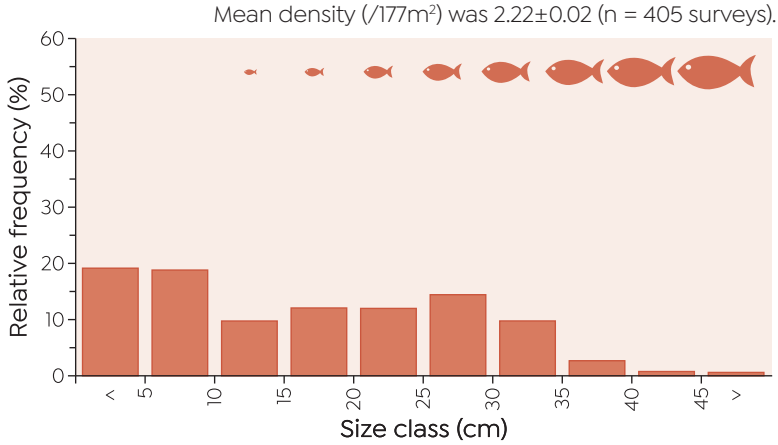
Mean density (/177m²) was 0.62±0.01 (n = 304 surveys).



Size-class distribution of *Sparisoma viride* in S.E. Florida.

Florida Keys

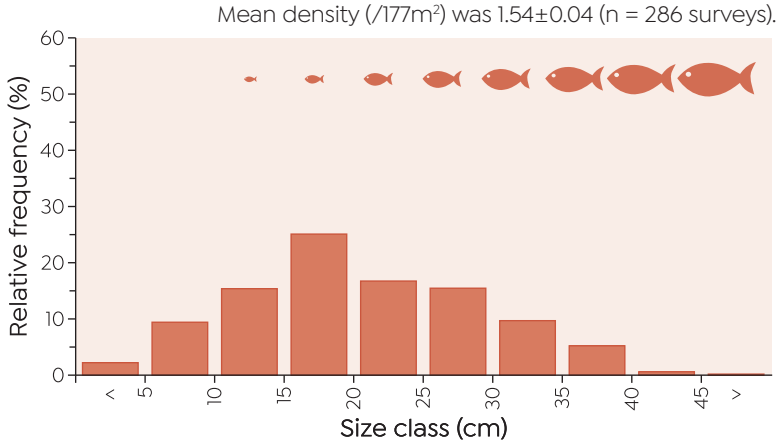
Mean density (/177m²) was 2.22±0.02 (n = 405 surveys).



Size-class distribution of *Sparisoma viride* in the Florida Keys.

Dry Tortugas

Mean density (/177m²) was 1.54±0.04 (n = 286 surveys).



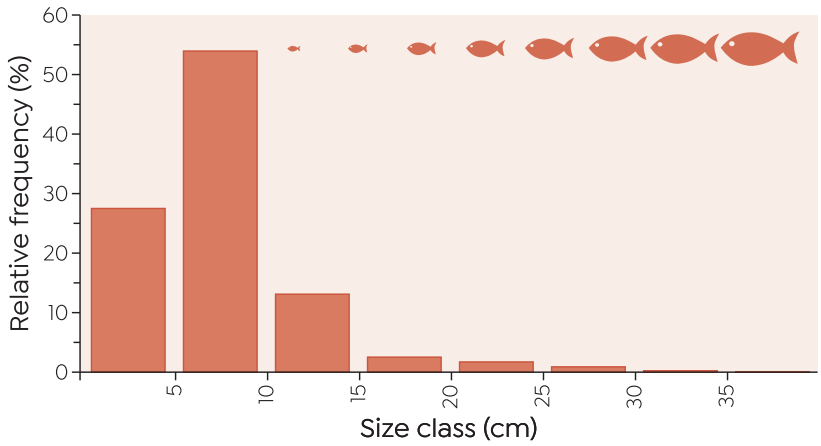
Size-class distribution of *Sparisoma viride* in the Dry Tortugas.

Striped Parrotfish (*Scarus iseri*)

Family: **Scaridae**
Targeted: **No**

S.E. Florida

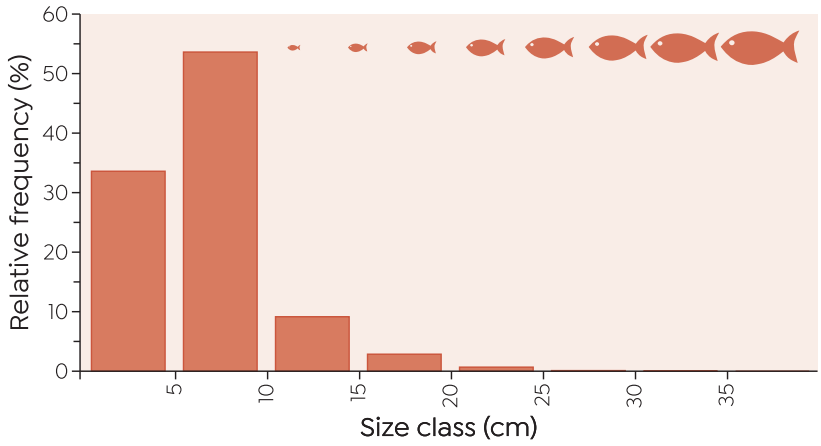
Mean density (/177m²) was 2.17±0.05 (n = 304 surveys).

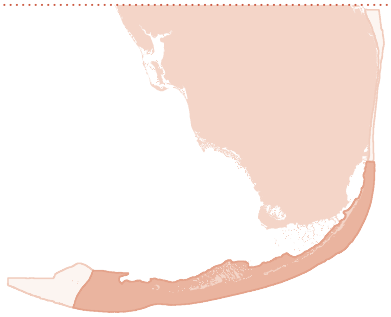


Size-class distribution of *Scarus iseri* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 10.13±0.19 (n = 405 surveys).

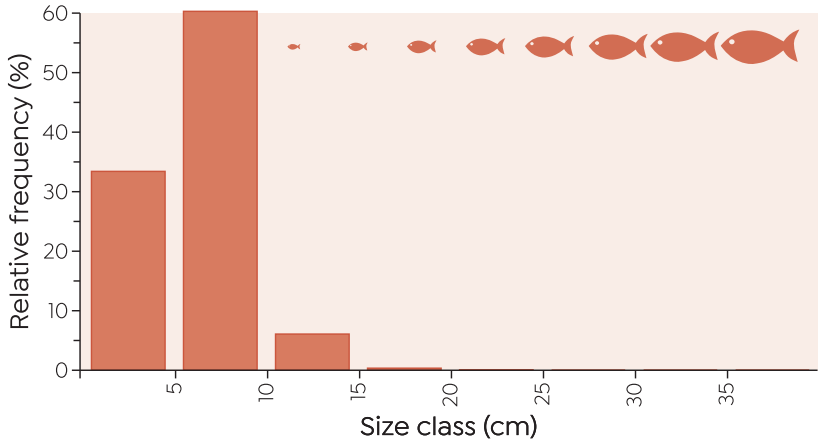


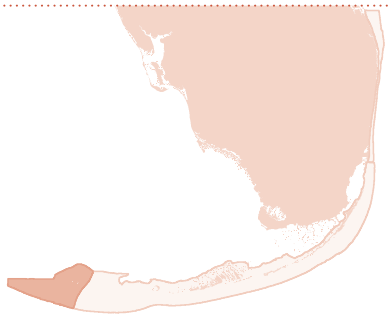


Size-class distribution of *Scarus iseri* in the Florida Keys.

Dry Tortugas

Mean density (/177m²) was 9.95±0.30 (n = 286 surveys).





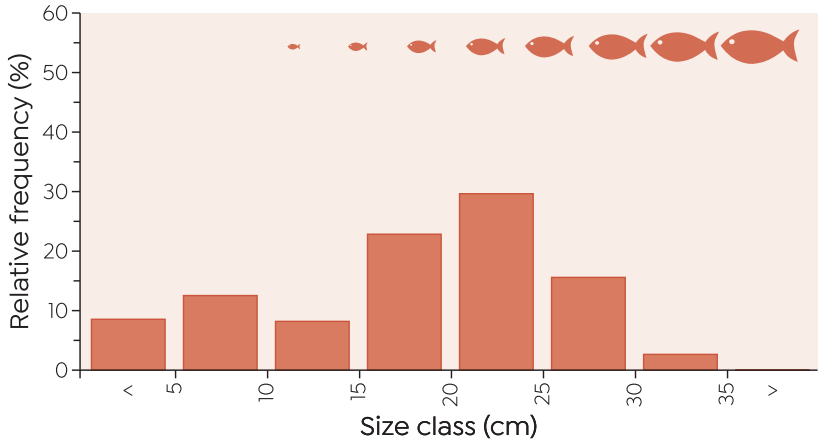
Size-class distribution of *Scarus iseri* in the Dry Tortugas.

Blue Tang (*Acanthurus coeruleus*)

Family: **Acanthuridae**
Targeted: **No**

S.E. Florida

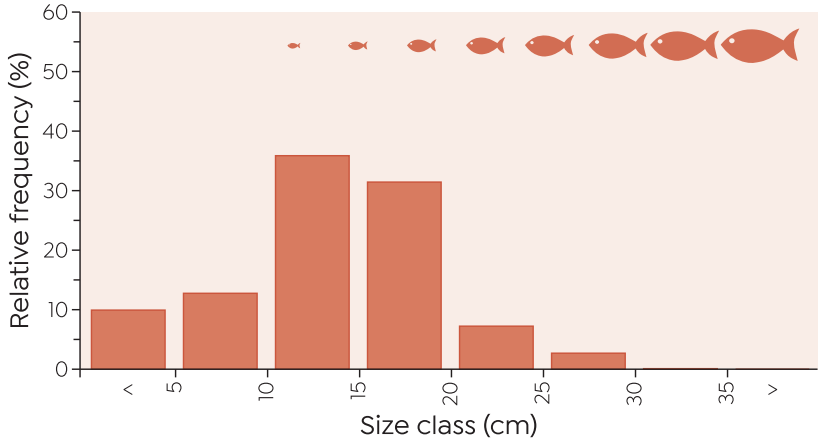
Mean density (/177m²) was 1.38±0.01 (n = 304 surveys).

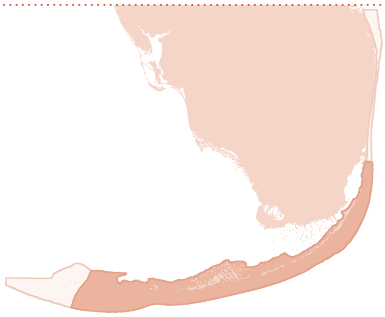


Size-class distribution of *Acanthurus coeruleus* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 4.30±0.14 (n = 405 surveys).

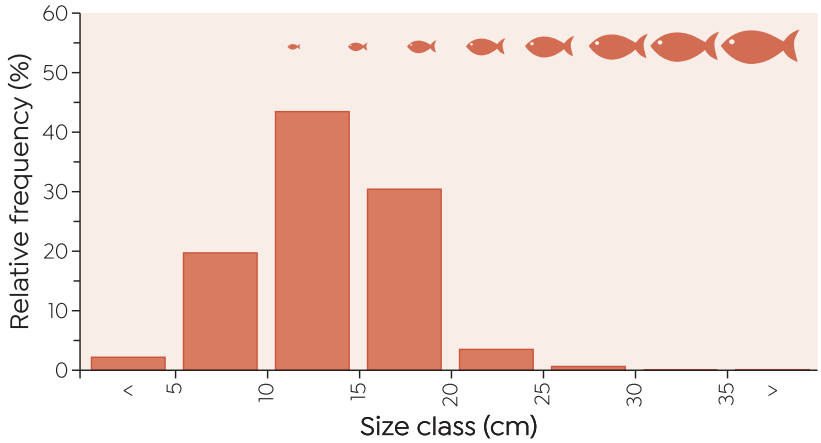


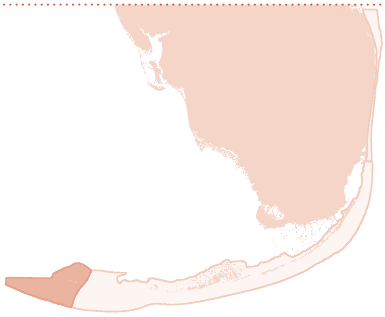


Size-class distribution of *Acanthurus coeruleus* in the Florida Keys.

Dry Tortugas

Mean density (/177m²) was 2.24±0.02 (n = 286 surveys).





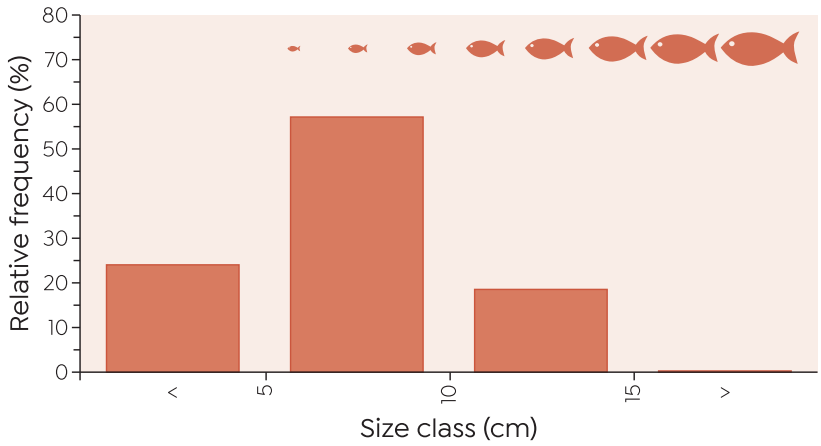
Size-class distribution of *Acanthurus coeruleus* in the Dry Tortugas.

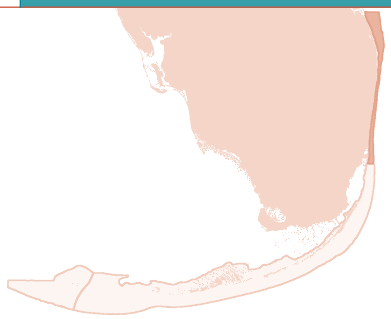
Yellowhead Wrasse (*Halichoeres garnoti*)

Family: **Labridae**
Targeted: **No**

S.E. Florida

Mean density (/177m²) was 4.16±0.14 (n = 304 surveys).

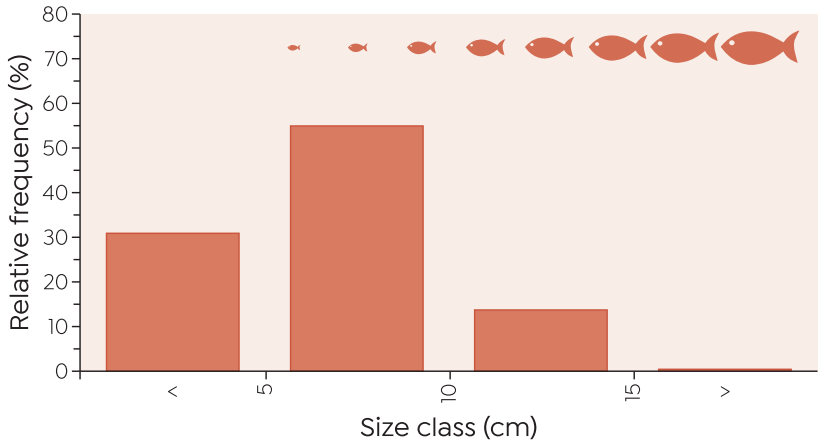


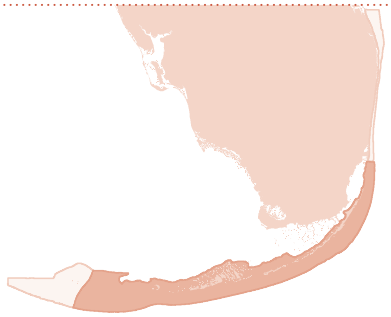


Size-class distribution of *Halichoeres garnoti* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 5.91±0.08 (n = 405 surveys).

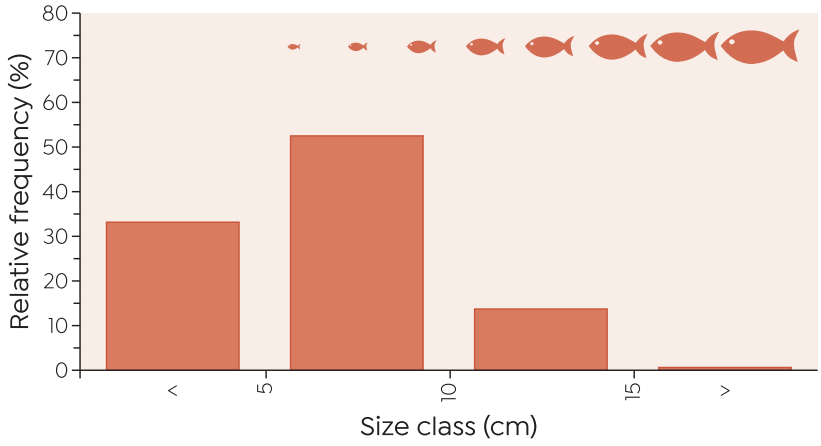


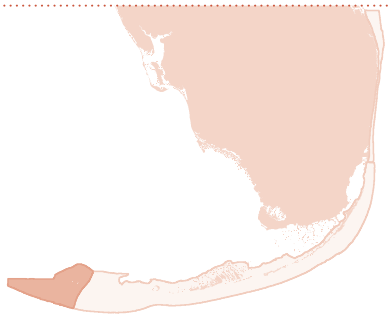


Size-class distribution of *Halichoeres garnoti* in the Florida Keys.

Dry Tortugas

Mean density (/177m²) was 6.19±0.18 (n = 286 surveys).





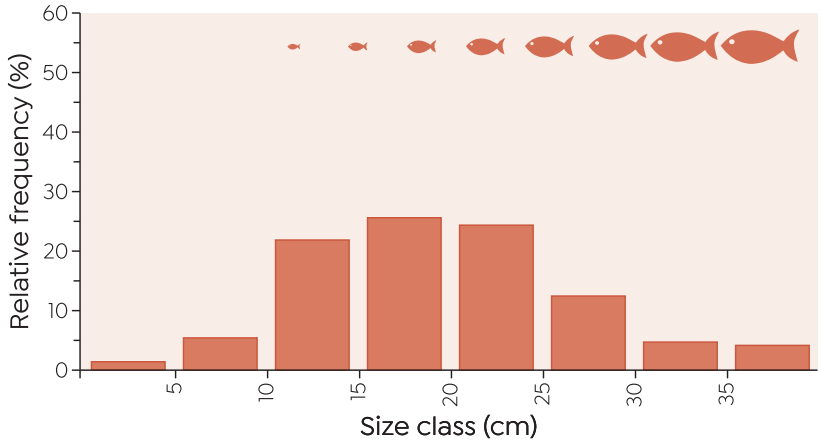
Size-class distribution of *Halichoeres garnoti* in the Dry Tortugas.

White Grunt (*Haemulon plumierii*)

Family: **Haemulidae**
Targeted: **No**

S.E. Florida

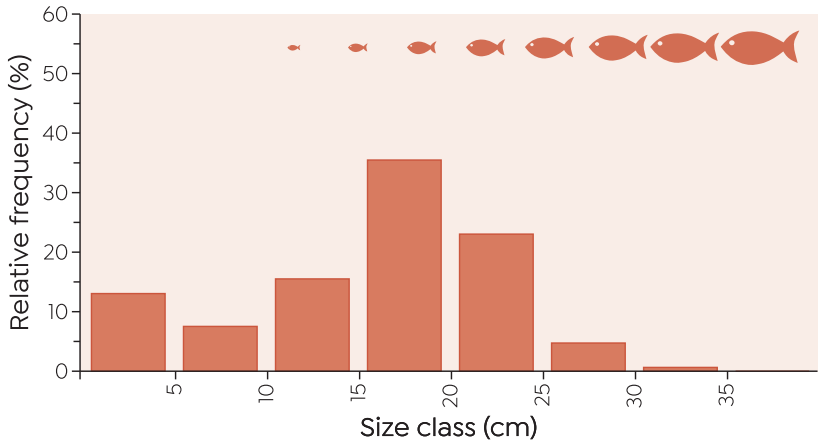
Mean density (/177m²) was 2.02±0.08 (n = 304 surveys).

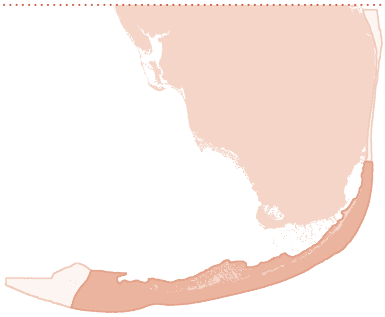


Size-class distribution of *Haemulon plumierii* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 10.07±1.29 (n = 405 surveys).

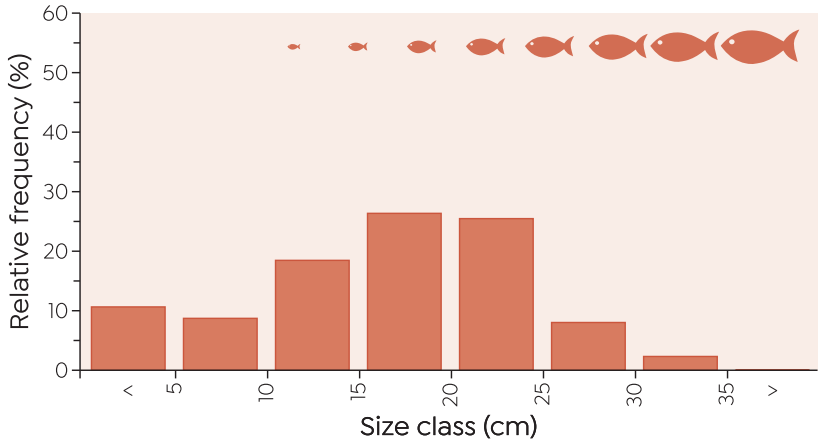


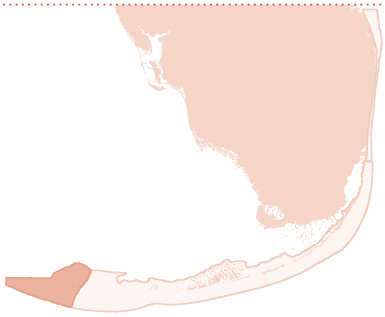


Size-class distribution of *Haemulon plumierii* in the Florida Keys.

Dry Tortugas

Mean density (/177m²) was 5.53±0.42 (n = 286 surveys).





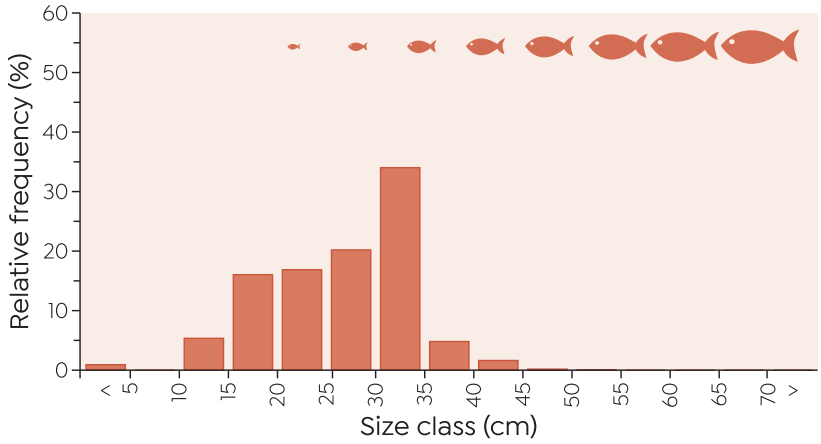
Size-class distribution of *Haemulon plumierii* in the Dry Tortugas.

Hogfish (*Lachnolaimus maximus*)

Family: **Labridae**
Targeted: **Yes**

S.E. Florida

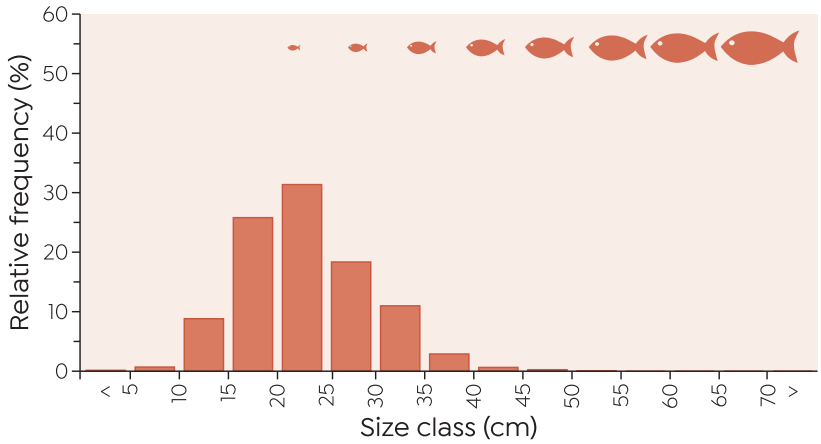
Mean density (/177m²) was 0.39±0.00 (n = 304 surveys).

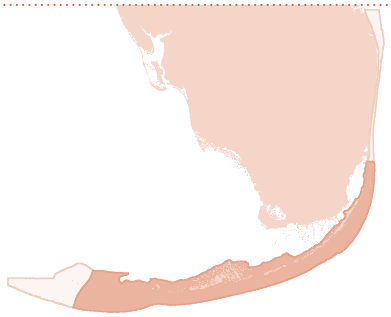


Size-class distribution of *Lachnolaimus maximus* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 1.84±0.01 (n = 405 surveys).

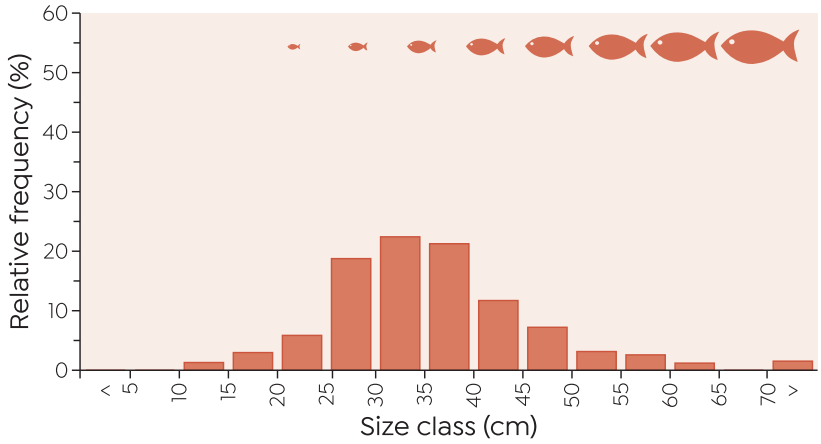


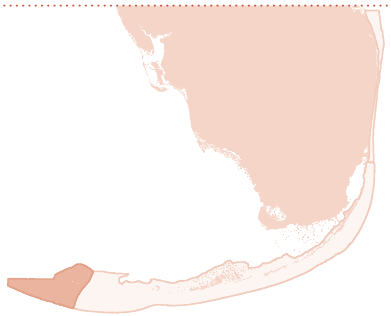


Size-class distribution of *Lachnolaimus maximus* in the Florida Keys.

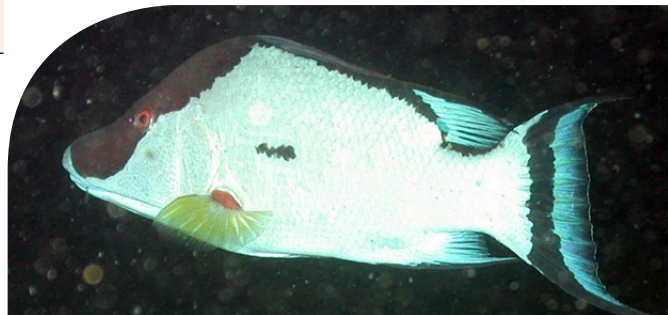
Dry Tortugas

Mean density (/177m²) was 0.50±0.01 (n = 286 surveys).





Size-class distribution of *Lachnolaimus maximus* in the Dry Tortugas.

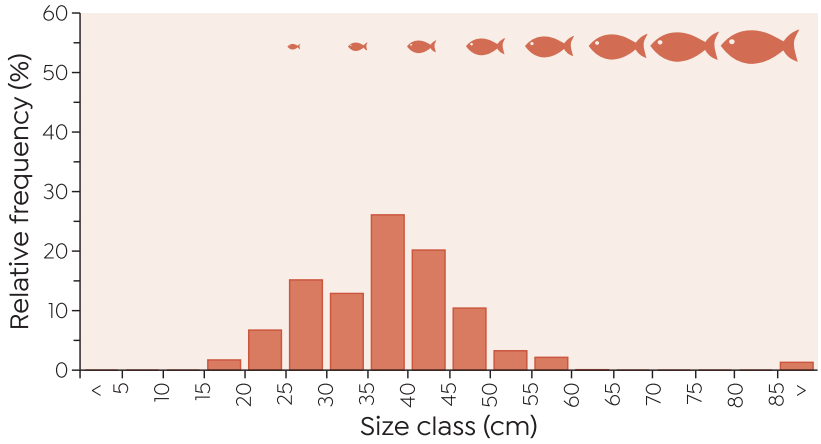


Red Grouper (*Epinephelus morio*)

Family: **Serranidae**
Targeted: **Yes**

S.E. Florida

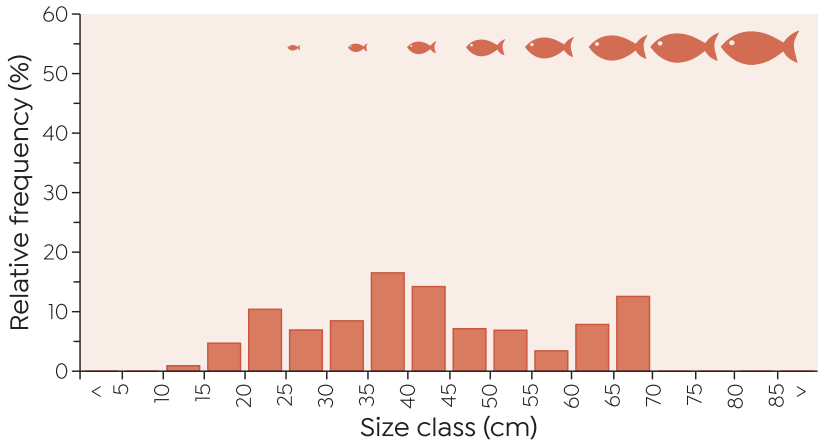
Mean density (/177m²) was 0.09±0.00 (n = 304 surveys).

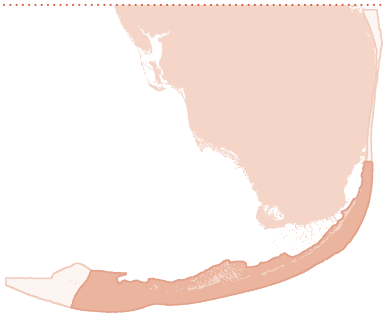


Size-class distribution of *Epinephelus morio* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 0.10±0.00 (n = 405 surveys).

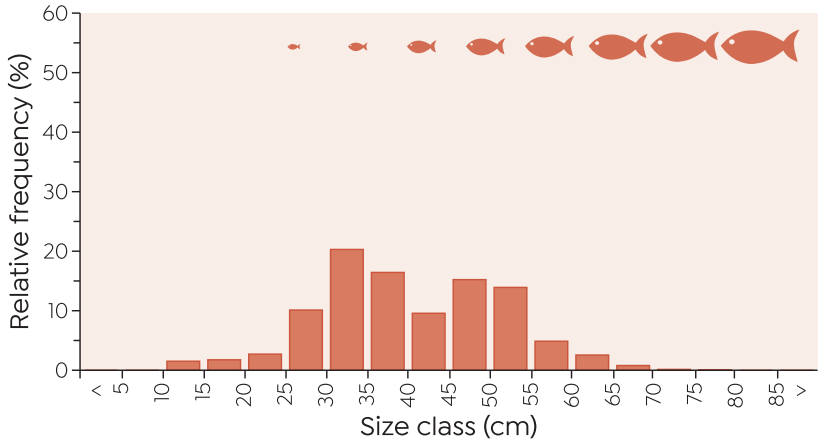


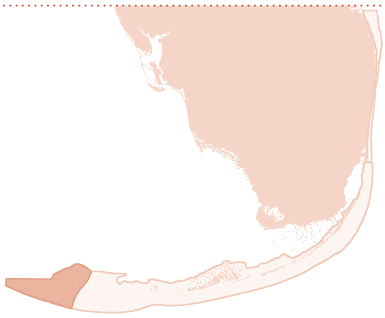


Size-class distribution of *Epinephelus morio* in the Florida Keys

Dry Tortugas

Mean density (/177m²) was 0.61±0.01 (n = 286 surveys).





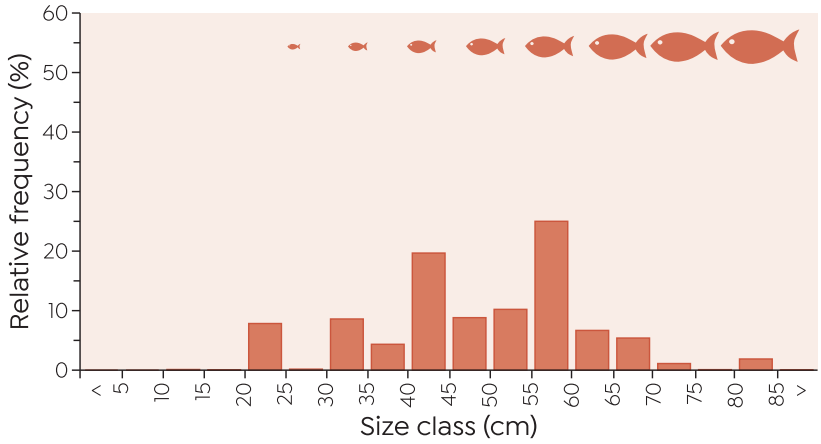
Size-class distribution of *Epinephelus morio* in the Dry Tortugas

Black Grouper (*Mycteroperca bonaci*)

Family: **Serranidae**
Targeted: **Yes**

Florida Keys

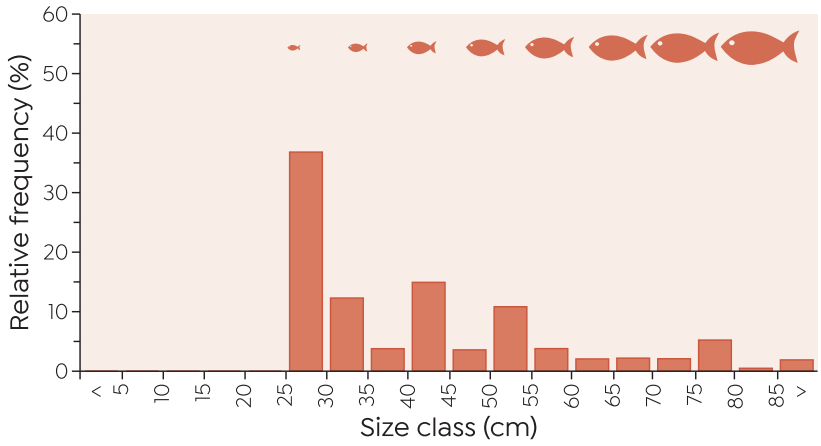
Mean density (/177m²) was 0.07±0.00 (n = 405 surveys).

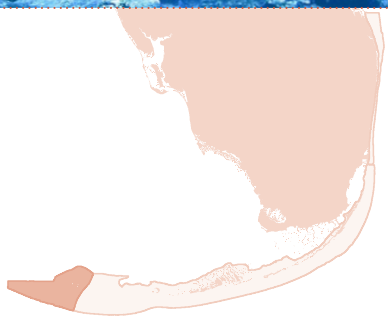


Size-class distribution of *Mycteroperca bonaci* in the Florida Keys

Dry Tortugas

Mean density (/177m²) was 0.07±0.00 (n = 286 surveys).





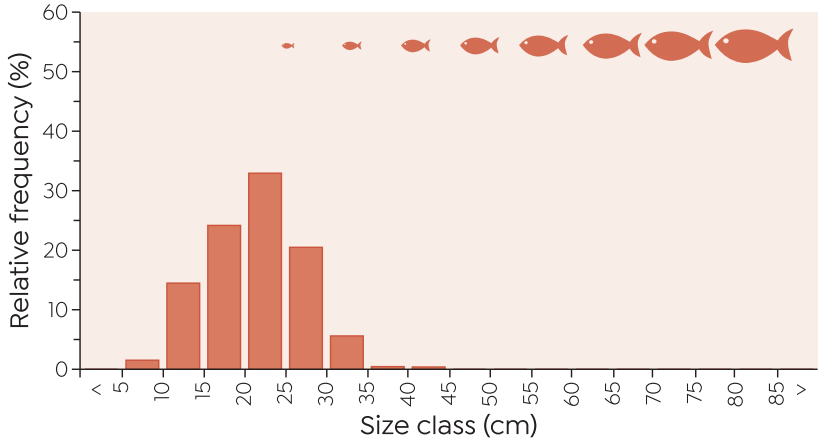
Size-class distribution of *Mycteroperca bonaci* in the Dry Tortugas

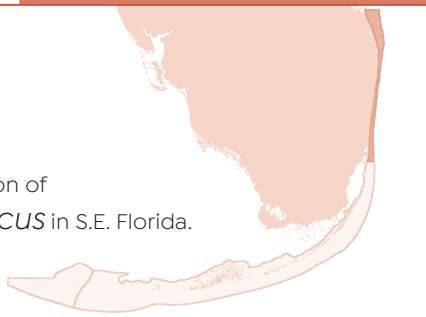
Gray Triggerfish (*Balistes capriscus*)

Family: **Balistidae**
Targeted: **Yes**

S.E. Florida

Mean density (/177m²) was 2.68±0.10 (n = 304 surveys).





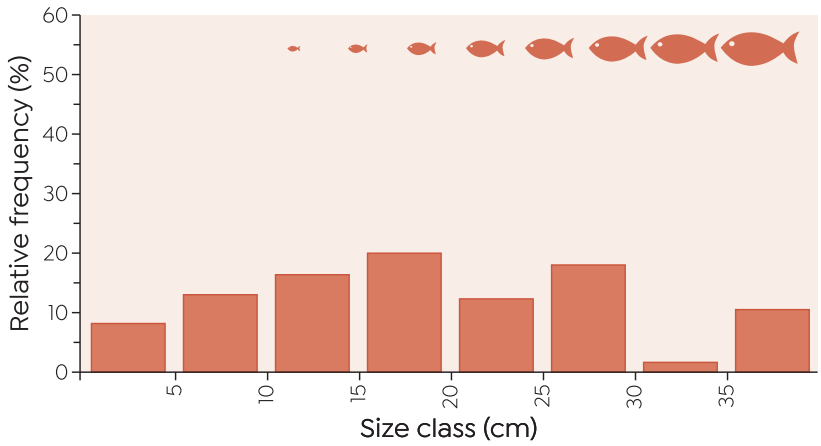
Size-class distribution of *Balistes capriscus* in S.E. Florida.

Yellowtail Snapper (*Ocyurus chrysurus*)

Family: **Lutjanidae**
Targeted: **Yes**

S.E. Florida

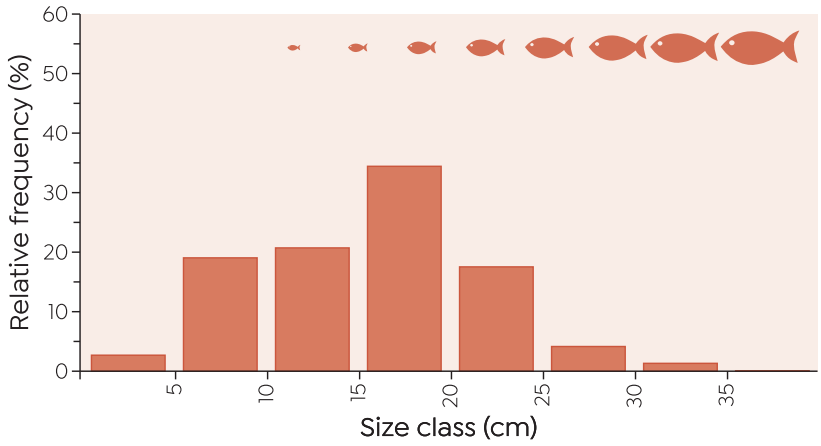
Mean density (/177m²) was 0.65±0.01 (n = 304 surveys).

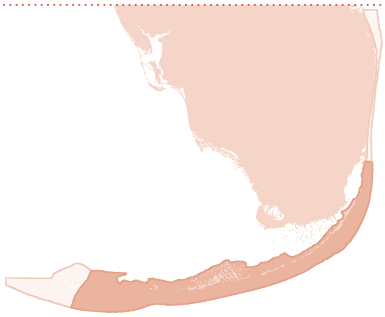


Size-class distribution of *Ocyurus chrysurus* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 4.85±0.36 (n = 405 surveys).

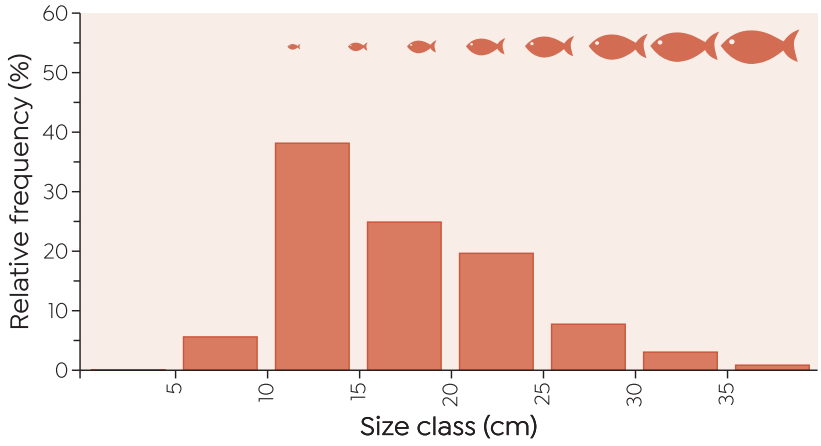


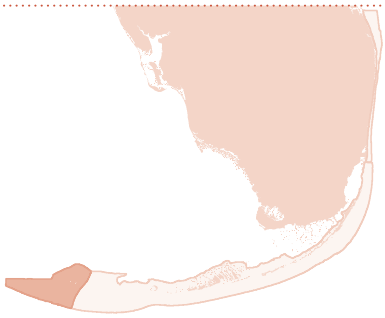


Size-class distribution of *Ocyurus chrysurus* in the Florida Keys

Dry Tortugas

Mean density (/177m²) was 8.69±0.68 (n = 286 surveys).





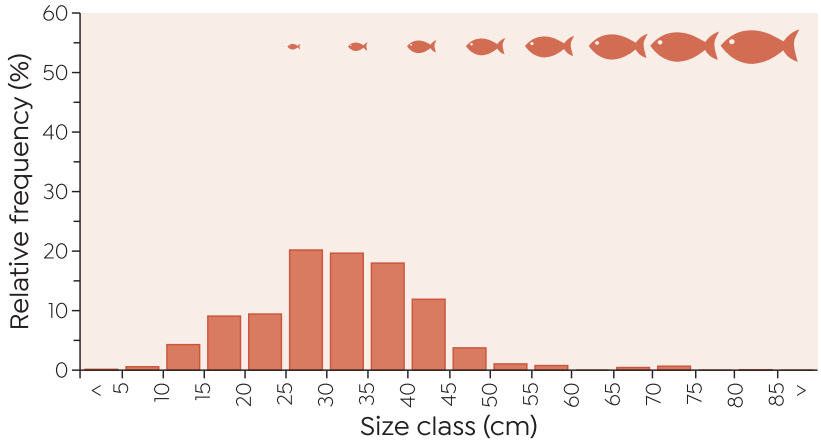
Size-class distribution of *Ocyurus chrysurus* in the Dry Tortugas

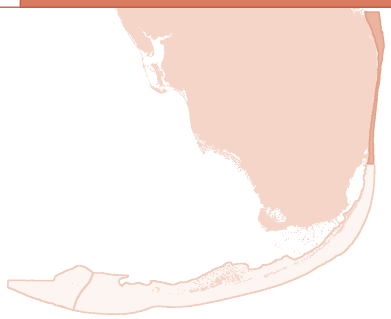
Mutton Snapper (*Lutjanus analis*)

Family: **Lutjanidae**
Targeted: **Yes**

S.E. Florida

Mean density (/177m²) was 0.59±0.01 (n = 304 surveys).

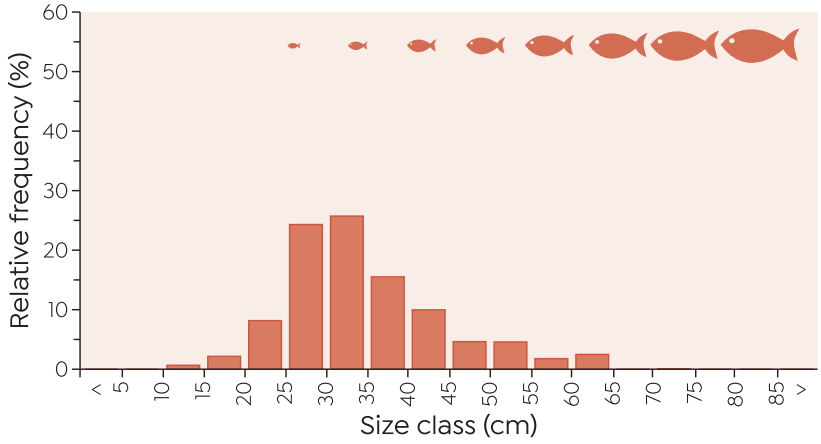


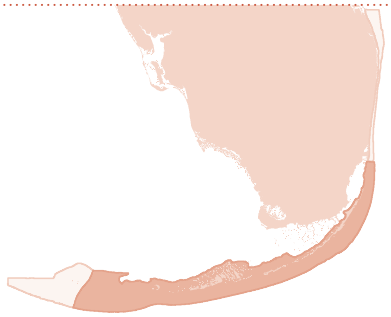


Size-class distribution of *Lutjanus analis* in S.E. Florida.

Florida Keys

Mean density (/177m²) was 0.30±0.00 (n = 405 surveys).

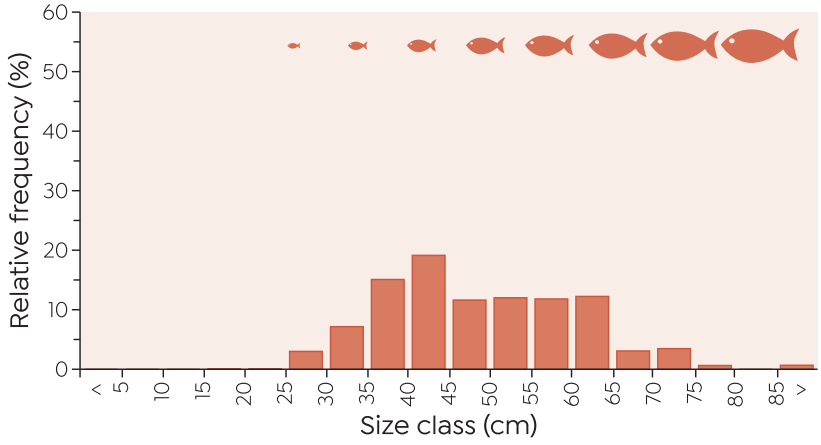


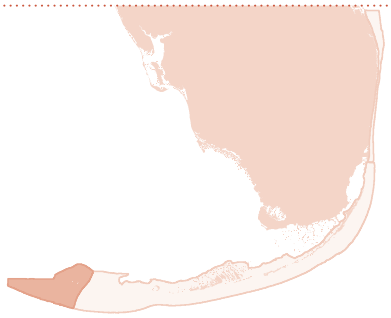


Size-class distribution of *Lutjanus analis* in the Florida Keys.

Dry Tortugas

Mean density (/177m²) was 0.39±0.00 (n = 286 surveys).



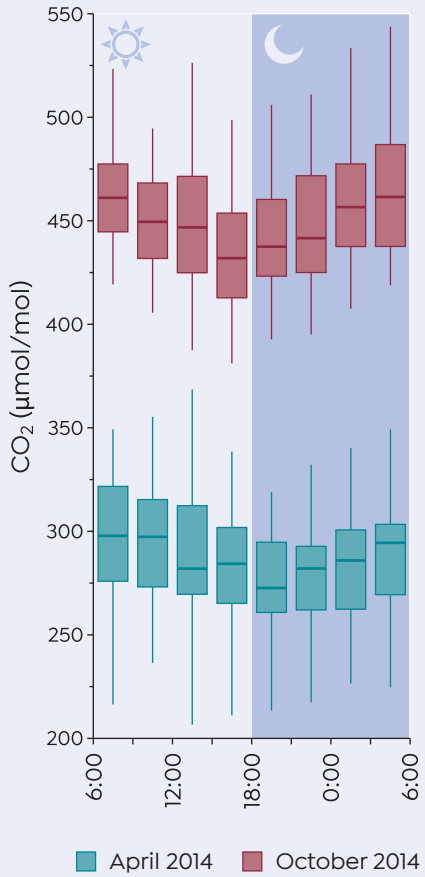


Size-class distribution of *Lutjanus analis* in the Dry Tortugas.

Chemistry (2014-2017) – South Florida

This section represents the first Florida NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the NOAA Atlantic Oceanographic and Meteorological Laboratory and the NOAA Coral Reef Watch program.

Diurnal CO_2 – Cheeca Rocks

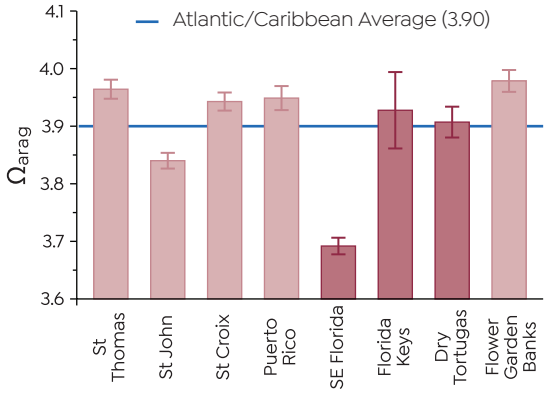


Processes driving local CO_2 concentration and pH* vary throughout the day. Photosynthesis drives down CO_2 during the day as organisms calcify. Higher CO_2 (and lower pH) conditions can return at night as photosynthesis stops and respiration continues to release CO_2 into the water column. In addition to diurnal variability in seawater CO_2 and pH, there is also considerable seasonal variability. Seawater CO_2 is considerably higher in April, at the end of the cool season, than it is in October, just after the warm season.

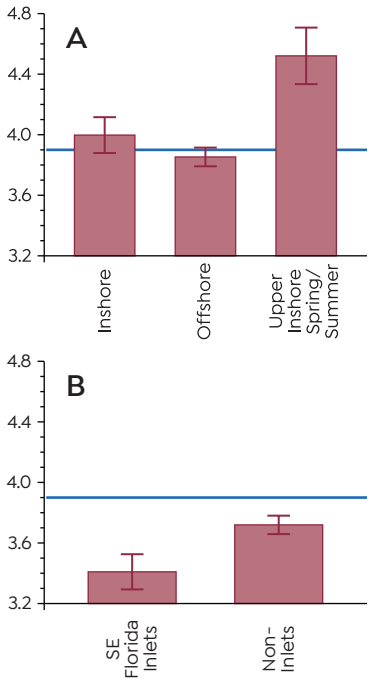
Highlights

- Aragonite saturation state was right at the Atlantic/Caribbean average in the Florida Keys and Dry Tortugas but was well below the average in SE Florida.
- Heat stress accumulation triggered Alert Level 2 throughout Florida in 2015 and extensive severe bleaching was observed that year.

Aragonite saturation state

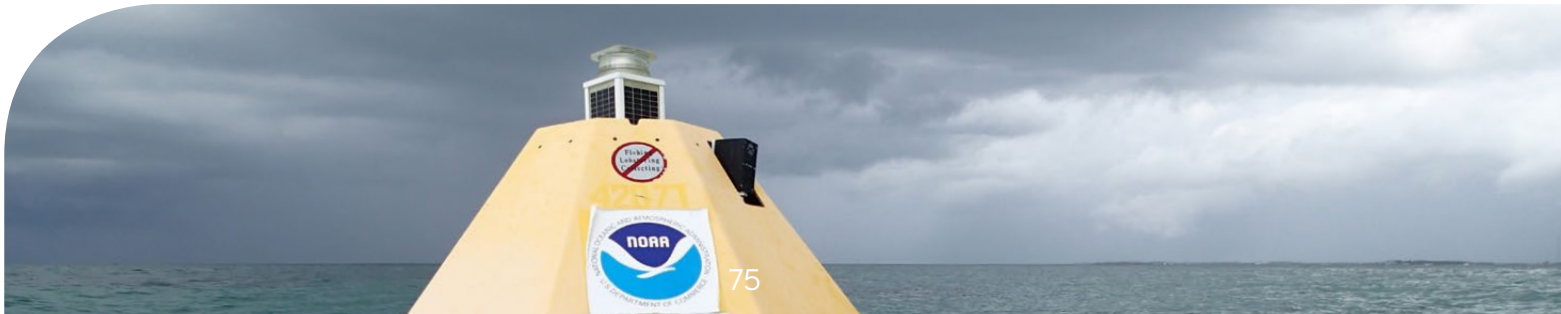


Ω_{arag} values in the Dry Tortugas and the Florida Keys were similar to the other US coral reef jurisdictions in the Atlantic. In SE Florida Ω_{arag} values were the lowest measured in all US jurisdictions. Sites in Florida have been sampled year round, providing information on seasonal variability not available for the other US jurisdictions. In the Florida Keys, there is a drawdown in seawater CO_2 and large elevation in Ω_{arag} values during spring and summer at inshore sites coincident with the seagrass growing season. This leads to an overall higher average Ω_{arag} values at inshore coral reefs – a likely factor in the higher calcification rates found on inshore reefs of this area. In SE Florida, inlets represent a source of acidified waters that may exacerbate ocean acidification impacts in localized areas. The overall lower Ω_{arag} values in this region were also due to cool temperatures during winter months. SE Florida reefs had very low reef accretion rates and are highly susceptible to sea-level rise. The low Ω_{arag} values of this region suggest that it may also be highly susceptible to ocean acidification.



Mean (± std. error of mean) aragonite saturation Ω_{arag} values of US jurisdictions during summer months from 2013-2015. Data from SE FL and Florida Keys represent annual averages, including data from other seasons. Red dashed line is mean for Atlantic sites, excluding outlier sites of inshore Florida Keys and inlet sites of SE Florida Region. (A) Annual average Ω_{arag} values for inshore and offshore coral reef sites in Florida Keys, as well as spring and summer values at inshore sites. (B) Annual average Ω_{arag} values of waters exiting inlets versus those not directly impacted by inlets in SE Florida.

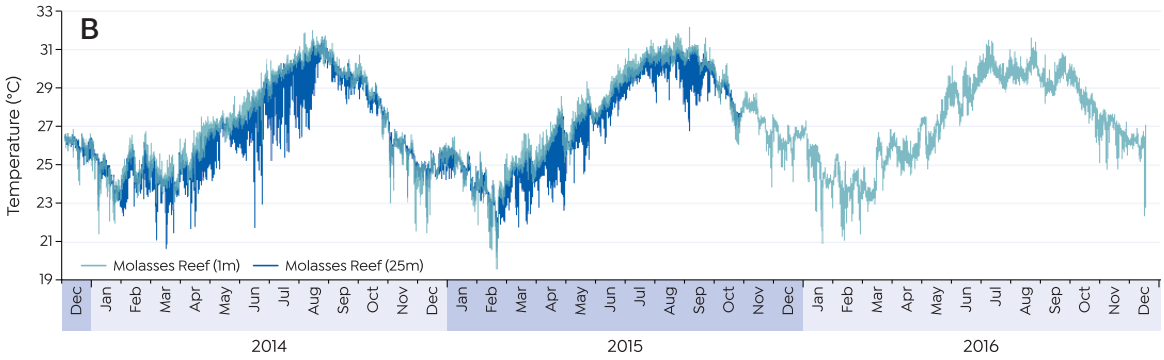
*CO_2 concentration has been graphed due to an incomplete pH record at Cheeca Rocks. Inverse diurnal patterns of CO_2 and pH can be seen for Puerto Rico (p. 45).



Subsurface temperature

Subsurface temperature time series

Sea temperatures off Broward County Florida at 8 m (turquoise line) and 17 m (blue line) from Dec 2013 thru Nov 2015.



Sea temperatures at Molasses Reef at 1 m (turquoise line) and 25 m (blue line) from Dec 2013 thru Nov 2016.

Sea temperatures at Pulaski Shoals (1 m, turquoise line) and Black Coral Rock (25 m, blue line) in the Dry Tortugas from Sept 2015 thru Dec 2017.

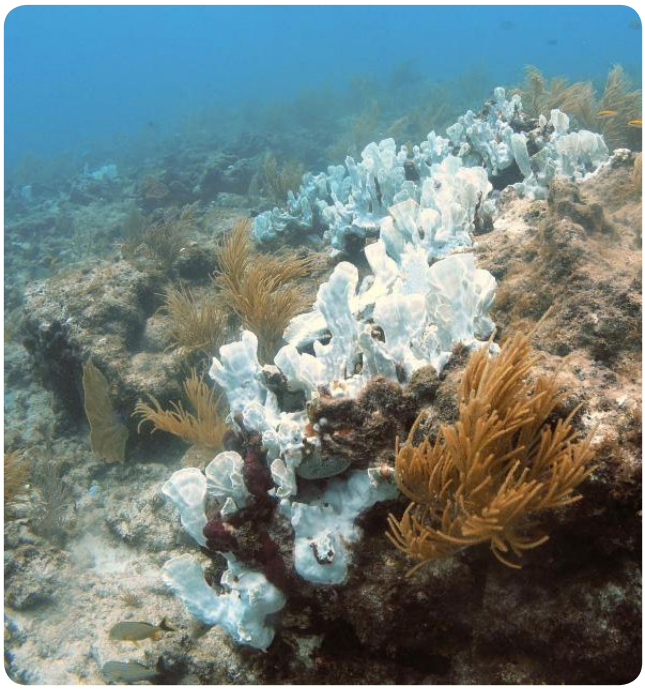
The coral reefs of southeast Florida (A) consist of an inner, middle, and outer reef, as well as nearshore ridge complex. As such, sites adhering to the NCRMP 1, 5, 15, and 25 m depth strata do not occur. However, there was marked variability between the deepest (17 m, outer reef) and shallowest sites (8 m, nearshore ridge complex), indicating that there is cooling at the deepest, outer reefs. It is unclear if this resulted in less bleaching with depth, but does illustrate that cooler temperatures do occur at depth at this site.

The Florida Keys (B) have experienced seven keys-wide mass coral bleaching events since 1987, with the two most recent taking place in 2014 and 2015. At Molasses Reef, there was a near continuous record of sea temperatures at 1 m depth since 1988. 2015 was the hottest summer on record and 2014 was the 2nd hottest summer on record. At 25 m depth, there was much higher variability in sea temperatures and cooling in both of these summers. It is unclear if this resulted in less bleaching with depth, but does illustrate that cooler temperatures do occur at depth at this site.

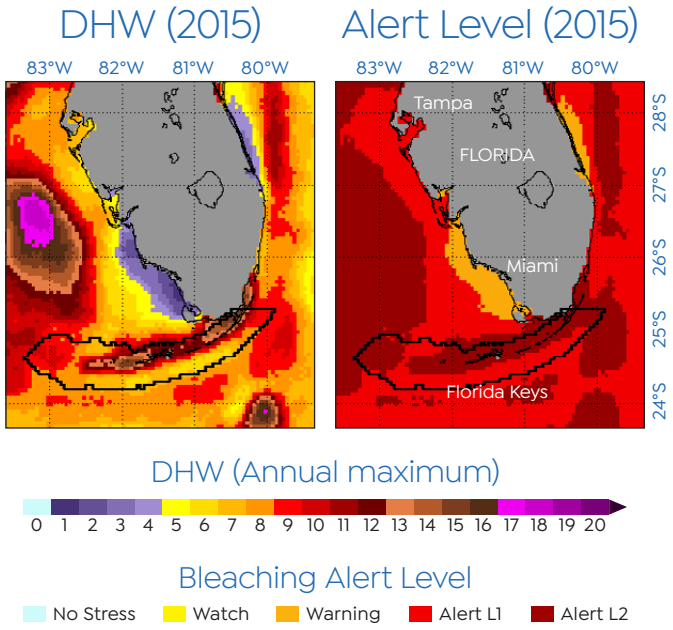
There was pronounced and repeated cooling at 25 m depth in the Dry Tortugas (C) in the summer of 2016 that may be a result of upwelling. Temperatures dropped > 6°C over the course of two weeks at the end of July 2016. There was considerable temperature variability at depth in the summer of 2017 as well, but less so than 2016. Future research is necessary to understand if this magnitude of temperature variability occurs regularly at depth in the Dry Tortugas and if this could create refugia from heat stress.

Heat stress and coral bleaching

The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in Southeast Florida in 2005 and 2014, and in the Florida Keys in 1997, 2005, 2007, 2009, 2010, 2011, 2014, 2015, 2016, and 2017.

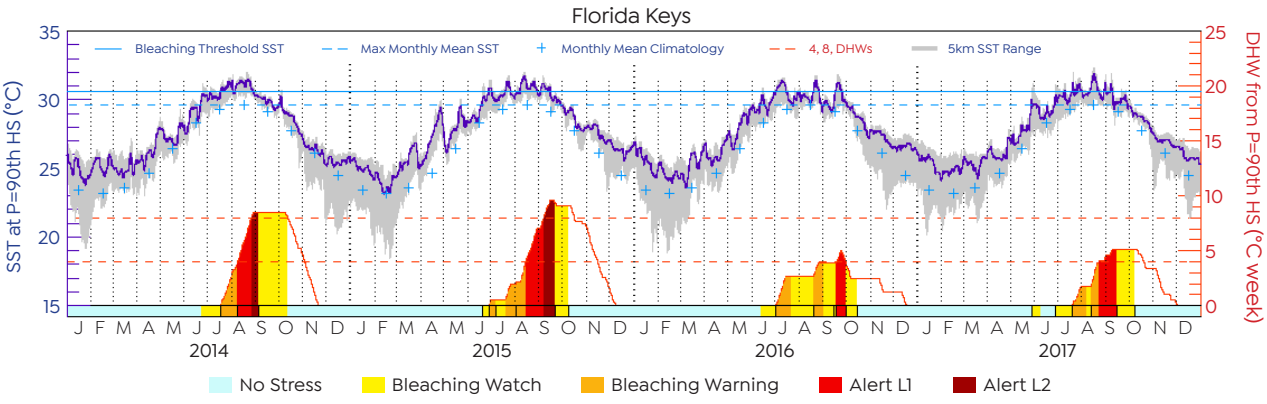


Coral bleaching, Islamorada, Florida Keys

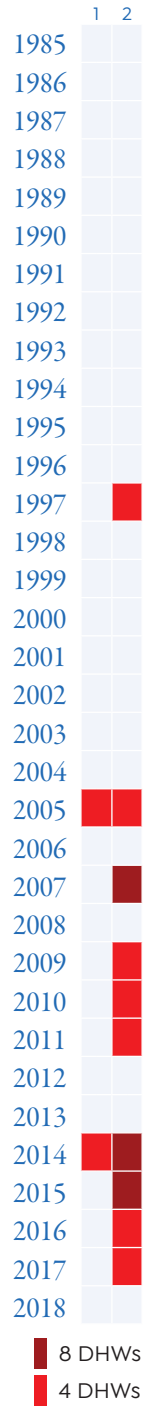


Annual maximum Degree Heating Weeks (DHWs) in 2015 (left panel) were as high as 15 in parts of the Florida Keys when at least nine DHWs accumulated at all reefs in the Keys.

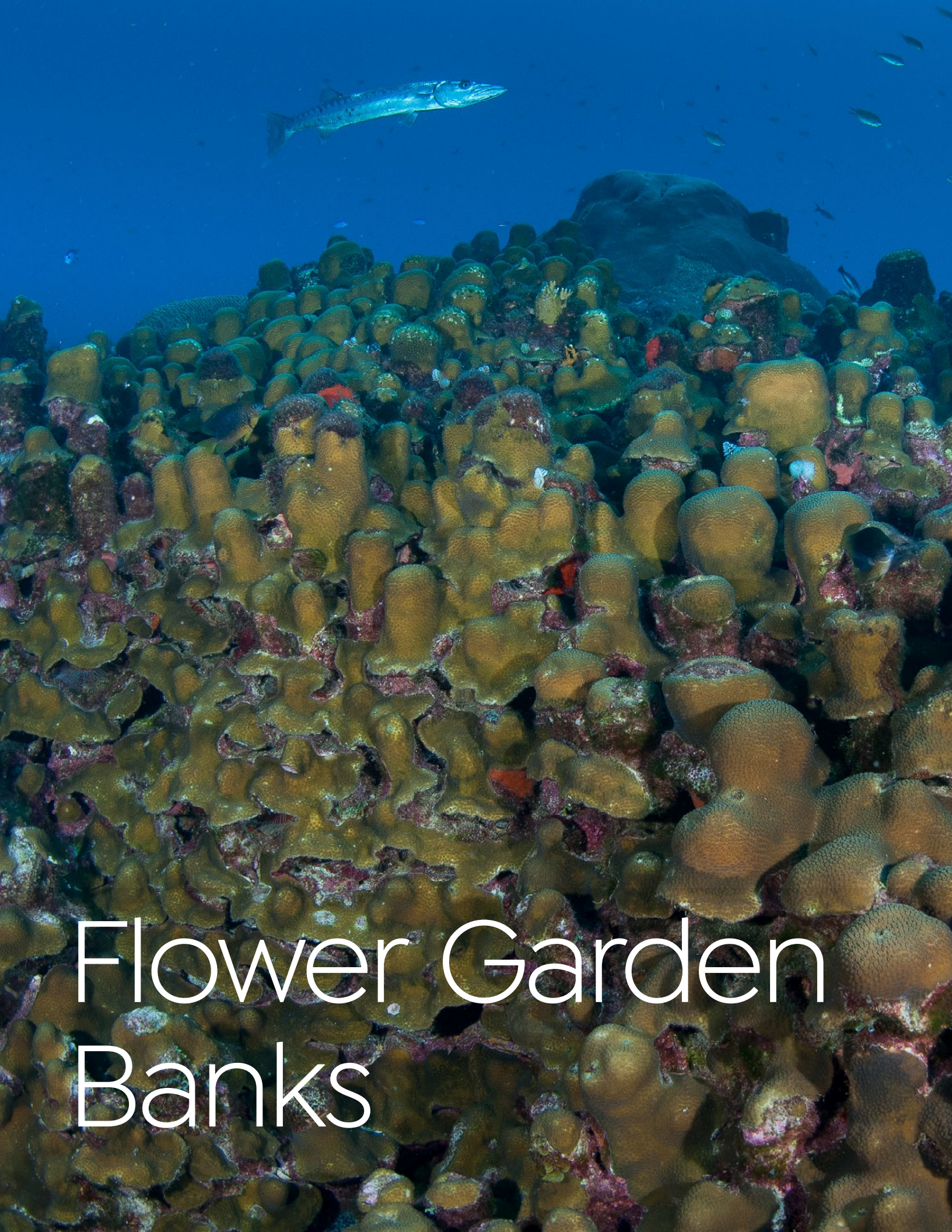
Heat stress accumulation triggered Alert Level 2 throughout the region in 2015 (right panel) and extensive severe bleaching was observed that year.



Degree Heating Week (DHW) accumulation from 2014-2017 in the Florida Keys. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in 2014, 2015, 2016, and 2017. Alert Level 2 was triggered in 2014 and 2015 and extensive coral bleaching occurred in those years.



* 1. Southeast Florida, 2. Florida Keys



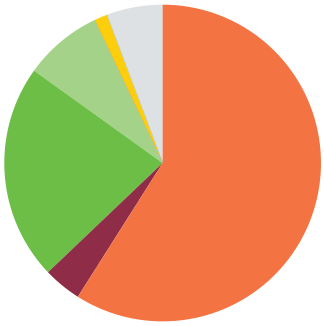
Flower Garden Banks

Coral reefs – Flower Garden Banks (2015)*

Benthic cover

Coral cover was 59%, and macroalgae cover was 22%, in the Flower Garden Banks.

Region



Coral 59.0±14.2%
Macroalgae 22.0±10.7%

- » Coral disease was not observed in the 2015 surveys.
- » Recent mortality was 0.4% and old mortality was 5.7% in the Flower Garden Banks.
- » Three species listed as Threatened under the Endangered Species Act were observed on reefs in the Flower Garden Banks in 2015.

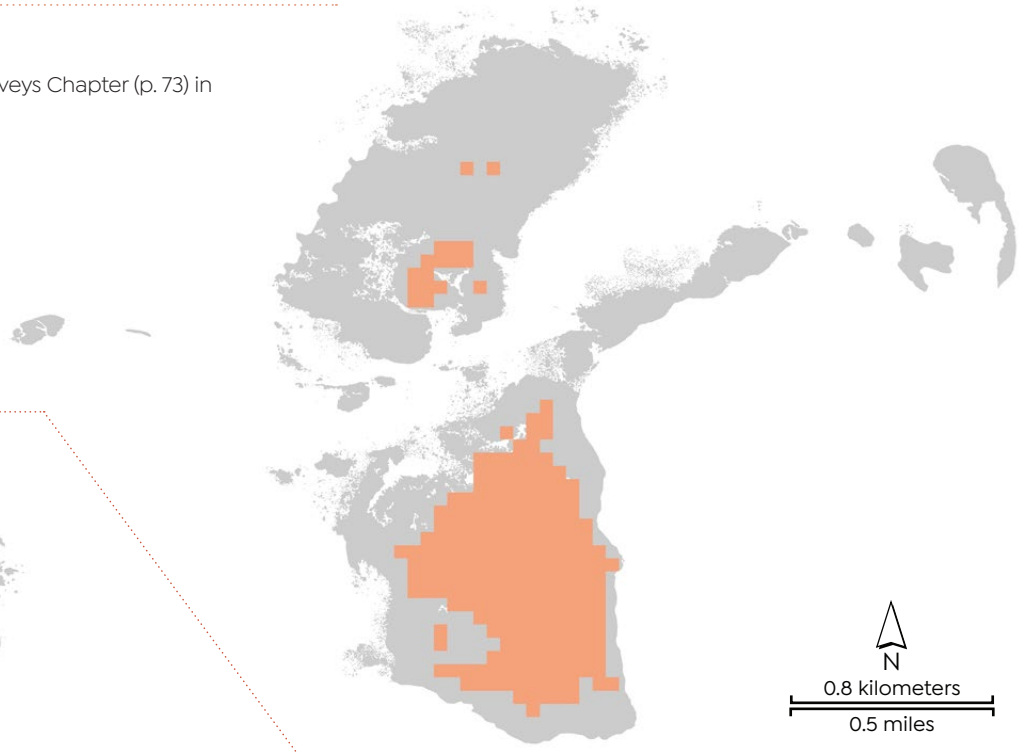
Benthic cover

- Hard coral
- Crustose coralline algae
- Macroalgae
- Turf algae
- Soft corals
- Sponges
- *Ramicrusta* spp.
- Other

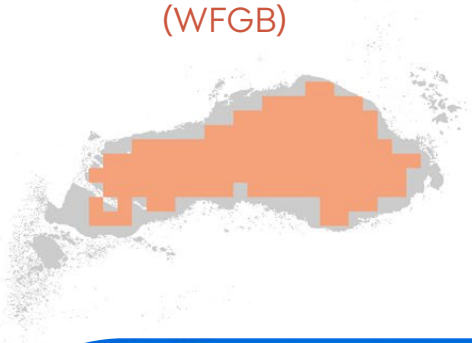
*Notes:

- » Stetson Bank was not surveyed
- » For 2016 reef rish survey data, see Fish Surveys Chapter (p. 73) in Johnston et al. (2016).

East Flower Garden Bank (EFGB)



West Flower Garden Bank (WFGB)



Habitat Strata
(Flower Garden Banks)

- Habitat strata
- Coral reef zone

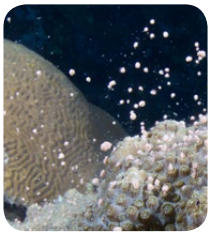
N
0.8 kilometers
0.5 miles

Coral reefs – Flower Garden Banks* (2015)

Benthic communities

*Stetson Bank was not surveyed.

- Diadema (sea urchin) density was 0.01/m^2 in the Flower Garden Banks.
- Coral density (mean weighted) was 5.8/m^2.
- Species richness was 5.9.
- Coral diversity was 5.31.
- Disease was not observed in the Flower Garden Banks in 2015.
- Recent mortality (unweighted) was 0.4%; old mortality was 5.7%.



Benthic data collected in 2015 for the habitats of the Flower Garden Banks. Transects (n) describes how sampling effort varied among the habitats.

Habitat strata	Transects (n)	Diadema density	Coral density	Species richness	Coral diversity (Simpsons)	Disease prevalence (%)	Recent mortality	Old mortality
Flower Garden Banks	30	0.01±0.01	5.72±1.78	5.90±2.43	5.31	0.00	0.44±0.43	5.67±3.21

Endangered coral species

Three species listed as Threatened under the Endangered Species Act were observed on reefs in the Flower Garden Banks in 2015, *Orbicella annularis*, *Orbicella faveolata*, and *Orbicella franksi*.

Acropora palmata

Acropora cervicornis

Dendrogyra cylindrus

Mycetophyllia ferox

Orbicella annularis

Orbicella faveolata

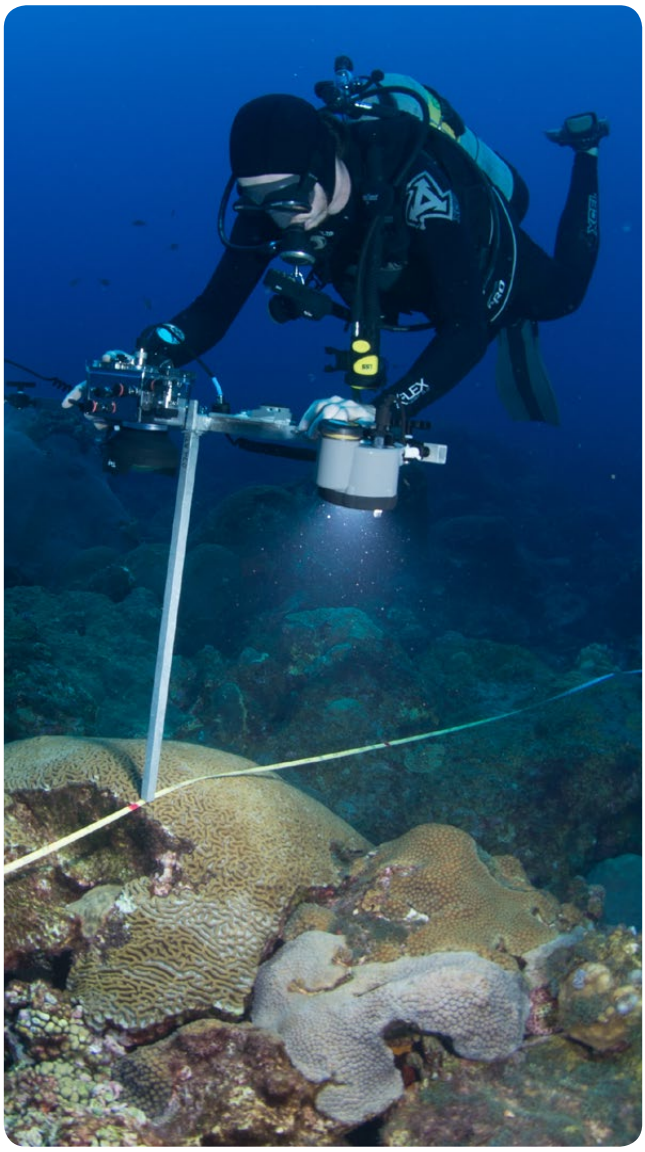
Orbicella franksi

Presence of coral species listed as Threatened under the Endangered Species Act (ESA).

Habitat strata	No. ESA coral species	*Acropora palmata*	*Acropora cervicornis*	*Dendrogyra cylindrus*	*Mycetophyllia ferox*	*Orbicella annularis*	*Orbicella faveolata*	*Orbicella franksi*
Flower Garden Banks	3	○	○	○	○	●	●	●

Chemistry (2013-2015) – FGB

This section represents the first Flower Garden Banks NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the NOAA Atlantic Oceanographic and Meteorological Laboratory and the NOAA Coral Reef Watch program.

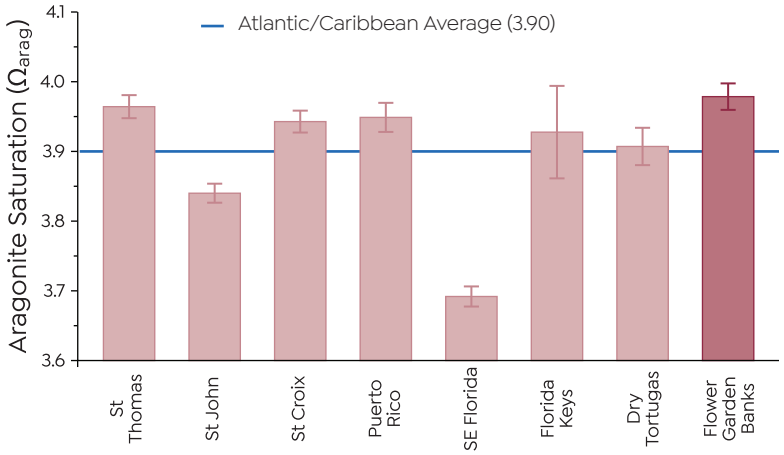


Random photo transects are conducted annually to assess coral cover at the East and West Flower Garden Banks.

Highlights

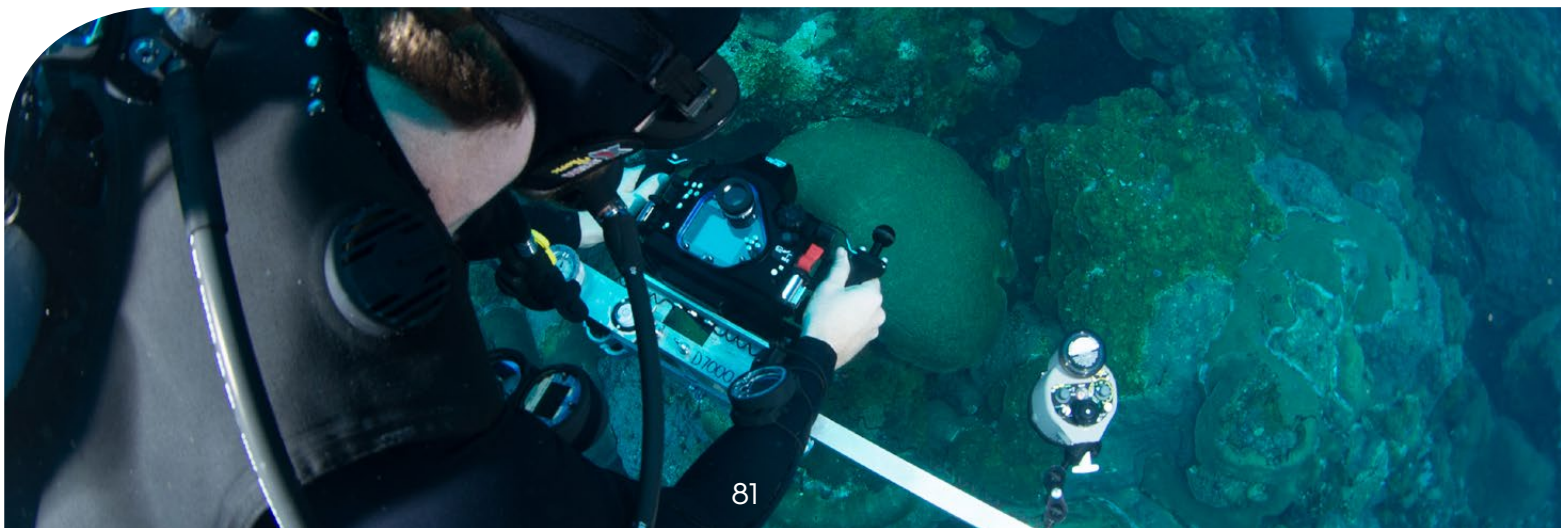
- The Flower Garden Banks experiences the highest aragonite saturation state values of all US coral reef areas during the summer months.
- Heat stress accumulation triggered Alert Level 1 throughout the Flower Garden Banks area in 2016 and bleaching was observed.

Aragonite saturation state



Mean (± std. error of mean) aragonite saturation Ω_{arag} values of US jurisdictions during summer months from 2013-2015. Data from SE FL and Florida Keys represent annual averages. Blue line is mean for Atlantic sites, excluding outlier sites of inshore Florida Keys and inlet sites of SE Florida Region.

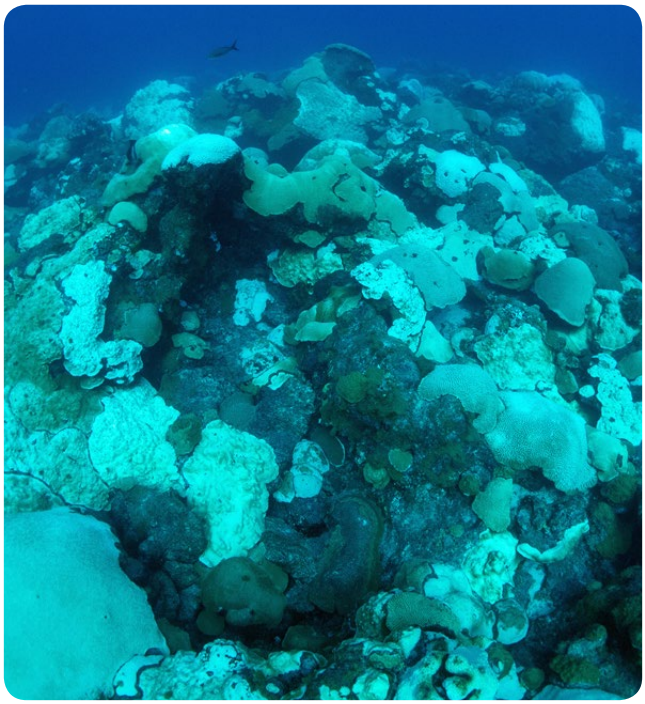
The Flower Garden Banks (FGB) experienced the highest Ω_{arag} values of all US jurisdictions during the summer months. FGB does experience cooler temperatures during winter months than all other sites except for Florida and as a consequence, Ω_{arag} values are likely lower in the winter months than the other US jurisdictions.



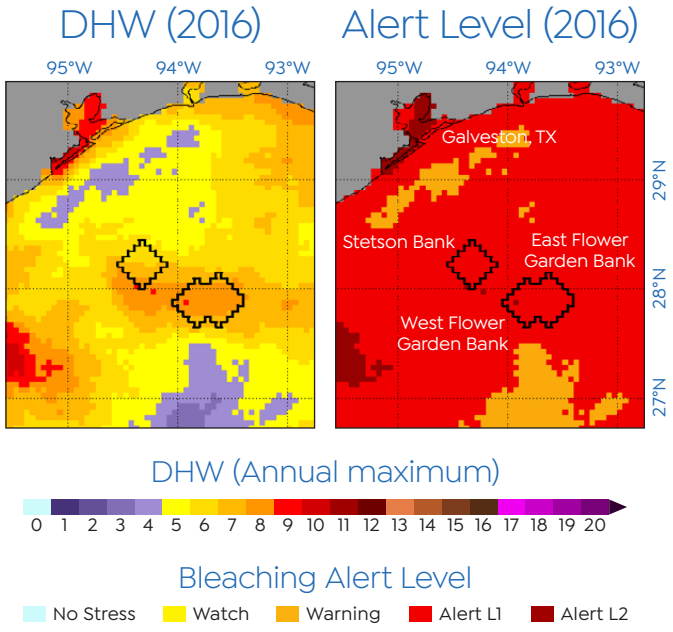
Schools of rockhind and creolefish rest along the reef, Flower Garden Banks National Marine Sanctuary.

Heat stress and coral bleaching

The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in the Flower Garden Banks in 1991, 1995, 2005, 2010, 2015, and 2016.

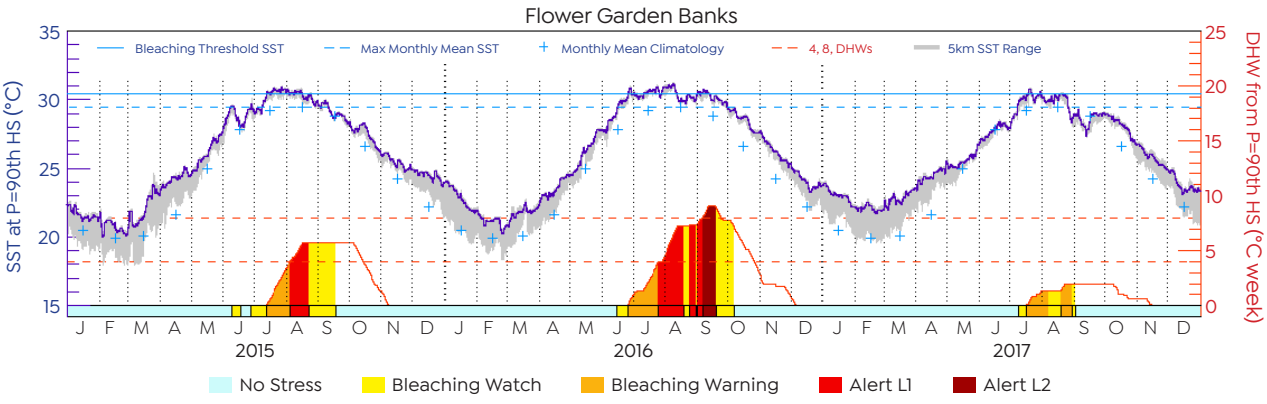


Bleaching and paling coral at East Flower Garden Bank in 2016



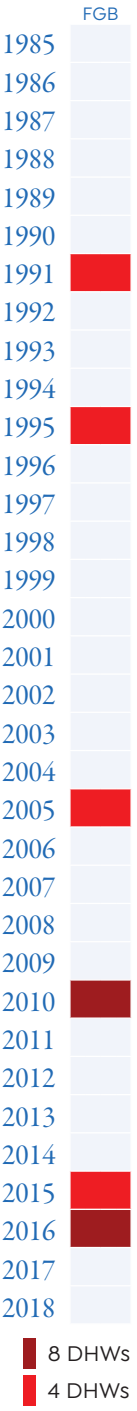
Annual maximum Degree Heating Weeks (DHWs) in 2016 (left panel) exceeded eight at East and West Flower Garden Banks, while at least six DHWs accumulated at Stetson Bank.

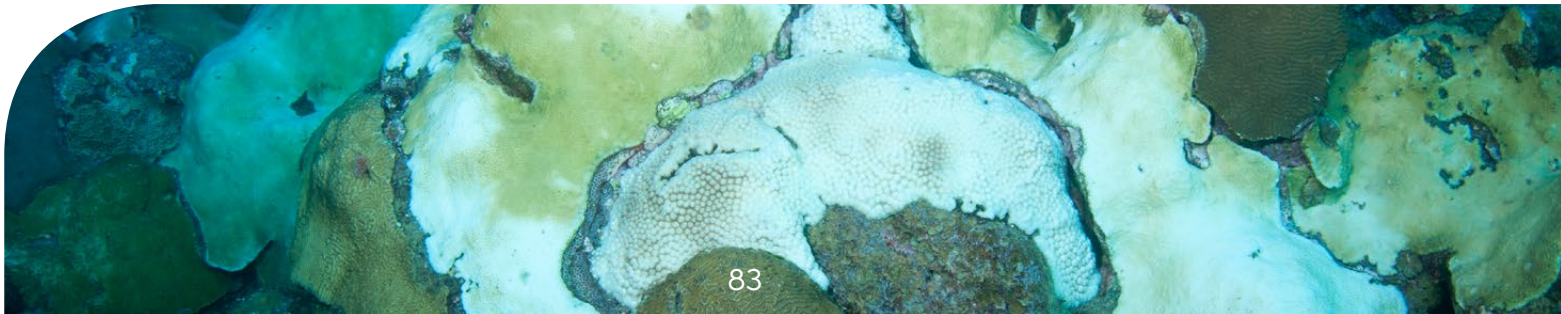
Heat stress accumulation triggered Alert Level 1 throughout the Flower Garden Banks area in 2016 (right panel) and coral bleaching was observed.



Degree Heating Week (DHW) accumulation from 2015-2017 in the Flower Garden Banks. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in 2015 and 2016. Alert Level 2 was triggered in 2016, and extensive coral bleaching occurred in that year.

Thermal History






Hawai‘i

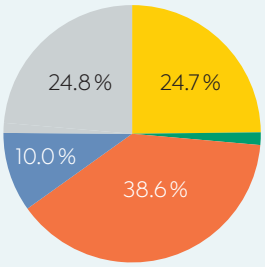
Demographics, values, resource use, and information sources

This Human Connections section presents findings from the Hawai'i NCRMP socioeconomic data collection and includes data never collected before in Hawai'i. These are baseline data on social indicators from household surveys conducted in November 2014, and from secondary sources.

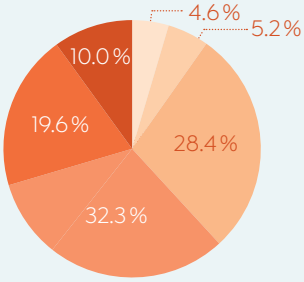
Highlights

- The great majority of residents agreed that coral reefs provide protection from erosion and natural disasters, attract tourists, and are culturally important.
- The dominant perception of the status of water quality, and diversity and size of fish, was that the current status was good and future trend will make these worse or there will be no change.
- Of the potential threats to coral reefs, residents were least familiar with ocean acidification.
- Residents were generally very supportive of marine management policies – more than 80% are supportive of designating marine managed areas, increasing law enforcement for existing rules and regulations, regulation of land use, and better treatment of wastewater.

Race

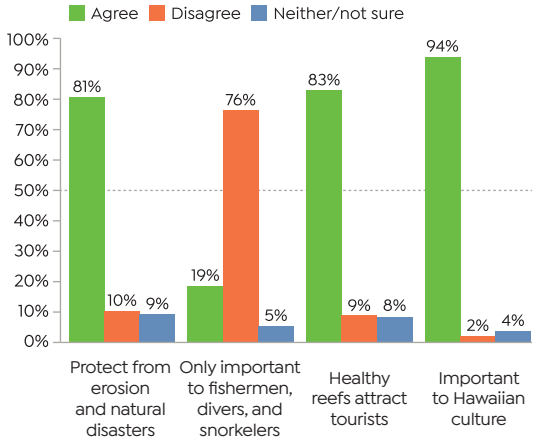


Educational attainment



The population of Hawai'i was predominantly composed of Asian (39%), Other (25%) and White (25%) ethnicity. Over 90% of the population had at least completed high school, ~62% had completed at least some college or an associate's degree, and ~30% a bachelor's degree or graduate degree.

Values and awareness



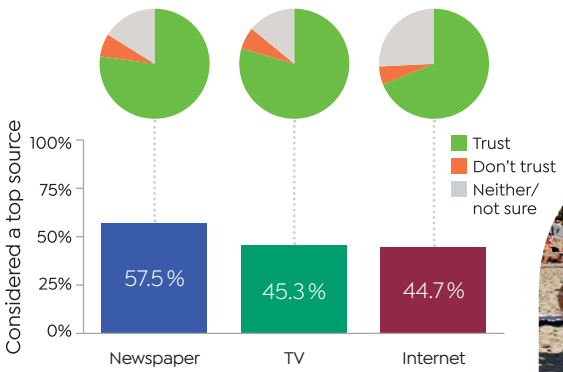
When asked about important services provided by reef resources, most residents agreed that coral reefs protect Hawai'i from erosion and natural disasters (81%), that coral reefs attract tourists (83%), and that coral reefs are important to Hawaiian culture (94%). The majority of residents (76%) disagreed with the statement that coral reefs are only important to fishermen, divers, and snorkelers.

Resource use

PERCENT OF POPULATION PARTICIPATING IN EACH ACTIVITY

Information sources

Nearly 60% considered newspapers to be a top source for information on the environment, including status of coral reefs and present and future threats. Greater than 75% of residents who claimed newspapers, TV, and internet were top sources indicated these sources were trustworthy.



2014 survey data (n=2,240)

Perceptions of resource condition, threats, and severity

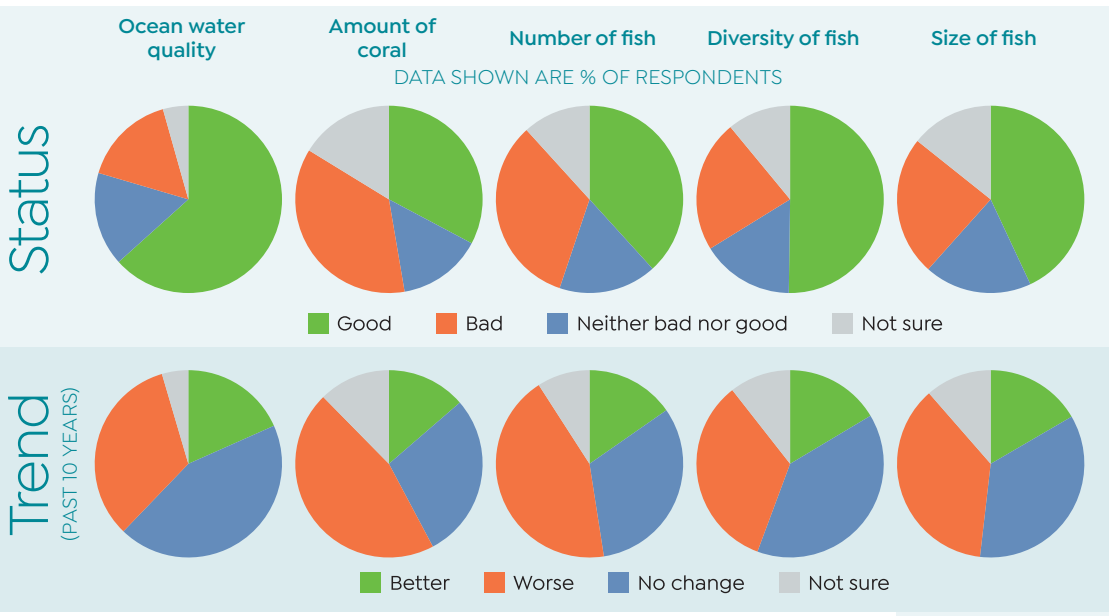
Threats

PERCENT OF THE POPULATION FAMILIAR WITH EACH THREAT

Threats not shown above: **Ocean acidification** (44 %).

In general, residents were familiar with potential threats facing coral reefs in Hawaii, with at least half of residents stating they were familiar or very familiar with each potential threat shown above. Of the potential threats mentioned, residents were least familiar with ocean acidification (44 %) and coral bleaching (58 %). Respondents have likely become much more familiar with coral bleaching since these surveys were conducted in early 2014. Bleaching events occurred in Hawai'i in 2014 and 2015 and had broad media coverage.

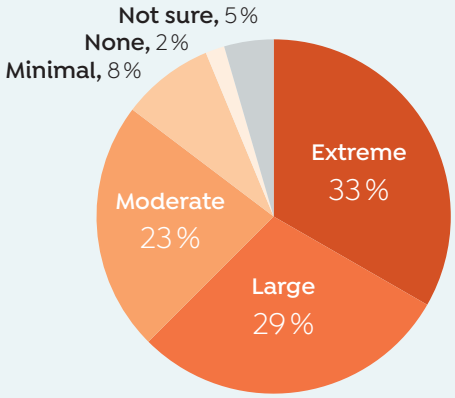
PERCEPTIONS OF



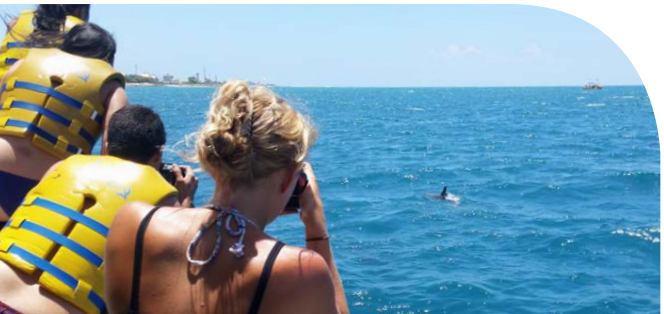
Status and trend

More residents felt confident in their perception of the status of water quality, the amount of corals, and the number, diversity, and size of fish (~20% not sure). For those confident in their perception, roughly 35-65% of residents felt the current status was good and roughly 20-40 % felt the current status was bad for all status variables. A different pattern was evident in the perceptions of trend. For those confident in their perception of the trend of water quality, the amount of corals, and the number, diversity, and size of fish, ~40 % felt it had gotten worse, ~40% felt there had been no change and ~15% felt status had gotten better. Overall, the dominant perception of the status and trends of water quality, and diversity and size of fish, was that the current status was good, however the dominant perception for trend was that the status had gotten worse or remained the same over the last ten years.

Severity of threats

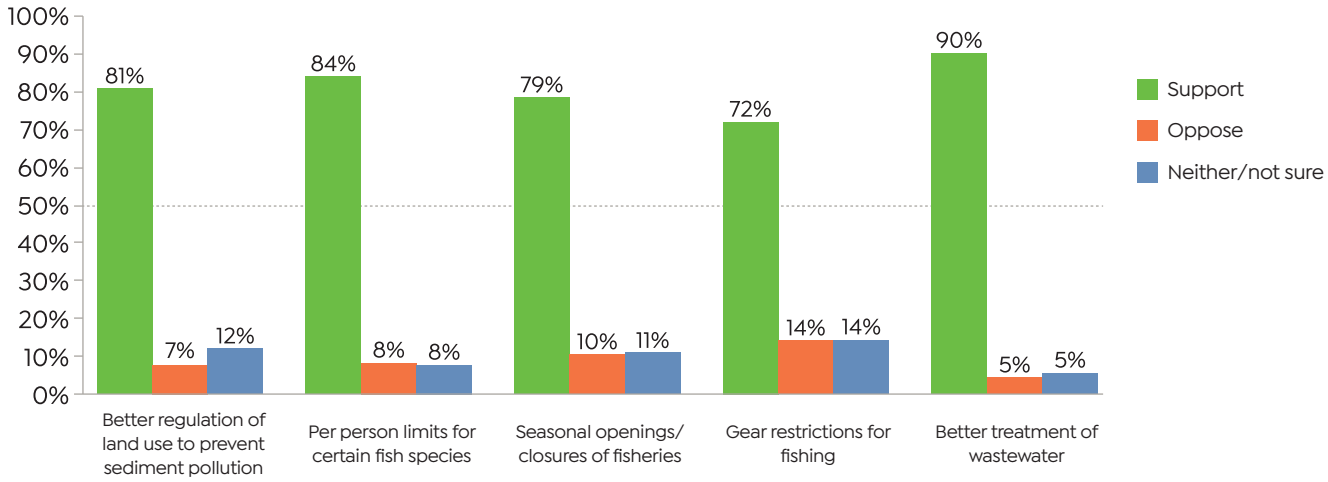


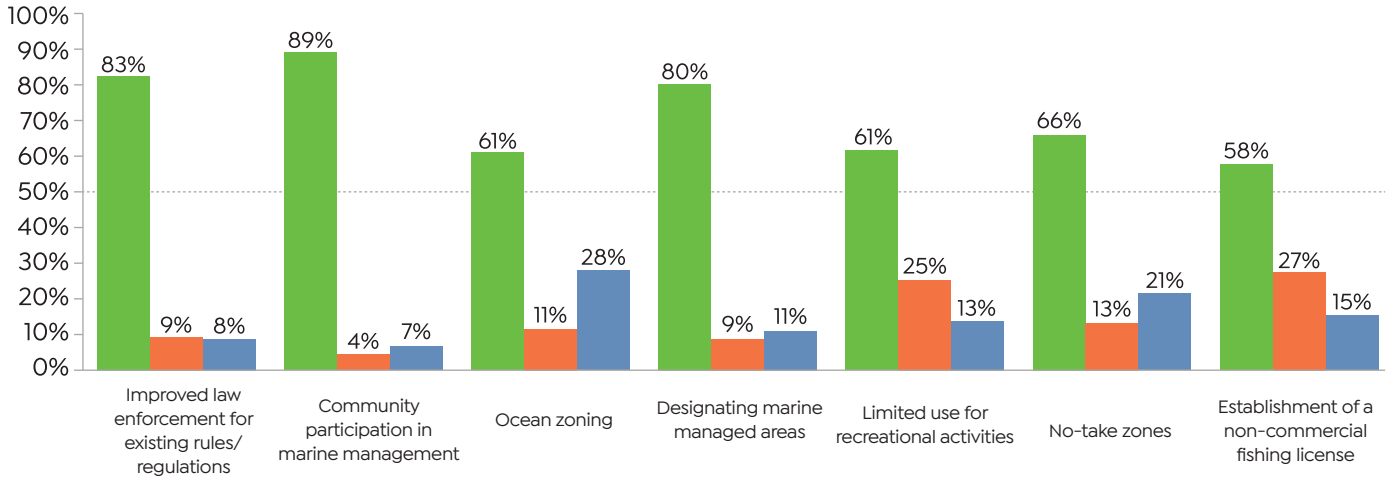
Residents were generally concerned about threats to coral reefs in Hawaii. Thirty-three percent of residents stated that they thought threats were extreme and 29 % thought threats were large. A small percentage (10 %) stated that threats were either minimal or believe there are no threats.



Perceptions of reef management policies

Management policies

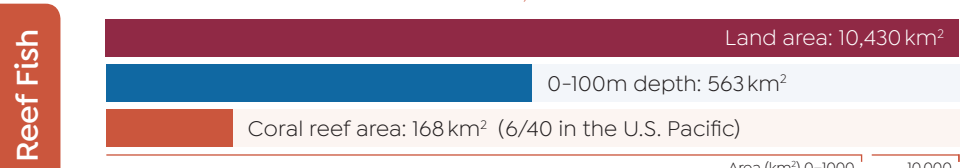




Residents were generally supportive of current marine management policies. There was extremely high support for better treatment of wastewater (90%), community participation in marine management (89%), per person limits for certain fish species (84%), improved law enforcement for existing rules (83%), better regulation of land use to prevent sediment pollution (81%), and designating marine managed areas (80%). There was less but still strong support for seasonal openings and closures of fisheries (79%) and gear restrictions for fishing (72%).

Coral reefs – Hawai'i (2016)

19° 33' N, 155° 40' W



Population: 185,079 (2010)

The coral reefs of Hawai'i were surveyed in July to September 2016.

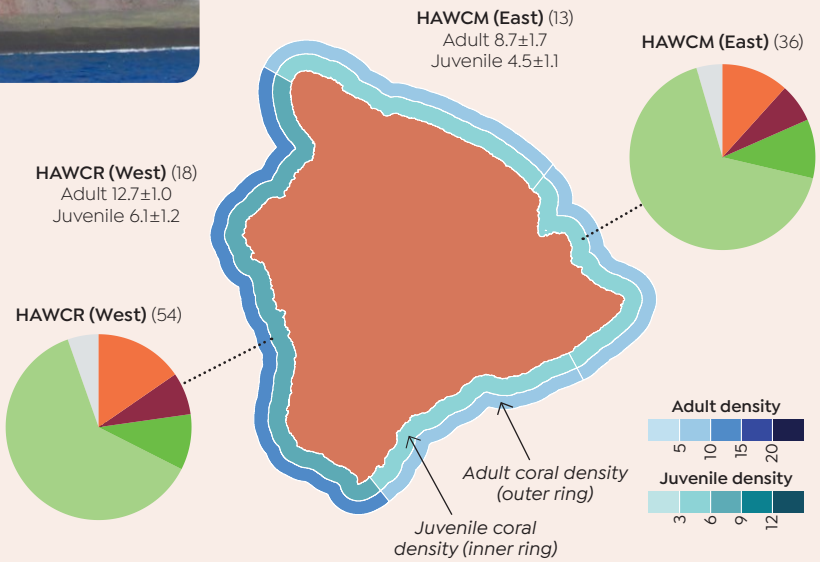
- Coral cover was highest in the West (15.4%) and lowest in the East (11.7%).
- Acute coral disease and recent mortality were <1.3% in all sectors. Chronic coral disease was 1.7% in the West and 5.8% in the East.
- Old mortality of corals was 21.8% in the West and 18.8% in the East.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

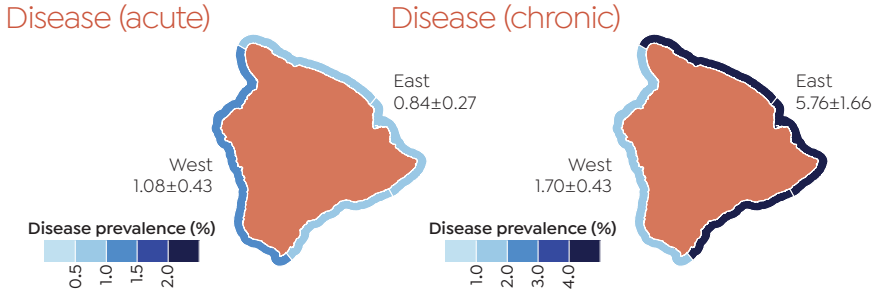
HAWCR (West) = Hawai'i coral rich sector.
HAWCM (East) = Hawai'i complex sectors combined.



Benthic cover: Hard coral | CCA | Macroalgae | Turf algae | Other

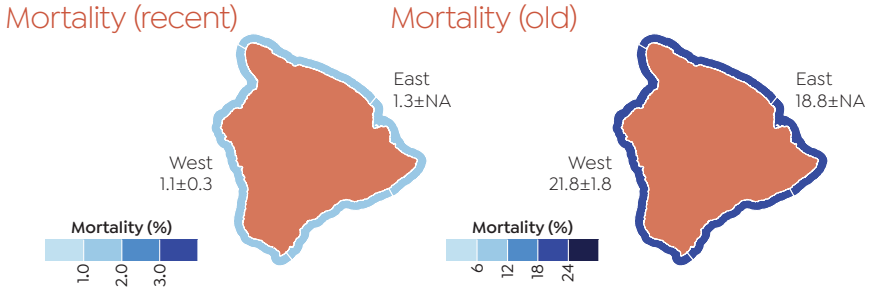
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Hawai'i (2010-2016)

19° 33' N, 155° 40' W

Reef fish biomass: 28.1±1.5 g/m²

100 g/m²

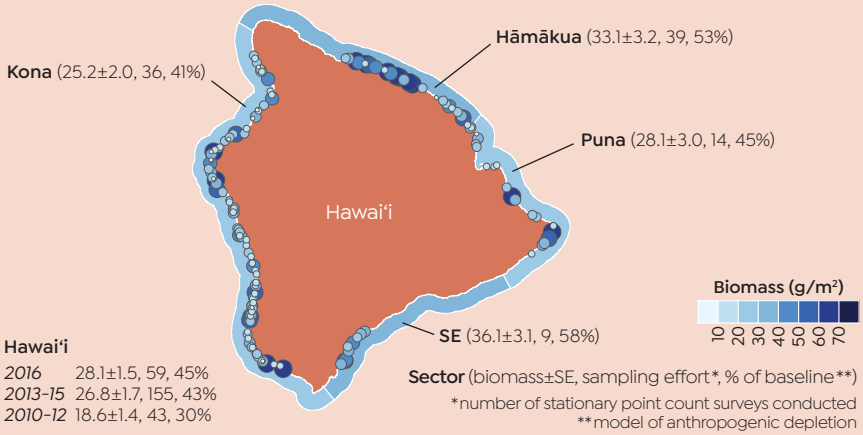
Coral reef fish surveys were conducted in 2016, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass ranged from 25.2±2.0 g/m² (41 % of baseline) in Kona to 36.1±3.1 g/m² (58 % of baseline) in the SE.
- Reef fish biomass was 18.6±1.4 g/m² in 2010-2012, 26.8±1.7 g/m² in 2013-2015, and 28.1±1.5 g/m² in 2016.
- >50 % of the reef fish sampled were <30 cm in length during the 2010-2012, 2013-2015, and 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Hawai'i

2016	28.1±1.5, 59, 45%
2013-15	26.8±1.7, 155, 43%
2010-12	18.6±1.4, 43, 30%

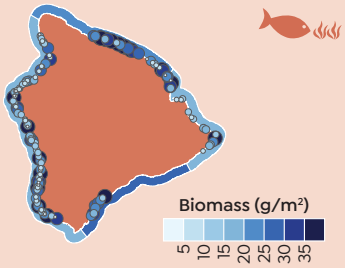
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

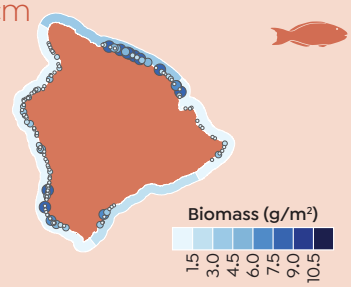
Herbivores

2016	17.8±1.0
2013-15	18.7±1.0
2010-12	13.4±1.3



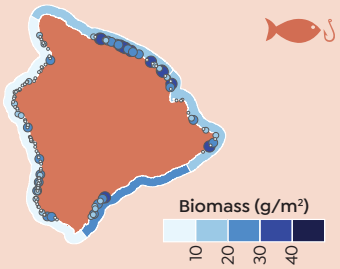
Parrotfish >30 cm

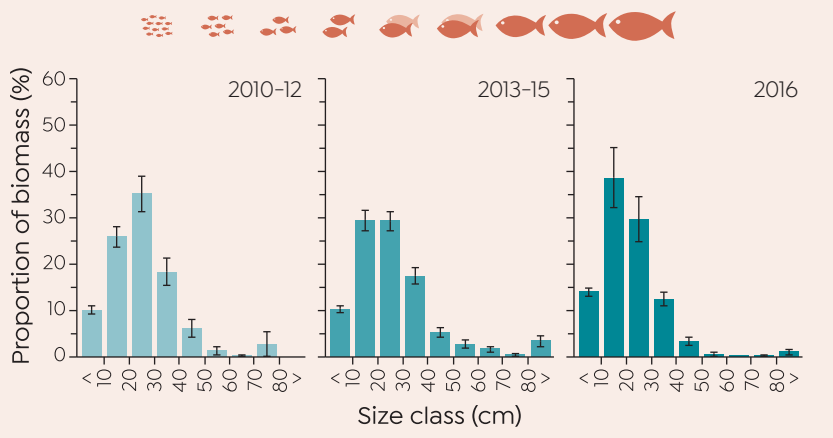
2016	0.7±0.2
2013-15	2.0±0.2
2010-12	2.2±0.4



Targeted fish

2016	10.4±1.2
2013-15	11.3±0.8
2010-12	9.0±1.0



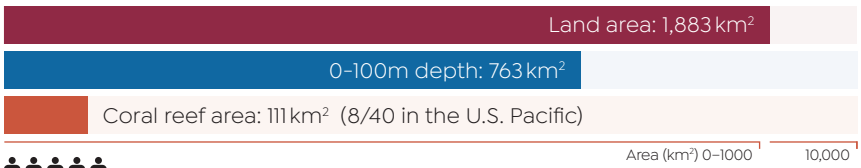


Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral reefs – Maui (2016)

20° 48' N, 156° 20' W



Population: 154,834 (2015-16)

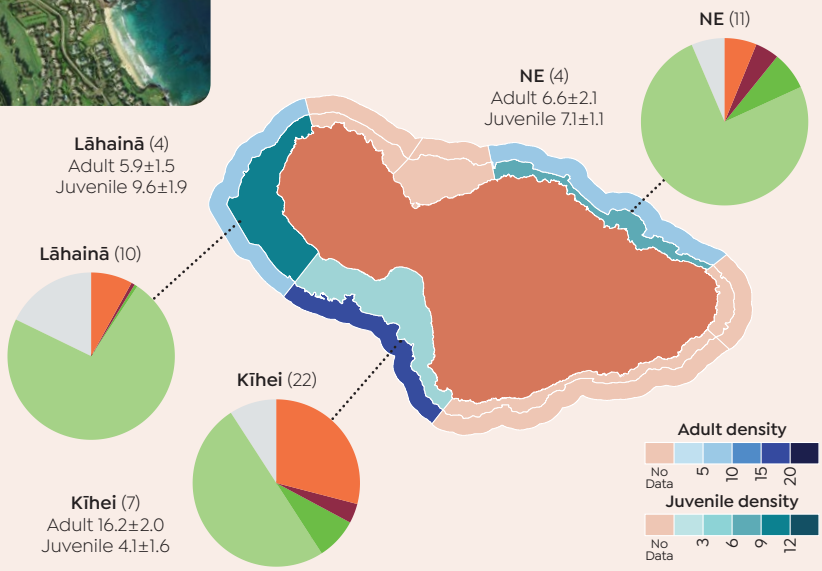
The coral reefs of Maui were surveyed in July to September 2016.

- Coral cover was highest in Kīhei (29%) and lowest in the NE (6.2%).
- Acute coral disease and recent mortality were <1.5% in all sectors. Chronic coral disease ranged from 1.7% in the NE and Kīhei to 2.3% in Lāhainā.
- Old mortality of corals ranged from 17.8% in the NE to 24.3% in Lāhainā.

Benthic cover and coral density

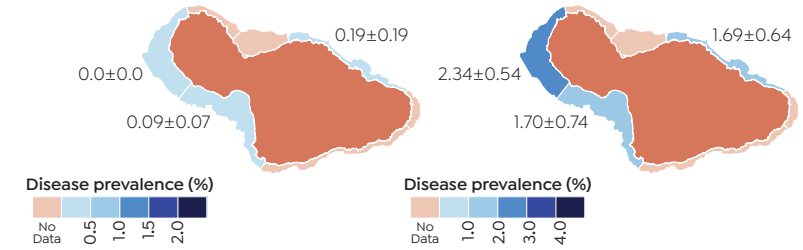
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



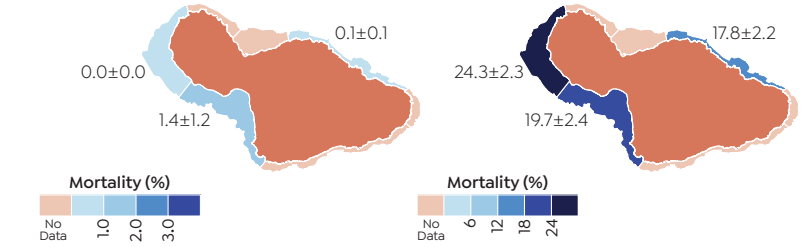
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Maui (2010-2016*)

20° 48' N, 156° 20' W

Reef fish biomass: 20.7±2.2 g/m²

100 g/m²

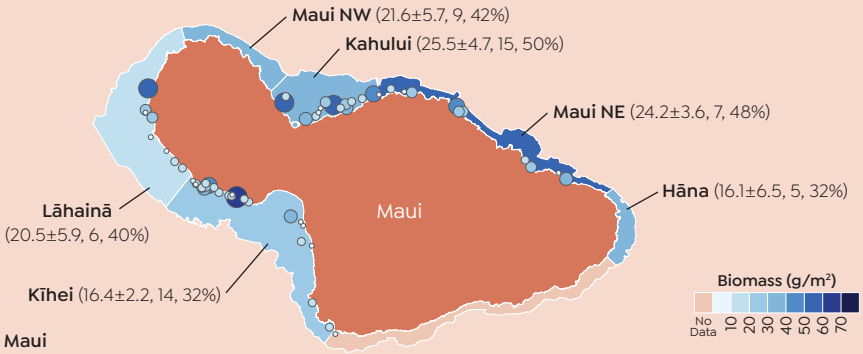
Coral reef fish surveys were conducted in 2016, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass ranged from 16.1±6.5 g/m² (32 % of baseline) in Hāna to 25.5±4.7 g/m² (50 % of baseline) in Kahului.
- Reef fish biomass was 18.6±1.9 g/m² in 2010-2012, 21.9±2.3 g/m², in 2013-2015, and 20.7±2.2 g/m² in 2016.
- >50 % of the reef fish sampled were <30 cm in length during the 2010-2012, 2013-2015, and 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Maui

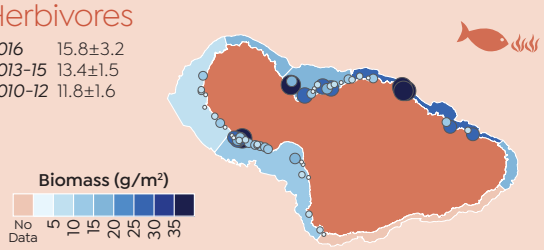
2016 20.7±2.2, 27, 41%
2013-15 21.9±2.3, 63, 42%
2010-12 18.6±1.9, 77, 36%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

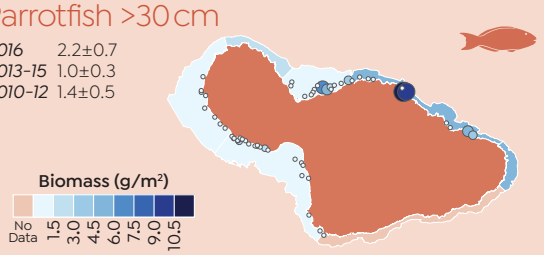
Herbivores

2016 15.8±3.2
2013-15 13.4±1.5
2010-12 11.8±1.6



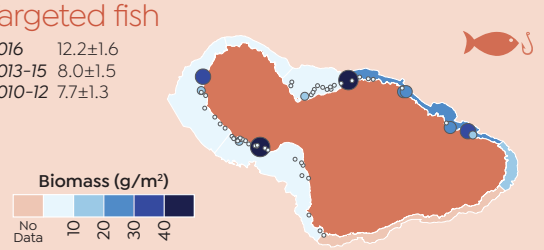
Parrotfish >30 cm

2016 2.2±0.7
2013-15 1.0±0.3
2010-12 1.4±0.5



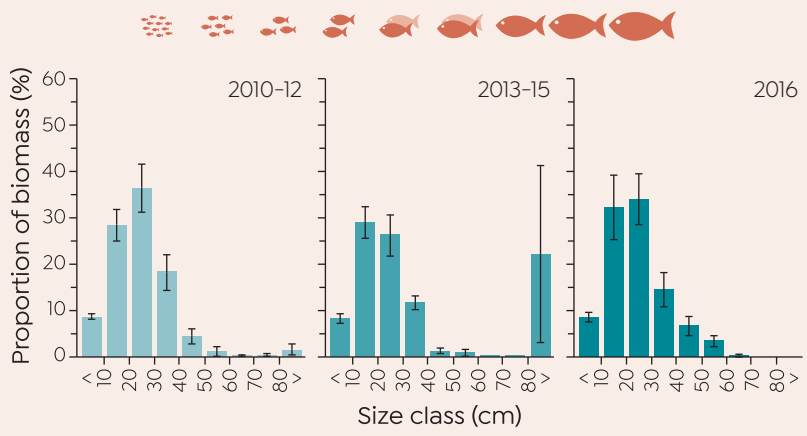
Targeted fish

2016 12.2±1.6
2013-15 8.0±1.5
2010-12 7.7±1.3



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



*Sector-level data for Maui NW and Hāna are from 2010-12 and for Kahului are from 2013-15. No data are available for Maui SE.

Coral reefs – Kaho‘olawe (2016)

20° 33’ N, 156° 36’ W

Land area: 115.5 km²

0–100m depth: Data not available

Coral reef area: 12.0 km² (24/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

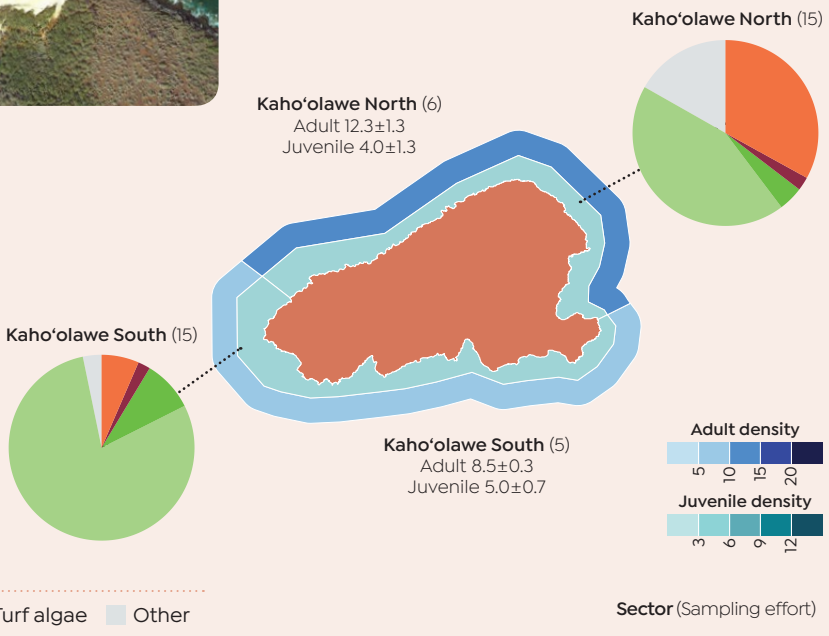
The coral reefs of Kaho‘olawe were surveyed in July to September 2016.

- Coral cover was highest in the North (33%) and lowest in the South (6.5%).
- Acute coral disease and recent mortality were <1% in all sectors. Chronic coral disease was 1.2% in the North and 3.7% in the South.
- Old mortality of corals ranged from 20% in the North and 27% in the South.

Benthic cover and coral density

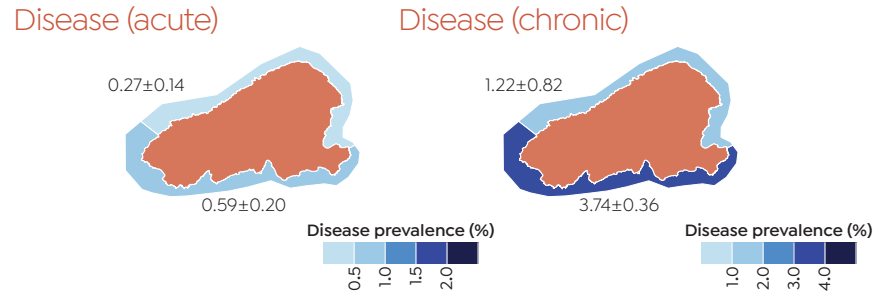
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



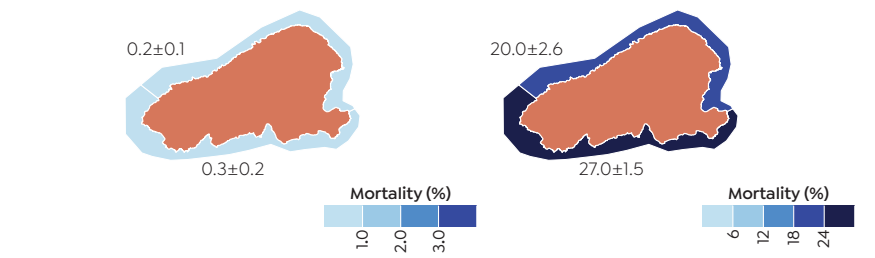
Coral disease

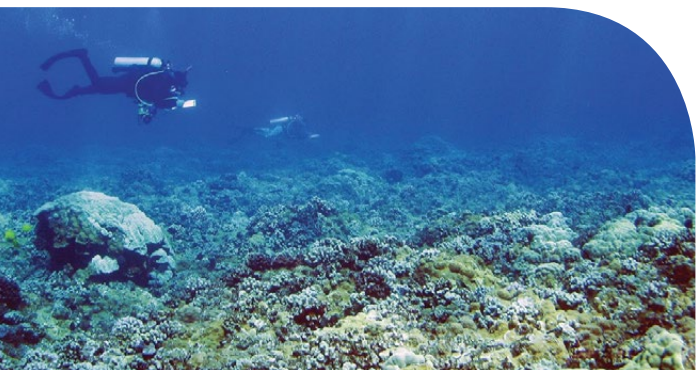
The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.





Coral reef fish – Kaho'olawe (2016)

20° 33' N, 156° 36' W

Reef fish biomass: 38.4±4.7 g/m²

100 g/m²

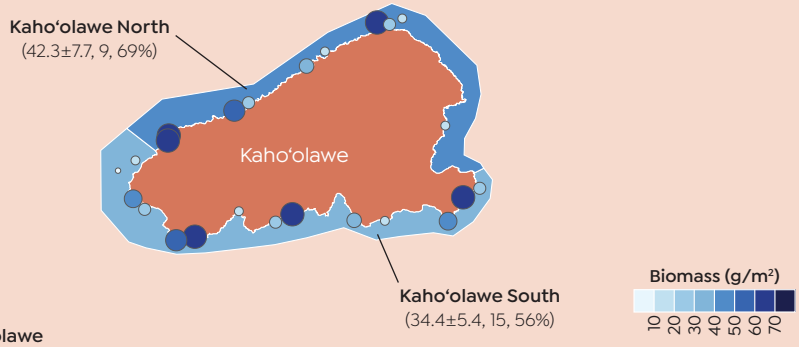
Coral reef fish surveys were conducted in 2016.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 34.4±5.4 g/m² (56% of baseline) in the South and 42.3±7.7 g/m² in the North.
- Reef fish biomass was 38.4±4.7 g/m² in 2016 (island-wide).
- >50% of the reef fish sampled were <30 cm in length during the 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.

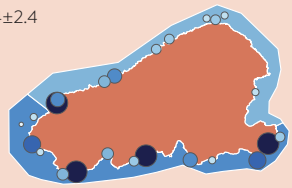


Kaho'olawe
2016 38.4±4.7, 24, 63%

Sector (biomass±SE, sampling effort*, % of baseline**)
*number of stationary point count surveys conducted
**model of anthropogenic depletion

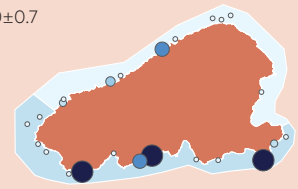
Herbivores

2016 18.4±2.4



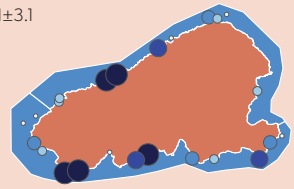
Parrotfish >30 cm

2016 2.0±0.7



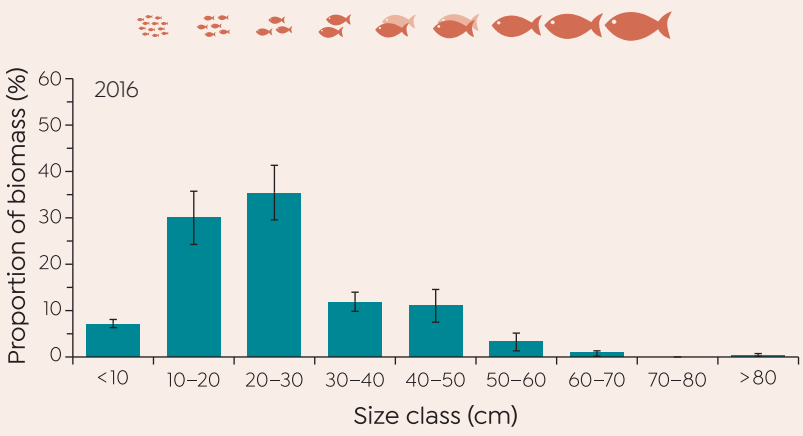
Targeted fish

2016 22.1±3.1



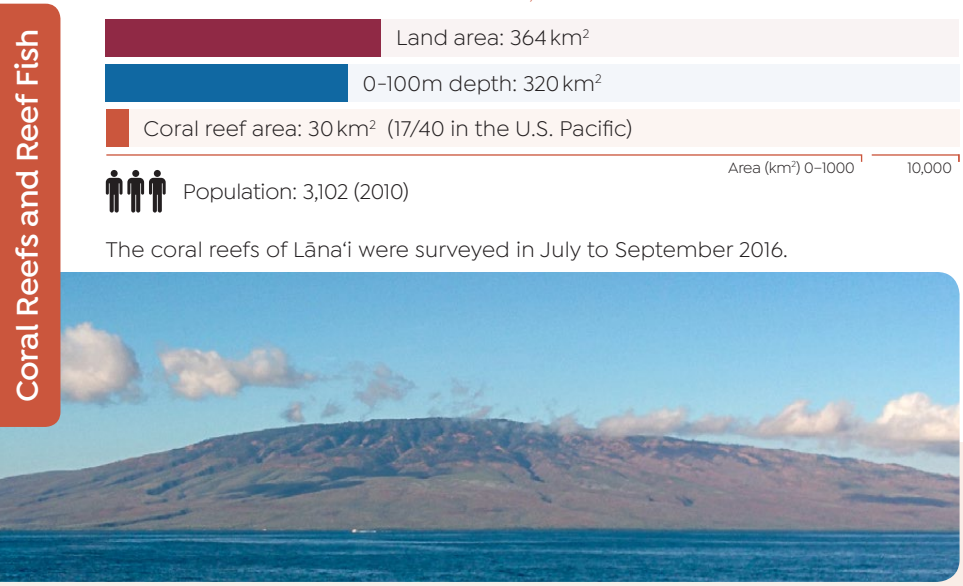
Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Lāna‘i (2016)

20° 49’ N, 156° 56’ W



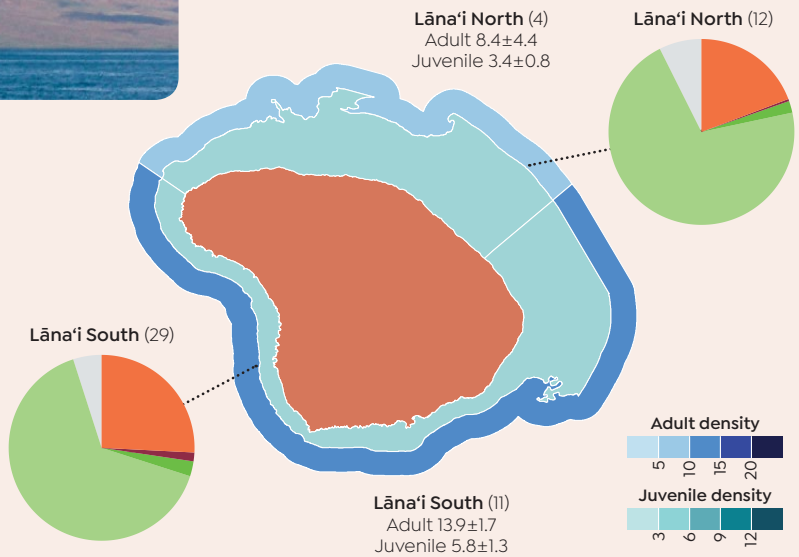
The coral reefs of Lāna‘i were surveyed in July to September 2016.

- Coral cover was highest in the South (25.8 %) and lowest in the North (19.2 %).
- Acute coral disease and recent mortality were <1% in all sectors. Chronic coral disease was 2.4 % in the South and 3.1 % in the North.
- Old mortality of corals was 21.8 % in the North and 26.4 % in the South.

Benthic cover and coral density

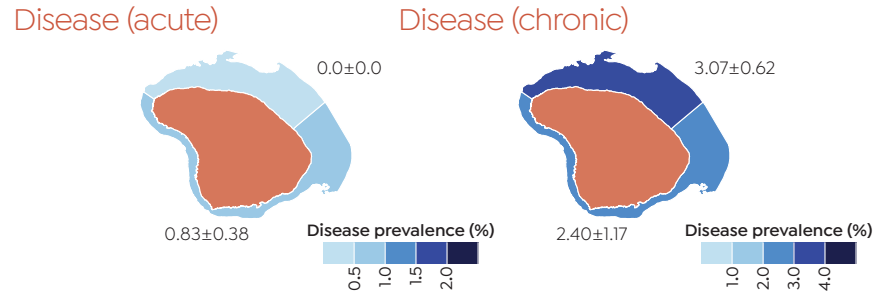
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



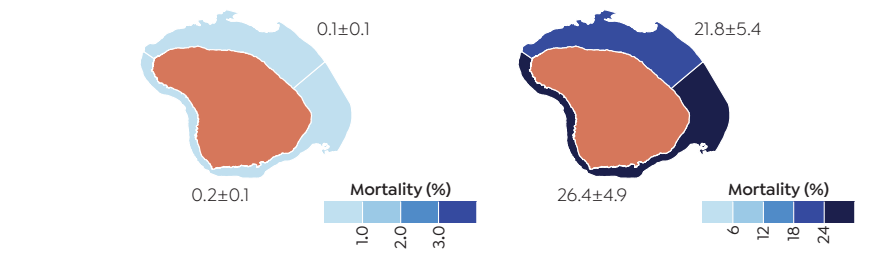
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Lāna'i (2010-2016)

20° 49' N, 156° 56' W

Reef fish biomass: 20.7±2.4 g/m²

100 g/m²

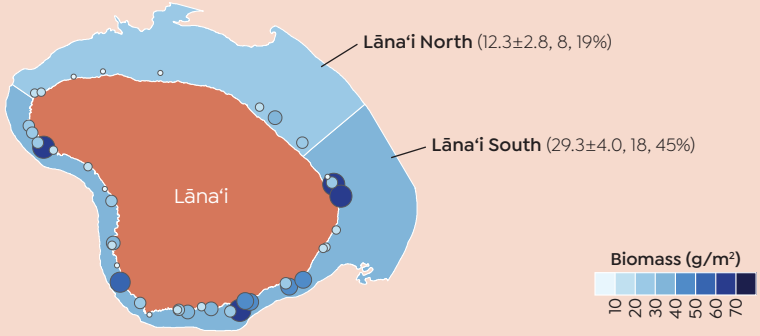
Coral reef fish surveys were conducted in 2016, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 12.3±2.8 g/m² (19 % of baseline) in the North and 29.3±4.0 g/m² (45 % of baseline) in the South.
- Reef fish biomass was 21.1±2.9 g/m² in 2010-2012, 20.2±2.8 g/m² in 2013-2015, and 20.7±2.4 g/m² in 2016.
- >50 % of the reef fish sampled were <30 cm in length during the 2010-2012, 2013-2015, and 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Lana'i

2016	20.7±2.4, 26, 32%
2013-15	20.2±2.8, 44, 31%
2010-12	21.1±2.9, 44, 32%

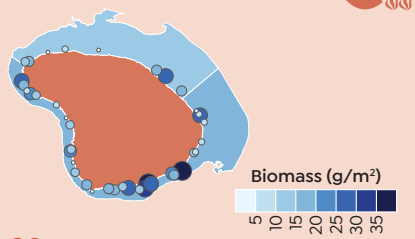
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

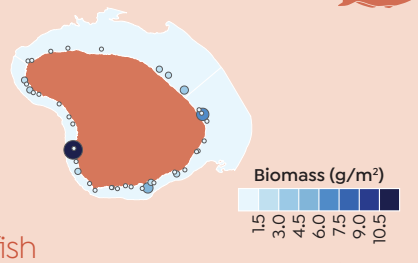
Herbivores

2016	14.9±2.5
2013-15	11.6±1.6
2010-12	12.3±2.0



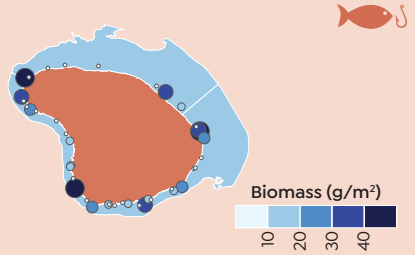
Parrotfish >30 cm

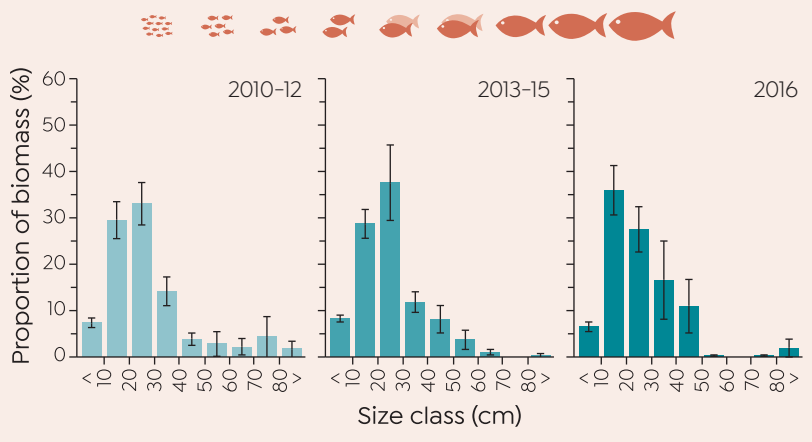
2016	0.8±0.2
2013-15	1.3±0.5
2010-12	1.6±0.5



Targeted fish

2016	11.1±2.5
2013-15	10.4±1.9
2010-12	9.5±1.3



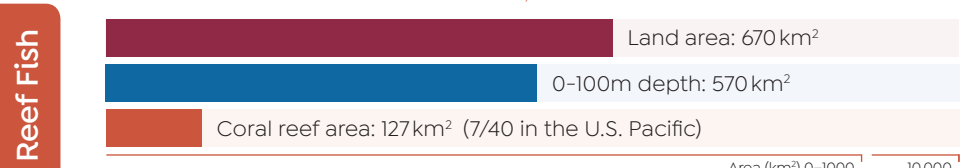


Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral reefs – Moloka'i (2016)

21° 09' N, 157° 01' W



Population: 7,345 (2010)

The coral reefs of Moloka'i were surveyed in July to September 2016.

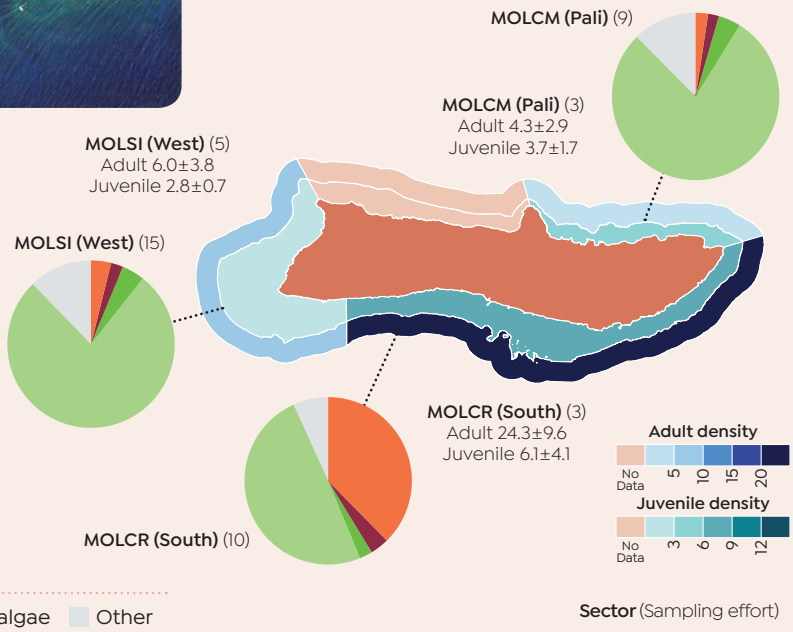
- Coral cover was highest in the South (37.7%) and lowest in Pali (2.4%).
- Acute coral disease and recent mortality were <1.6% in all sectors. Chronic coral disease ranged from 0.2% in the South to 4.3% in the Northeast.
- Old mortality of corals ranged from 17.5% in Pali to 22.6% in the West.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

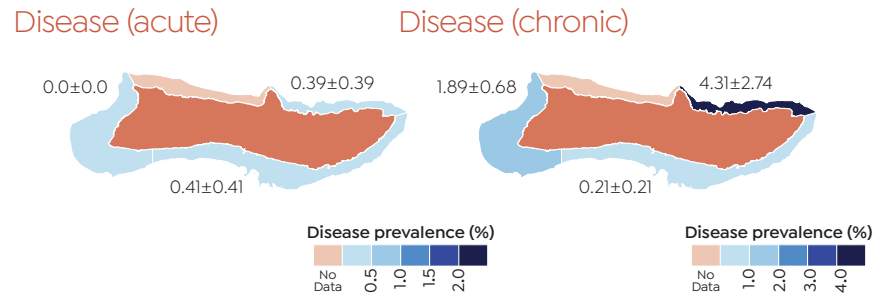
Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

MOLCM (Pali) = Moloka'i complex.
MOLCR (South) = Moloka'i coral rich.
MOLSI (West) = Moloka'i simple.



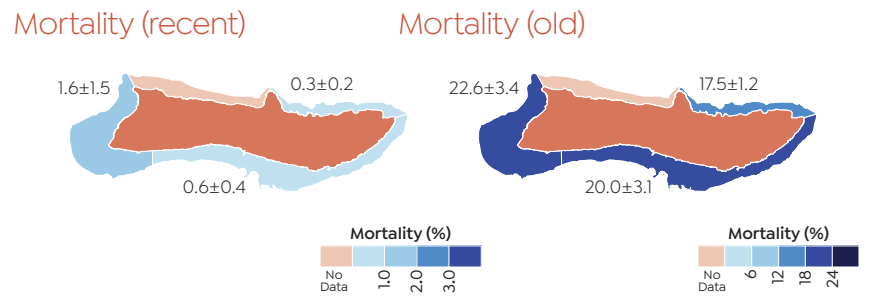
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Moloka'i (2010-2016*)

21° 09' N, 157° 01' W

Reef fish biomass: 25.2±8.5 g/m²

100 g/m²

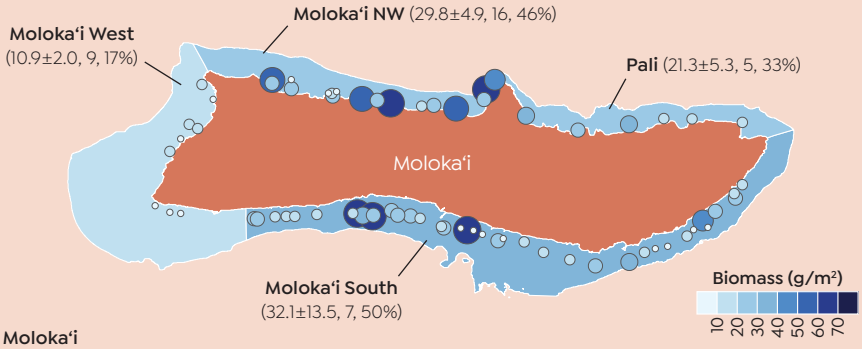
Coral reef fish surveys were conducted in 2016, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass ranged from 10.9±2.0 g/m² (17 % of baseline) in the West to 32.1±13.5 g/m² (50 % of baseline) in the South.
- Reef fish biomass was 16.2±1.6 g/m² in 2010-2012, 23.5±2.2 g/m² in 2013-2015, and 25.2±8.5 g/m² in 2016.
- >50 % of the reef fish sampled were <30 cm in length during the 2010-2012, 2013-2015, and 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Moloka'i

2016	25.2±8.5, 21, 39%
2013-15	23.5±2.2, 87, 36%
2010-12	16.2±1.6, 60, 25%

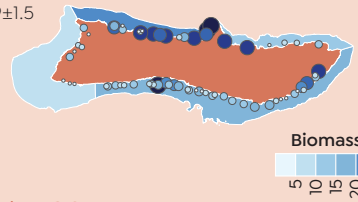
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

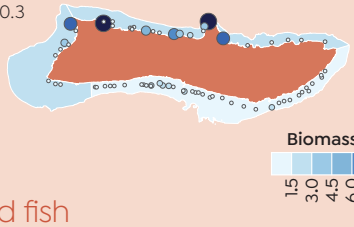
Herbivores

2016	14.1±5.5
2013-15	15.6±1.6
2010-12	10.9±1.5



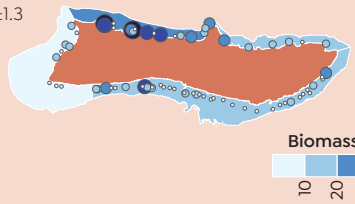
Parrotfish >30 cm

2016	0.7±0.3
2013-15	1.5±0.5
2010-12	1.3±0.3



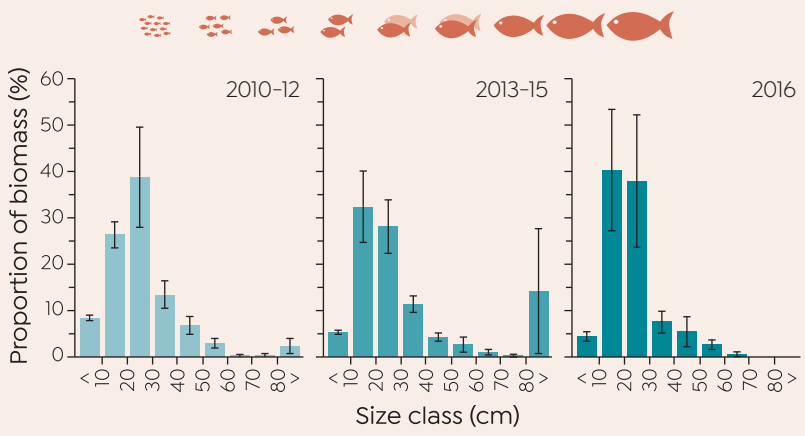
Targeted fish

2016	10.4±2.8
2013-15	10.9±1.5
2010-12	6.7±1.3



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



*Sector-level data for Moloka'i NW are from 2013-15.

Coral reefs – O‘ahu (2016)

21° 26’ N, 158° 00’ W

Population: 976,372 (2012)

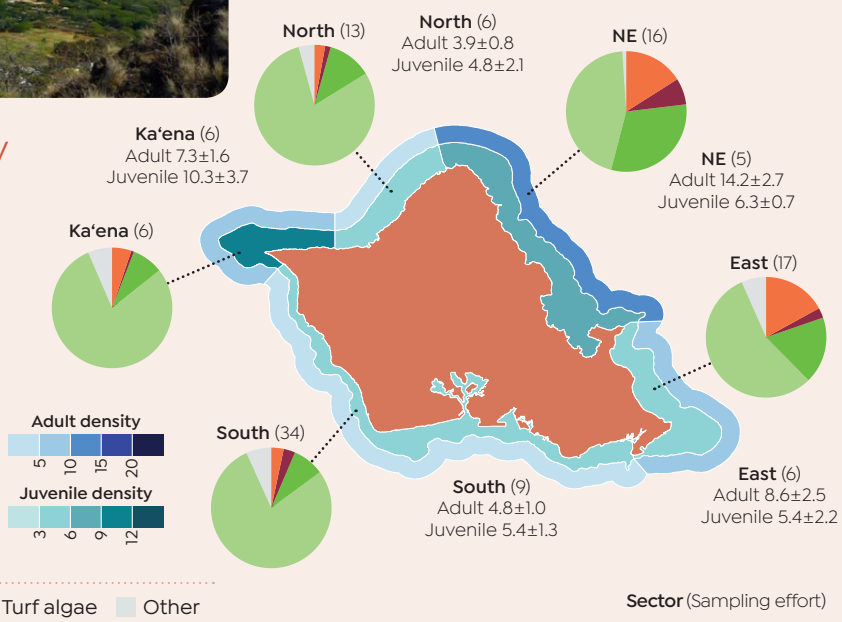
The coral reefs of O‘ahu were surveyed in July to September 2016.

- Coral cover was highest in the East (17%) and NE (16%) and lowest in the North (2.9%) and South (3.3%).
- Acute coral disease and recent mortality were <1.4% in all sectors. Chronic coral disease ranged from 1.7% in the North to 3.8% in Ka‘ena and the NE.
- Old mortality of corals ranged from 14.5% in in Ka‘ena to 24.9% in the North.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

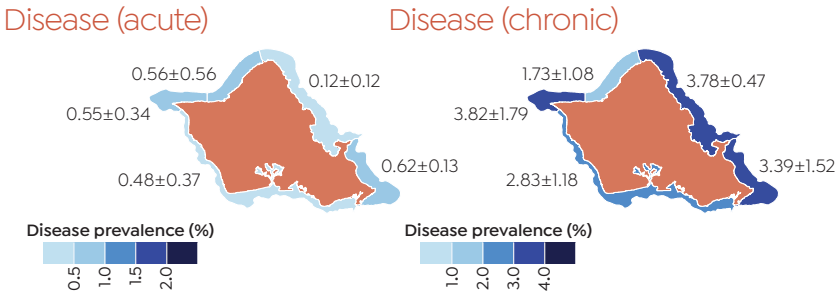


Benthic cover: Hard coral | CCA | Macroalgae | Turf algae | Other

Sector (Sampling effort)

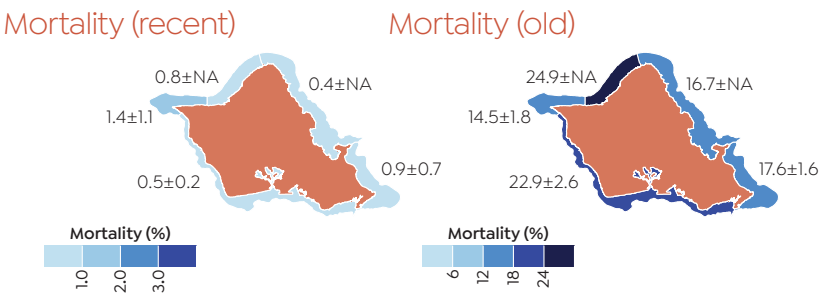
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – O'ahu (2010-2016*)

21° 26' N, 158° 00' W

Reef fish biomass: 13.4±1.5 g/m²

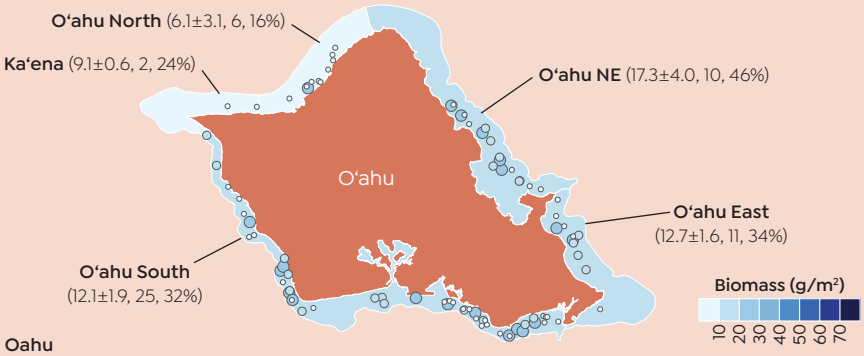
Coral reef fish surveys were conducted in 2016, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass ranged from 6.1±3.1 g/m² (16 % of baseline) in the North to 17.3±4.0 g/m² (46 % of baseline) in the NE.
- Reef fish biomass was 7.5±0.9 g/m² in 2010-2012, 9.5±0.7 g/m² in 2013-2015, and 13.4±1.5 g/m² in 2016.
- >50 % of the reef fish sampled were <30 cm in length during the 2010-2012, 2013-2015, and 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Oahu

2016	13.4±1.5, 52, 35%
2013-15	9.5±0.7, 98, 25%
2010-12	7.5±0.9, 73, 20%

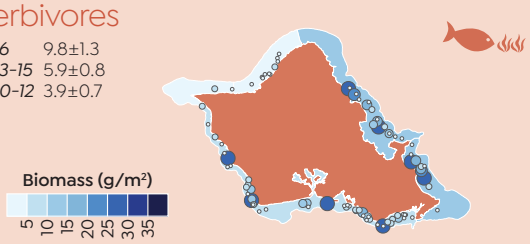
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

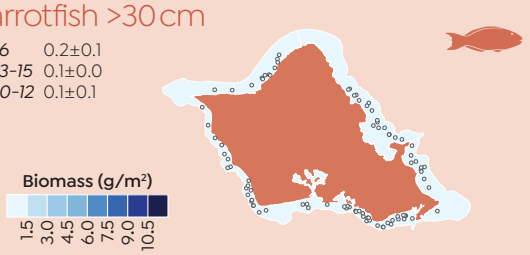
Herbivores

2016	9.8±1.3
2013-15	5.9±0.8
2010-12	3.9±0.7



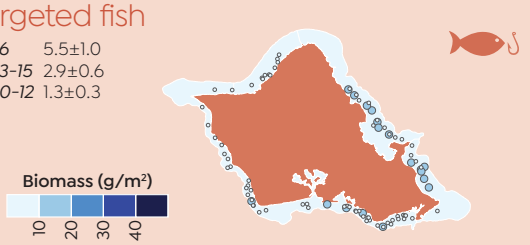
Parrotfish >30 cm

2016	0.2±0.1
2013-15	0.1±0.0
2010-12	0.1±0.1



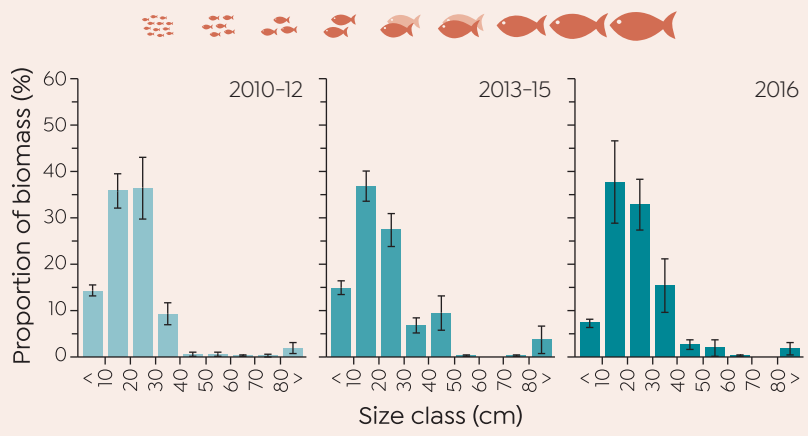
Targeted fish

2016	5.5±1.0
2013-15	2.9±0.6
2010-12	1.3±0.3



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



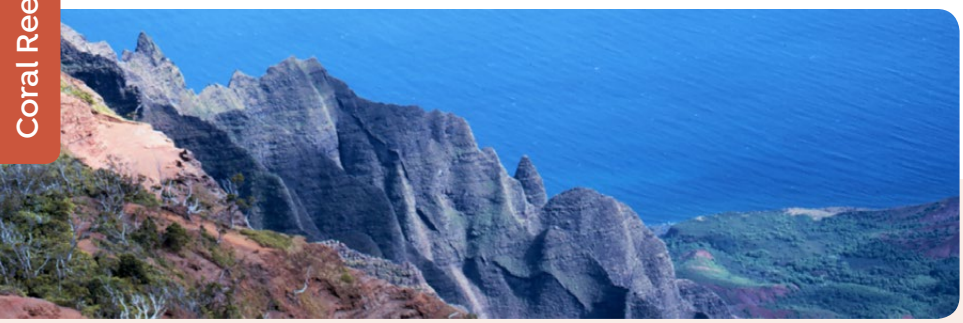
*Sector-level data for Ka'ena are from 2013-15.

Coral reefs – Kaua'i (2016)

22° 06' N, 159° 32' W

Population: 67,091 (2010)

The coral reefs of Kaua'i were surveyed in July to September 2016.

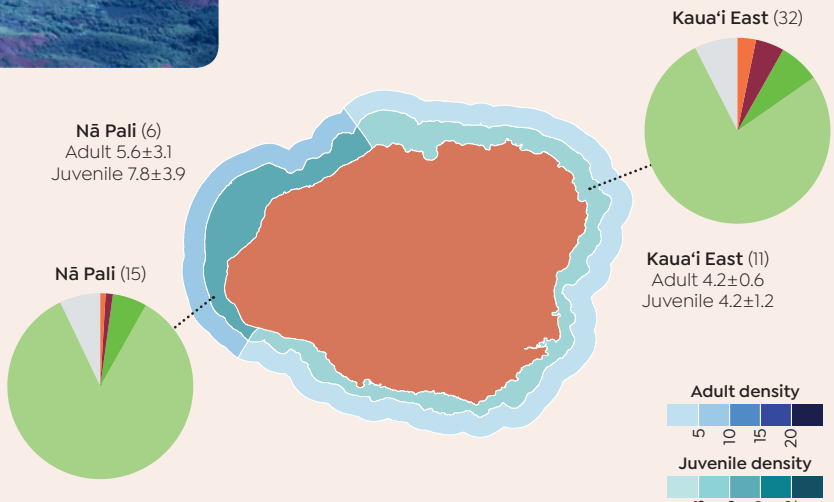


- Coral cover was highest in the East (3.2 %) and lowest in Nā Pali (0.9 %).
- Acute coral disease and recent mortality were <1.4 % in all sectors. Chronic coral disease was 3.4 % in the East and 1.0 % in Nā Pali.
- Old mortality of corals was 22.3 % in the East and 29.3 % in Nā Pali.

Benthic cover and coral density

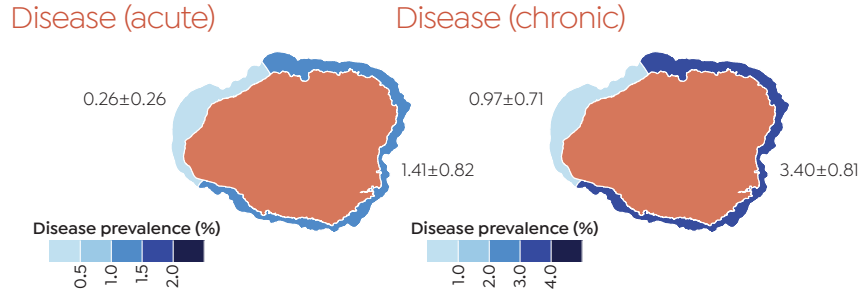
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



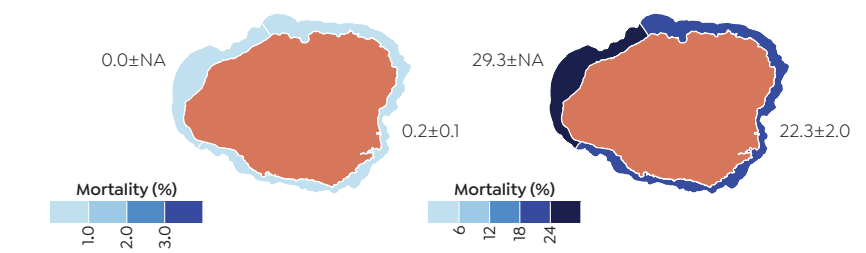
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Kaua'i (2010-2016)

22° 06' N, 159° 32' W

Reef fish biomass: 15.7±3.4 g/m²

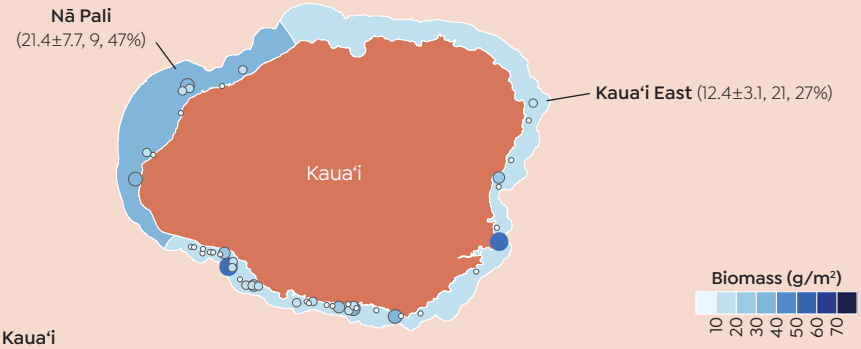
Coral reef fish surveys were conducted in 2016, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 12.4±3.1 g/m² (27% of baseline) in the East and 21.4±7.7 g/m² (47% of baseline) in Nā Pali.
- Reef fish biomass was 16.5±3.2 g/m² in 2010-2012, 16.1±2.0 g/m² in 2013-2015, and 15.7±3.4 g/m² in 2016.
- >50 % of the reef fish sampled were <30 cm in length during the 2010-2012, 2013-2015, and 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Kaua'i

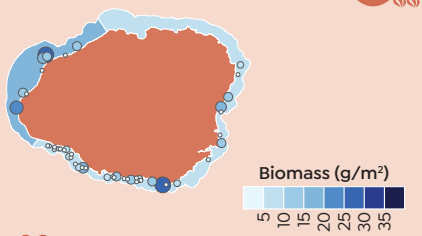
2016	15.7±3.4, 30, 35%
2013-15	16.1±2.0, 57, 35%
2010-12	16.5±3.2, 25, 36%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

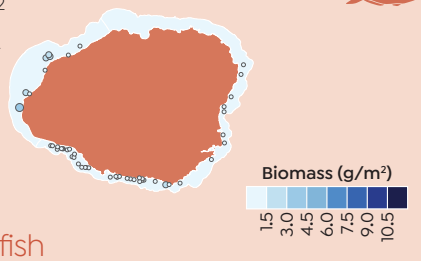
Herbivores

2016	9.2±2.3
2013-15	9.9±2.0
2010-12	6.9±1.3



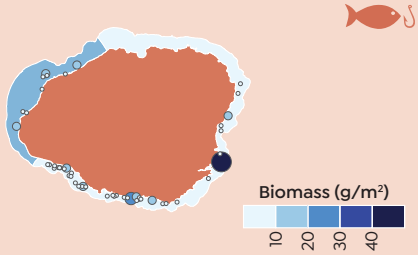
Parrotfish >30 cm

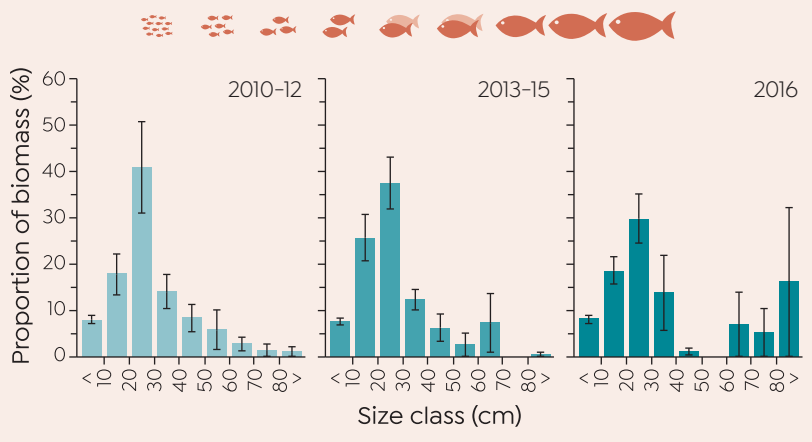
2016	0.4±0.2
2013-15	1.7±0.9
2010-12	1.0±0.4



Targeted fish

2016	7.6±1.6
2013-15	7.4±2.6
2010-12	8.1±1.7



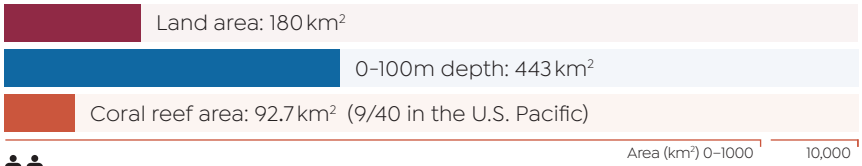


Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral reefs – Ni‘ihau (2013/2016)

21° 54' N, 160° 09' W



Population: 170 (2010)

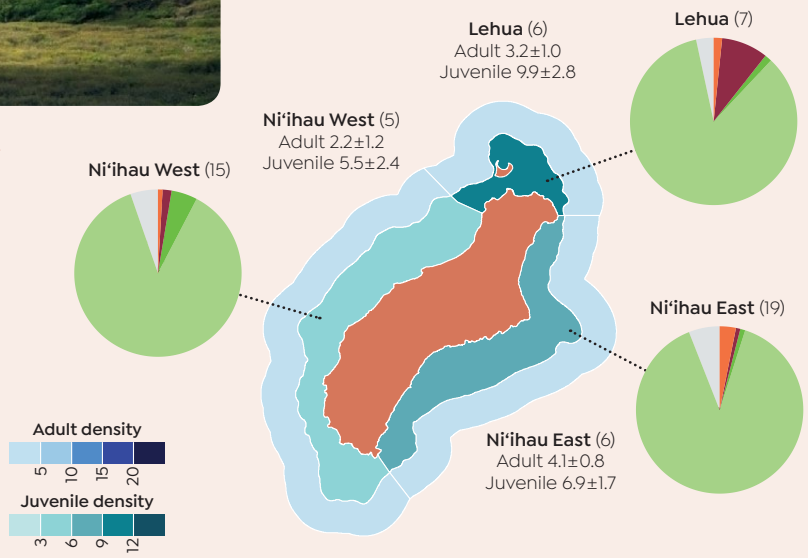
The coral reefs of Ni‘ihau were surveyed in July to September 2016.*

- Coral cover was highest in the East (3.1%) and lowest in the West (0.9%).
- Acute and chronic coral diseases and recent mortality were all <1.4% in all sectors.
- Old mortality of corals was 9.0% in Lehua and 26.3% in the West.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



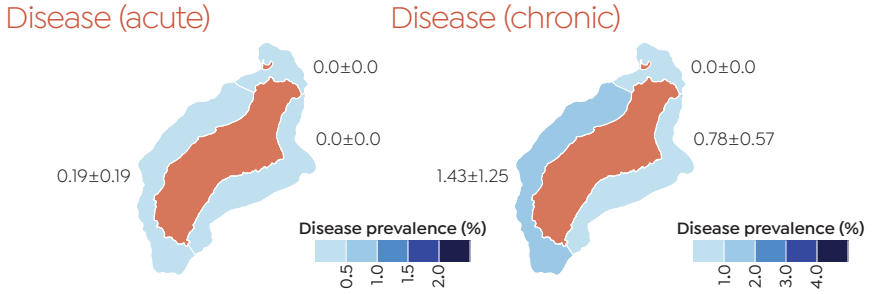
* Ni‘ihau West data are from 2016; other data from Jul to Oct 2013.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Sector (Sampling effort)

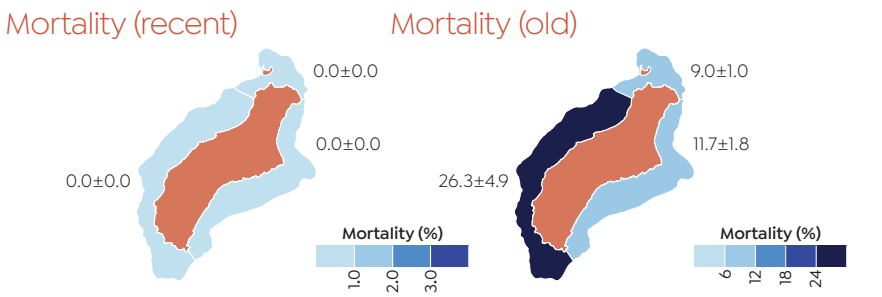
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Ni'ihau (2010-2016*)

21° 54' N, 160° 09' W

Reef fish biomass: 37.6±7.7 g/m²

100 g/m²

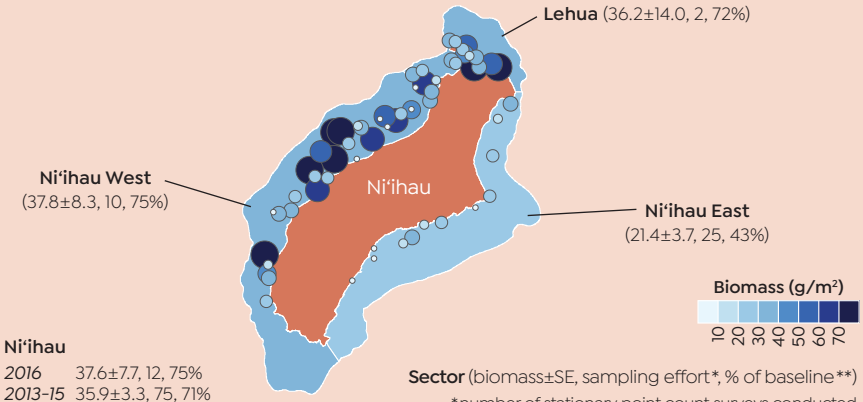
Coral reef fish surveys were conducted in 2016, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 21.4±3.7 g/m² (43% of baseline) in the East and 37.8±8.3 g/m² (75% of baseline) in the West.
- Reef fish biomass was 31.7±5.9 g/m² in 2010-2012, 35.9±3.3 g/m² in 2013-2015, and 37.6±7.7 g/m² in 2016.
- >50% of the reef fish sampled were <30 cm in length during the 2010-2012, 2013-2015, and 2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Ni'ihau

2016	37.6±7.7, 12, 75%
2013-15	35.9±3.3, 75, 71%
2010-12	31.7±5.9, 15, 63%

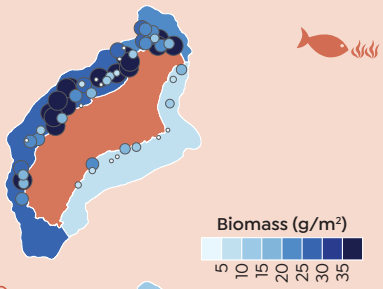
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

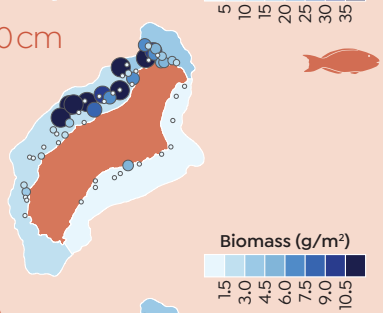
Herbivores

2016	27.3±4.8
2013-15	22.7±2.2
2010-12	18.1±3.1



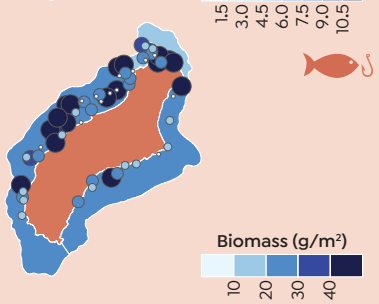
Parrotfish >30 cm

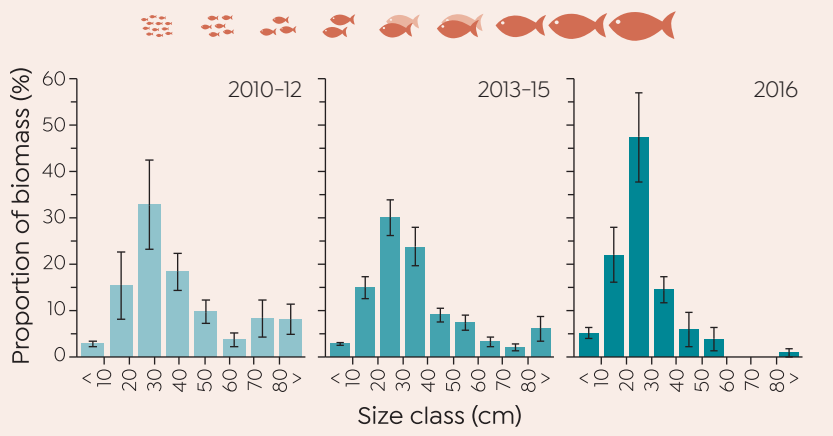
2016	2.9±1.7
2013-15	3.9±0.6
2010-12	3.1±0.8



Targeted fish

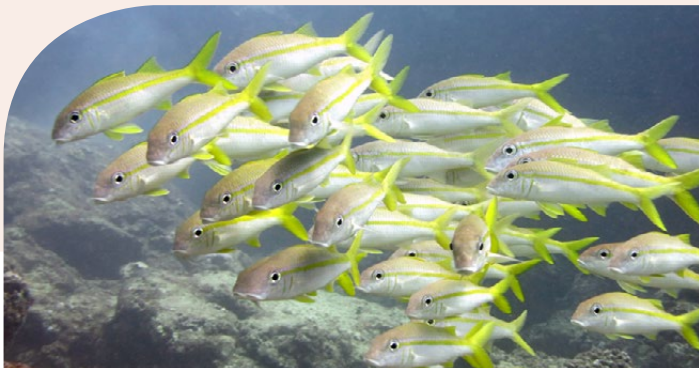
2016	20.8±5.5
2013-15	27.1±2.3
2010-12	28.1±4.3





Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



*Sector-level data for Ni'ihau East are from 2013-15.

Coral reefs – Nihoa Island (2011)

23° 04' N, 161° 55' W

Land area: 0.7 km²

0–100m depth: 432 km²

Coral reef area: Data not available

Area (km²) 0–1000 10,000

Uninhabited

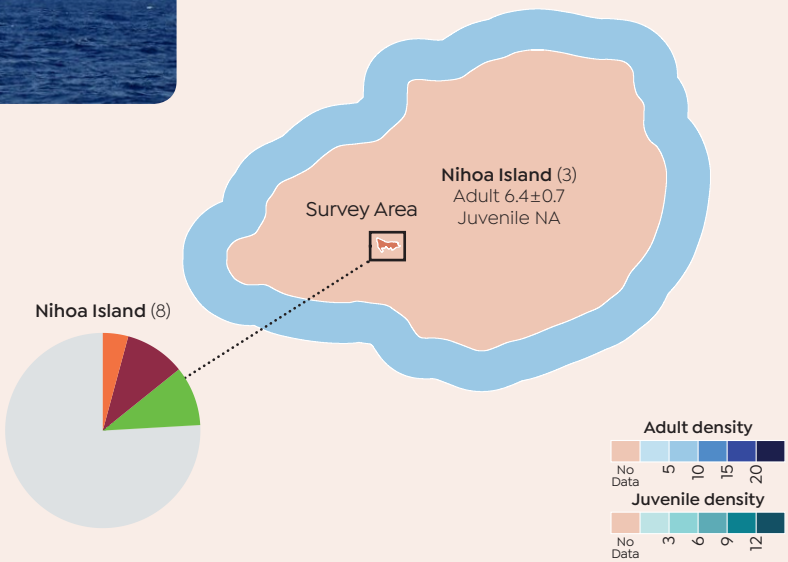
The coral reefs of Nihoa Island were surveyed in 2011–2012.

- Coral cover was 4.2 % at Nihoa Island.
- Acute coral disease and recent mortality were <0.3 %. Chronic coral disease was 1.9 %.
- Old mortality of corals was 12.2 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



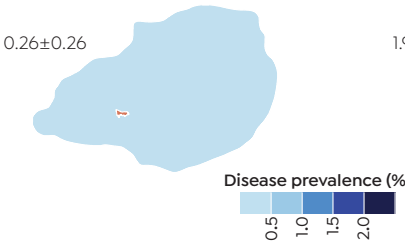
Benthic cover Hard coral CCA Macroalgae Other (inc. turf algae)

Sector (Sampling effort)

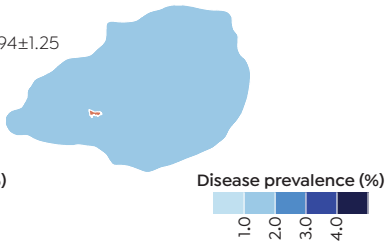
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).

Disease (acute)



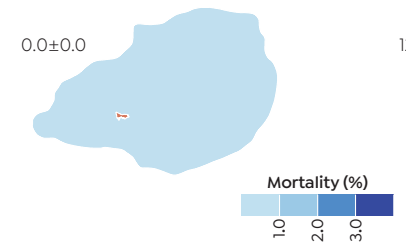
Disease (chronic)



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

Mortality (recent)



Mortality (old)

Coral reef fish – Nihoa Island (2010-2012)

23° 04' N, 161° 55' W

Reef fish biomass: 67.0±58.2 g/m²

100 g/m²

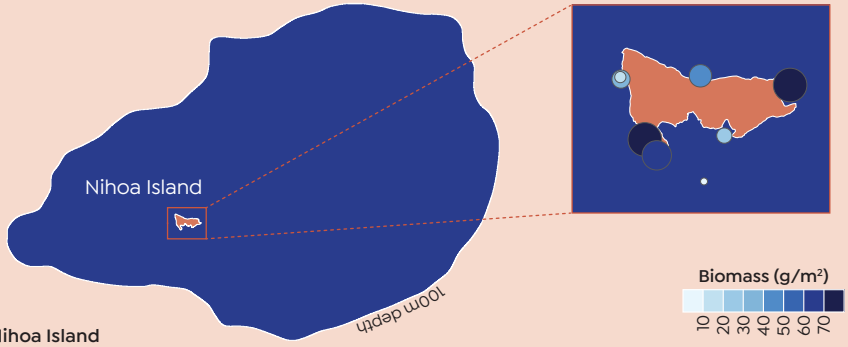
Coral reef fish surveys were conducted in 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 67.0±58.2 g/m² (117% of baseline) in Nihoa in 2010-2012.
- >50% of the reef fish sampled were >40 cm in length during the 2010-2012 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



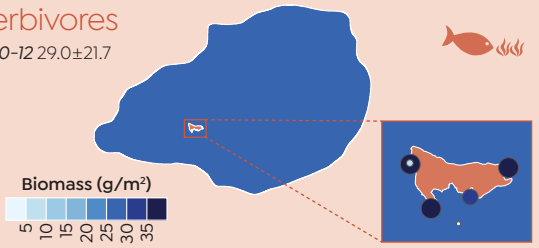
Nihoa Island
2010-12 67.0±58.2, 8, 117%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

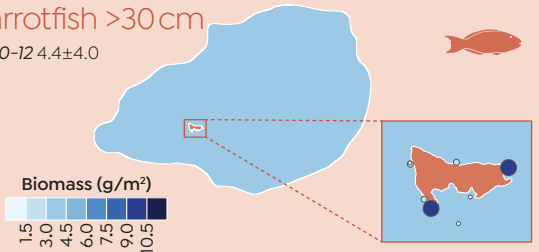
Herbivores

2010-12 29.0±21.7



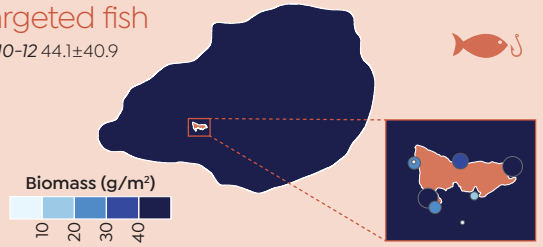
Parrotfish >30 cm

2010-12 4.4±4.0



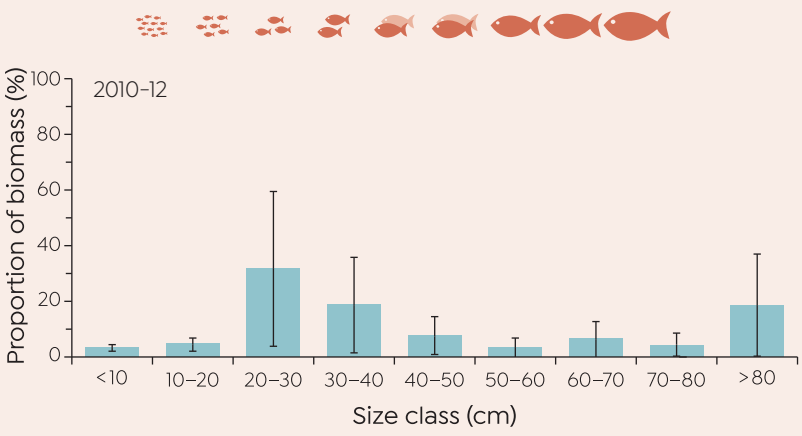
Targeted fish

2010-12 44.1±40.9



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral Reefs and Reef Fish

Coral reefs – Necker Island (2011-2012)

18° 32' N, 64° 22' W

Land area: 0.2 km²

0–100m depth: 763 km²

Coral reef area: Data not available

Area (km²) 0–1000 10,000

Uninhabited

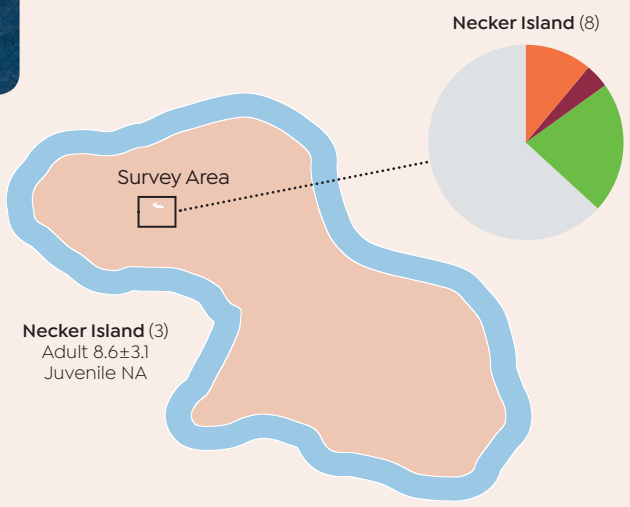
The coral reefs of Necker Island were surveyed in 2011-2012.

- Coral cover was 11.1% at Necker Island.
- Acute and chronic coral diseases and recent mortality were all absent (<0.01%).
- Old mortality of corals was 10.1%.

Benthic cover and coral density

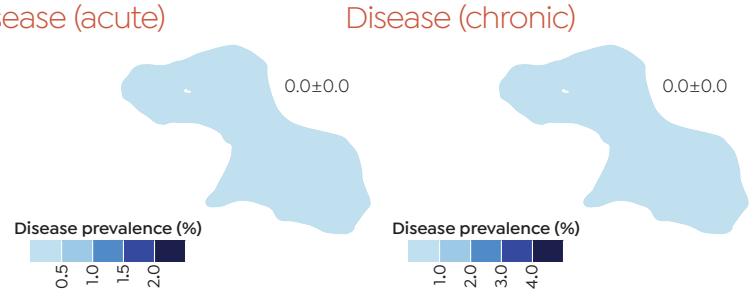
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

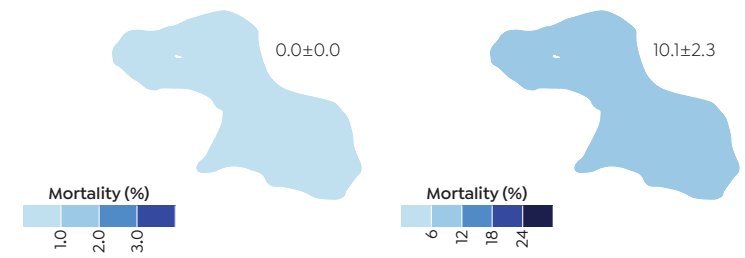


TABLE OF CONTENTS

Coral reef fish – Necker Island (2010-2012)

18° 32' N, 64° 22' W

Reef fish biomass: 45.6±22.1 g/m²

100 g/m²

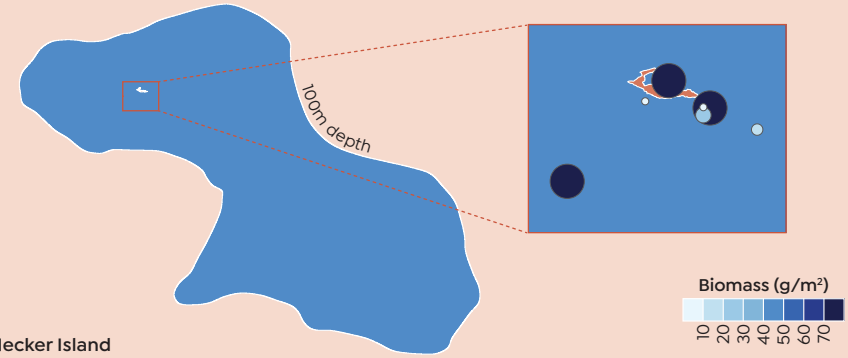
Coral reef fish surveys were conducted in 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 45.6±22.1 g/m² (86 % of baseline) in Necker Island in 2010-2012.
- >50 % of the reef fish sampled were >40 cm in length during the 2010-2012 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



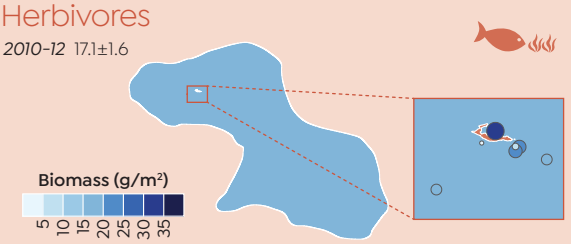
Necker Island
2010-12 45.6±22.1, 8, 86%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

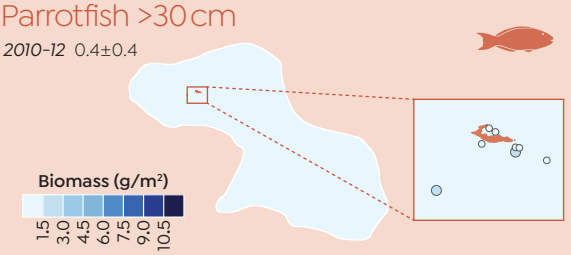
Herbivores

2010-12 17.1±1.6



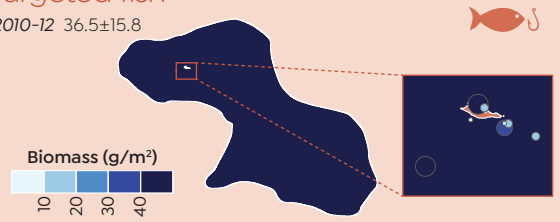
Parrotfish >30 cm

2010-12 0.4±0.4



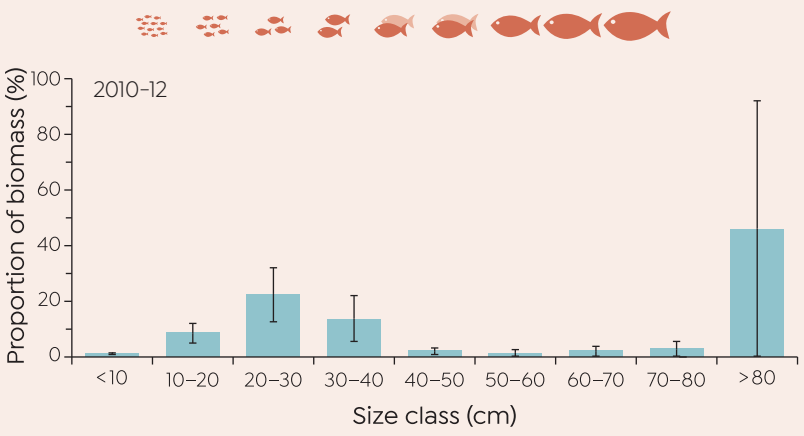
Targeted fish

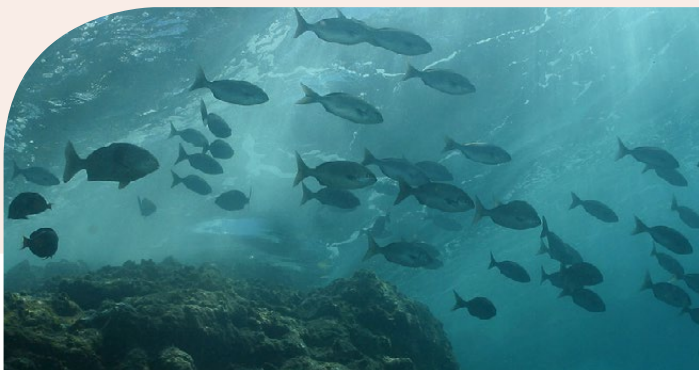
2010-12 36.5±15.8



Size class distribution

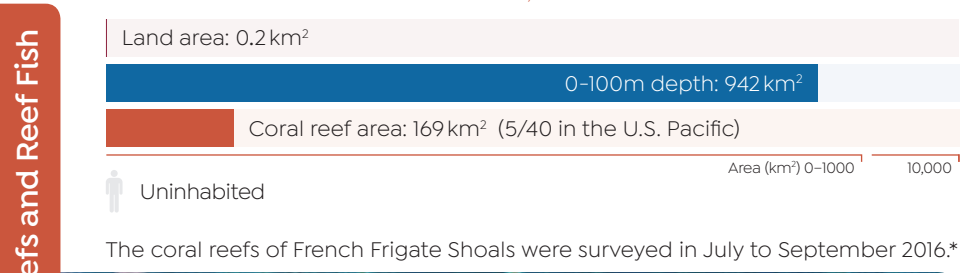
Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.





Coral reefs – French Frigate Shoals (2016)

23° 45' N, 166° 09' W



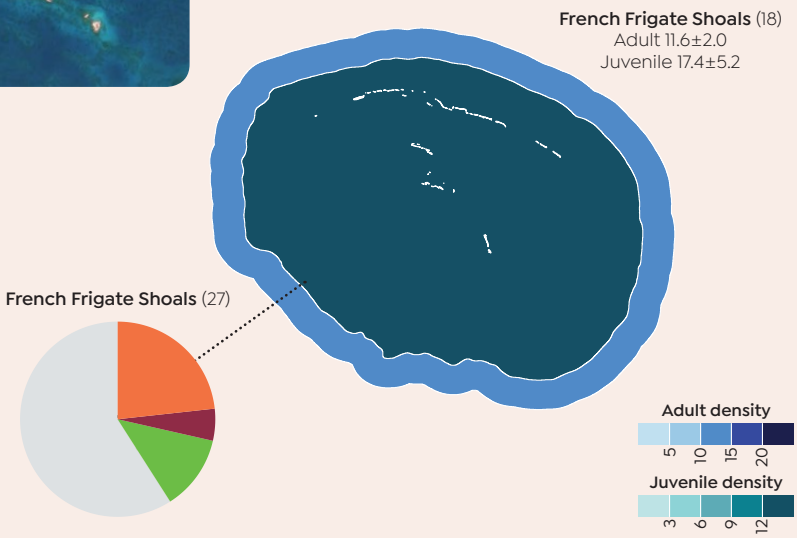
The coral reefs of French Frigate Shoals were surveyed in July to September 2016.*

- Coral cover was 23.3% at French Frigate Shoals.
- Acute and chronic coral diseases and recent mortality were all <1.7%.
- Old mortality of corals was 13.7%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

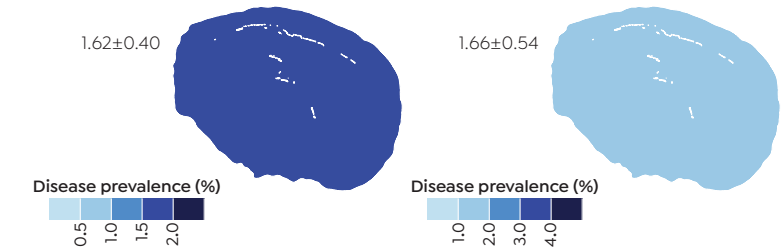


*Benthic cover data are from 2017 fish surveys.

Benthic cover: Hard coral, CCA, Macroalgae, Other (inc. turf algae)

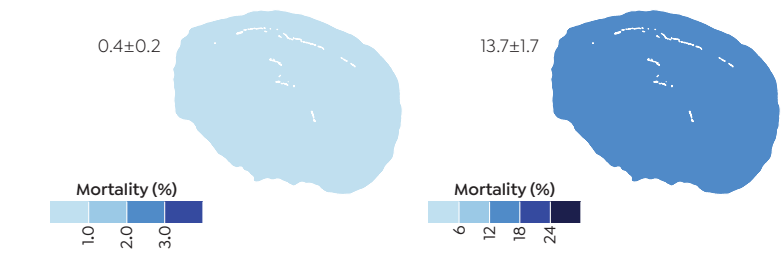
Coral disease

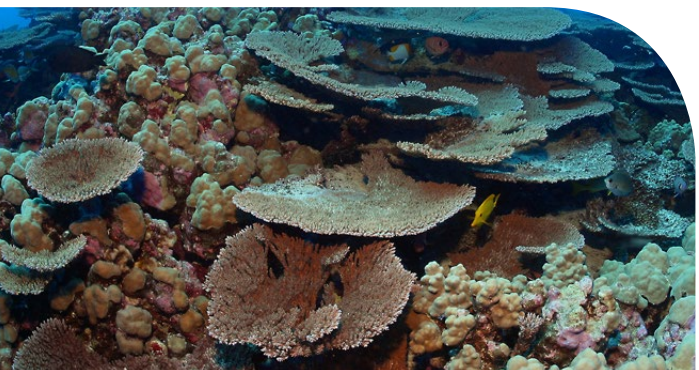
The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.





Coral reef fish – French Frigate Shoals (2010-2017)

23° 45' N, 166° 09' W

Reef fish biomass: 31.4±3.6 g/m²

100 g/m²

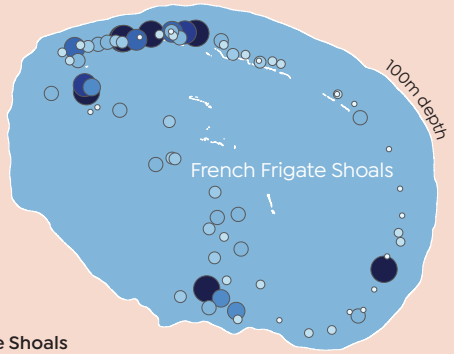
Coral reef fish surveys were conducted in 2016-17, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 38.8±5.0 g/m² in 2010-2012, 38.6±13.7 g/m² in 2013-2015, and 31.4±3.6 g/m² in 2016-2017.
- >50 % of the reef fish sampled were >60 cm in length during the 2010-2012, 2013-2015, and 2016-2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

French Frigate Shoals

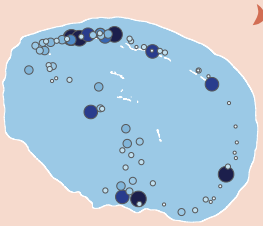
2016-17 31.4±3.6, 68, 59%
2013-15 38.6±13.7, 31, 75%
2010-12 38.8±5.0, 35, 72%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

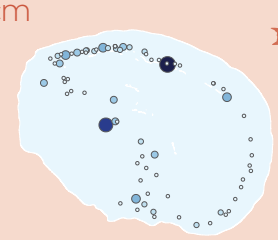
2016-17 13.7±1.6
2013-15 12.2±2.1
2010-12 12.7±1.5



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

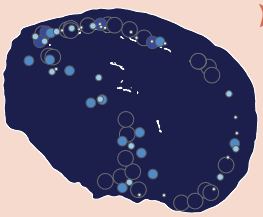
2016-17 1.3±0.4
2013-15 1.6±0.7
2010-12 1.6±0.5



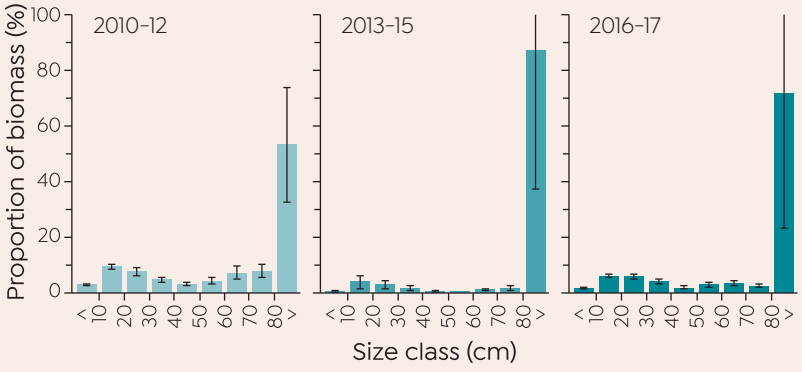
Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

2016-17 57.4±10.7
2013-15 157.6±68.0
2010-12 65.9±13.3



Biomass (g/m²)
10 20 30 40



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral reefs – Gardner Pinnacles (2011-2012)

25° 00' N, 168° 00' W

Land area: 0.02 km²

0–100m depth: 2448 km²

Coral reef area: Data not available

Area (km²) 0–1000 10,000

Uninhabited

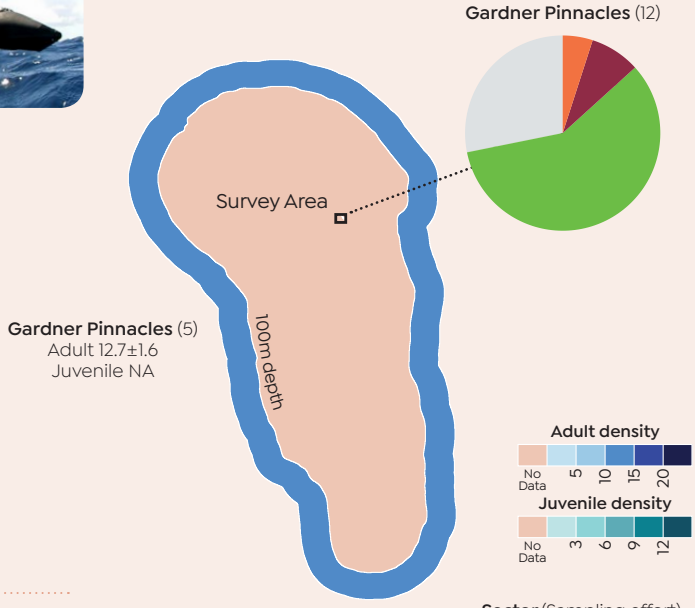
The coral reefs of Gardner Pinnacles were surveyed in 2011-2012.

- Coral cover was 5.0 % at Gardner Pinnacles.
- Acute and chronic coral diseases and recent mortality were all <0.25 %.
- Old mortality of corals was 5.2 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

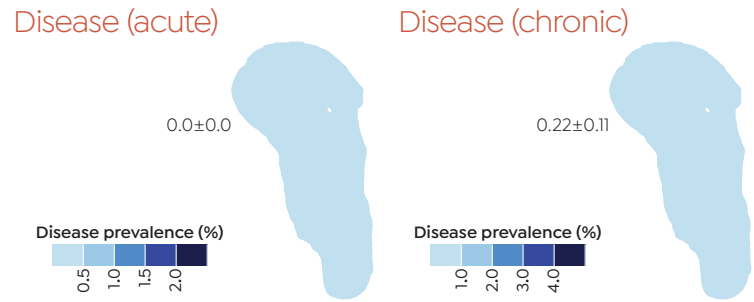
Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



Benthic cover Hard coral CCA Macroalgae Other (inc. turf algae)

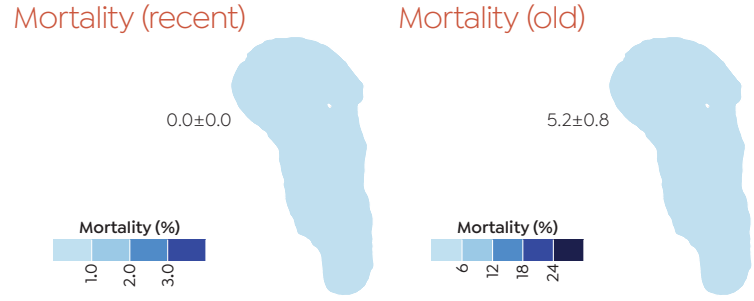
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Gardner Pinnacles (2010-2012)

25° 00' N, 168° 00' W

Reef fish biomass: 14.6±3.4 g/m²

100 g/m²

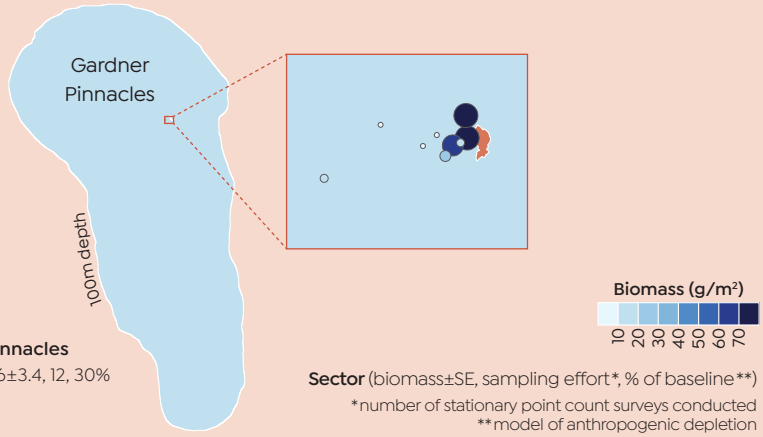
Coral reef fish surveys were conducted in 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 14.6±3.4 g/m² in 2010-2012.
- >60 % of the reef fish sampled were >80 cm in length during the 2010-2012 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.

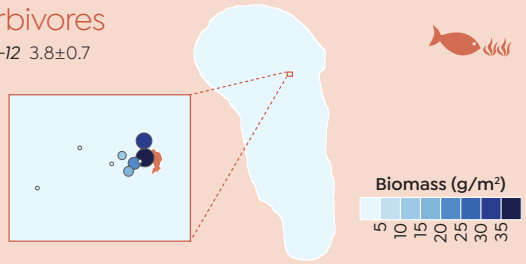


Gardner Pinnacles
2010-12 14.6±3.4, 12, 30%

Sector (biomass±SE, sampling effort*, % of baseline**)
*number of stationary point count surveys conducted
**model of anthropogenic depletion

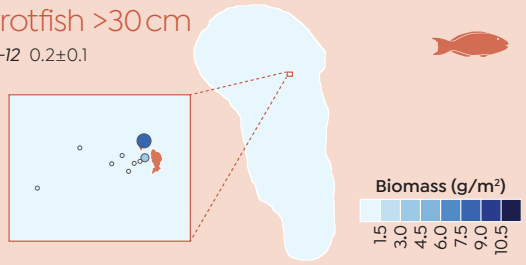
Herbivores

2010-12 3.8±0.7



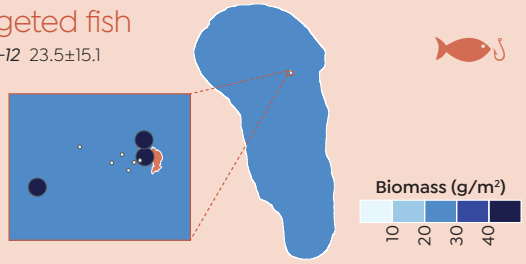
Parrotfish >30 cm

2010-12 0.2±0.1



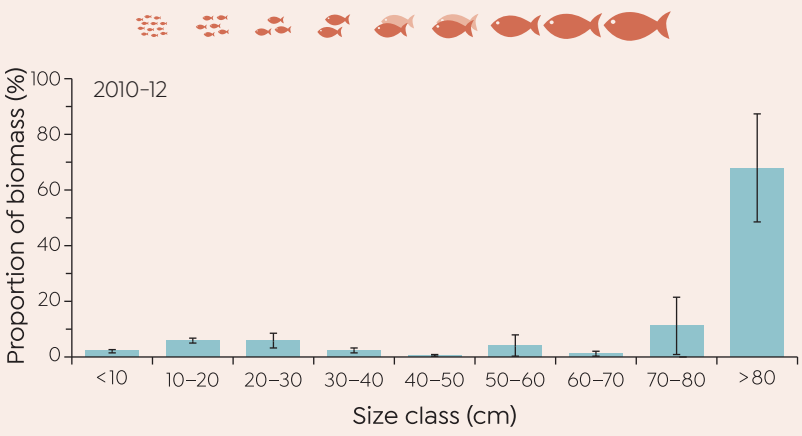
Targeted fish

2010-12 23.5±15.1



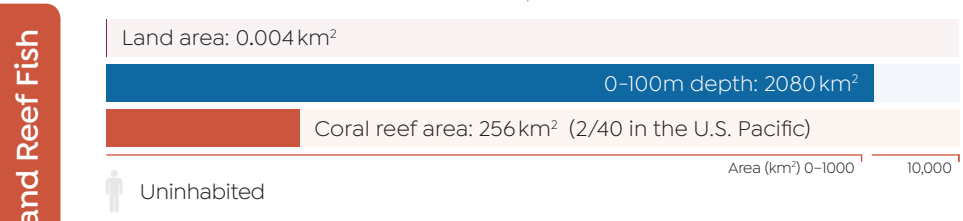
Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Maro Reef (2014-2015)

25° 25' N, 170° 35' W



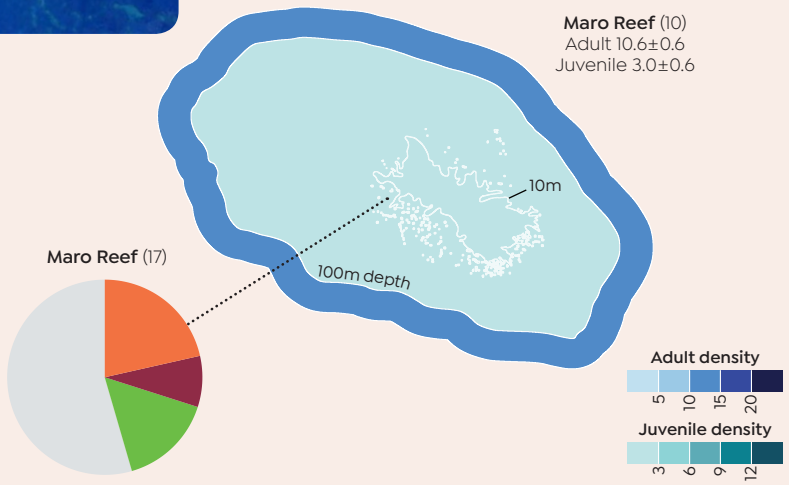
The coral reefs of Maro Reef were surveyed in 2014-2015

- Coral cover was 21.5 % at Maro Reef.
- Acute coral disease prevalence was 3.2 % and chronic coral disease prevalence was 15.9 %.
- Recent mortality prevalence was 4.4 % and old mortality was 3.6 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

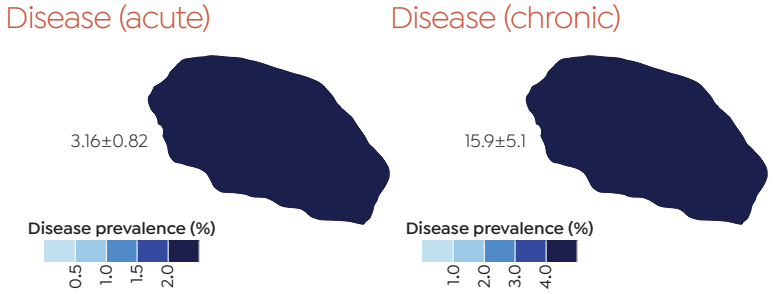


Benthic cover: Hard coral, CCA, Macroalgae, Other (inc. turf algae)

Sector (Sampling effort)

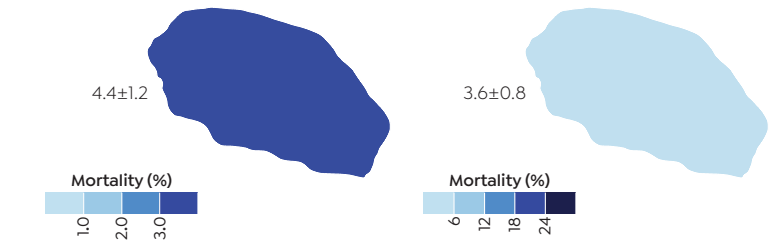
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Maro Reef (2010-2015)

25° 25' N, 170° 35' W

Reef fish biomass: 46.1±9.4 g/m²

100 g/m²

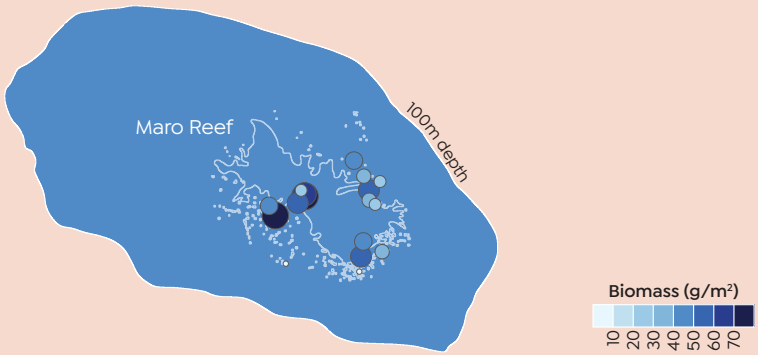
Coral reef fish surveys were conducted in 2013-15 and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 42.4±7.5 g/m² in 2010-2012 and 46.1±9.4 g/m² in 2013-2015.
- >50 % of the reef fish sampled were >60 cm in length during the 2010-2012 and 2013-2015 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



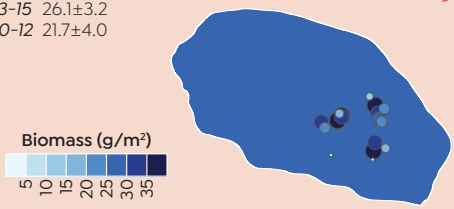
Maro Reef
2013-15 46.1±9.4, 17, 80%
2010-12 42.4±7.5, 21, 71%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

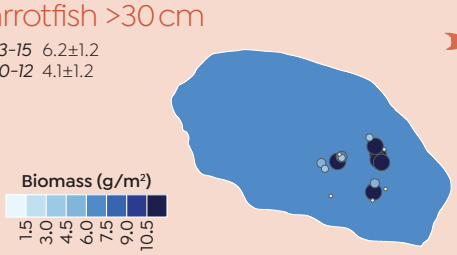
Herbivores

2013-15 26.1±3.2
2010-12 21.7±4.0



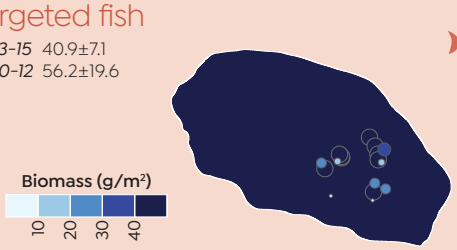
Parrotfish >30 cm

2013-15 6.2±1.2
2010-12 4.1±1.2



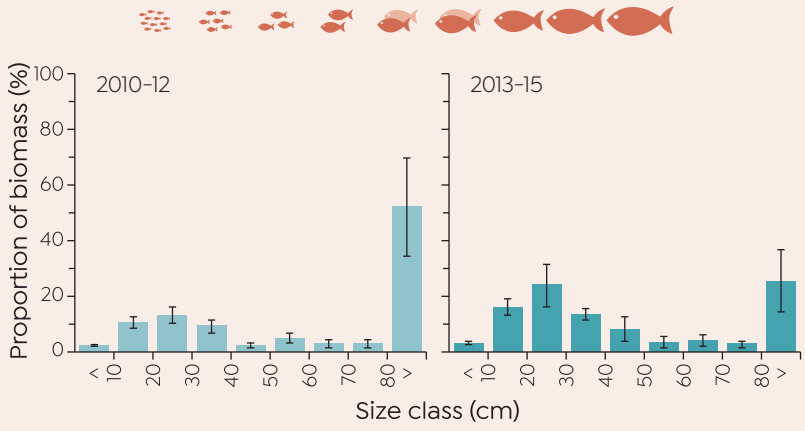
Targeted fish

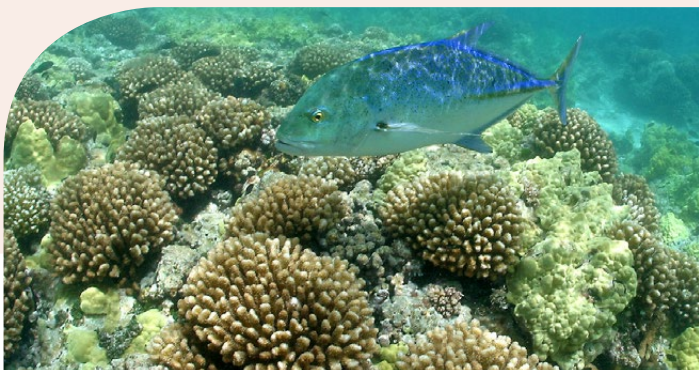
2013-15 40.9±7.1
2010-12 56.2±19.6



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.





‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral reefs – Laysan Island (2016)

25° 46' N, 171° 44' W

Land area: 4.1 km²

0–100m depth: 419 km²

Coral reef area: 34.0 km² (15/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

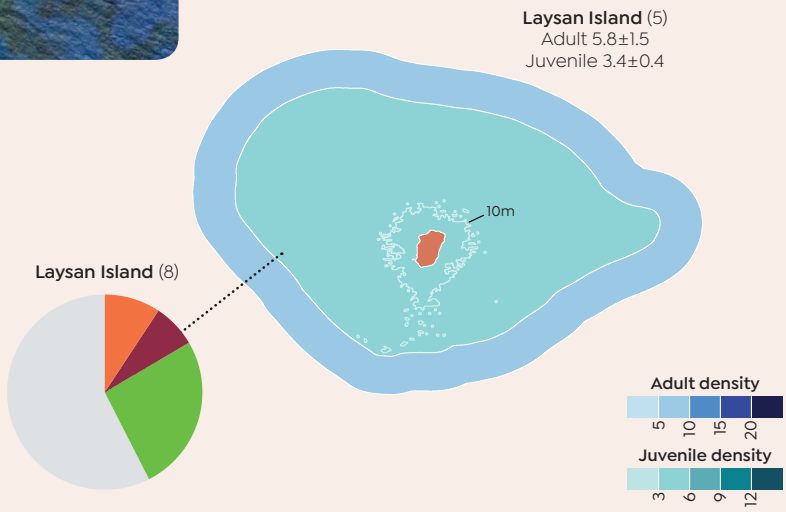
The coral reefs of Laysan Island were surveyed in July to September 2016.*

- Coral cover was 9.3% at Laysan Island.
- Acute coral disease prevalence was 1.5% and chronic coral disease prevalence was 4.3%.
- Recent mortality prevalence was 2.9% and old mortality was 2.2%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

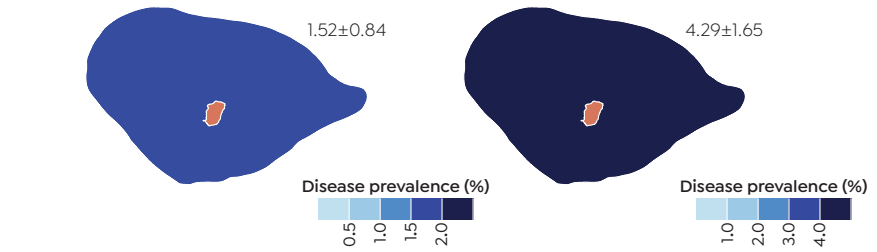


*Benthic cover data are from 2017 fish surveys.

Benthic cover: Hard coral, CCA, Macroalgae, Other (inc. turf algae)

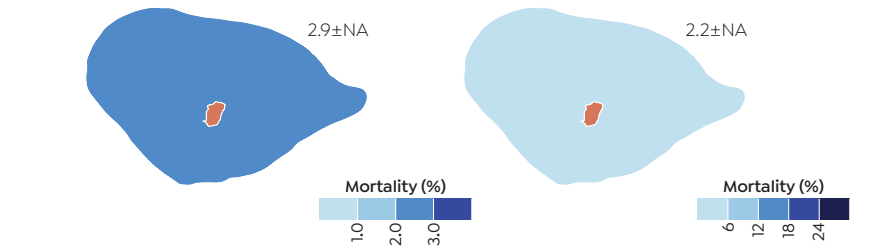
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Laysan Island (2010-2017)

25° 46' N, 171° 44' W

Reef fish biomass: 8.7±1.5 g/m²

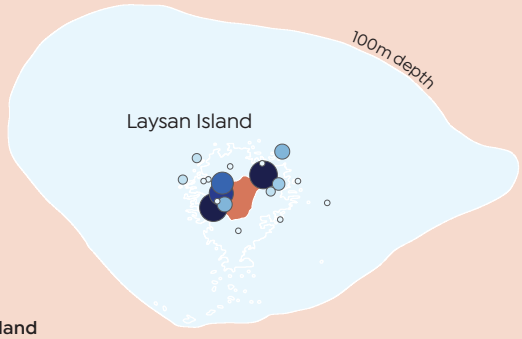
Coral reef fish surveys were conducted in 2016-17, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 35.6±6.9 g/m² in 2010-2012, 34.2±13.1 g/m² in 2013-2015, and 8.7±1.5 g/m² in 2016-2017.
- >50 % of the reef fish sampled were >60 cm in length during the 2010-2012, 2013-2015, and 2016-2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



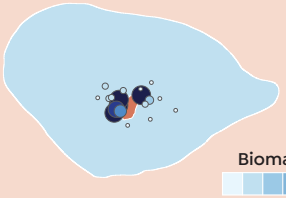
Biomass (g/m²)
10 20 30 40 50 60 70

Laysan Island
2016-17 8.7±1.5, 11, 23%
2013-15 34.2±13.1, 8, 87%
2010-12 35.6±6.9, 23, 90%

Sector (biomass±SE, sampling effort*, % of baseline**)
*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

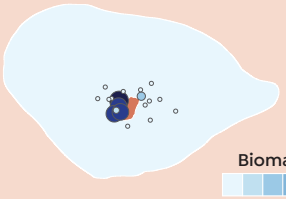
2016-17 7.3±2.5
2013-15 14.6±6.5
2010-12 14.8±3.6



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

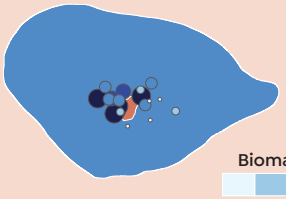
2016-17 0.7±0.1
2013-15 1.8±1.4
2010-12 2.3±0.8



Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

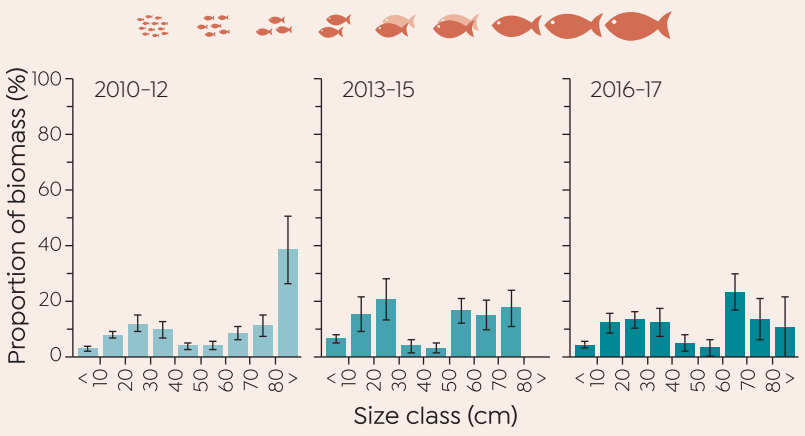
2016-17 23.1±8.3
2013-15 34.2±8.3
2010-12 54.8±9.9



Biomass (g/m²)
10 20 30 40

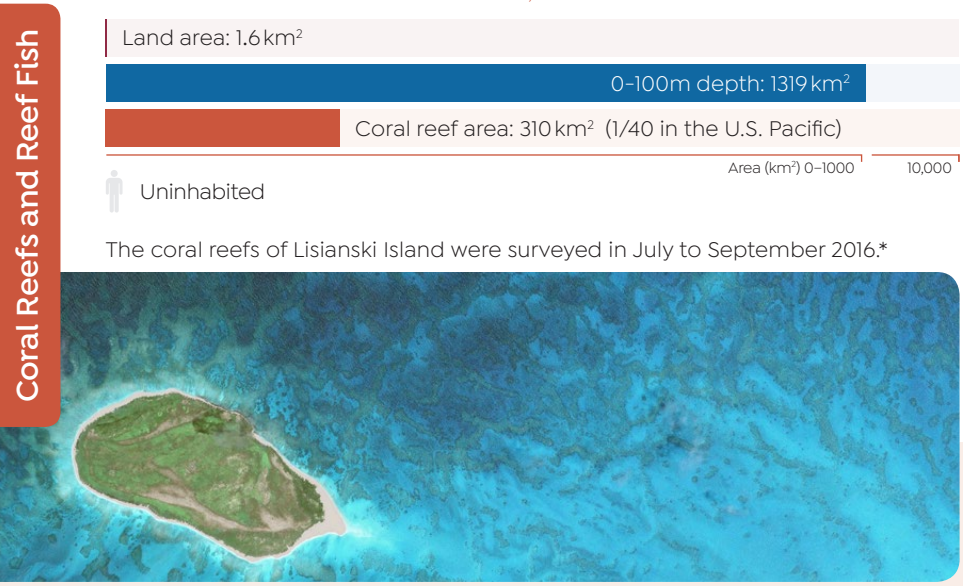
Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Lisianski Island (2016)

26° 04' N, 173° 58' W



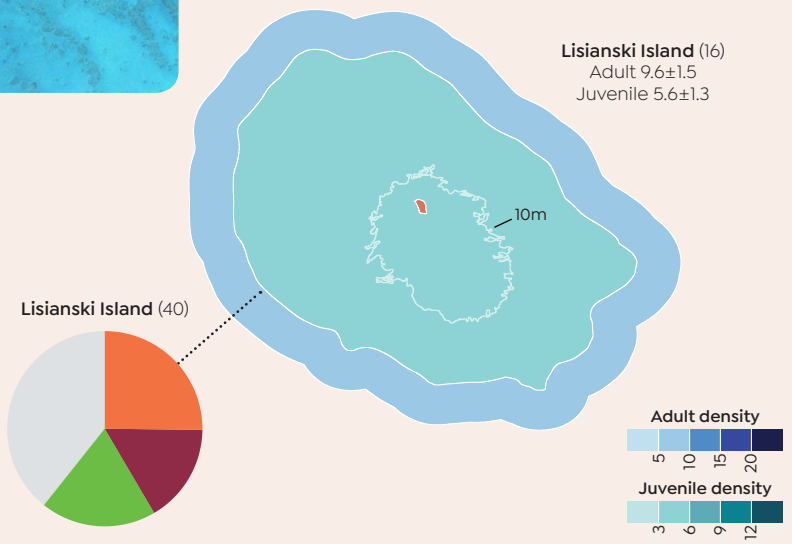
The coral reefs of Lisianski Island were surveyed in July to September 2016.*

- Coral cover was 25.2% at Lisianski Island.
- Acute coral disease prevalence was 2.3% and chronic coral disease prevalence was 3.1%.
- Recent mortality prevalence was 0.6% and old mortality was 15.9%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

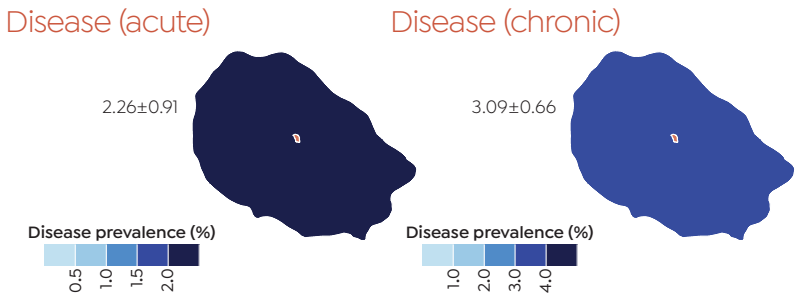


*Benthic cover data are from 2017 fish surveys.

Benthic cover ■ Hard coral ■ CCA ■ Macroalgae ■ Other (inc. turf algae)

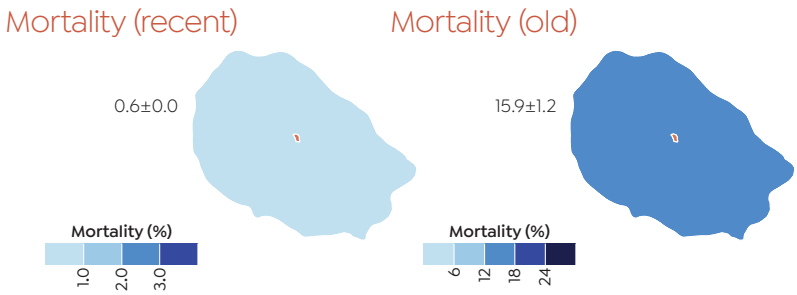
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Lisianski Island (2010-2017)

26° 04' N, 173° 58' W

Reef fish biomass: 24.3±2.8 g/m²

100 g/m²

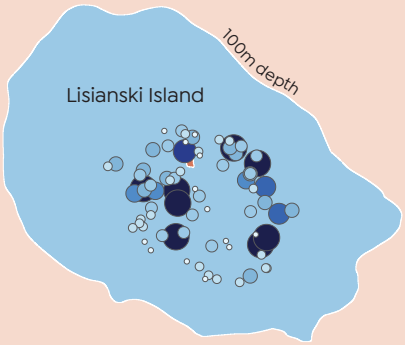
Coral reef fish surveys were conducted in 2016-17, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 41.4±4.4 g/m² in 2010-2012, 28.3±3.1 g/m² in 2013-2015, and 24.3±2.8 g/m² in 2016-2017.
- >50 % of the reef fish sampled were >60 cm in length during the 2010-2012, 2013-2015, and 2016-2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

Lisianski Island
2016-17 24.3±2.8, 57, 56%
2013-15 28.3±3.1, 46, 65%
2010-12 41.4±4.4, 59, 93%

Sector (biomass±SE, sampling effort*, % of baseline**)
*number of stationary point count surveys conducted
**model of anthropogenic depletion

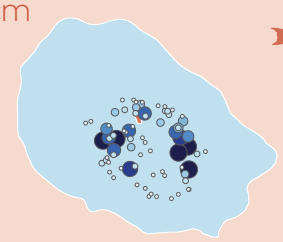
Herbivores

2016-17 16.1±2.2
2013-15 18.8±2.1
2010-12 19.9±1.9

Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

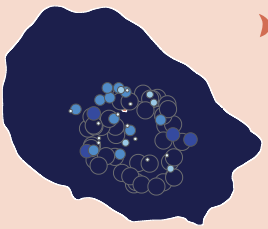
2016-17 2.6±0.6
2013-15 2.4±0.5
2010-12 4.8±0.8



Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

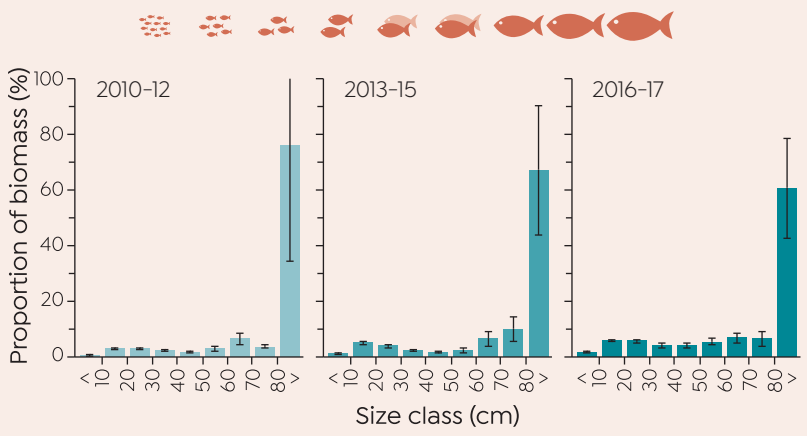
2016-17 91.0±13.8
2013-15 137.2±23.0
2010-12 142.6±22.0



Biomass (g/m²)
10 20 30 40

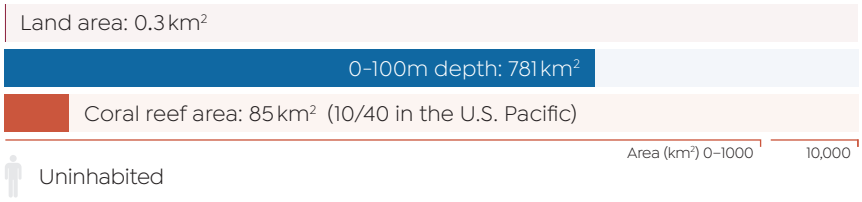
Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

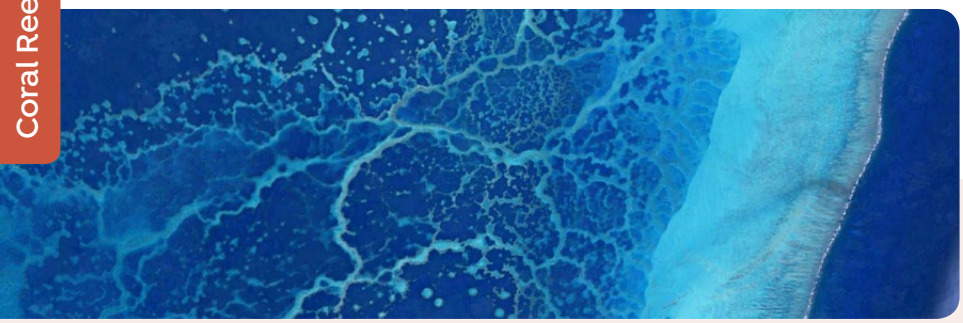


Coral reefs – Pearl and Hermes Atoll (2016)

27° 50' N, 175° 50' W



The coral reefs of Pearl and Hermes Atoll were surveyed in July to September 2016.

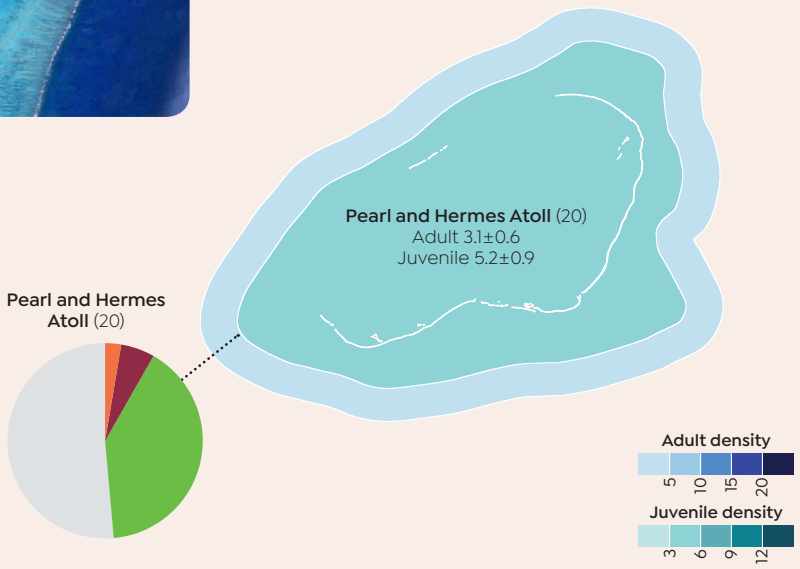


- Coral cover was 2.7% at Pearl and Hermes Atoll.
- Acute coral disease prevalence was 3.5% and chronic coral disease prevalence was 2.2%.
- Recent mortality prevalence was 1.9% and old mortality was 15.5%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

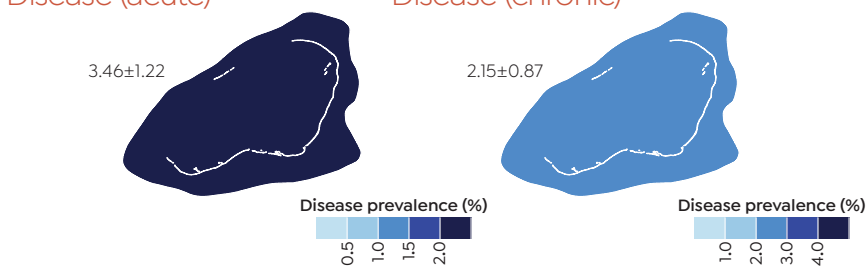


*Benthic cover data are from 2017 fish surveys.

Benthic cover: Hard coral, CCA, Macroalgae, Other (inc. turf algae)

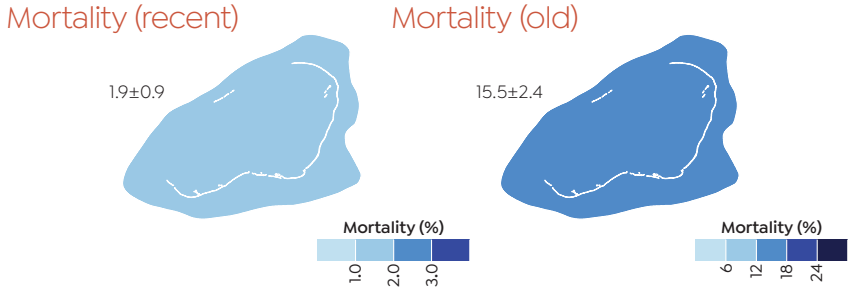
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Pearl and Hermes Atoll (2010-2017)

27° 50' N, 175° 50' W

Reef fish biomass: 31.4±3.0 g/m²

100 g/m²

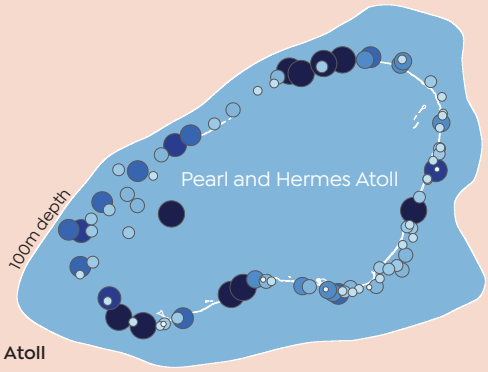
Coral reef fish surveys were conducted in 2016-17, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 30.5±2.9 g/m² in 2010-2012, 54.9±9.4 g/m² in 2013-2015, and 31.4±3.0 g/m² in 2016-2017.
- >50 % of the reef fish sampled were >60 cm in length during the 2010-2012, 2013-2015, and 2016-2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Pearl and Hermes Atoll

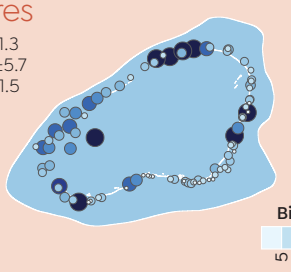
2016-17 31.4±3.0, 71, 67%
2013-15 54.9±9.4, 21, 117%
2010-12 30.5±2.9, 48, 65%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

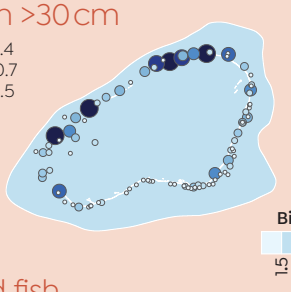
Herbivores

2016-17 12.5±1.3
2013-15 26.6±5.7
2010-12 14.6±1.5



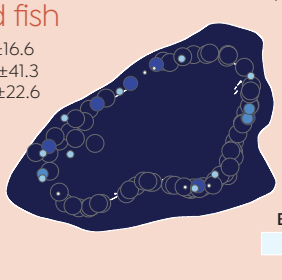
Parrotfish >30 cm

2016-17 2.1±0.4
2013-15 2.5±0.7
2010-12 3.1±0.5



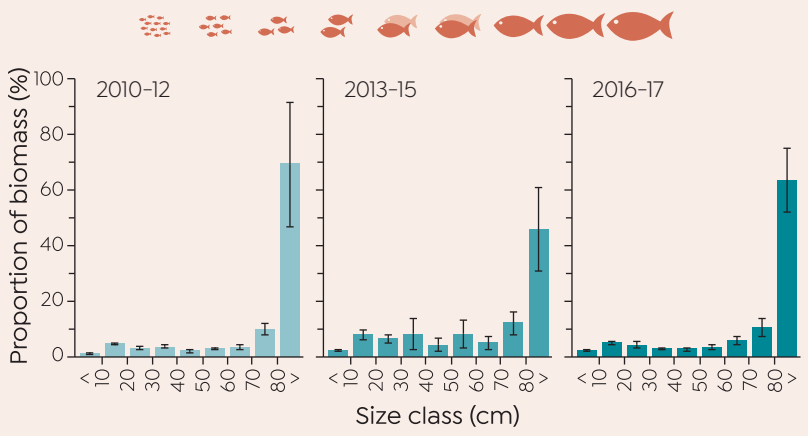
Targeted fish

2016-17 142.1±16.6
2013-15 186.7±41.3
2010-12 137.4±22.6



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral reefs – Midway Atoll (2014-2015)

28° 12' N, 177° 22' W

Land area: 6.2 km²

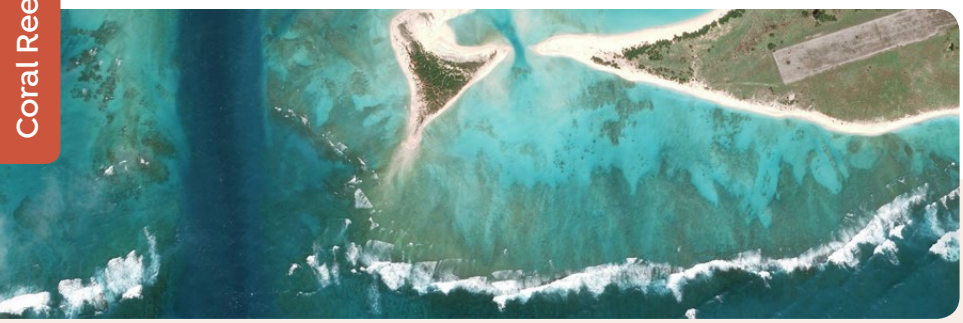
0–100m depth: 386 km²

Coral reef area: 32.9 km² (16/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: approx. 40 (2018)

The coral reefs of Midway Atoll were surveyed in 2014-2015.*

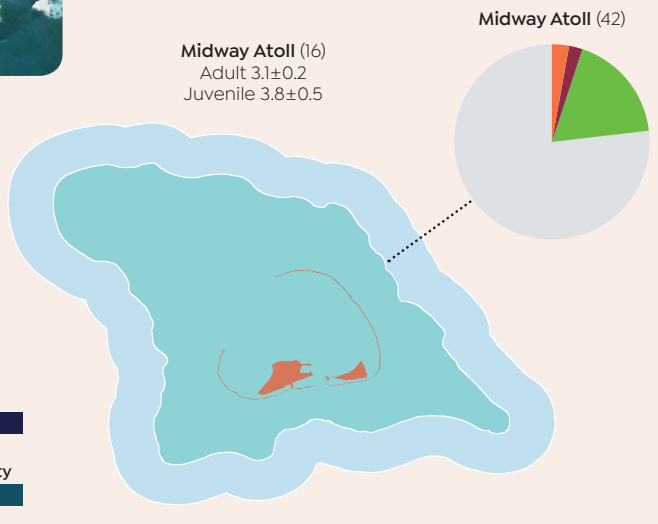


- Coral cover was 2.9 % at Midway Atoll.
- Acute coral disease prevalence was 5.0 % and chronic coral disease prevalence was 8.8 %.
- Recent mortality prevalence was 1.8 % and old mortality was 6.0 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

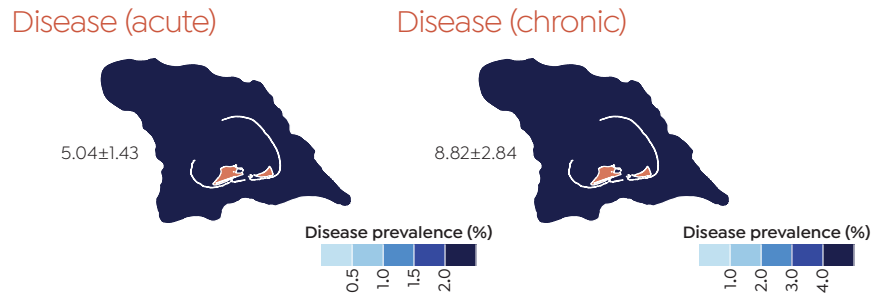


*Benthic cover data are from 2017 fish surveys.

Benthic cover: Hard coral, CCA, Macroalgae, Other (inc. turf algae)

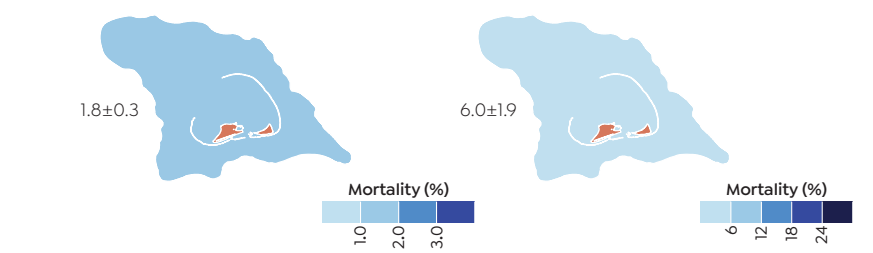
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Midway Atoll (2010-2017)

28° 12' N, 177° 22' W

Reef fish biomass: 43.2±9.7 g/m²

100 g/m²

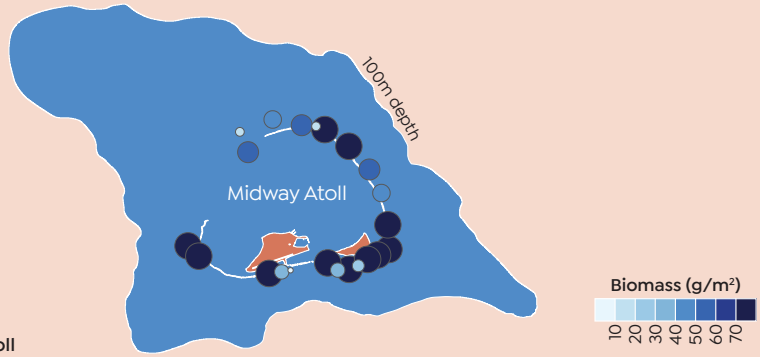
Coral reef fish surveys were conducted in 2016-17, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 60.3±9.3 g/m² in 2010-2012, 68.6±5.5 g/m² in 2013-2015, and 43.2±9.7 g/m² in 2016-2017.
- >50 % of the reef fish sampled were >60 cm in length during the 2010-2012, 2013-2015, and 2016-2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Midway Atoll

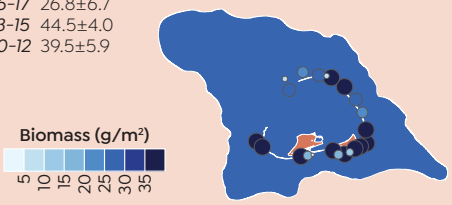
2016-17 43.2±9.7, 10, 77%
2013-15 68.6±5.5, 42, 125%
2010-12 60.3±9.3, 17, 109%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

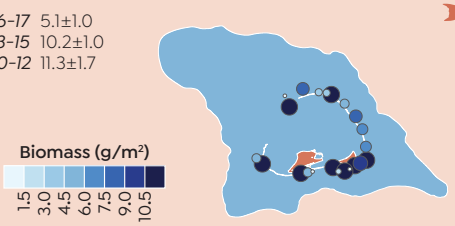
Herbivores

2016-17 26.8±6.7
2013-15 44.5±4.0
2010-12 39.5±5.9



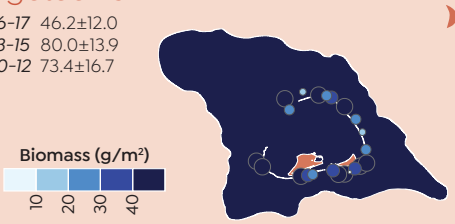
Parrotfish >30 cm

2016-17 5.1±1.0
2013-15 10.2±1.0
2010-12 11.3±1.7



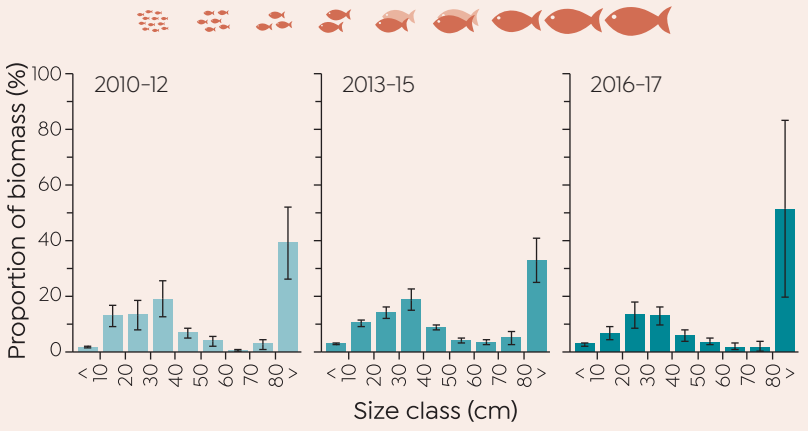
Targeted fish

2016-17 46.2±12.0
2013-15 80.0±13.9
2010-12 73.4±16.7



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral reefs – Kure Atoll (2016)

28° 24' N, 178° 18' W

Land area: 0.9 km²

0–100m depth: 93.1 km²

Coral reef area: 24.4 km² (19/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

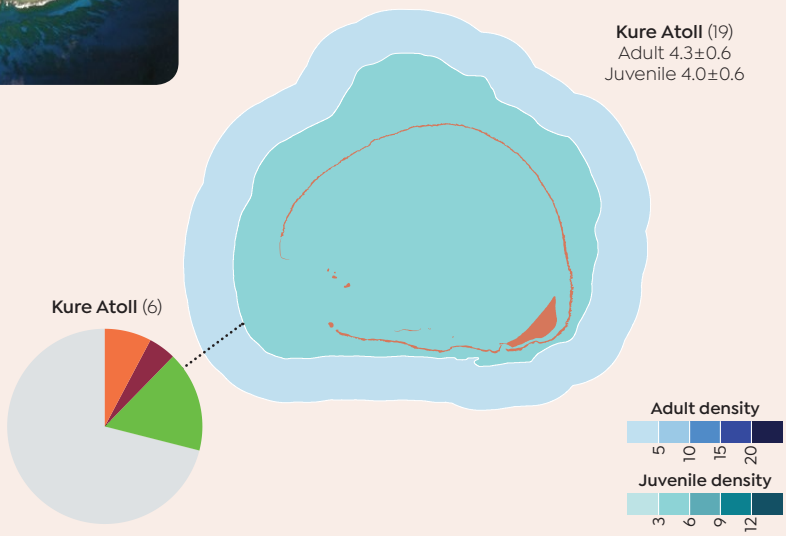
The coral reefs of Kure Atoll were surveyed in July to September 2016.*

- Coral cover was 7.8 % at Kure Atoll.
- Acute coral disease prevalence was 1.3 % and chronic coral disease prevalence was 2.7 %.
- Recent mortality prevalence was 1.0 % and old mortality was 10.1 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

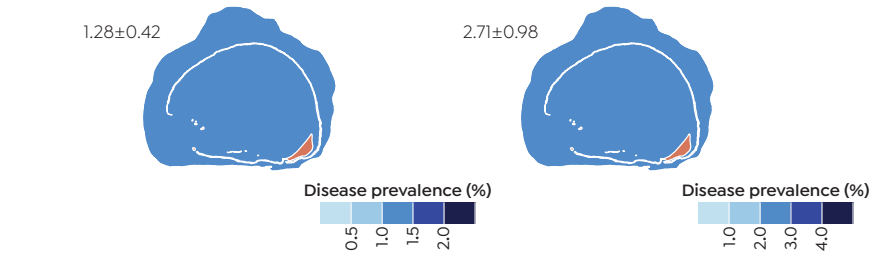


* Benthic cover data are from 2017 fish surveys.

Benthic cover: Hard coral, CCA, Macroalgae, Other (inc. turf algae)

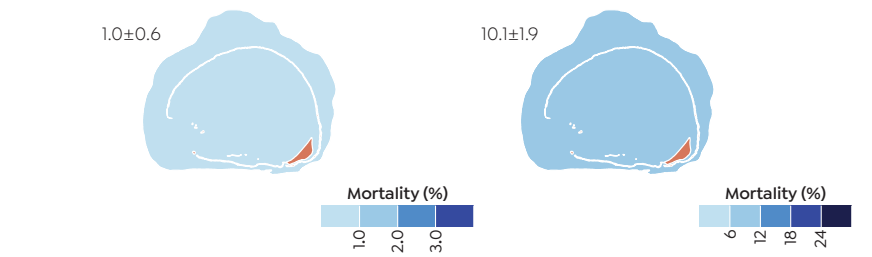
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Kure Atoll (2010-2017)

28° 24' N, 178° 18' W

Reef fish biomass: 29.7±3.1 g/m²

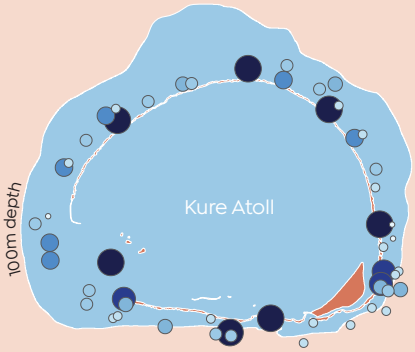
Coral reef fish surveys were conducted in 2016-17, 2013-15, and 2010-12.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 39.7±4.8 g/m² in 2010-2012, 60.4±7.5 g/m² in 2013-2015, and 29.7±3.1 g/m² in 2016-2017.
- >50 % of the reef fish sampled were >60 cm in length during the 2010-2012, 2013-2015, and 2016-2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Kure Atoll

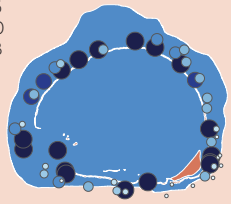
2016-17 29.7±3.1, 45, 65%
2013-15 60.4±7.5, 8, 134%
2010-12 39.7±4.8, 30, 87%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

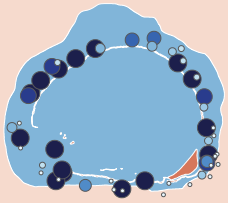
Herbivores

2016-17 21.3±2.5
2013-15 44.1±5.0
2010-12 21.4±2.8



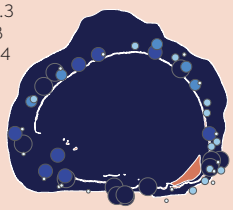
Parrotfish >30 cm

2016-17 5.6±0.9
2013-15 8.2±1.4
2010-12 7.0±1.0



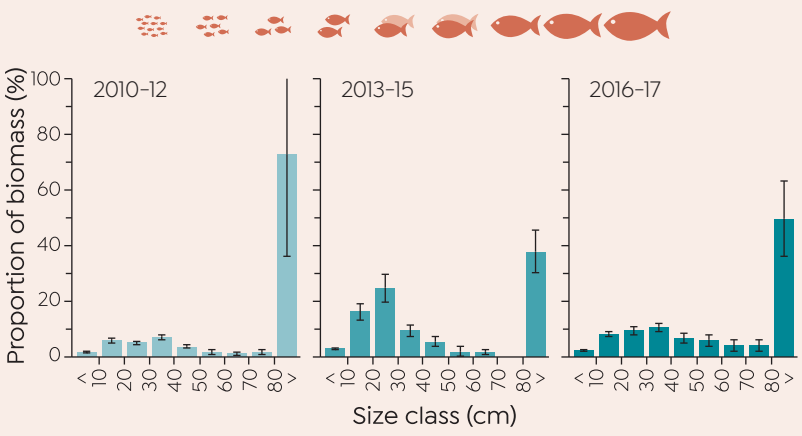
Targeted fish

2016-17 46.3±14.3
2013-15 21.3±5.8
2010-12 49.9±12.4



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



‡ Backreef and lagoon data were removed prior to calculating the sector level values.

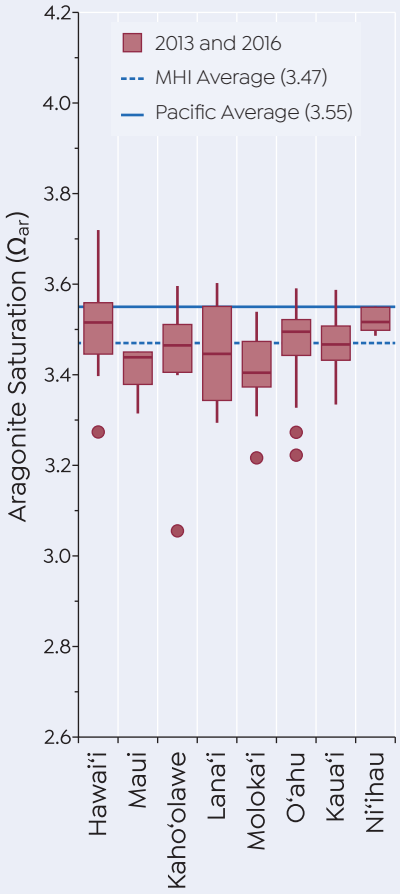
A rainbow frames the NOAA Ship Hiʻialakai as a small boat is hoisted aboard.

Ocean Chemistry and Temperature

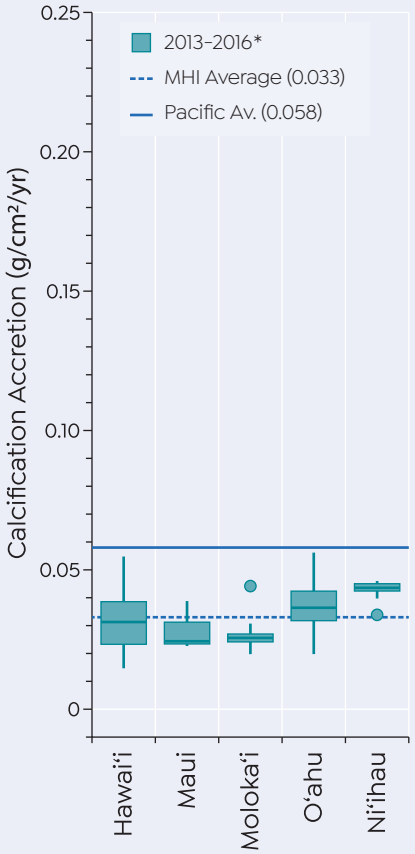
Chemistry (2012–2016)

This section represents the first Main Hawaiian Islands (MHI) NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the Ecosystem Sciences Division of the NOAA Pacific Islands Fisheries Science Center and the NOAA Coral Reef Watch program.

Aragonite saturation state



Calcium carbonate accretion



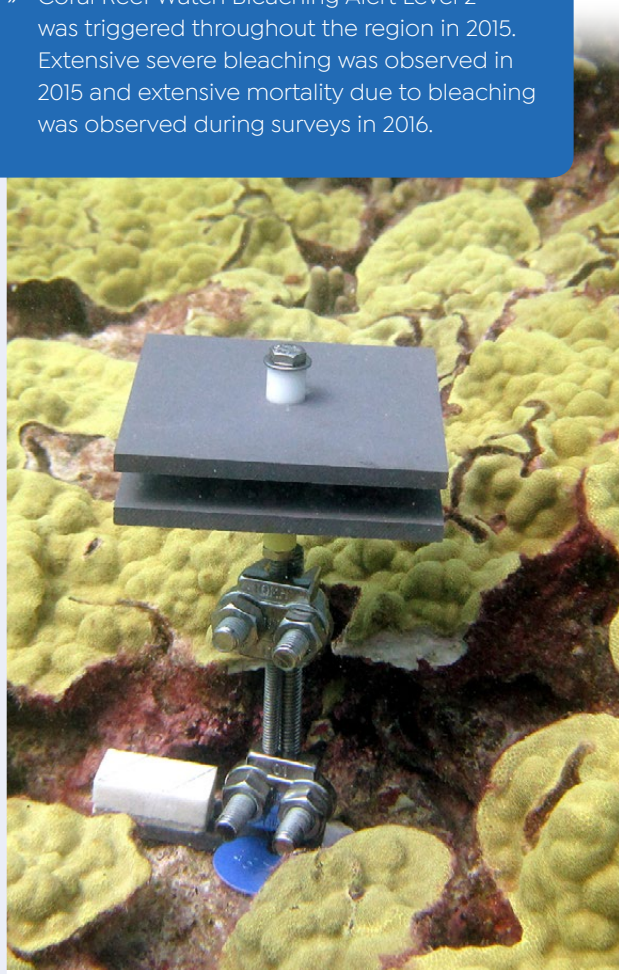
Aragonite saturation state measures carbonate ion concentration; the greater the concentration of carbonate ions is, the easier it is for organisms like stony corals to calcify. Aragonite saturation state was below the Pacific average throughout the MHI. Aragonite saturation state can be seen as an exposure term – i.e., exposure of calcifying organisms to the conditions that drive calcification.

Calcification Accretion Units measure the response of calcifying organisms to those conditions as the net accretion of calcium carbonate produced over the deployment period (see photos to right). Calcium carbonate accretion was lower than the Pacific average throughout the MHI.

*O'ahu calcium carbonate accretion data are from 2012-2016

Highlights

- Calcium carbonate accretion in the MHI was below the US Pacific average at all islands.
- Bias-corrected subsurface temperature data reveals that depths >20 m did not provide a refuge for corals from heat stress during the 2015 bleaching event.
- Coral Reef Watch Bleaching Alert Level 2 was triggered throughout the region in 2015. Extensive severe bleaching was observed in 2015 and extensive mortality due to bleaching was observed during surveys in 2016.



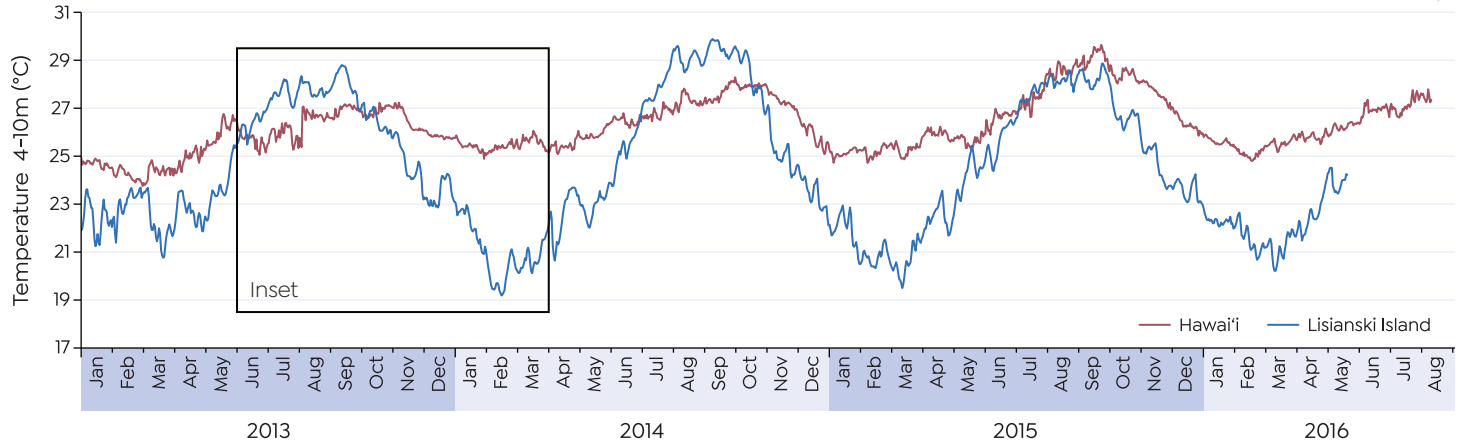
Calcification accretion unit (CAU) deployed on the reef.

Rates of net calcium carbonate accretion are monitored with calcification accretion units (CAUs), which allow for recruitment and colonization of crustose coralline algae and hard corals. Photos show a CAU newly deployed (left) and two years after deployment (right).

Ocean Chemistry and Temperature

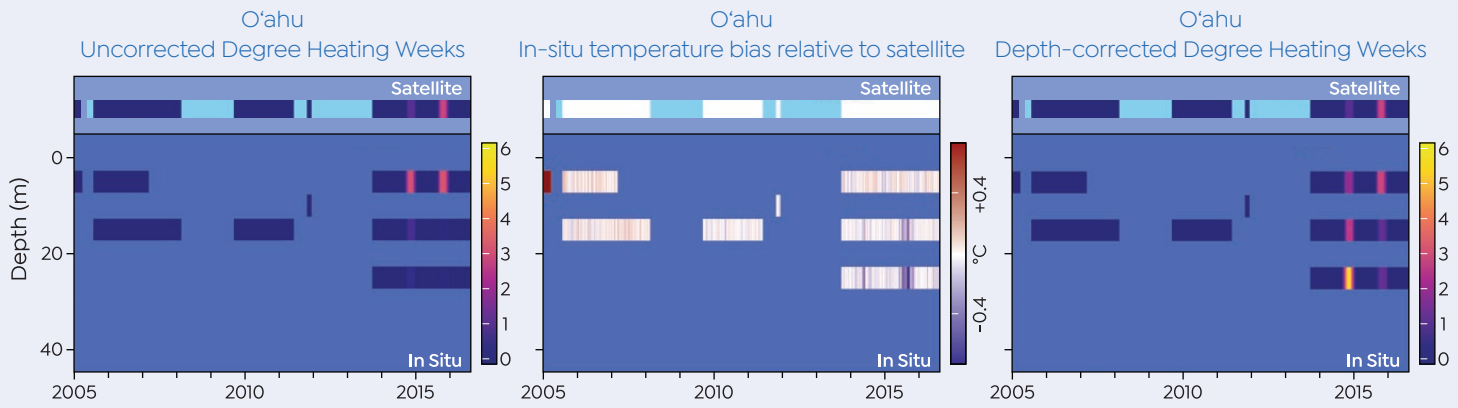
Subsurface temperature

Subsurface temperature time series



Subsurface temperature time series for 4–10 m for 2013–2016 comparing Hawai'i Island (in MHI) and Lisianski Island (in the Northwestern Hawaiian Islands – NWHI). Warm season months at these islands (May to August) at this depth were very similar. Cool season months (December to March) were much cooler in 2013–14, 2014–15, and 2015–16 at Lisianski Island than Hawai'i Island (see inset graph, right). Cool season temperatures provided much less of a reprieve from warm season temperatures at Hawai'i Island than at Lisianski Island.


NOAA ship *Oscar Elton Sette* off Maui

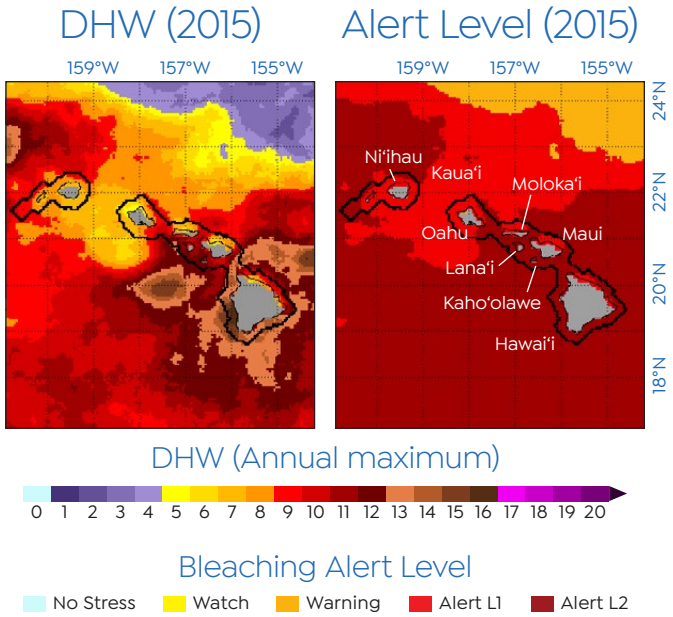


Sea temperature data can be used to calculate Degree Heating Weeks; a metric of the accumulation of heat stress. Remotely sensed sea surface temperature data from satellites are used to calculate Degree Heating Weeks for the surface of the ocean. The difference between temperatures at the surface recorded by satellites and temperatures at depth can be calculated ('the bias'). The resultant bias-correction can be applied to temperatures at depth, enabling more accurate calculations of heat stress at depth. The 10-year time series of sub-surface temperature from O'ahu shows that depths below 20 m did not always provide a refuge from heat stress. Heat stress that may have caused bleaching at depths greater than 20 m accumulated in 2015.

Heat stress and coral bleaching

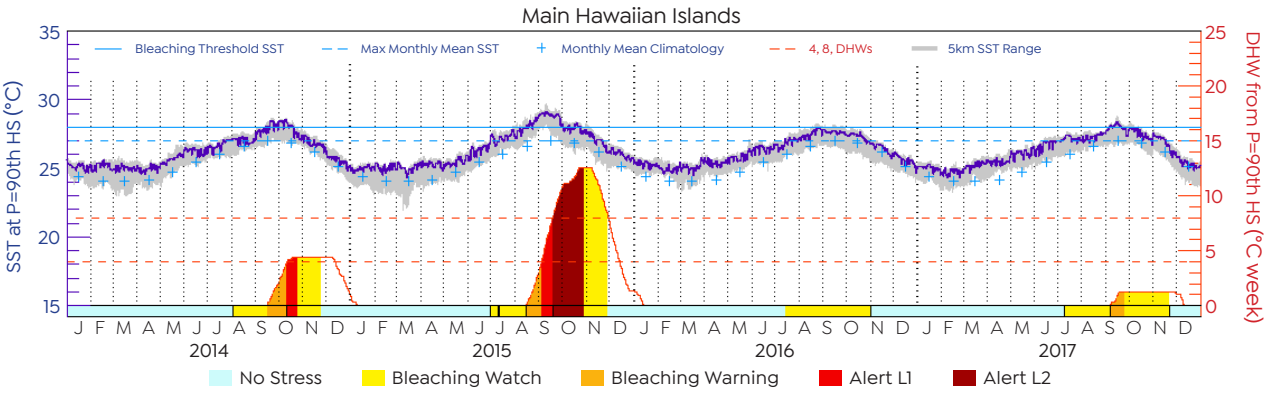
The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in the Main Hawaiian Islands (MHI) in 2014 and 2015.

Coral bleaching, west Hawai'i



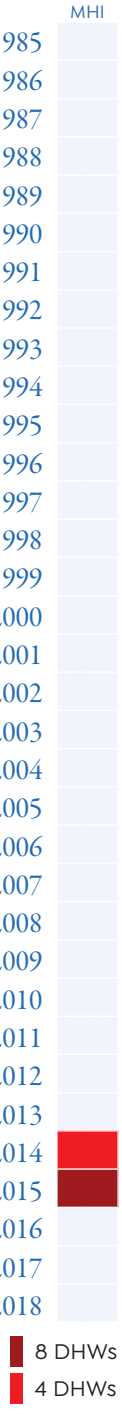
Annual maximum Degree Heating Weeks (DHWs) in 2015 (left panel) were as high as 15 in parts of the MHI when at least five DHWs accumulated at all islands in the region.

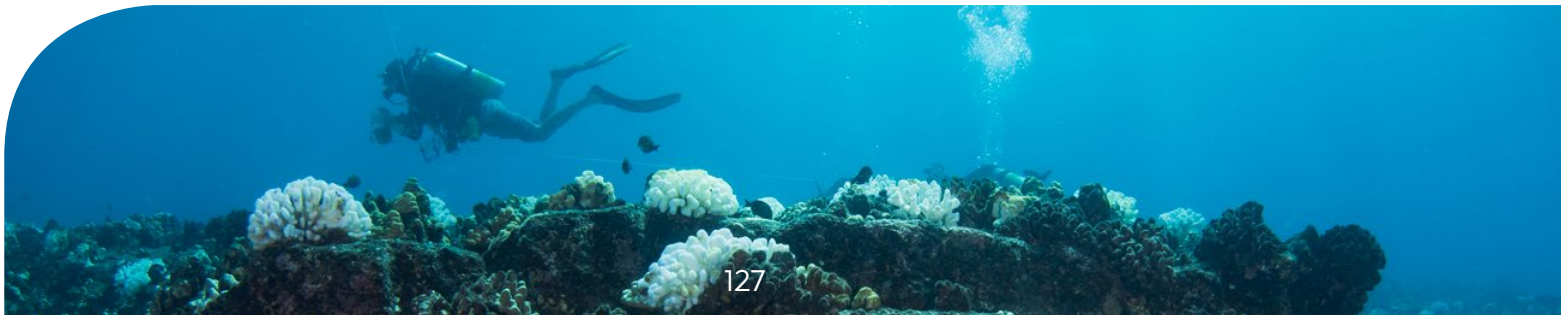
Heat stress accumulation triggered Alert Level 2 throughout the region in 2015 (right panel) and extensive severe bleaching was observed that year and extensive mortality due to bleaching was observed during surveys in 2016.



Degree Heating Week (DHW) accumulation from 2014–2017 in the MHI. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in 2014 and 2015 and Alert Level 2 was triggered in 2015 and extensive coral bleaching occurred in 2015.

Thermal History





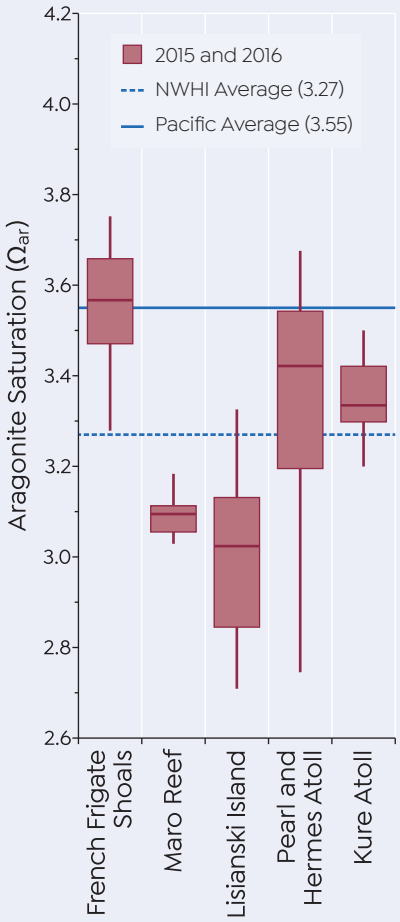
Scientists hang on as the small boat “Metal Shark” transits into rougher weather on the way to one of their permanent sites.

Ocean Chemistry and Temperature

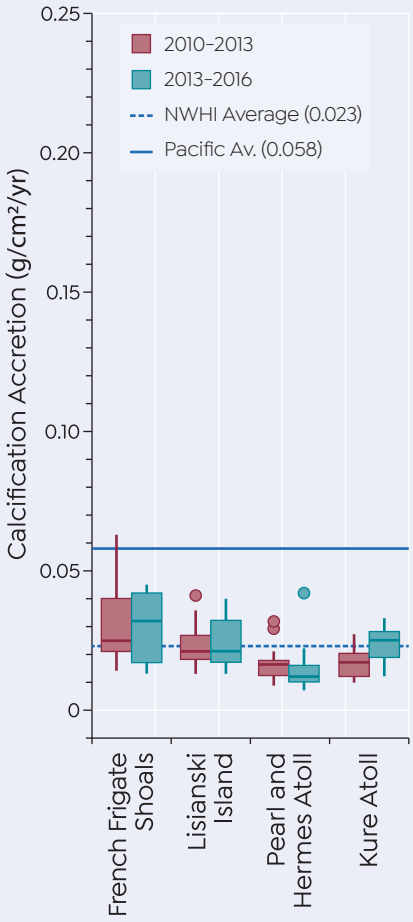
Chemistry (2010–2016)

This section represents the first Northwestern Hawaiian Islands (NWHI) NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the Ecosystem Sciences Division of the NOAA Pacific Islands Fisheries Science Center and the NOAA Coral Reef Watch program.

Aragonite saturation state



Calcium carbonate accretion



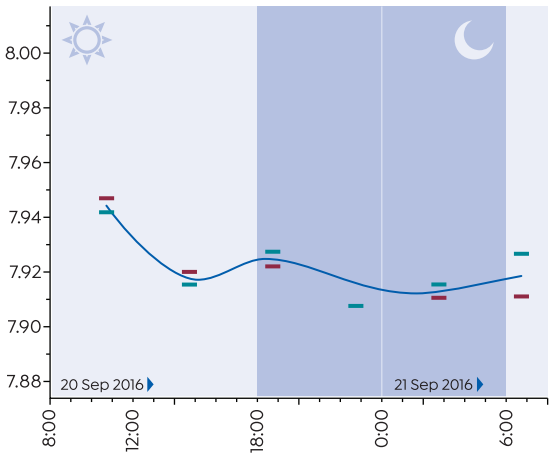
Aragonite saturation state measures carbonate ion concentration; the greater the concentration of carbonate ions is, the easier it is for organisms like stony corals to calcify. Aragonite saturation state was below the Pacific average for all locations in the NWHI except the French Frigate Shoals. Aragonite saturation state can be seen as an exposure term – i.e., exposure of calcifying organisms to the conditions that drive calcification.

Calcification Accretion Units measure the response of calcifying organisms to those conditions as the net accretion of calcium carbonate produced over the deployment period (see photos to right). Calcium carbonate accretion was lower than the Pacific average throughout the NWHI.

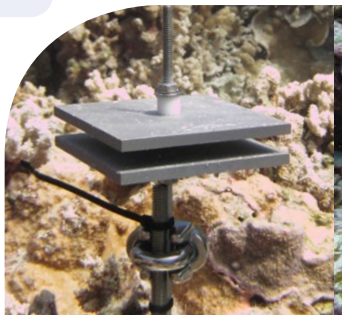
Highlights

- Calcium carbonate accretion in the NWHI was below the US Pacific average at all islands.
- Bias-corrected subsurface temperature data reveals that depths >20 m did not provide a refuge for corals from heat stress during the 2015 bleaching event.
- Coral Reef Watch Bleaching Alert Level 2 was triggered throughout the region in 2014, and Alert Level 1 was triggered in 2015. Extensive severe bleaching was observed in 2014.

Diurnal pH – Lisianski Island



Processes driving local pH vary throughout the day. Photosynthesis drives up the pH during the day as organisms calcify. pH declines again at night as photosynthesis stops and respiration continues to release CO_2 into the water column. Data are from bottle samples only.

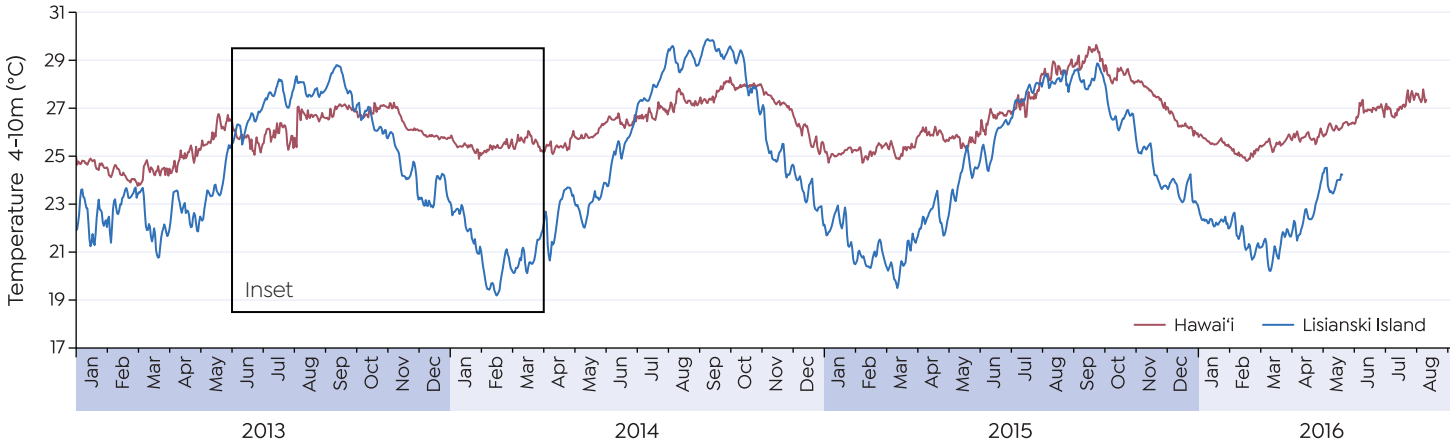


Rates of net calcium carbonate accretion are monitored with calcification accretion units (CAUs), which allow for recruitment and colonization of crustose coralline algae and hard corals. Photos show a CAU newly deployed (left) and two years after deployment (right).

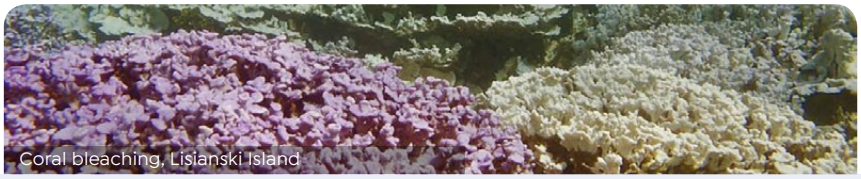
Ocean Chemistry and Temperature

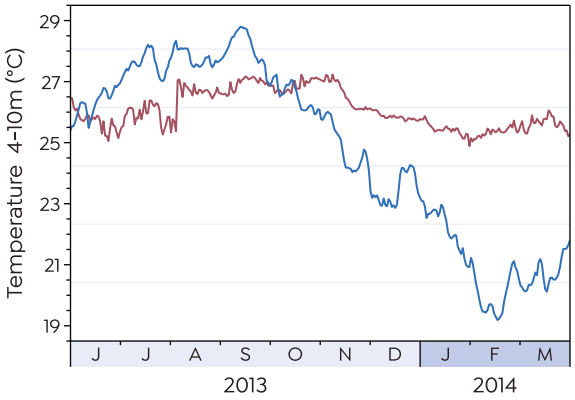
Subsurface temperature

Subsurface temperature time series



Subsurface temperature time series for 4–10 m for 2013–2016 comparing Hawai'i Island (in MHI) and Lisianski Island (in the Northwestern Hawaiian Islands — NWHI). Warm season months at these islands (May to August) at this depth were very similar. Cool season months (December to March) were much cooler in 2013–14, 2014–15, and 2015–16 at Lisianski Island than Hawai'i Island (see inset graph, right). Cool season temperatures provided much less of a reprieve from warm season temperatures at Hawai'i Island than at Lisianski Island.

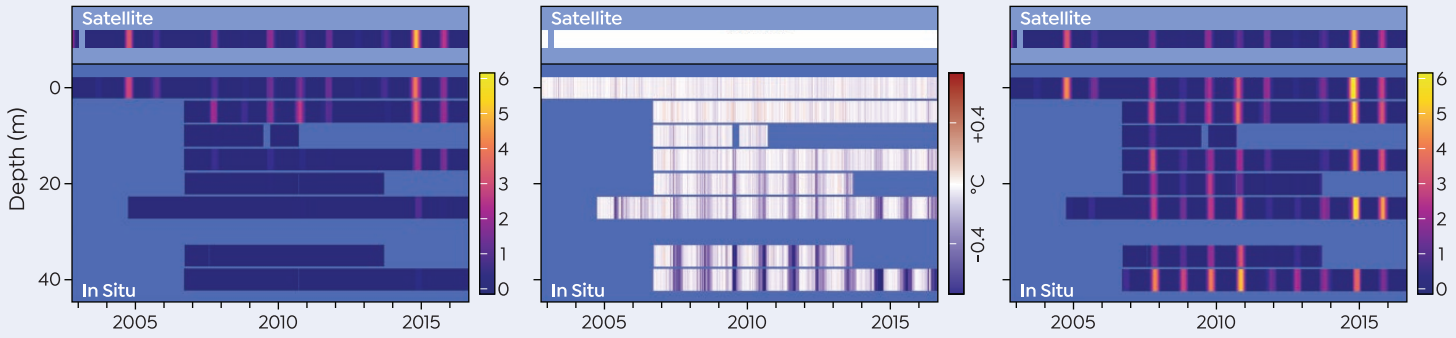

Coral bleaching, Lisianski Island



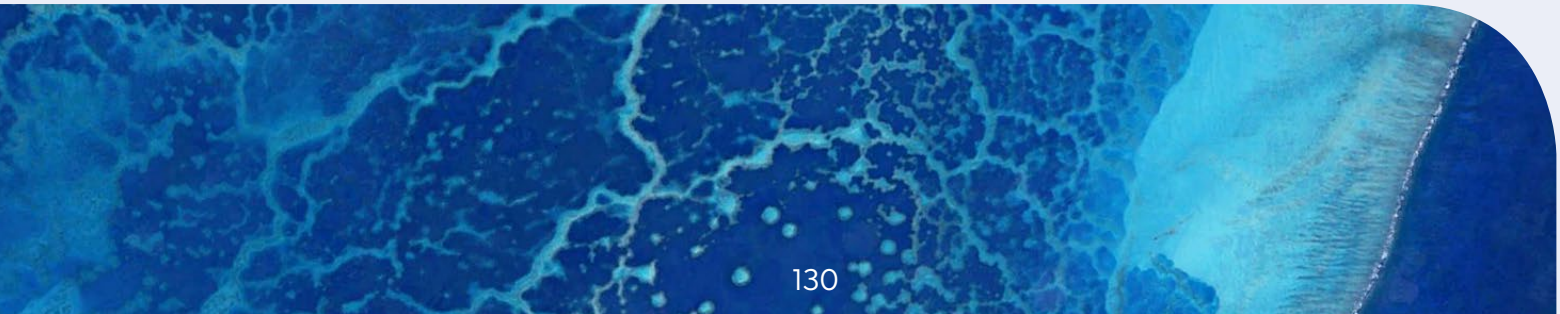
Pearl and Hermes Atoll
Uncorrected Degree Heating Weeks

Pearl and Hermes Atoll
In-situ temperature bias relative to satellite

Pearl and Hermes Atoll
Depth-corrected Degree Heating Weeks



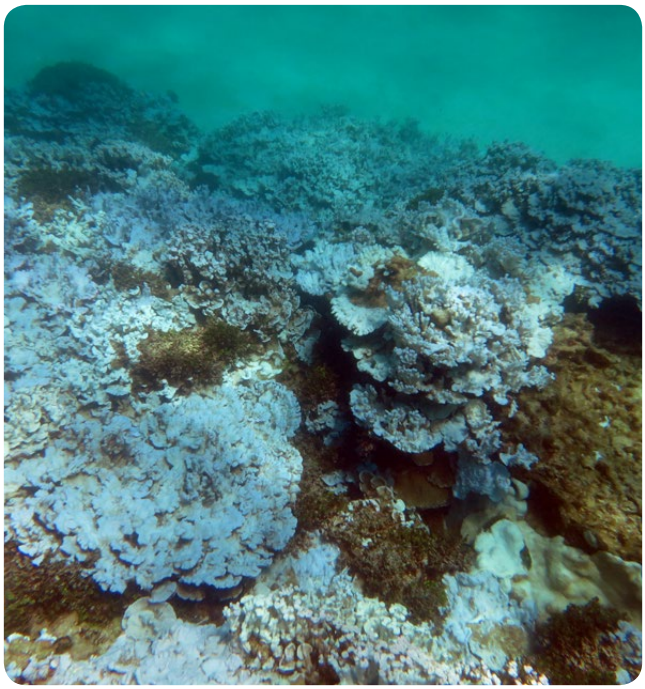
Sea temperature data can be used to calculate Degree Heating Weeks; a metric of the accumulation of heat stress. Remotely sensed sea surface temperature data from satellites are used to calculate Degree Heating Weeks for the surface of the ocean. The difference between temperatures at the surface recorded by satellites and temperatures at depth can be calculated ('the bias'). The resultant bias-correction can be applied to temperatures at depth, enabling more accurate calculations of heat stress at depth. The 10-year time series of sub-surface temperature from Pearl and Hermes Atoll shows that depths below 20 m did not always provide a refuge from heat stress. Heat stress that may have caused bleaching at depths greater than 20 m accumulated in 2015, and at depths greater than 40 m in 2008, 2010, 2011, and 2015.



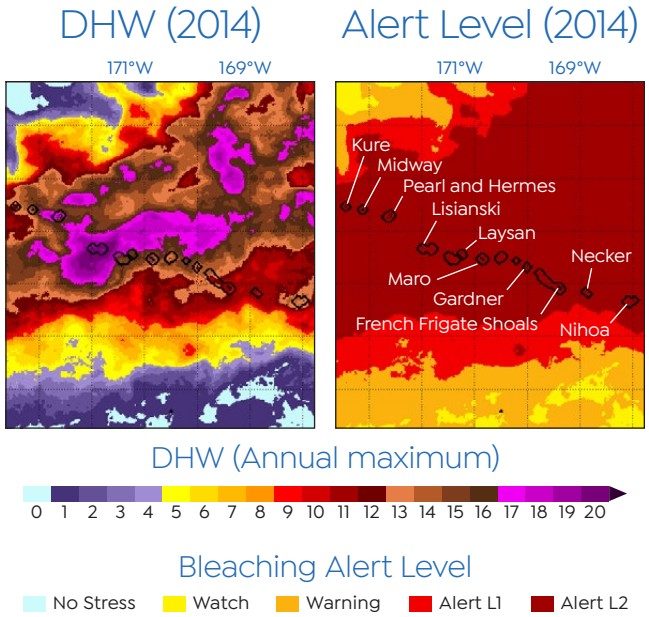
Ocean Chemistry and Temperature

Heat stress and coral bleaching

The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in the Northwestern Hawaiian Islands (NWHI) in 1997, 2002, 2004, 2005, 2014, 2015, and 2017.

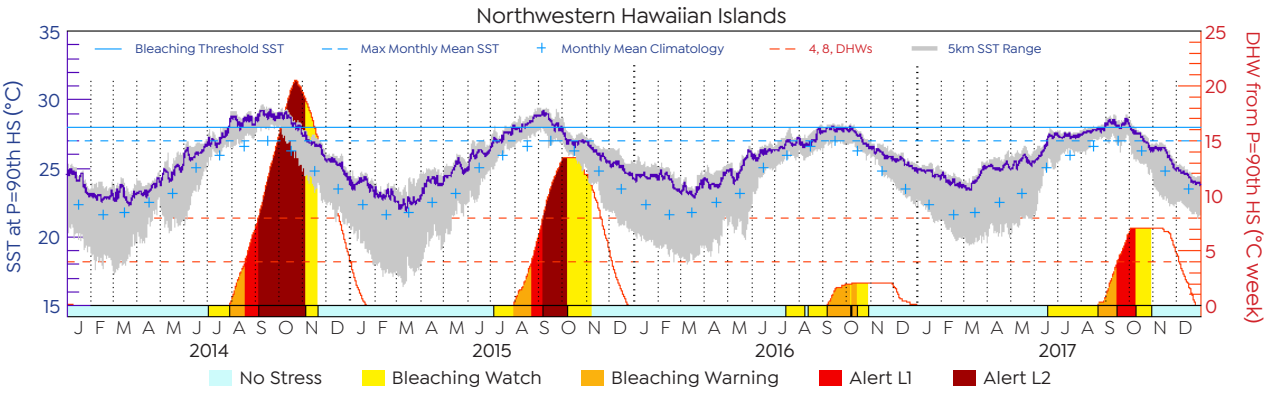


Coral bleaching, Lisianski Island



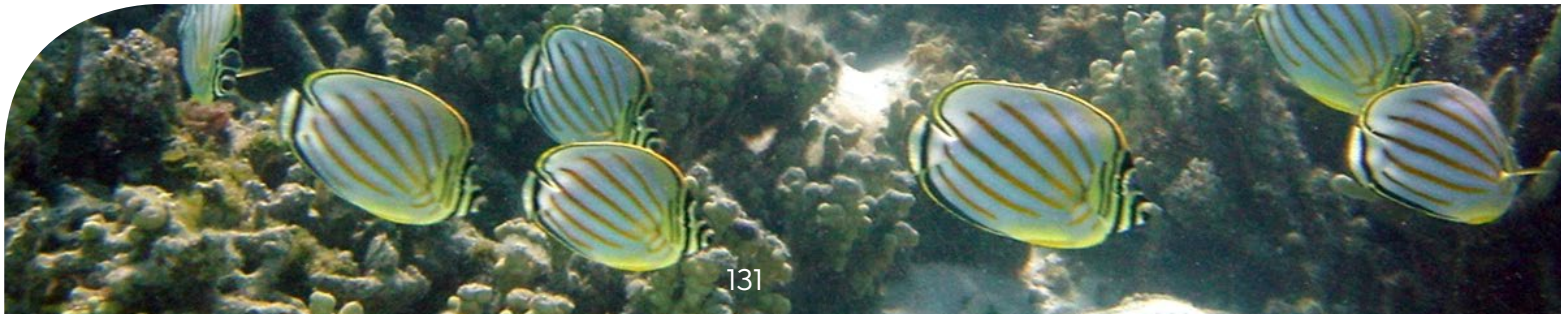
Annual maximum Degree Heating Weeks (DHWs) in 2014 (left panel) were as high as 20 in parts of the NWHI when at least nine DHWs accumulated at all islands in the region.

Heat stress accumulation triggered Alert Level 2 throughout the region in 2014 (right panel) and extensive bleaching was observed. Alert Level 1 was triggered throughout the region in 2015 and extensive bleaching was observed again that year.



Degree Heating Week (DHW) accumulation from 2014–2017 in the NWHI. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in 2014, 2015, and 2017 and Alert Level 2 was triggered in 2014 and 2015.

Thermal History



American Sāmoa

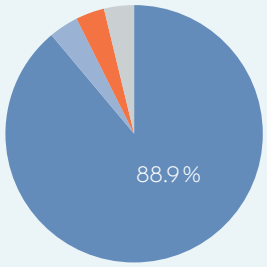
Demographics, values, resource use, and information sources

This Human Connections section presents findings from the first American Sāmoa NCRMP socioeconomic data collection and includes data never collected before in American Sāmoa. These are baseline data on social indicators from household surveys conducted in January and February, 2014, and from secondary sources.

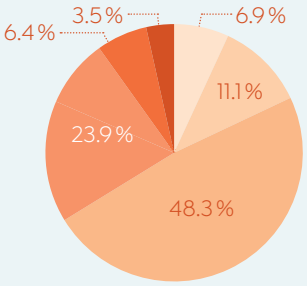
Highlights

- The great majority of residents agreed that coral reefs provide protection from erosion and natural disasters, attract tourists, and are culturally important.
- There was no dominant perception of the status or trends of water quality or the amount of corals, fish, and animals for gleaning.
- Of the potential threats to coral reefs, residents were least familiar with climate change, coral bleaching, and invasive species.
- Residents were generally very supportive of marine management policies – over 80% agreed with establishing more marine protected areas if evidence shows current ones are effective.

Race



Educational attainment

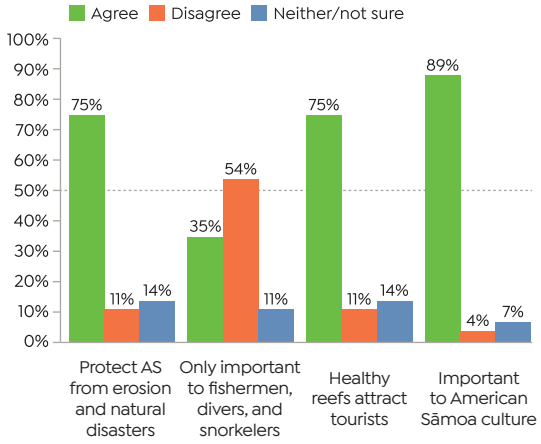


American Samoa's population was predominantly composed of Pacific Islander ethnicity, with the majority identifying as Native Samoan or part Samoan (89%). The next largest ethnic category was Asian (3.6%). 82% of the population had at least completed high school, a third had completed at least some college or an associates degree, and ~10% a bachelor's or graduate degree. 18% of Samoans 25 years or older had not completed high school.

Resource use

PERCENT OF POPULATION PARTICIPATING IN EACH ACTIVITY

Values and awareness

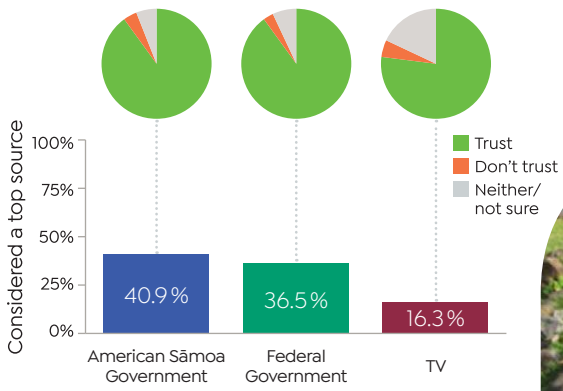


When asked about important services provided by reef resources, most residents agreed that coral reefs protect American Sāmoa from erosion and natural disasters (75%), that coral reefs attract tourists (75%), and that coral reefs are important to American Sāmoan culture (89%). The majority of residents disagreed with the statement that coral reefs are only important to fishermen, divers, and snorkelers.

2014 survey data (n = 448)

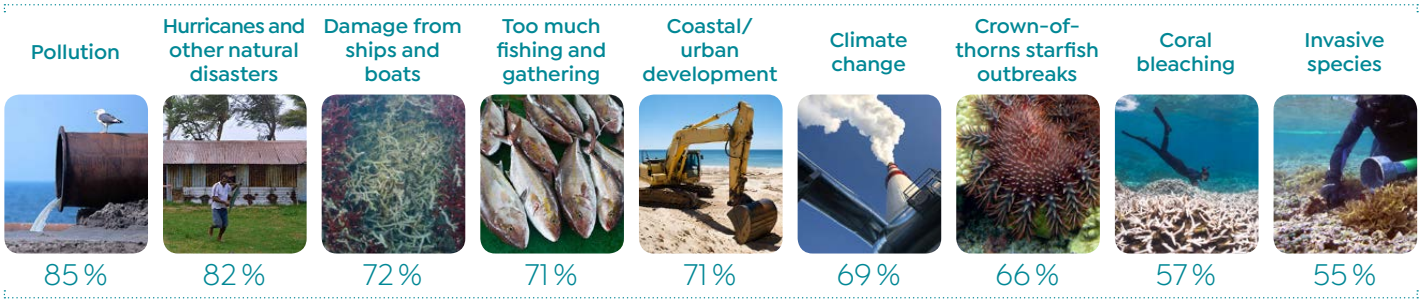
Information sources

The great majority (77.4%) of residents considered the American Sāmoa or Federal Government to be their top source for information on the environment, including status of coral reefs and present and future threats. Greater than 90% of residents who claimed government was a top source indicate that this information source was trusworthy. A far lower percentage (16.3%) named TV as a top source and fewer of these residents (75%) indicated trust for this source.

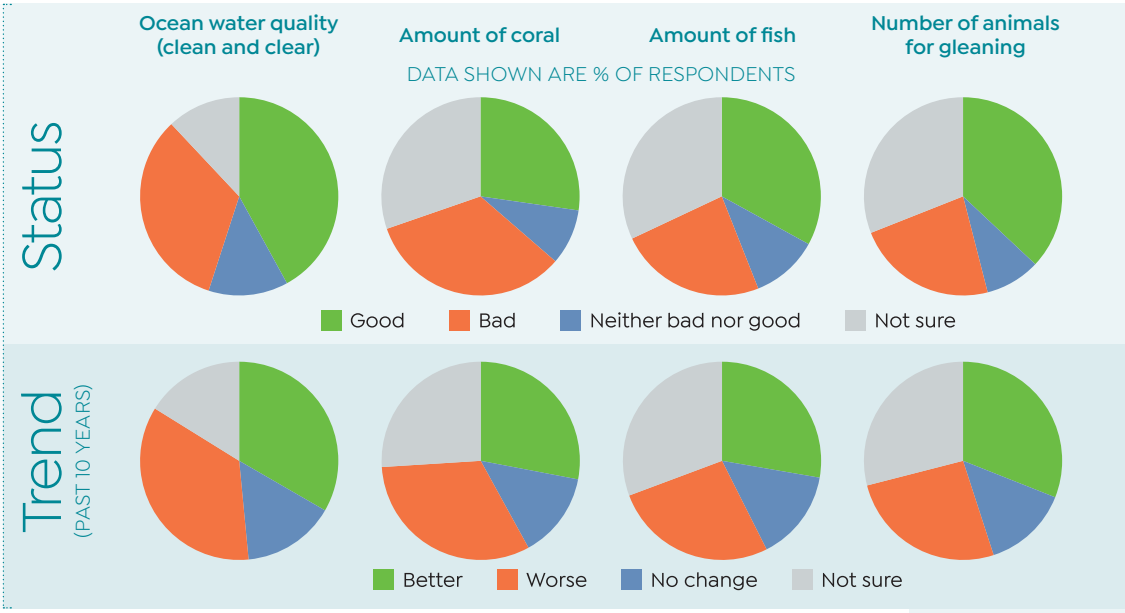


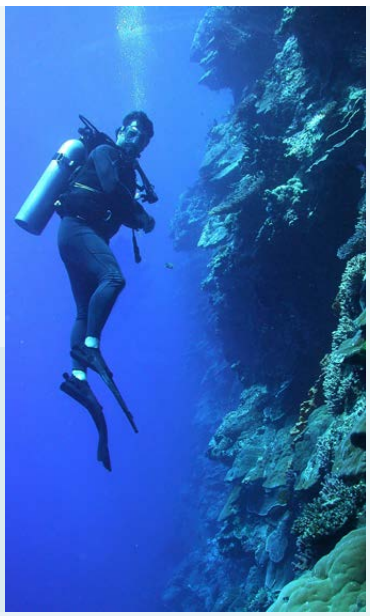
Perceptions of resource condition, threats, and severity

Threats



In general, residents were familiar with potential threats facing coral reefs in American Sāmoa, with well over half of residents stating they were familiar or very familiar with each potential threat shown above. Of the potential threats mentioned, residents were least familiar with climate change, coral bleaching, invasive species, and crown of thorn starfish outbreaks. Residents exhibited highest levels of familiarity with threats from pollution and hurricanes or other natural disasters.

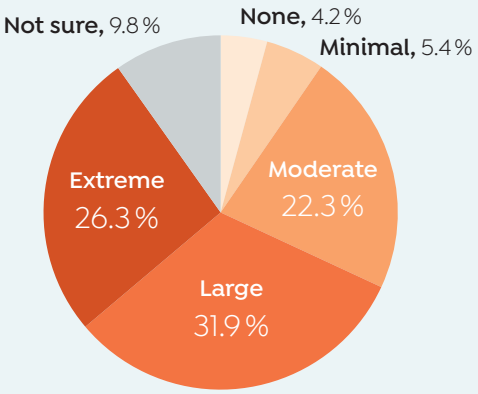




Status and trend

More residents felt confident in their perception of the status of ocean water quality (<15 % not sure) than for the amounts of coral, fish, and animals for gleaning (30 %+ percent not sure). For those confident in their perceptions, roughly 35–50 % felt the current status was good and roughly 35–50 % felt the current status was bad for all status variables. The same pattern was found in the perceptions of trend. For those confident in their perception of the trend of ocean water quality and amount of corals, fish and animals for gleaning, roughly 35–45 % felt it had gotten better and roughly 35–45 % felt it had gotten worse. Overall, there was no consensus among the general population regarding the current status or past and future trends of coral reef resources in American Sāmoa.

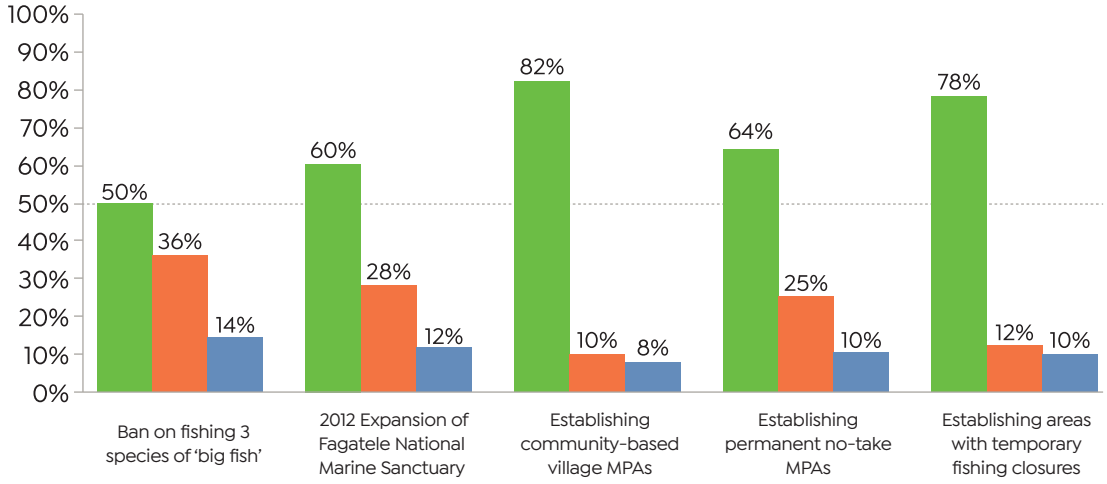
Severity of threats



Residents were generally concerned about threats to coral reefs in American Sāmoa. Twenty-six percent of residents stated that they thought threats were extreme and 32 % thought threats were large. A small percentage (9 %) stated that threats were either minimal or believe there are no threats.

Perceptions of reef management policies

Management policies

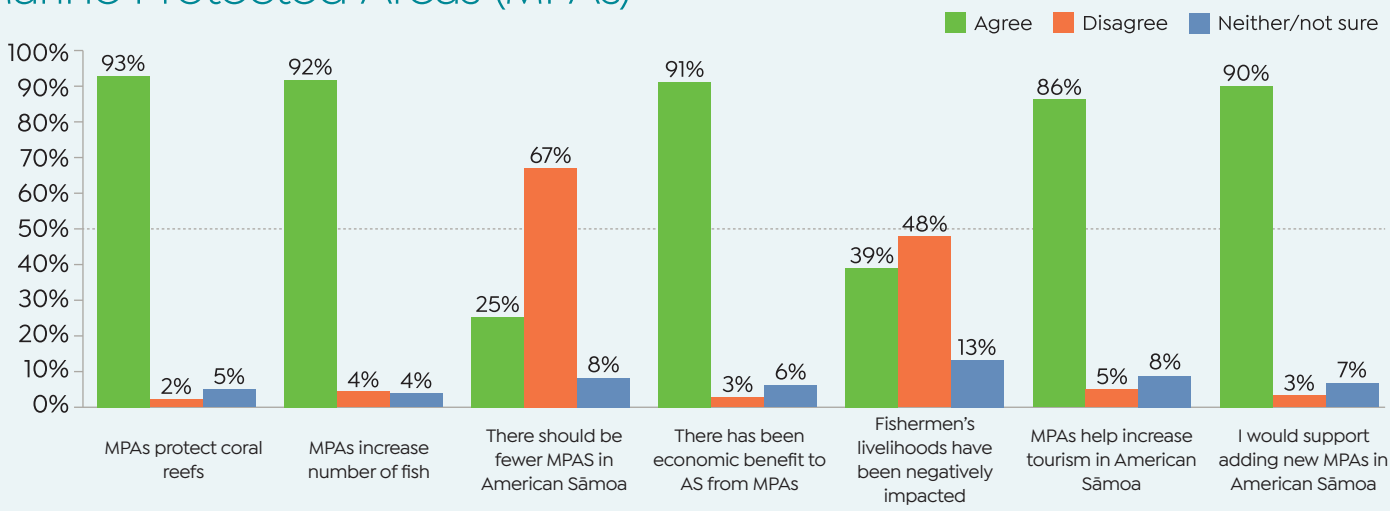


Residents were generally supportive of current marine management policies. There was extremely high support for community-based village MPAs (82%) and temporary fishing closures (78%). The village of Fagamalo, for example, had established two marine protected sites, an MPA with temporary take and a no-take MPA as part of the Community-based Fisheries Management Program (see photos, right). The ban on fishing "big fish" species (humphead wrasse, bumphead parrotfish, and giant grouper) was the only management measure not supported by a majority of residents – 50% agreed with that policy.

Fagamalo village

MPA sign

Marine Protected Areas (MPAs)



Respondents mostly agreed that MPAs provide benefits. Ninety percent or more of residents agreed or strongly agreed that MPAs protect coral reefs, increase number of fish, attract tourists, and provide economic benefits to residents of American Sāmoa. The vast majority of residents also supported adding new MPAs in American Sāmoa if evidence shows current ones are effective (89%). Only 24% of residents stated that there should be fewer MPAs in American Sāmoa. There was less certainty regarding whether or not fishermen's livelihoods have been negatively impacted by MPAs, with 48% disagreeing with this statement, and 39% agreeing.

Community-based fisheries management area in the villages of Faganeanea and Matu'u.

Coral reefs – Tutuila (2015)

14° 20' S, 170° 44' W

Land area: 142 km²

0–100m depth: 349 km²

Coral reef area: 40.8 km² (13/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 54,359 (2010)

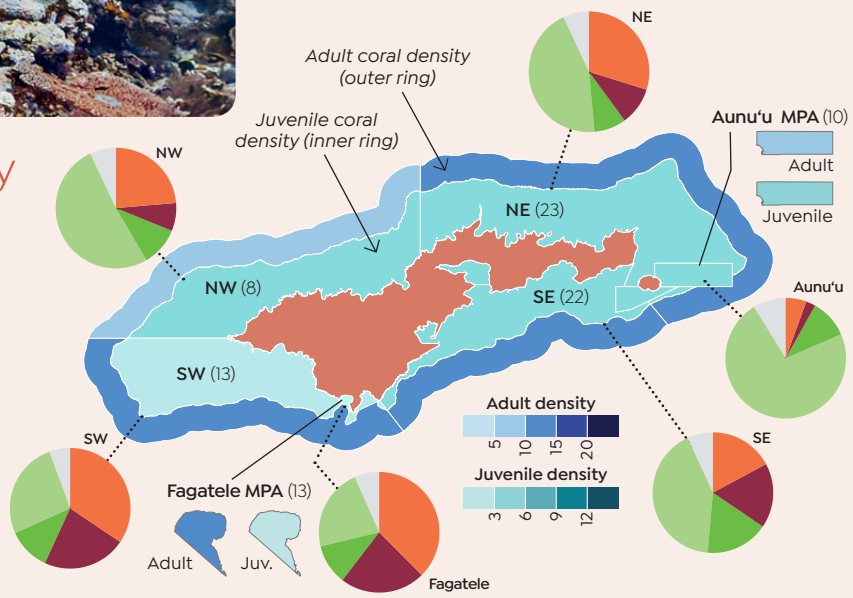
The coral reefs of Tutuila were surveyed in February and March of 2015.

- Coral cover was highest in Fagatele (37.5%) and lowest in the Aunu'u Management Area (5.6%).
- Acute and chronic coral diseases were <1% in all sectors, as was recent mortality.
- Old mortality of corals ranged from 8.8% in the NE to 17.5% in the Aunu'u Management Area.

Benthic cover and coral density

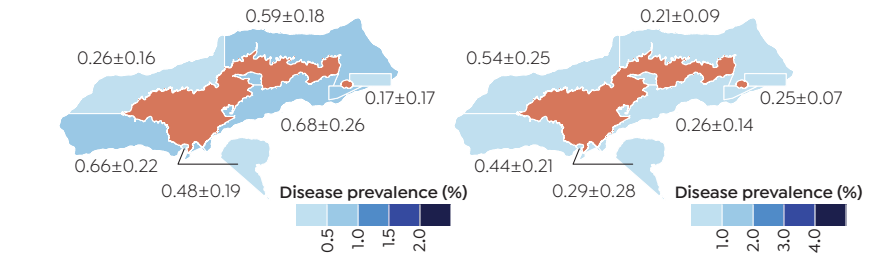
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

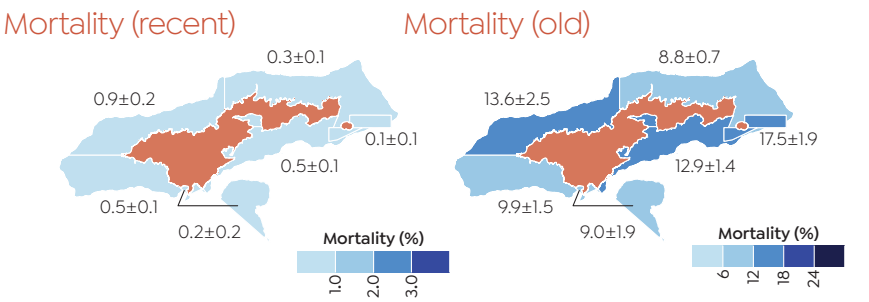


TABLE OF CONTENTS

Coral reef fish – Tutuila (2010-2016)

14° 20' S, 170° 44' W

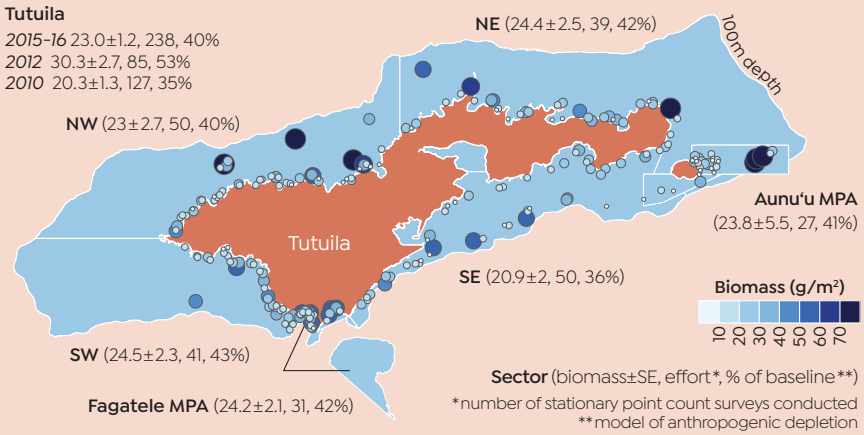
Coral reef fish surveys were conducted in 2015-16, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

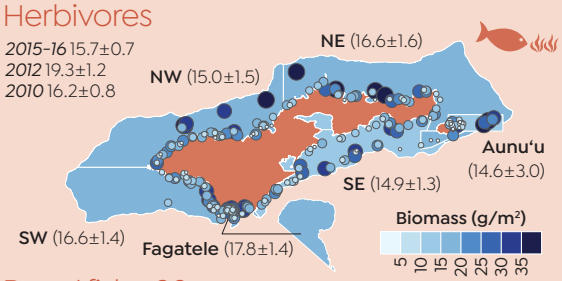
- Reef fish biomass ranged from 20.9±2 g/m² (36% of baseline) in the SE to 24.5±2.3, (43% of baseline) in the SW.
- Reef fish biomass was 20.3±1.3 g/m² in 2010, 30.3±2.7 g/m² in 2012, and 23.0±1.2 g/m² in 2015-2016.
- 50% of the reef fish sampled were 10-30 cm in length during the 2010, 2012, and 2015-2016 surveys.

Reef fish biomass

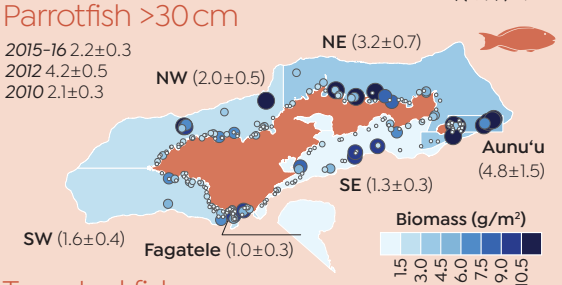
Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



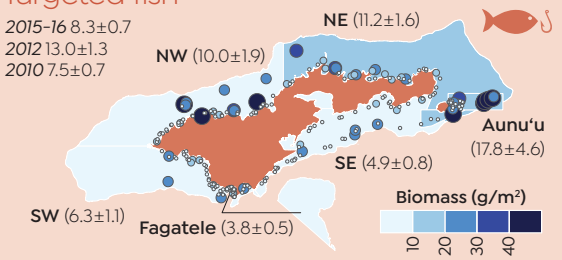
Herbivores



Parrotfish >30 cm

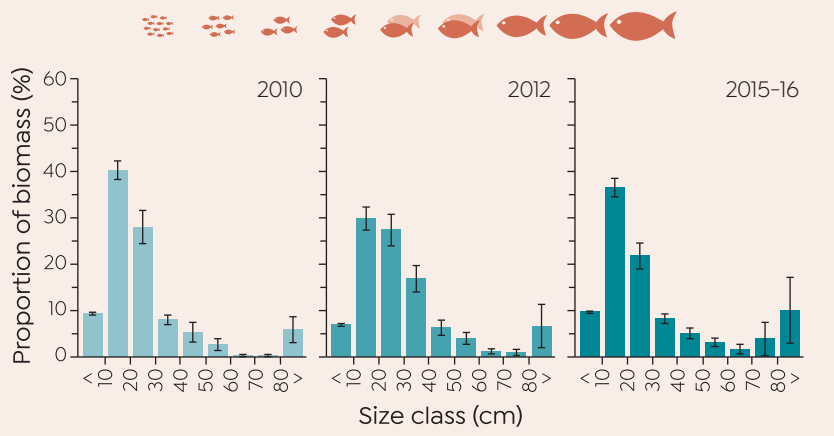


Targeted fish



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Ofu and Olosega (2015)

14° 11' S, 169° 37' W

Land area: 12.0 km²

0–100m depth: 32.8 km²

Coral reef area: 7.9 km² (27/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 353 (2010) – Ofu (176), Olosega (177)

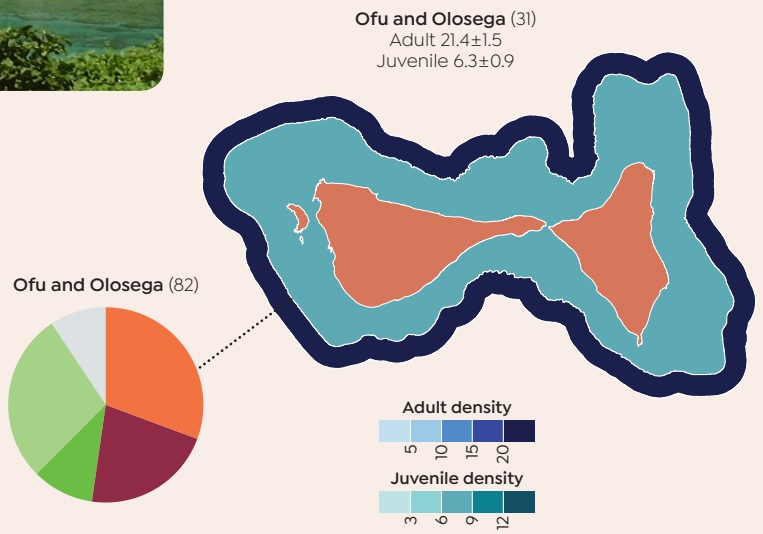
The coral reefs of Ofu and Olosega were surveyed in February and March of 2015.

- Coral cover was 30.7% in Ofu and Olosega.
- Acute and chronic coral diseases were <1%.
- Old mortality of corals was 11.4%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

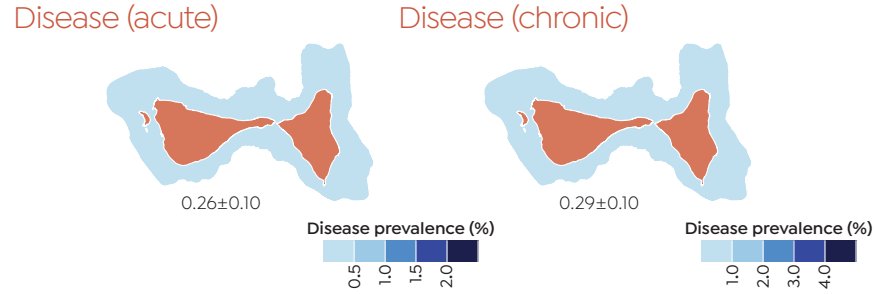


Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Sector (Sampling effort)

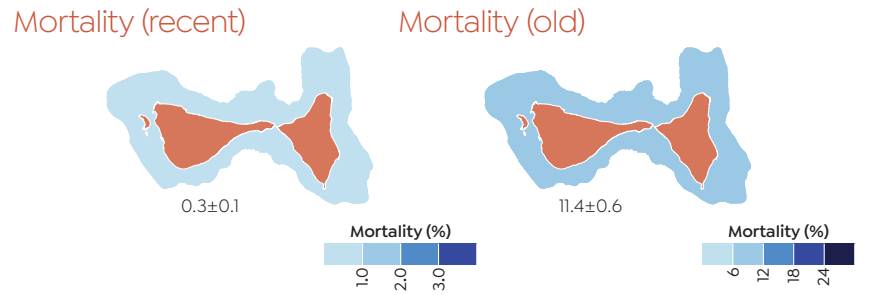
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



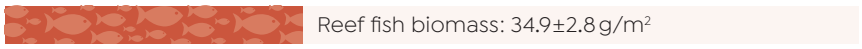
Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Ofu and Olosega (2010-2016)

14°11'S, 169°37'W



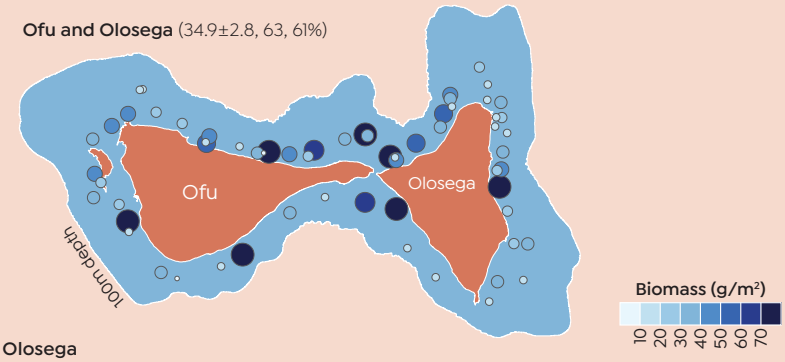
Coral reef fish surveys were conducted in 2015-16, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 25.8±2.3 g/m² in 2010, 60.7±6.0 g/m² in 2012, and 34.9±2.8 g/m² in 2015-2016.
- 50 % of the reef fish sampled were 10-30 cm in length during the 2010, 2012, and 2015-2016 surveys. There were fish observed >80 cm in length during all survey years.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Ofu and Olosega

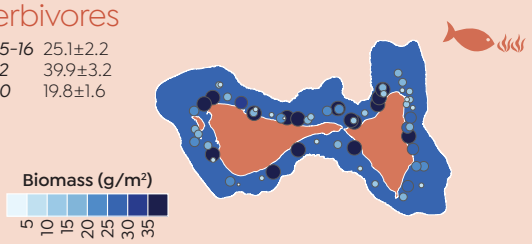
2015-16	34.9±2.8, 63, 61%
2012	60.7±6.0, 30, 106%
2010	25.8±2.3, 30, 45%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

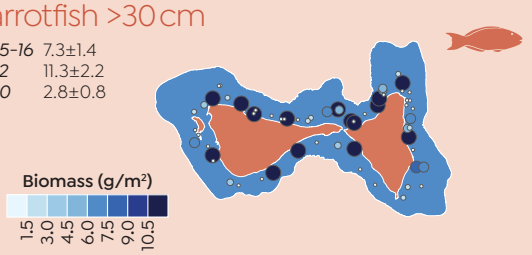
Herbivores

2015-16	25.1±2.2
2012	39.9±3.2
2010	19.8±1.6



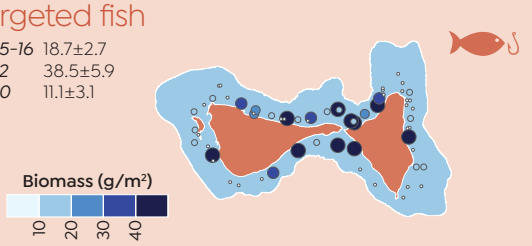
Parrotfish >30 cm

2015-16	7.3±1.4
2012	11.3±2.2
2010	2.8±0.8



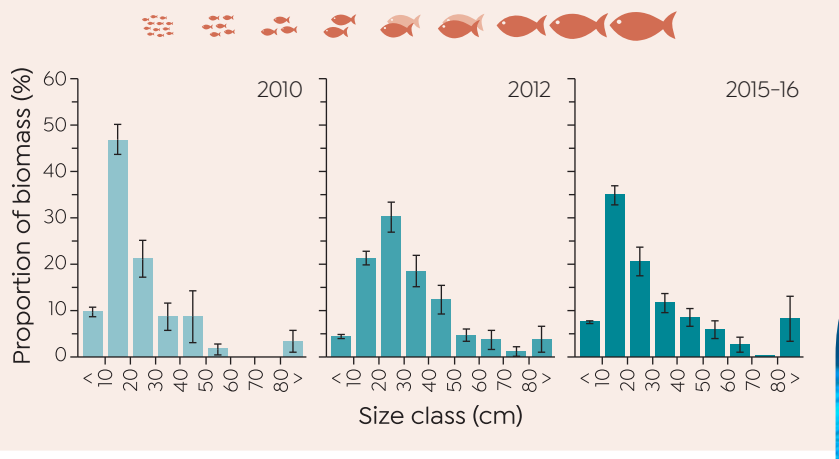
Targeted fish

2015-16	18.7±2.7
2012	38.5±5.9
2010	11.1±3.1



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Ta‘ū (2015)

14°14’S, 169°26’W

Land area: 44.3 km²

0–100m depth: 16.3 km²

Coral reef area: 9.0 km² (25/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 358 (2010)

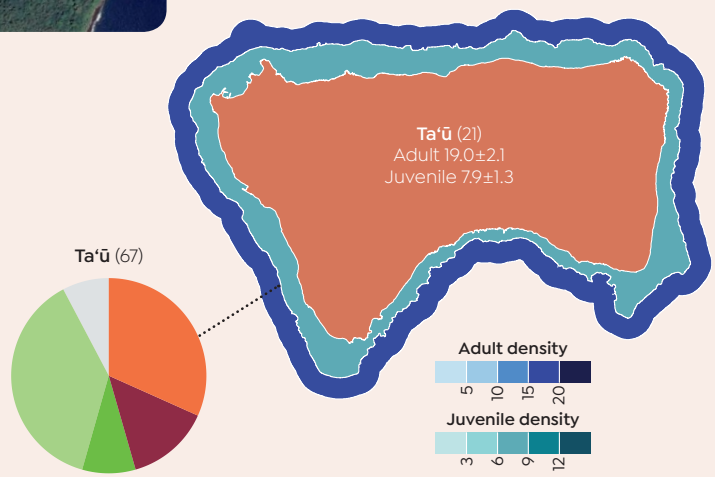
The coral reefs of Ta‘ū were surveyed in February and March of 2015.

- Coral cover was 31.7% in Ta‘ū.
- Acute and chronic coral diseases were <1%.
- Old mortality of corals was 12.3%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1cm in height), turf algae (<1cm in height), and other as a percentage.

Adult (>5cm) and juvenile (<5cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



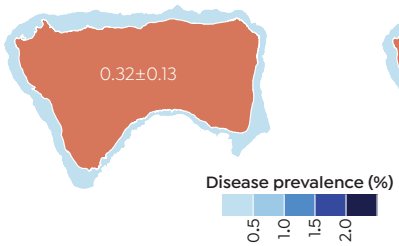
Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Sector (Sampling effort)

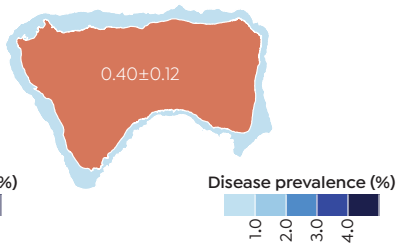
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).

Disease (acute)



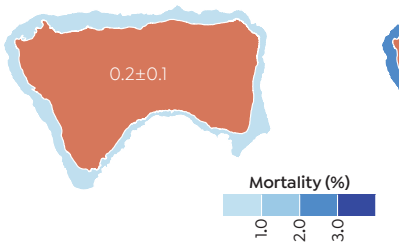
Disease (chronic)



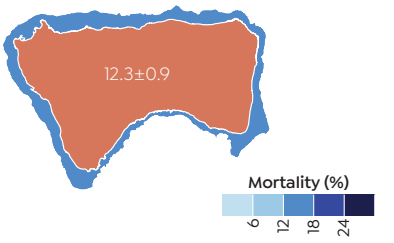
Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

Mortality (recent)



Mortality (old)



Coral reef fish – Ta'ū (2010-2016)

14°14' S, 169°26' W

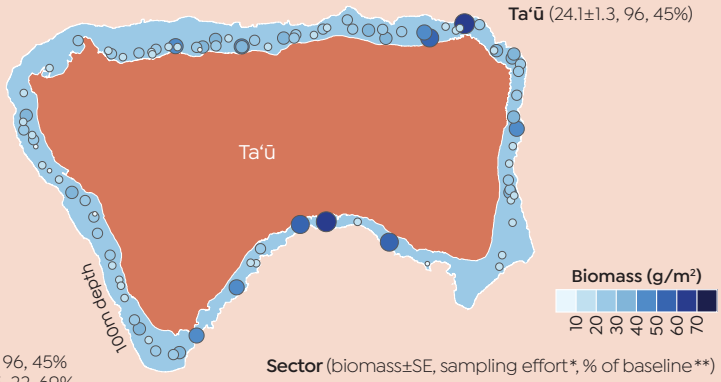
Coral reef fish surveys were conducted in 2015-16, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 23.4±2.5 g/m² in 2010, 37.5±4.5 g/m² in 2012, and 24.1±1.3 g/m² in 2015-2016.
- 50 % of the reef fish sampled were 10-30 cm in length during the 2010, 2012, and 2015-2016 surveys. There were fish observed >80 cm in length during all survey years.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Ta'ū

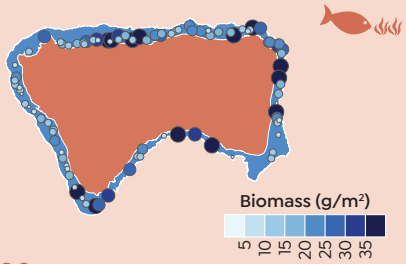
2015-16	24.1±1.3, 96, 45%
2012	37.5±4.5, 22, 69%
2010	23.4±2.5, 24, 43%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

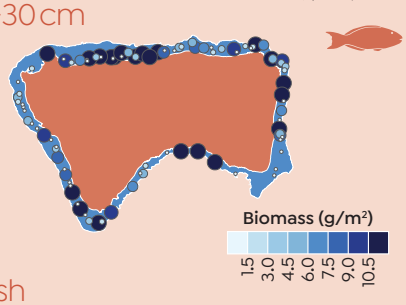
Herbivores

2015-16	20.7±1.5
2012	27.4±3.8
2010	18.1±2.0



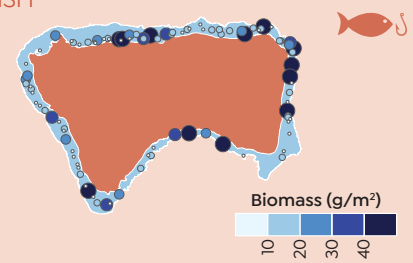
Parrotfish >30 cm

2015-16	6.8±0.9
2012	9.2±2.2
2010	5.6±1.4



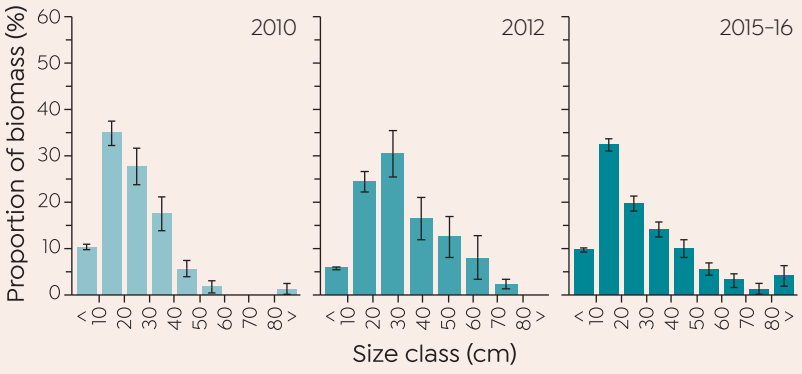
Targeted fish

2015-16	17.1±1.6
2012	19.1±4.1
2010	14.3±2.1



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Swains Island (2015)

11° 03' S, 171° 05' W

Land area: 1.5 km²

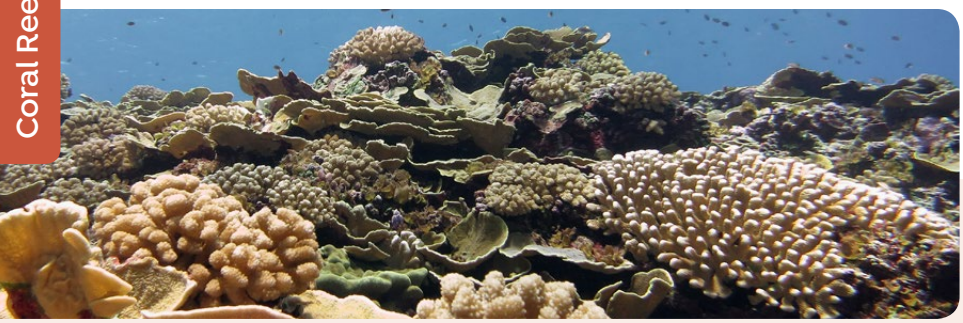
0–100m depth: 2.8 km²

Coral reef area: 2.8 km² (33/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 17 (2010)

The coral reefs of Swains Island were surveyed in February and March of 2015.

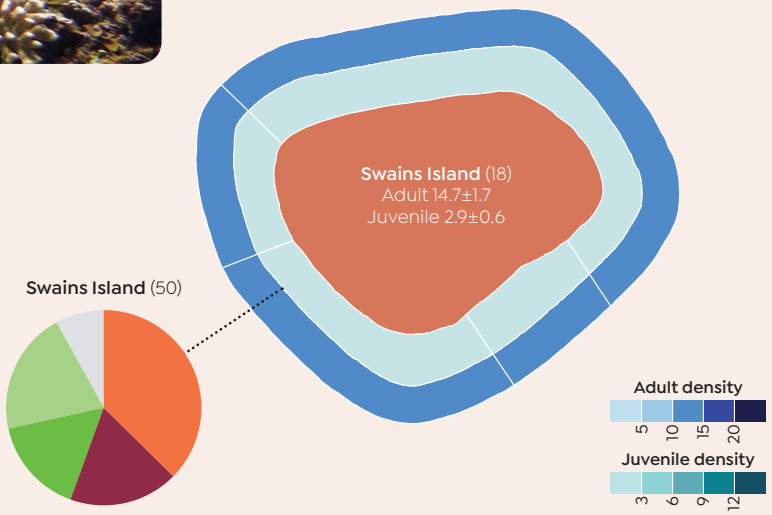


- Coral cover was 37.4 % in Swains Island.
- Acute coral disease was 1.4 %; chronic coral disease was < 1 %.
- Recent mortality of corals was 0.3 %; old mortality was 9.8 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

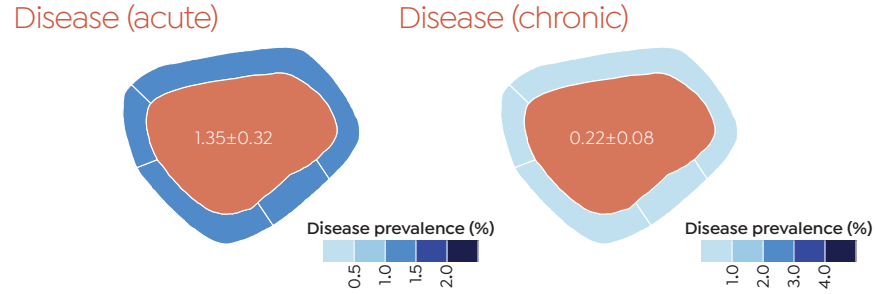


Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Sector (Sampling effort)

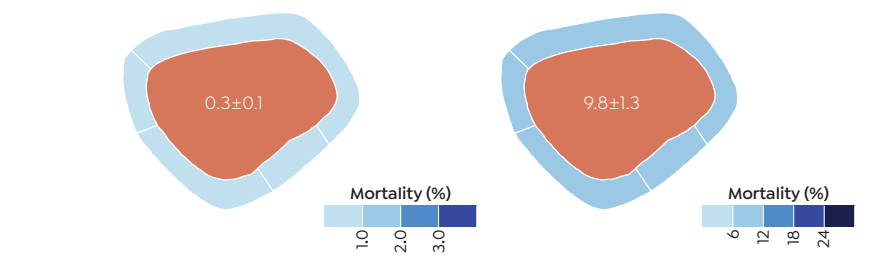
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Swains Island (2010-2016)

11° 03' S, 171° 05' W

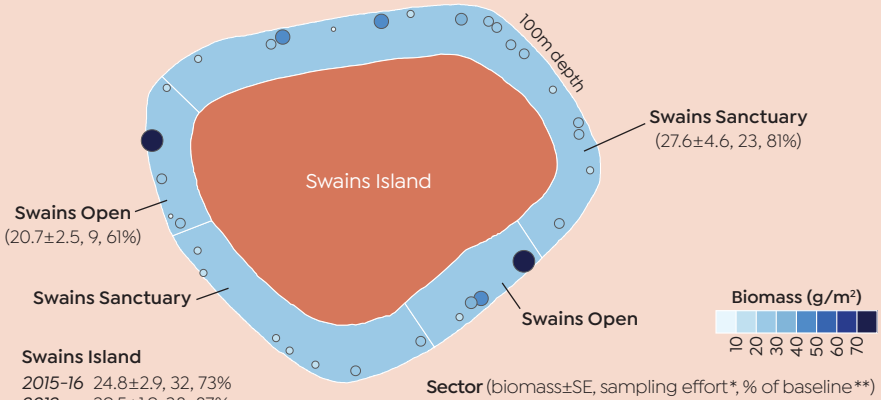
Coral reef fish surveys were conducted in 2015-16, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 20.7±5.9 g/m² in 2010, 29.5±1.9 g/m² in 2012, and 24.8±2.9 g/m² in 2015-2016.
- >50 % of the reef fish sampled were >30 cm in length during the 2012 and 2015-2016 surveys. There were fish observed >80 cm in length during the 2012 and 2015-2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Swains Island

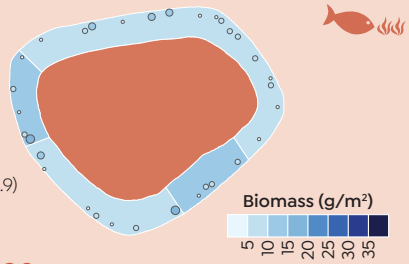
2015-16	24.8±2.9, 32, 73%
2012	29.5±1.9, 38, 87%
2010	20.7±5.9, 24, 61%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

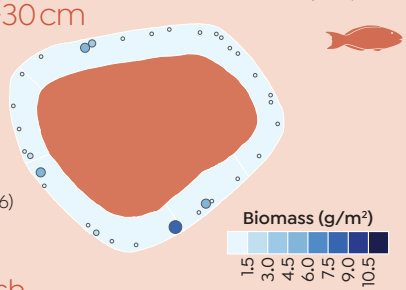
Herbivores

2015-16	8.2±1.4
2012	9.9±1.2
2010	6.3±1.8



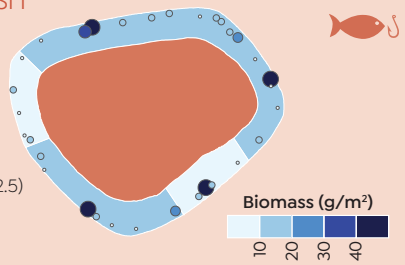
Parrotfish >30 cm

2015-16	1.0±0.5
2012	1.6±0.6
2010	0.3±0.1



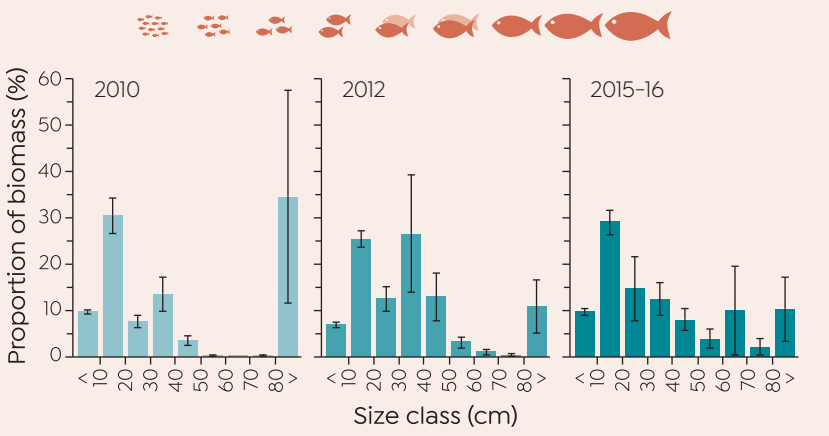
Targeted fish

2015-16	11.8±1.9
2012	20.9±3.8
2010	7.8±1.5



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Rose Atoll (2015)

14° 33' S, 168° 09' W

Land area: 0.2 km²

0–100m depth: 8.9km²

Coral reef area: 1.2 km² (40/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

The coral reefs of Rose Atoll were surveyed in February and March of 2015.

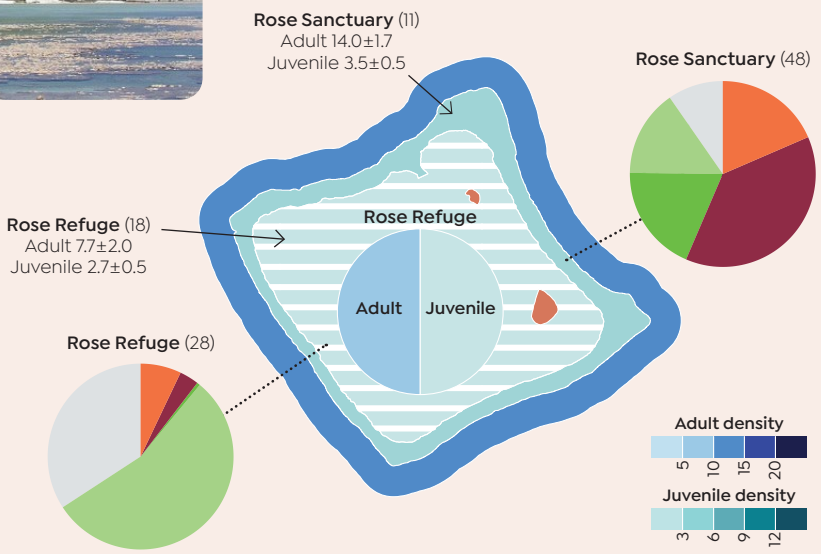
- Coral cover was highest in Rose Sanctuary (18.51%) and lowest in Rose Open (7.1%).
- Acute disease was <1% and chronic was 1.1%.
- Old mortality of corals ranged from 10.7% in Rose Sanctuary to 19.6% in Rose Refuge.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>5cm in height), turf algae (<5 cm in height), and other as a percentage of total cover.

For Rose Sanctuary, adult and juvenile coral density is shown as an inner and outer ring around the sanctuary boundary*. For Rose Refuge, density is shown in the split circle within this sector. Sampling effort (number of surveys) is shown within brackets after the sector name.

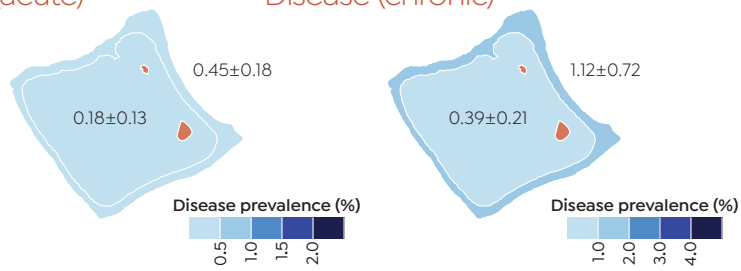
*The inner sanctuary boundary is adjacent to the seaward boundary of the Rose Atoll National Wildlife Refuge. Hence, the sanctuary does not include the land or lagoon waters that make up the refuge.



Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

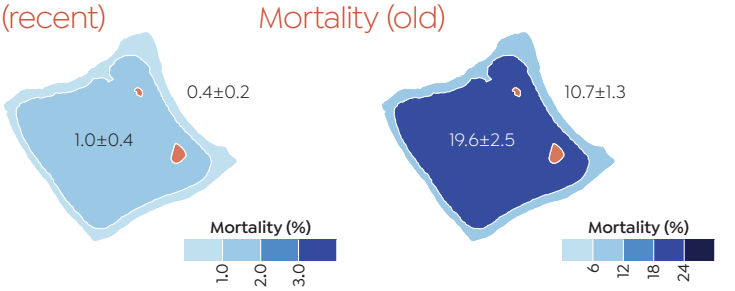
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



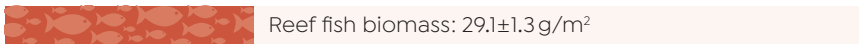
Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Rose Atoll (2010-2016)

14° 33' S, 168° 09' W



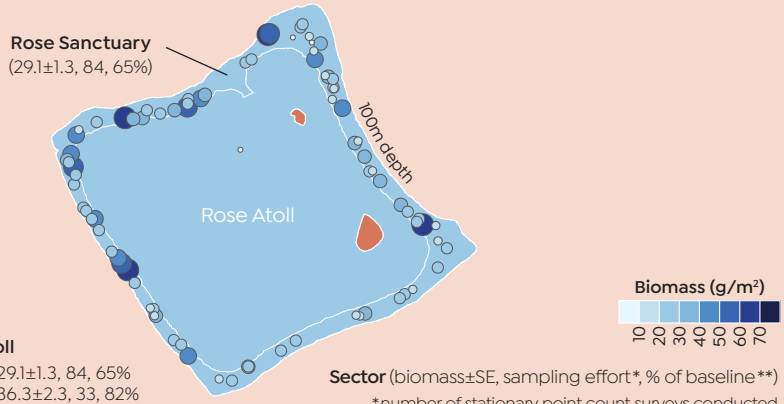
Coral reef fish surveys were conducted in 2015-16, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 21.0±1.6 g/m² in 2010, 36.3±2.3 g/m² in 2012, and 29.1±1.3 g/m² in 2015-2016.
- 50 % of the reef fish sampled were 10-30 cm in length during the 2010, 2012, and 2015-2016 surveys. There were fish observed >80 cm in length during the 2012 and 2015-2016 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Rose Atoll

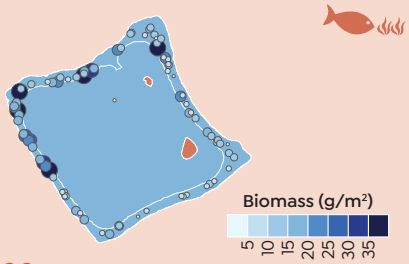
2015-16	29.1±1.3, 84, 65%
2012	36.3±2.3, 33, 82%
2010	21.0±1.6, 24, 47%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

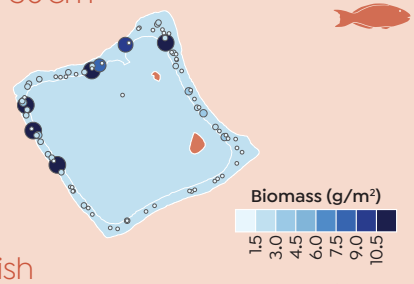
Herbivores

2015-16	15.5±0.9
2012	21.3±1.8
2010	12.6±1.3



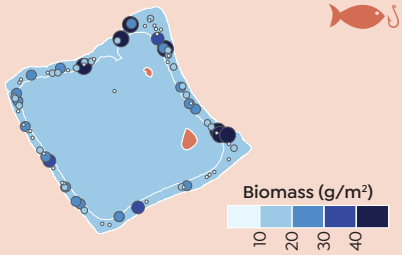
Parrotfish >30 cm

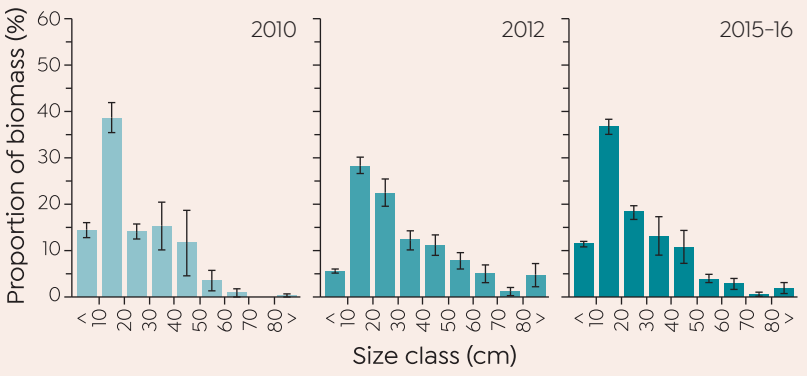
2015-16	1.9±0.4
2012	3.3±0.7
2010	0.7±0.4



Targeted fish

2015-16	16.6±1.6
2012	27.4±3.4
2010	14.8±3.3





Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

‡ Backreef and lagoon data were removed prior to calculating the sector level values.

NOAA diver monitoring coral reef condition in Tutuila, American Samoa.

Ocean Chemistry and Temperature

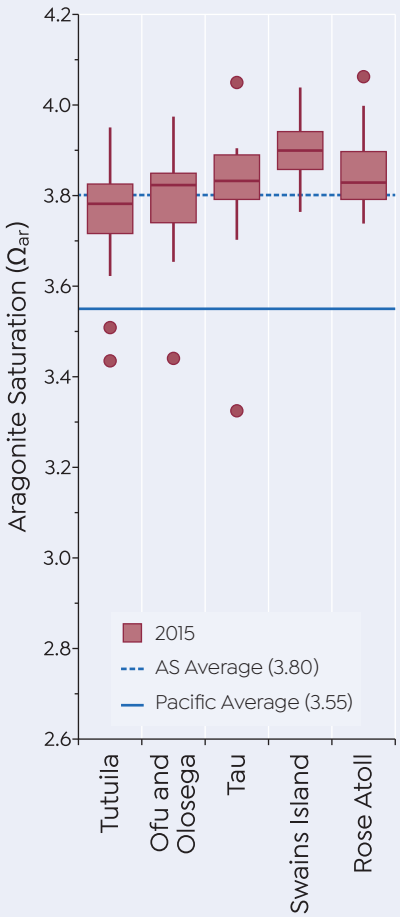
Chemistry (2010–2015)

This section represents the first American Sāmoa NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the Ecosystem Sciences Division of the NOAA Pacific Island Fisheries Science Center and the NOAA Coral Reef Watch program.

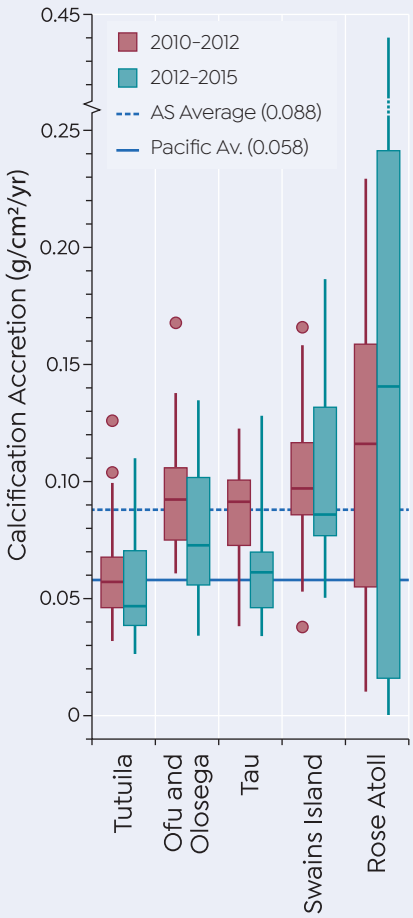
Highlights

- American Sāmoa has the most favorable environment for calcification in the US Pacific.
- Bias-corrected subsurface temperature data reveals that depths >20 m did not provide a refuge for corals from heat stress during the bleaching events of 2010 and 2014/2015.
- Coral Reef Watch Bleaching Alert Levels were triggered for nearly all of American Sāmoa during all years between 2014 and 2017 – extensive bleaching and bleaching-induced mortality were observed during this period.

Aragonite saturation state



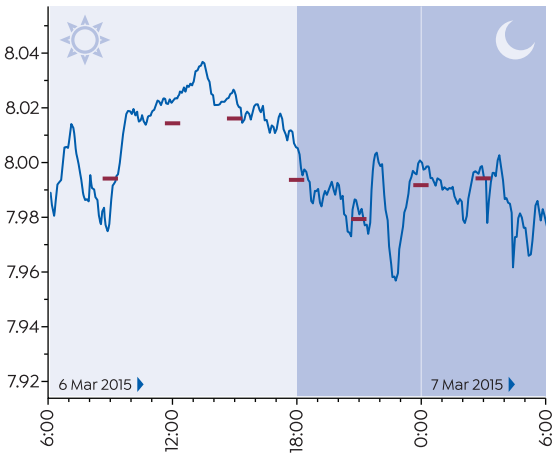
Calcium carbonate accretion



Aragonite saturation state measures carbonate ion concentration; the greater the concentration of carbonate ions is, the easier it is for organisms like stony corals to calcify. American Sāmoa had the most favorable environment for calcification in the US Pacific. Within the region, Swains Island and Rose Atoll had the highest aragonite saturation state. Rose Atoll gets its name from the pink colors of the crustose coralline algae (CCA) there. CCA is sensitive to aragonite saturation state and thrives at Rose Atoll. Aragonite saturation state can be seen as an exposure term – i.e., exposure of calcifying organisms to the conditions that drive calcification.

Calcification Accretion Units measure the response of calcifying organisms to those conditions as the net accretion of calcium carbonate produced over the deployment period (see photos to right). The American Sāmoa region showed high levels of accretion with Rose Atoll having the highest rates. The differences within an island between years were subtle, while differences among islands were stable across years, and therefore likely robust.

Diurnal pH – Fagatele

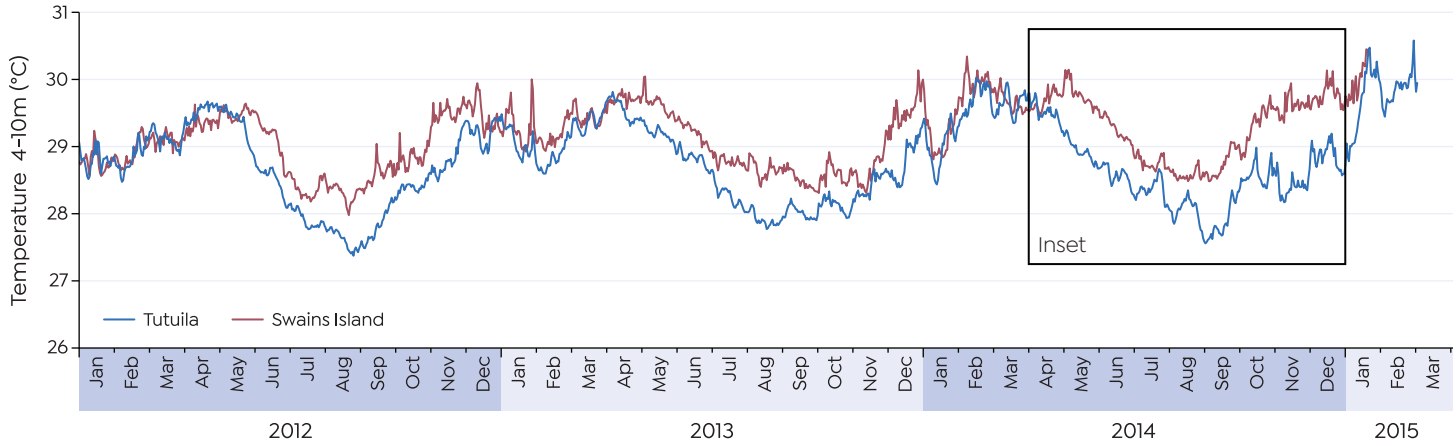


Processes driving local pH vary throughout the day. Photosynthesis drives up the pH during the day as organisms calcify. Lower pH conditions can return at night as photosynthesis stops and respiration continues to release CO_2 into the water column. Red lines on the plot are the bottle samples used to validate the 24-hour pH time series from the sensors.

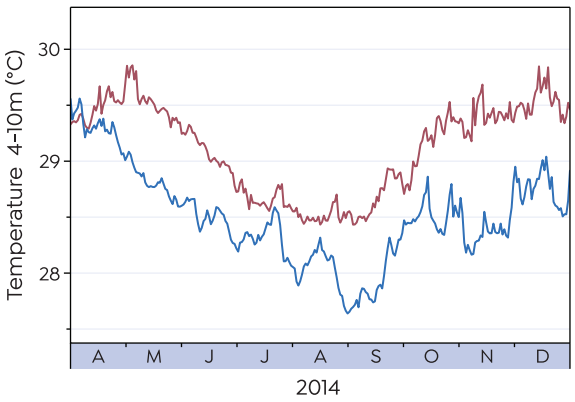
Rates of net calcium carbonate accretion are monitored with calcification accretion units (CAUs), which allow for recruitment and colonization of crustose coralline algae and hard corals. Photos show a CAU newly deployed (left) and two years after deployment (right).

Subsurface temperature

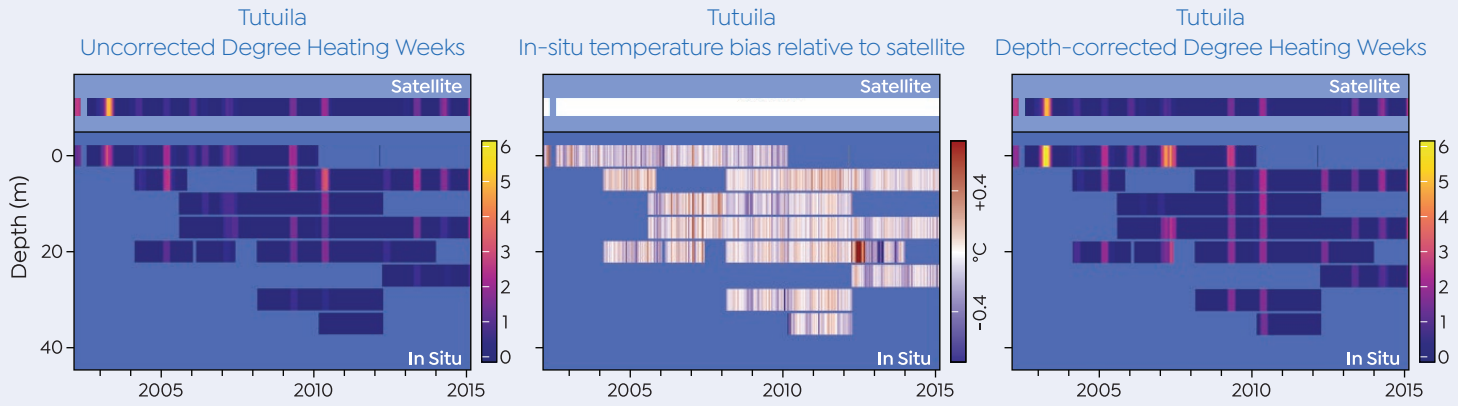
Subsurface temperature time series



Subsurface temperature time series for 4–10 m for 2012–2015 comparing Tutuila and Swains Island. Summer months at these locations (December to March) at this depth were indistinguishable. However, winter months (June to September) were 1–2°C cooler in Swains Island than in Tutuila (see inset graph, right). Winter temperatures provided less of a reprieve from warm summer temperatures in Tutuila than at Swains Island.



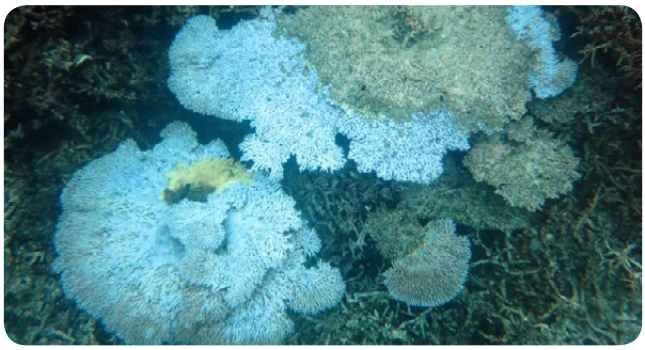

Coral bleaching, Fagatele Bay sanctuary, Tutuila



Sea temperature data can be used to calculate Degree Heating Weeks; a metric of the accumulation of heat stress. Remotely sensed sea surface temperature data from satellites are used to calculate Degree Heating Weeks for the surface of the ocean. The difference between temperatures at the surface recorded by satellites and temperatures at depth can be calculated (the 'bias'). The resultant bias-correction can be applied to temperatures at depth, enabling more accurate calculations of heat stress at depth. The 10-year time series of sub-surface temperature from Tutuila shows that depths below 20 m did not provide a refuge from heat stress. Heat stress that may have caused bleaching at depths greater than 20 m accumulated in 2005, 2010, and 2014.

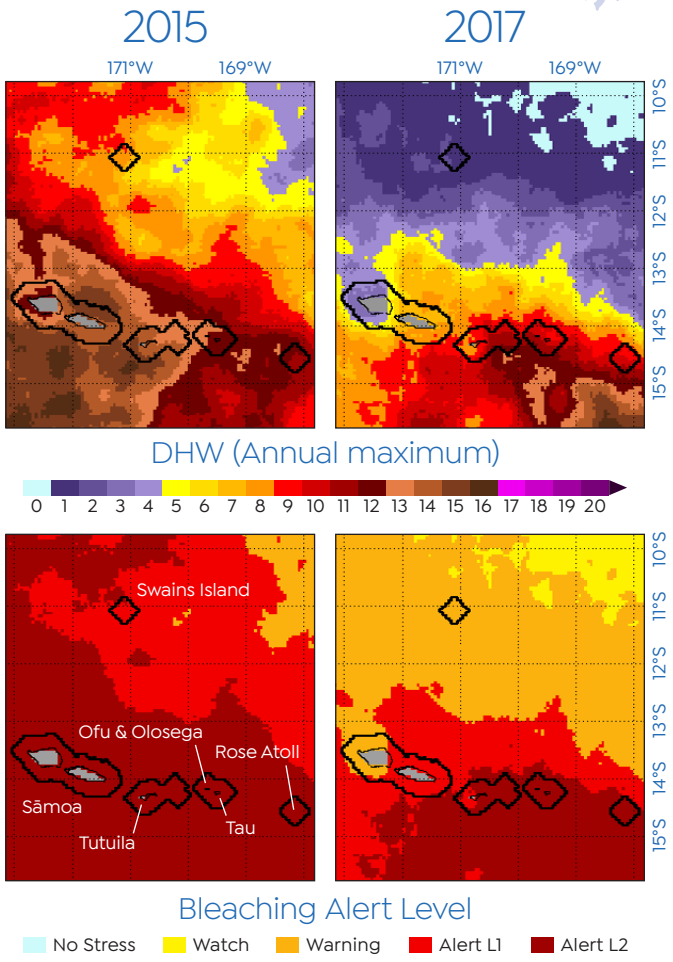
Heat stress and coral bleaching

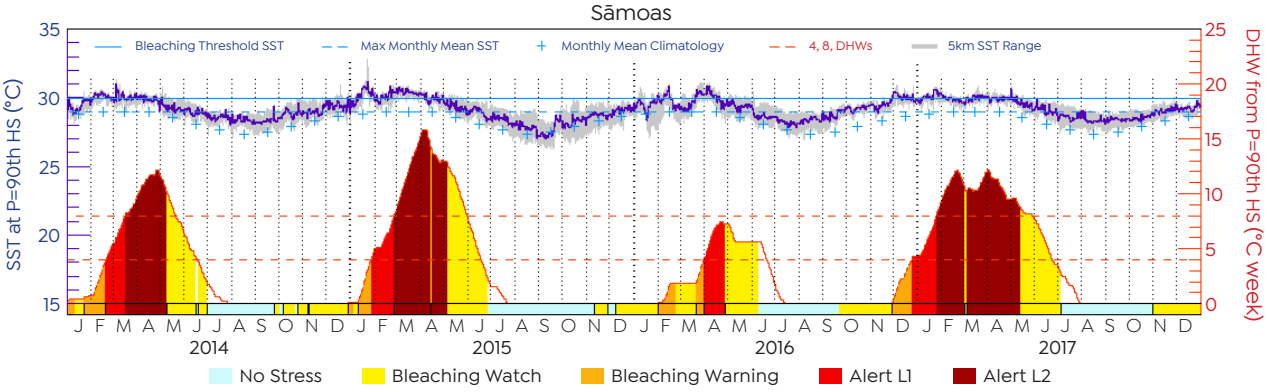
The NOAA Coral Reef Watch (CCRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in American Sāmoa in 1994, 2002, 2003, 2007, 2010, 2014, 2015, 2016, and 2017.



Coral bleaching, Fagatele Bay sanctuary, Tutuila

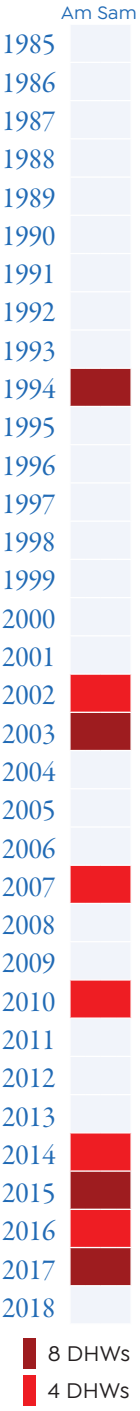
Annual maximum Degree Heating Weeks (DHWs) in 2015 were as high as 14 in parts of the Sāmoas when at least seven DHWs accumulated at all islands and atolls in the region. Heat stress accumulation triggered Alert Level 2 throughout the region in 2015 and extensive severe bleaching was observed that year and mortality due to bleaching in the following year. 2017 was also anomalously warm though not as warm as 2015. More than eight DHWs accumulated in much of the southern area of the region in 2017, including at Tutuila, Ofu and Olosega, Tau and Rose Atoll. Alert Level 2 was triggered at these locations in 2017 and more severe bleaching was observed.

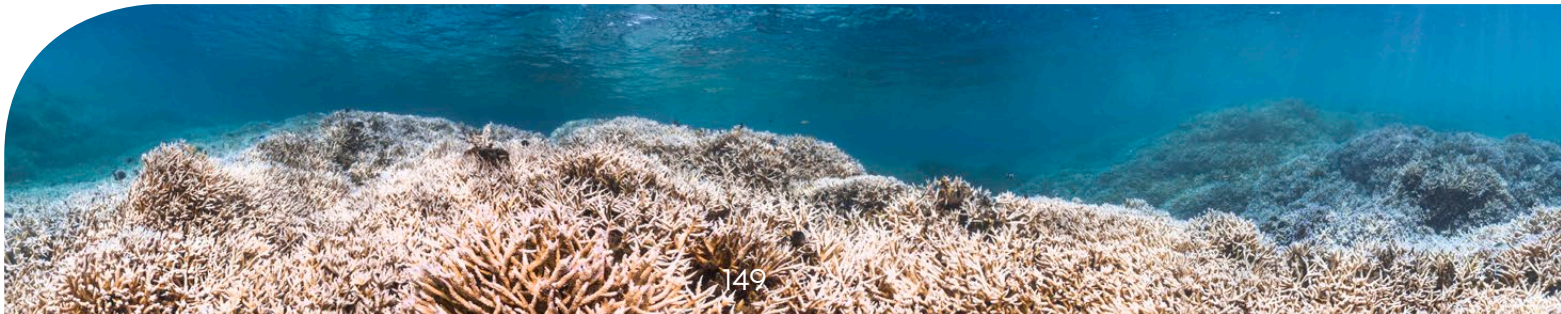




Degree Heating Week (DHW) accumulation from 2014–2017 in the Sāmoas. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in all four of these years and Alert Level 2 was triggered in 2014, 2015, and 2017, and extensive coral bleaching occurred during those years.

Thermal History





Guam

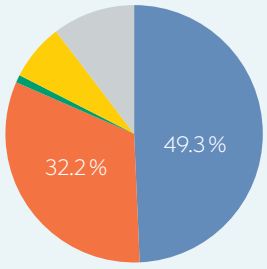
Demographics, values, resource use, and information sources

This Human Connections section presents findings from the Guam NCRMP socioeconomic data collection and includes data never collected before in Guam. These are baseline data on social indicators from household surveys conducted in February to July 2016 and from secondary sources.

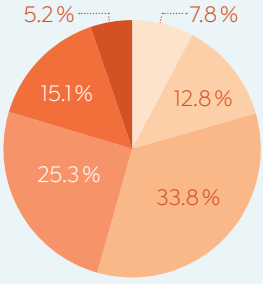
Highlights

- The great majority of residents agreed that coral reefs provide protection from erosion and natural disasters, attract tourists, and are culturally important.
- The dominant perception of the status of water quality and the amount of corals, fish and turtles was that the current status was good; however the dominant perception for trend was that the condition had worsened or remained the same over the past ten years.
- Of the potential threats to coral reefs, residents were least familiar with damage from small watercraft.
- Residents were generally very supportive of marine management policies.

Race

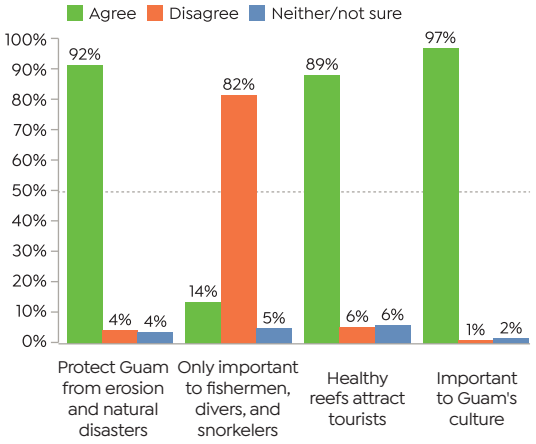


Educational attainment



The population of Guam was predominantly composed of Pacific Islander (50%) and Asian ethnicity (32%). Nearly 80% of the population had at least completed high school, ~46% had completed at least some college or an associate's degree, and ~20% a bachelor's degree or graduate degree.

Values and awareness



When asked about important services provided by reef resources, most residents agreed that coral reefs protect Guam from erosion and natural disasters (92%), that healthy coral reefs attract tourists (89%), and that coral reefs are important to Guam's culture (97%). The majority of residents (82%) disagreed with the statement that coral reefs are only important to fishermen, divers, and snorkelers.

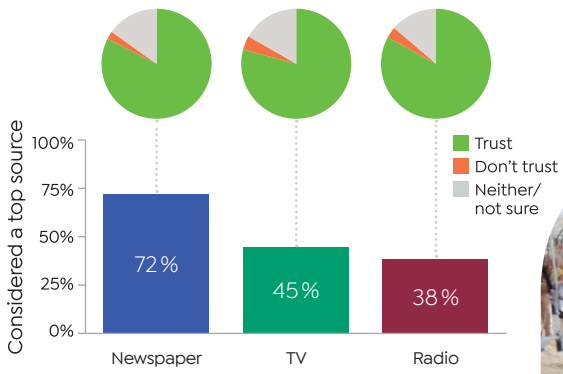
2016 survey data (n = 712)

Resource use

PERCENT OF POPULATION PARTICIPATING IN EACH ACTIVITY

Information sources

The majority (72%) of residents considered newspapers to be the top source for information on the environment, including status of coral reefs and present and future threats. Greater than 75% of residents who claimed newspapers, TV and radio are top sources indicated these sources were trustworthy.



Perceptions of resource condition, threats, and severity

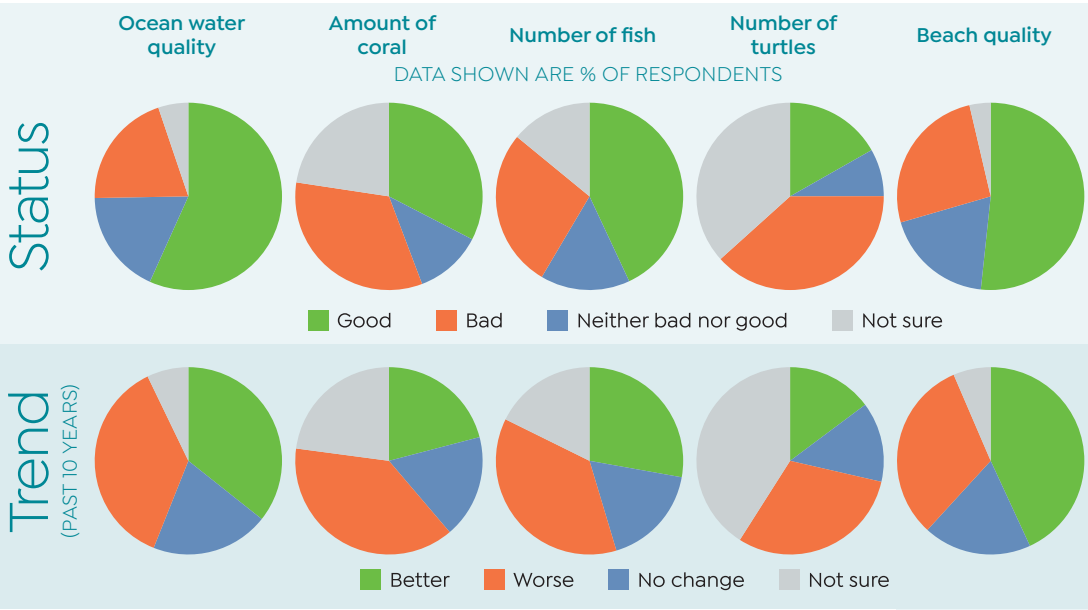
Threats

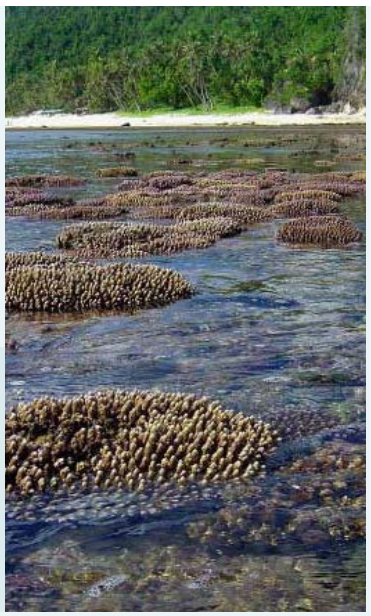
PERCENT OF THE POPULATION FAMILIAR WITH EACH THREAT

Threats not shown above: **Invasive species** (47 %), and **Damage from small watercraft** (44 %).

In general, residents were familiar with potential threats facing coral reefs in Guam, with at least 47 % of residents stating they were familiar or very familiar with each potential threat shown above. Of the potential threats mentioned, residents were least familiar with damage from small watercraft (44 %) and invasive species (47 %). Residents exhibited highest levels of familiarity with threats from trash and littering.

PERCEPTIONS OF

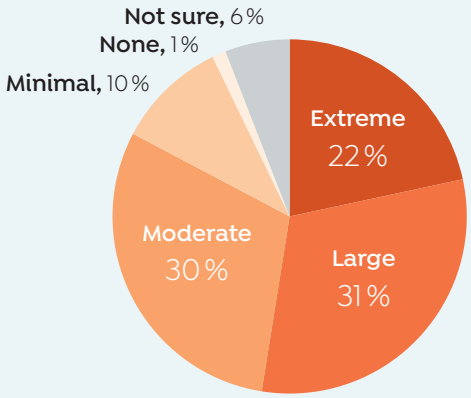




Status and trend

More residents felt confident in their perception of the status of ocean water quality and beach quality (<10 % not sure) than for the amounts of coral, fish, and turtles (>15 % not sure). For those confident in their perception, roughly 30–60 % of residents felt the current status was good, and roughly 20–60 % felt the current status was bad for all status variables. A different pattern was shown in the perceptions of trend. For those confident in their perception of the trend of ocean water quality and amount of corals, fish, and turtles, roughly 35–50 % felt it had gotten worse, roughly a quarter felt there had been no change and roughly 25–45 % felt the status had gotten better. Overall, the dominant perception of the status of marine resources was that the current status was good (except for number of turtles); however there was no dominant perception concerning trend in status over the last ten years.

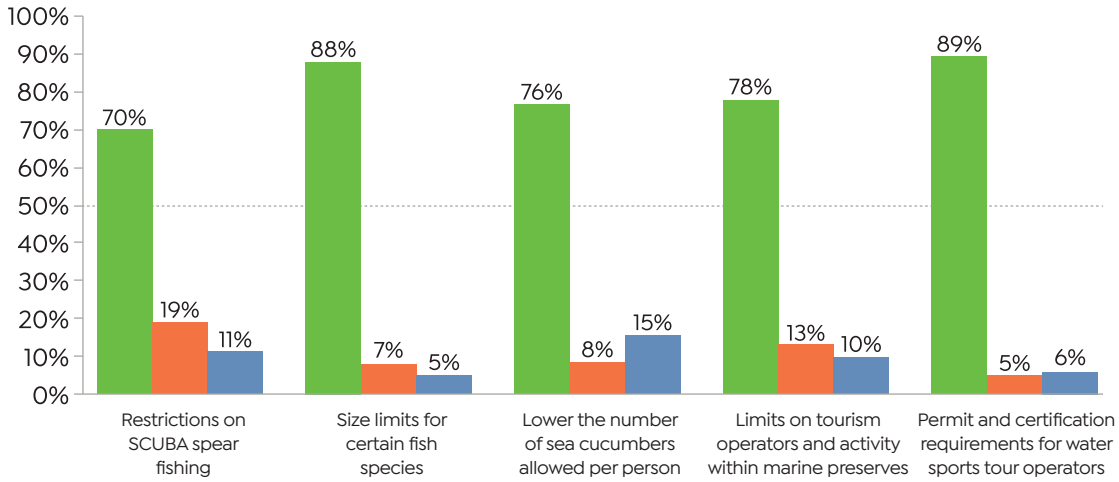
Severity of threats



Residents were generally concerned about threats to coral reefs in Guam. Twenty two percent of residents stated that they thought threats were extreme and 31 % thought threats were large. A small percentage (11 %) stated that threats were either minimal or believe there are no threats.

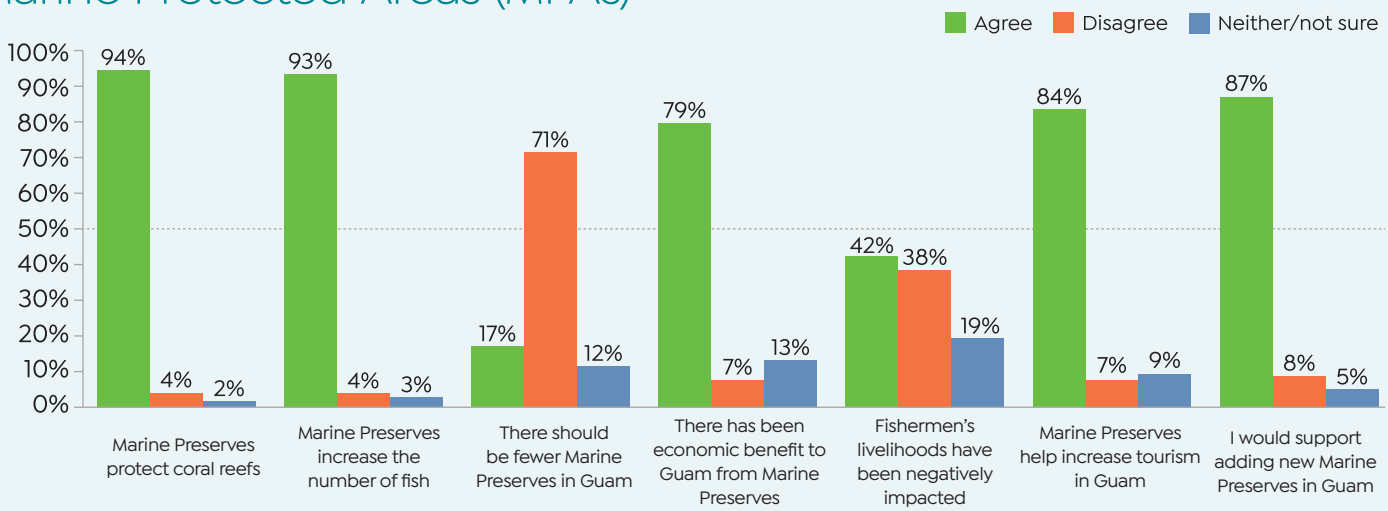
Perceptions of reef management policies

Management policies



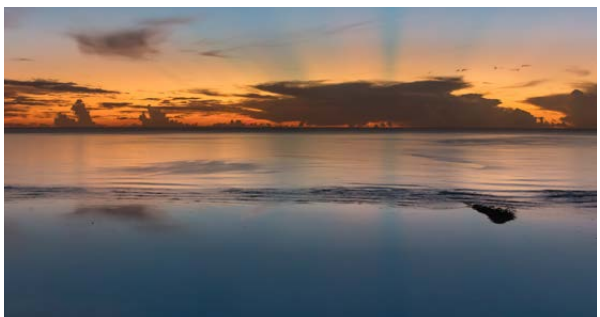
Residents were generally supportive of current marine management policies. There was high support for size limits for certain fish species (88%), and permit and certification requirements (89%). There was less but still strong support for limiting tourism operators and activity within marine preserves (78%) and lowering the number of sea cucumbers allowed per person (76%), and restricting SCUBA spear fishing (70%).

Marine Protected Areas (MPAs)



Respondents mostly agreed that MPAs provide benefits. Eighty-four percent or more of residents agreed or strongly agreed that MPAs protect coral reefs, increase number of fish, and attract tourists. The vast majority of residents also supported adding new MPAs in Guam if evidence was provided that current ones are effective (87%). Only 17% of residents stated that there should be fewer MPAs in Guam. There was less certainty regarding whether fishermen's livelihoods have been negatively impacted by MPAs, with 38% disagreeing with this statement, and 42% agreeing.

Tumon Bay Marine Preserve, Guam.



Coral reefs – Guam (2017)

13° 27' N, 144° 48' E

Land area: 544 km²

0–100m depth: 152 km²

Coral reef area: 51.1 km² (12/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 159,358 (2010)

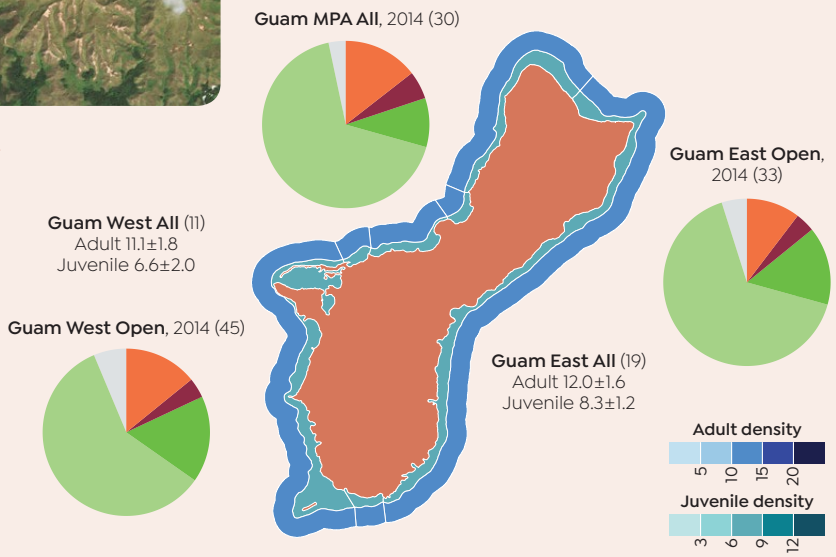
The coral reefs of Guam were surveyed in May and June of 2017.*

- Coral cover was highest in Guam MPA All (14.5%) and lowest in Guam East Open (10.4%).
- Acute and chronic coral diseases were between 1 and 2% in all sectors.
- Old mortality of corals was 15.4±1.1% in Guam East and 16.8±1.1% in Guam West.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

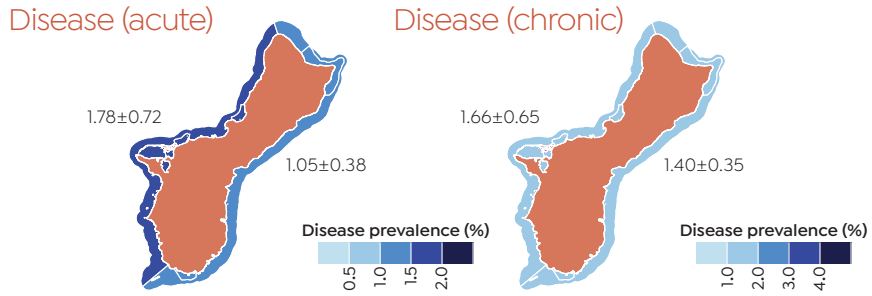


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

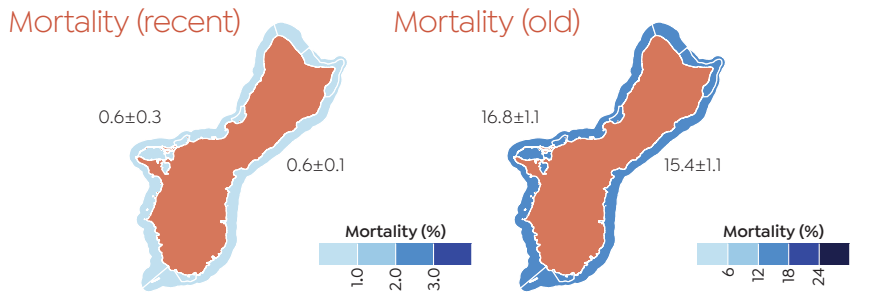
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Guam (2011-2017)

13° 27' N, 144° 48' E

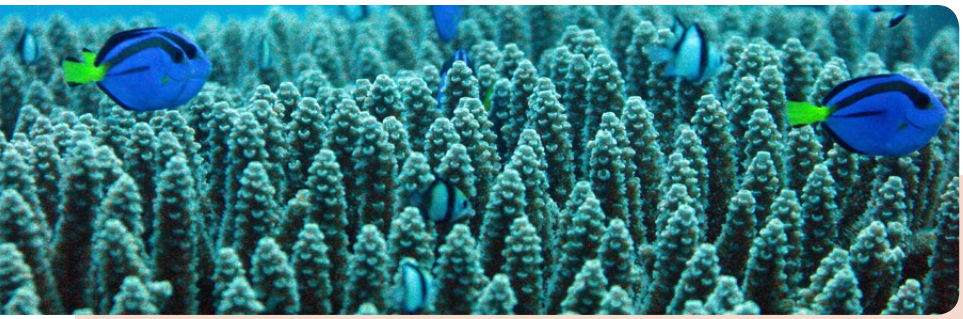
Reef fish biomass: 9.6±1.3 g/m²

100 g/m²

Coral reef fish surveys were conducted in 2017, 2014, and 2011.

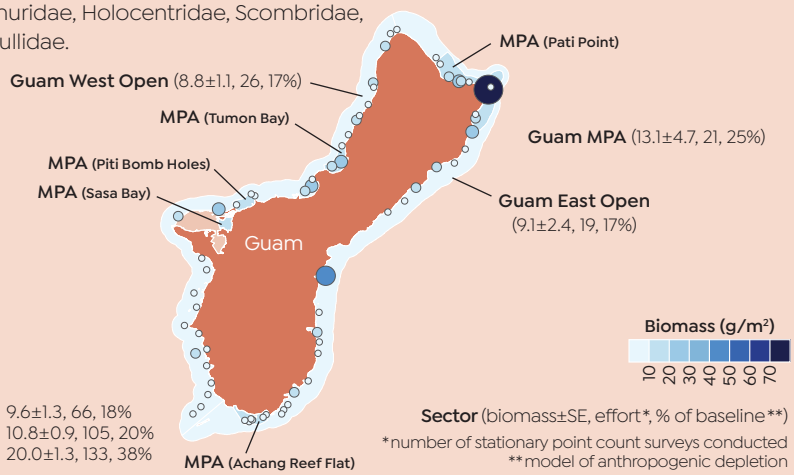
NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass ranged from 8.8±1.1 g/m² (17 % of baseline) in Guam West to 13.1±4.7 g/m² (25 % of baseline) in Guam MPA.
- Reef fish biomass was 20.0±1.3 g/m² in 2011, 10.8±0.9 g/m² in 2014, and 9.6±1.3 g/m² in 2017.
- 50 % of the reef fish sampled were >20 cm in length during the 2011, and 2014 surveys, and >50 % of the reef fish sampled were >30 cm in 2017.



Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Guam

2017	9.6±1.3, 66, 18%
2014	10.8±0.9, 105, 20%
2011	20.0±1.3, 133, 38%

Sector (biomass±SE, effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

Herbivores

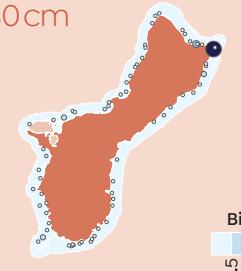
2017	5.3±0.8
2014	8.2±1.0
2011	14.3±1.0

West (5.1±0.8)
East (3.7±0.9)
MPA (9.9±4.3)

Parrotfish >30 cm

2017	0.3±0.2
2014	0.2±0.1
2011	1.7±0.3

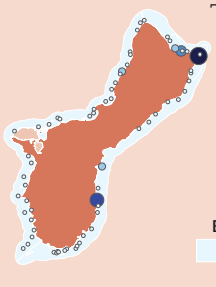
West (0.1±0.1)
East (0.1±0.1)
MPA (1.4±1.2)

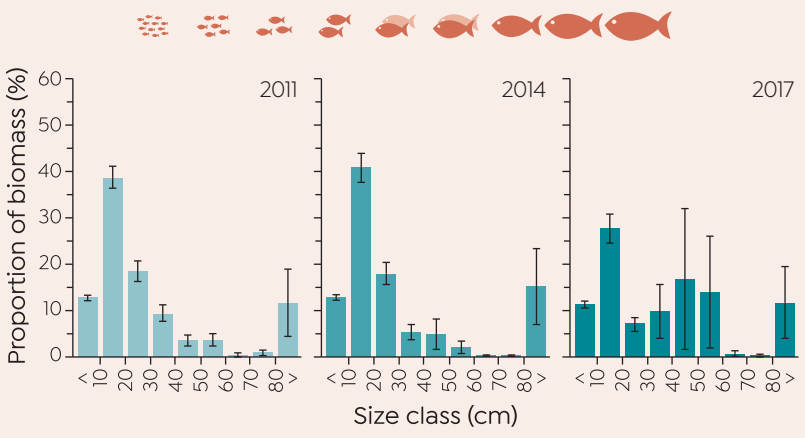


Targeted fish

2017	3.2±1.0
2014	4.7±1.0
2011	7.7±1.1

West (1.5±0.5)
East (3.3±1.7)
MPA (7.8±4.4)





Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

NOAA Ship Hi'ialakai in the Marianas Archipelago.

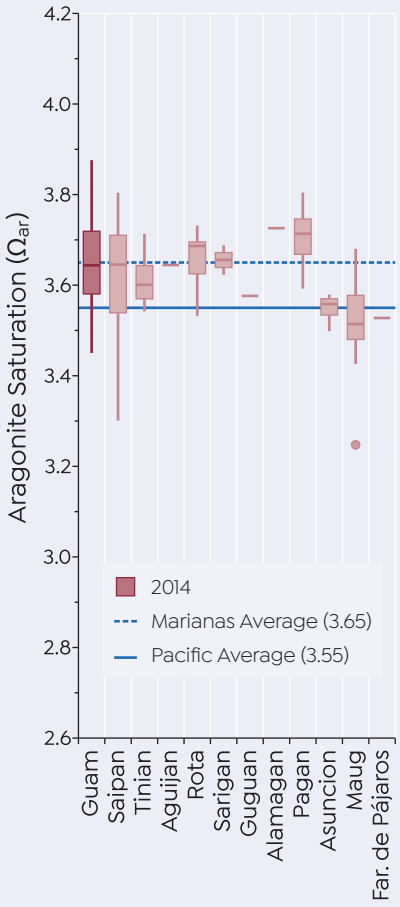
Chemistry (2011–2014)

This section represents the first Guam NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the Ecosystem Sciences Division of the NOAA Pacific Islands Fisheries Science Center and the NOAA Coral Reef Watch program.

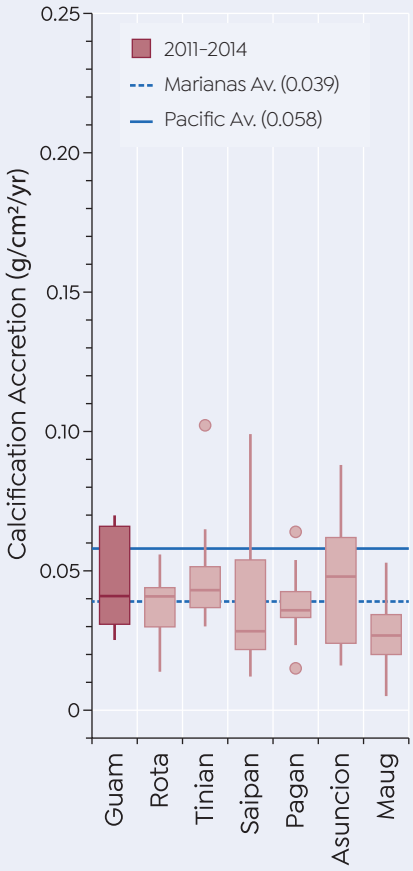
Highlights

- Calcium carbonate accretion in Guam was below the US Pacific average.
- Bias-corrected subsurface temperature data reveals that depths >20 m did not provide a refuge for corals from heat stress during the 2015 bleaching event.
- Coral Reef Watch Bleaching Alert Level 2 was triggered throughout the region in 2017. Extensive severe bleaching was observed in 2017 and extensive mortality due to bleaching was observed in 2018.

Aragonite saturation state



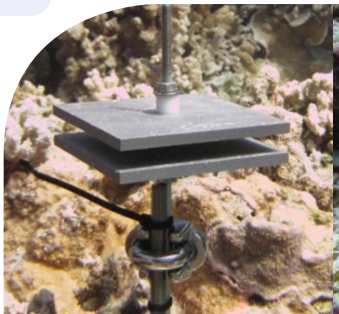
Calcium carbonate accretion



Aragonite saturation state measures carbonate ion concentration; the greater the concentration of carbonate ions is, the easier it is for organisms like stony corals to calcify. Aragonite saturation state was slightly above the Pacific average in Guam and was nearly the same at Saipan and Guam. Aragonite saturation state can be seen as an exposure term – i.e., exposure of calcifying organisms to the conditions that drive calcification.

Calcification Accretion Units measure the response of calcifying organisms to those conditions as the net accretion of calcium carbonate produced over the deployment period (see photos to right). Calcium carbonate accretion was lower than the Pacific average in Guam.

A range of calcifying organisms (coral species and crustose coralline algae) that contribute to reef building.



Rates of net calcium carbonate accretion are monitored with calcification accretion units (CAUs), which allow for recruitment and colonization of crustose coralline algae and hard corals. Photos show a CAU newly deployed (left) and two years after deployment (right).

Subsurface temperature

Subsurface temperature time series

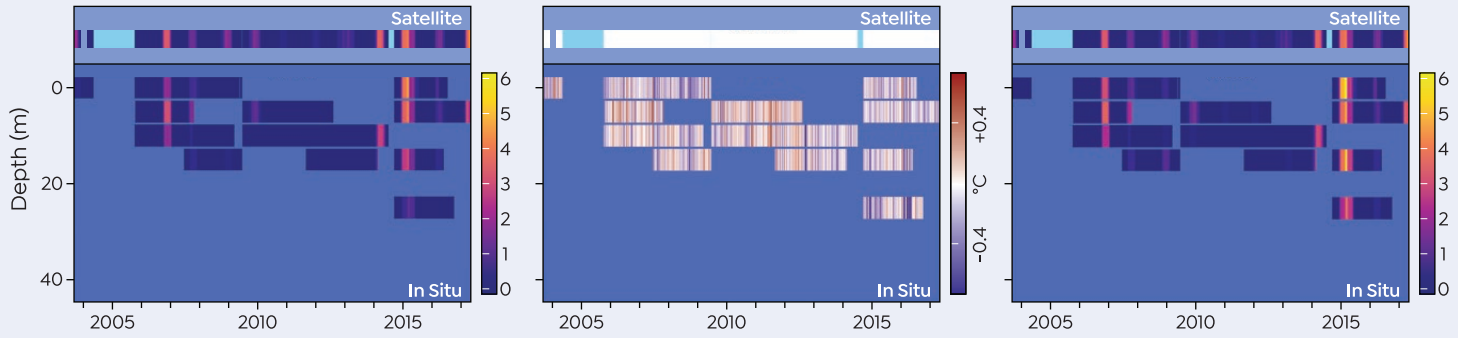
Subsurface temperature time series for 4–15 m for 2014–2016 comparing Guam and Pagan (in CNMI). Warm season months at these locations (May to August) at this depth were very similar between these islands, though slightly higher in Pagan in 2014, and slightly higher in Guam in 2015. Cool season months (December to March) were cooler in 2014–15 in Pagan than in Guam (see inset graph, right). Cool season temperatures provided less of a reprieve from warm season temperatures in Guam than in Pagan.


Coral bleaching, Guam

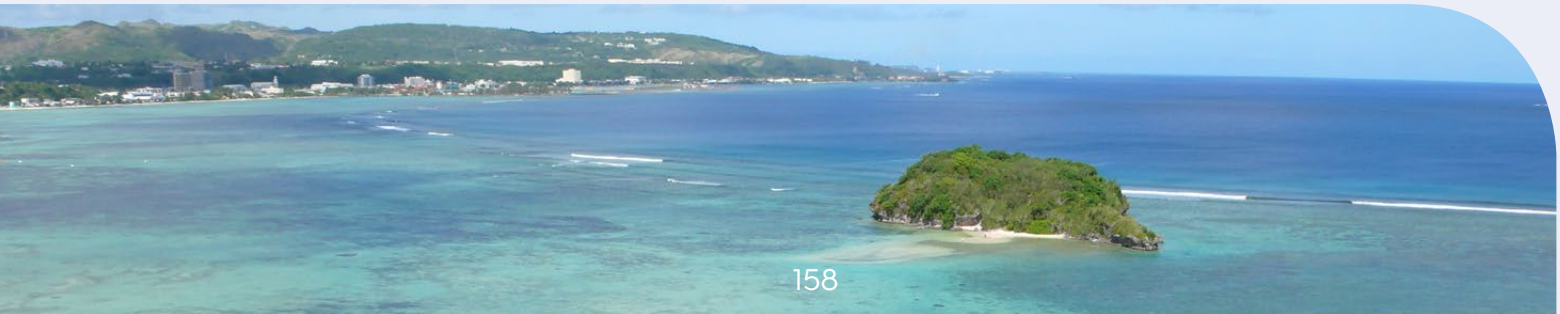
Guam
Uncorrected Degree Heating Weeks

Guam
In-situ temperature bias relative to satellite

Guam
Depth-corrected Degree Heating Weeks



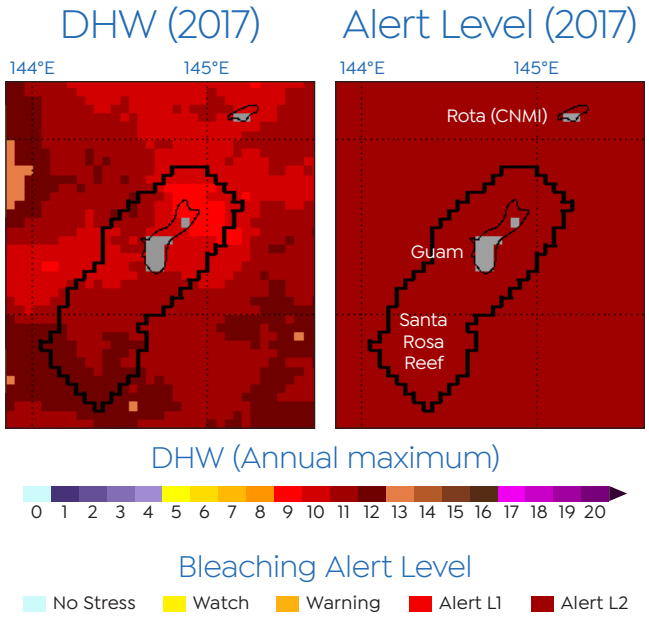
Sea temperature data can be used to calculate Degree Heating Weeks; a metric of the accumulation of heat stress. Remotely sensed sea surface temperature data from satellites are used to calculate Degree Heating Weeks for the surface of the ocean. The difference between temperatures at the surface recorded by satellites and temperatures at depth can be calculated ('the bias'). The resultant bias-correction can be applied to temperatures at depth, enabling more accurate calculations of heat stress at depth. The 10-year time series of sub-surface temperature from Guam shows that depths below 20 m did not always provide a refuge from heat stress. Heat stress that may have caused bleaching at depths greater than 20 m accumulated in 2015.



Heat stress and coral bleaching

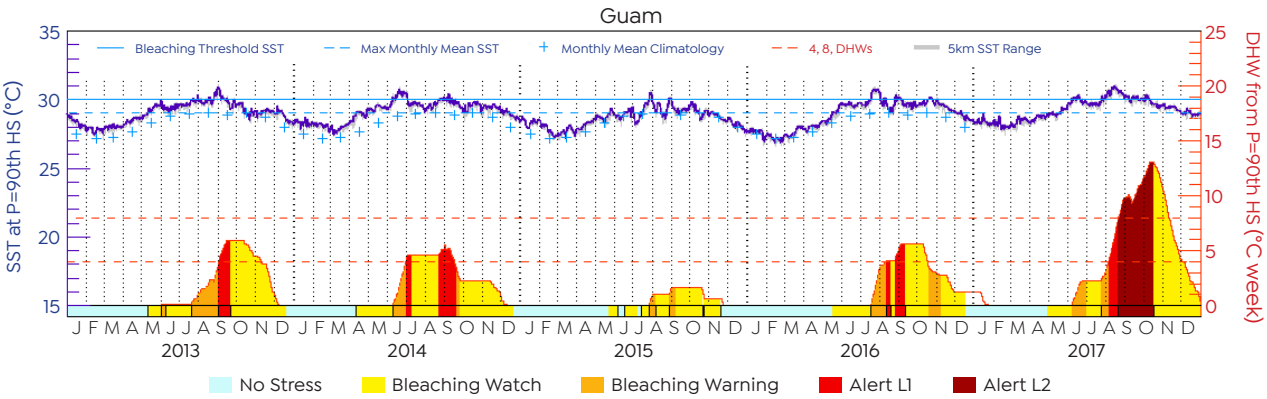
The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in Guam in 2006, 2013, 2014, 2016, and 2017.

Coral bleaching in Guam during a mass bleaching event in 2013



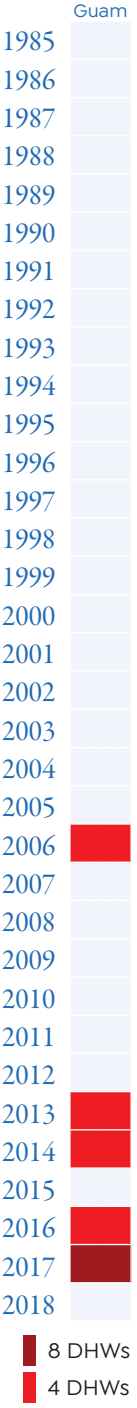
Annual maximum Degree Heating Weeks (DHWs) in 2017 (left panel) were as high as 10 in parts of Guam when at least nine DHWs accumulated at reefs surrounding Guam.

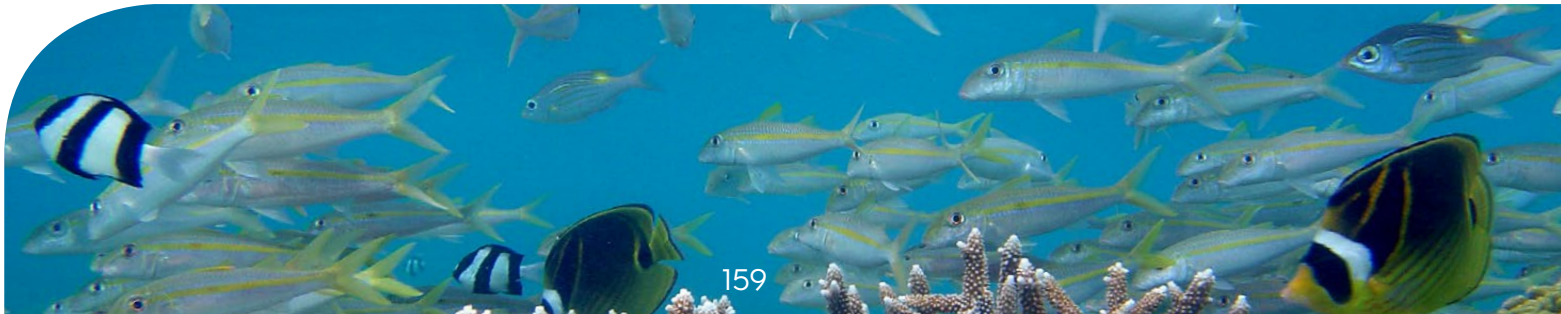
Heat stress accumulation triggered Alert Level 2 throughout the region in 2017 (right panel) and extensive severe bleaching was observed that year and extensive mortality due to bleaching was observed in 2018.



Degree Heating Week (DHW) accumulation from 2013–2017 in CNMI. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in 2013, 2014, 2016, and 2017 and Alert Level 2 was triggered in 2017, and extensive coral bleaching occurred in 2017.

Thermal History





Commonwealth of the Northern Mariana Islands

CNMI

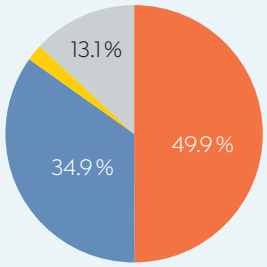
Demographics, values, resource use, and information sources

This Human Connections section presents findings from the CNMI NCRMP socioeconomic data collection and includes data never collected before in CNMI. These are baseline data on social indicators from household surveys conducted in August 2016 to April 2017, and from secondary sources.

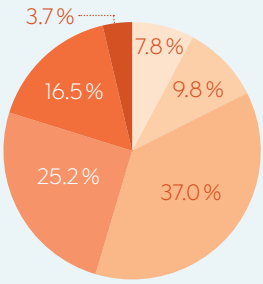
Highlights

- The great majority of residents agreed that coral reefs provide protection from erosion and natural disasters, attract tourists, and are culturally important.
- The dominant perception of the status and trends of water quality and the amount of corals, fish, and animals for gleaning was that the current status was good, but condition had declined over the last ten years.
- Of the potential threats to coral reefs, residents were least familiar with invasive species.
- Residents were generally very supportive of marine management policies – nearly 90% agreed that they generally support marine protected areas.

Race



Educational attainment

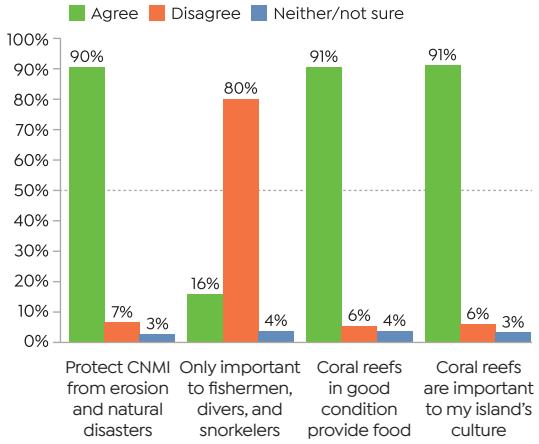


The population of CNMI was predominantly composed of Asian (50%) and Pacific Islander ethnicity (35%). Around 80% of the population had at least completed high school, ~45% had completed at least some college or an associate's degree, and ~20% a bachelor's degree or graduate degree.

Resource use

PERCENT OF POPULATION PARTICIPATING IN EACH ACTIVITY

Values and awareness

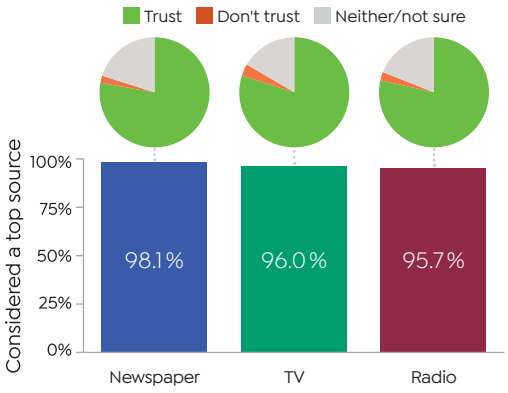


When asked about important services provided by reef resources, most residents agreed that coral reefs protect CNMI from erosion and natural disasters (90%), that coral reefs in good condition provide food (91%), and that coral reefs are important to CNMI culture (91%). The majority of residents (80%) disagreed with the statement that coral reefs are only important to fishermen, divers, and snorkelers.

2016-17 survey data (n = 722)

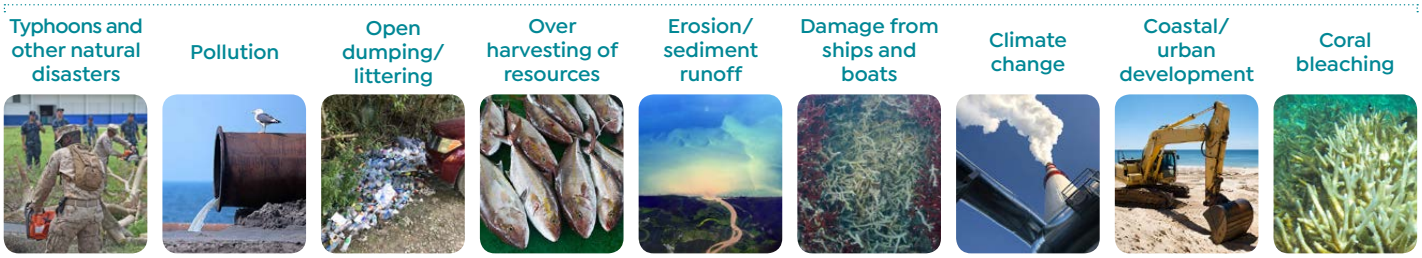
Information sources

The great majority (>95%) of residents considered newspapers, TV, and the radio to be a top source for information on the environment, including status of coral reefs and present and future threats. Greater than 75% of residents who claimed newspapers, TV and radio are top sources sources indicated these sources were trustworthy.



Perceptions of resource condition, threats, and severity

Threats

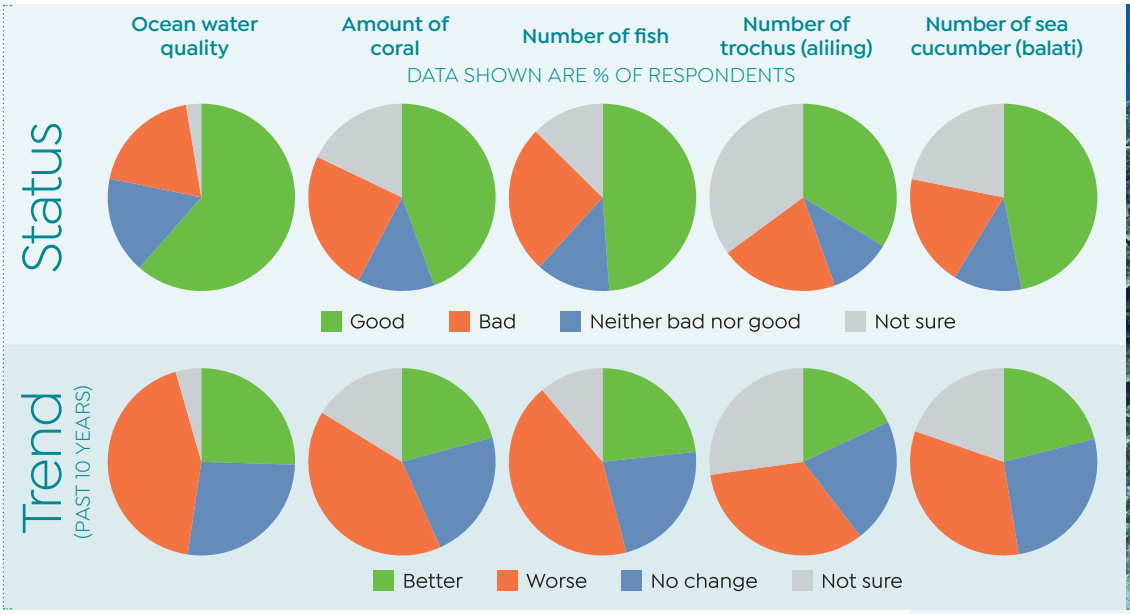


PERCENT OF THE POPULATION FAMILIAR WITH EACH THREAT

Threats not shown above: **Invasive species** (49 %).

In general, residents were familiar with potential threats facing coral reefs in CNMI, with at least half of residents stating they were familiar or very familiar with each potential threat mentioned except coral bleaching and invasive species (each 49 %). Residents exhibited highest levels of familiarity with threats from pollution and hurricanes.

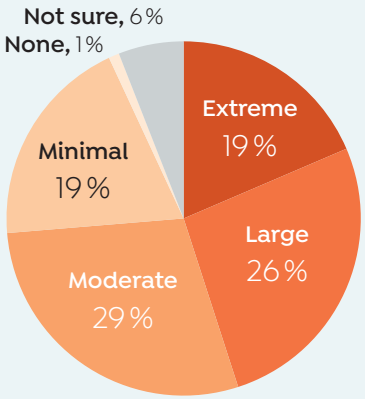
PERCEPTIONS OF



Status and trend

More residents felt confident in their perception of the status of ocean water quality (<3 % not sure) than for the amounts of coral, fish, and animals for gleaning (>13 % not sure). For those confident in their perception, roughly 50–65 % of residents felt the current status was good, and roughly 25 % felt the current status was bad for all status variables. A different pattern was shown in the perceptions of trend. For those confident in their perception of the trend of ocean water quality and amount of corals, fish and animals for gleaning, roughly half felt trend was worse, roughly a quarter felt there had been no change and roughly a quarter felt status had improved. Overall, the dominant perception of the status and trends of water quality or the amount of corals, fish, and animals for gleaning was that the current status was good but that the status of these marine resources had gotten worse over the last ten years.

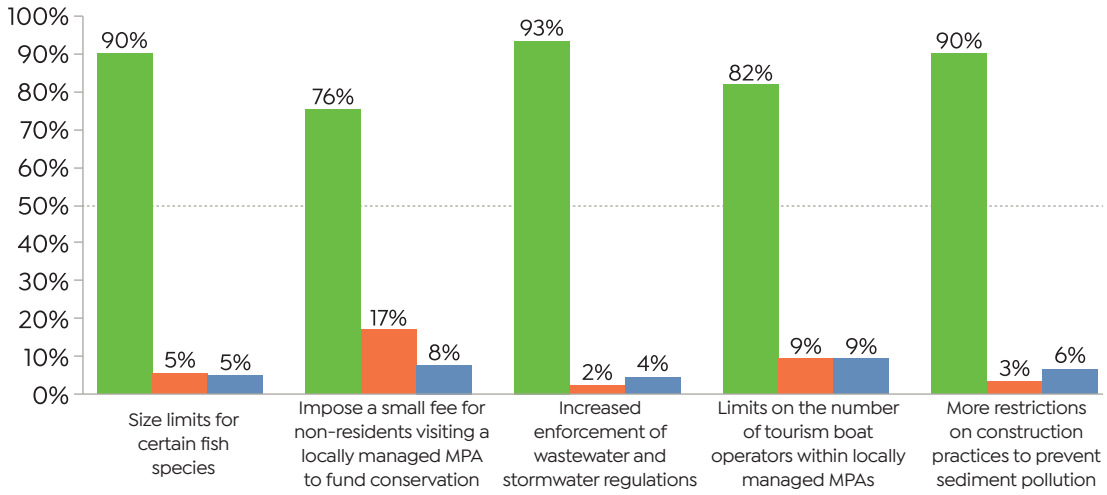
Severity of threats



Residents were generally concerned about threats to coral reefs in CNMI. Nineteen percent of residents stated that they thought threats were extreme and 26 % thought threats were large. Almost one fifth stated that threats were either minimal or believe there are no threats.

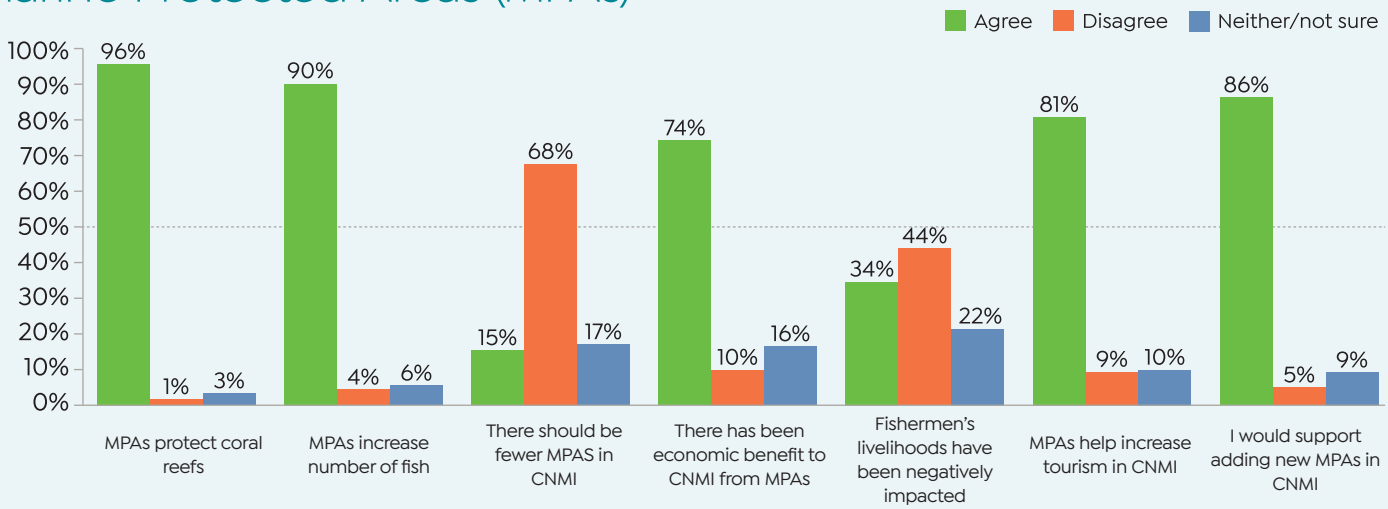
Perceptions of reef management policies

Management policies



Residents were generally supportive of current marine management policies. There was extremely high support for size limits for certain fish species (90%), increased enforcement of wastewater and stormwater regulations (93%), and more restrictions on construction practices to prevent sediment pollution (90%). There was less but still strong support for imposing fees on non-residents that visit locally managed MPAs (76%) and limiting the number of tourism boat operators within locally managed MPAs (82%).

Marine Protected Areas (MPAs)



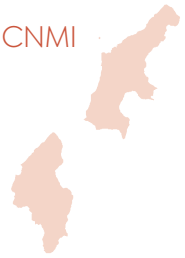
Respondents mostly agreed that MPAs provide benefits. Seventy-four percent or more of residents agreed or strongly agreed that MPAs protect coral reefs, increase number of fish, attract tourists, and provide economic benefits to residents of CNMI. The vast majority of residents also supported adding new MPAs in CNMI if evidence was shown current ones are effective (86%). Only 15% of residents stated that there should be fewer MPAs in CNMI. There was less certainty regarding whether fishermen's livelihoods have been negatively impacted by MPAs, with 44% disagreeing with this statement, and 34% agreeing.

Coral Gardens, Rota, the first MPA in CNMI.

Coral reefs – Saipan (2017)

15° 11' N, 145° 45' E

CNMI



Land area: 115 km²

0–100m depth: 112 km²

Coral reef area: 35.4 km² (14/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 48,220 (2010)

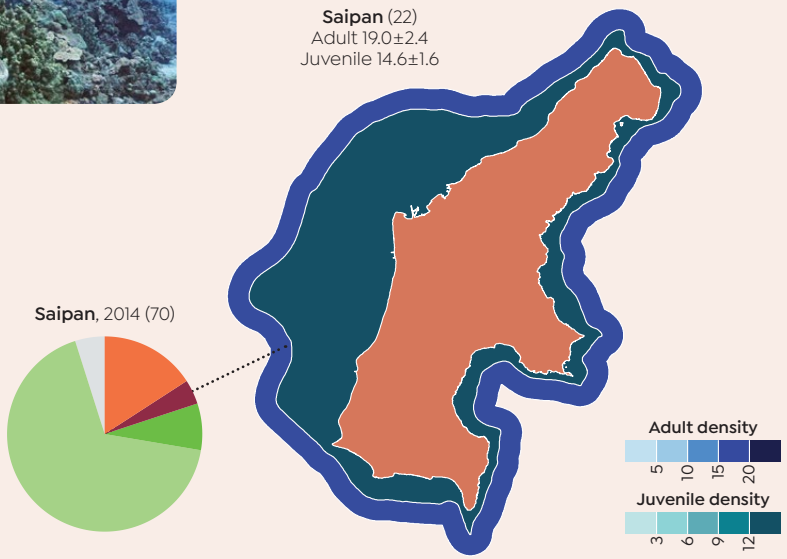
The coral reefs of Saipan were surveyed in May and June of 2017.*

- Coral cover was 15.9 % in Saipan.
- Acute and chronic coral diseases were <1 % in all sectors, as was recent mortality.
- Old mortality of corals was 12.2 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

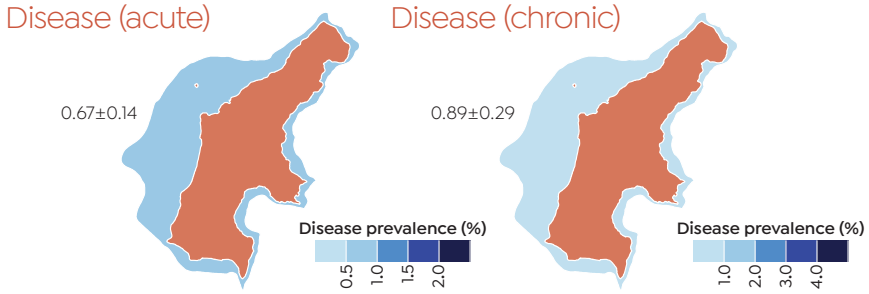


* Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

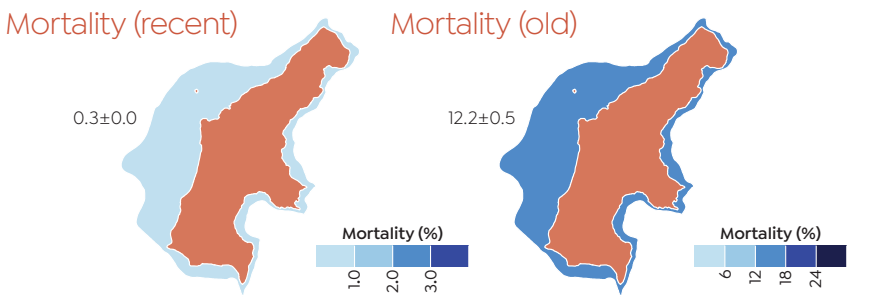
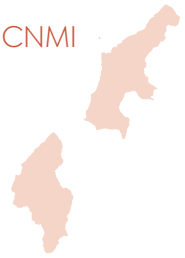


TABLE OF CONTENTS



Coral reef fish – Saipan (2011-2017)

15° 11' N, 145° 45' E

Reef fish biomass: 10.9±1.0 g/m²

100 g/m²

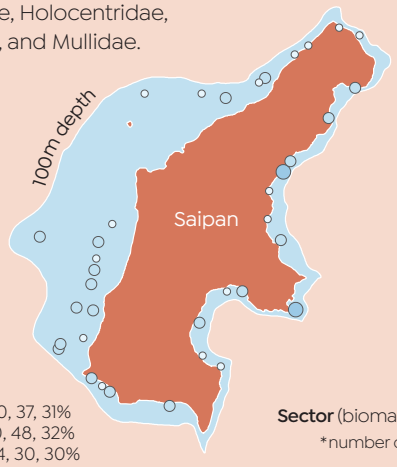
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 10.7±1.4 g/m² in 2011, 11.4±1.0 g/m² in 2014, and 10.9±1.0 g/m² in 2017.
- >50 % of the reef fish sampled were <20 cm in length during the 2011, 2014, and 2017 surveys.

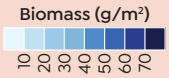
Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Saipan

2017	10.9±1.0, 37, 31%
2014	11.4±1.0, 48, 32%
2011	10.7±1.4, 30, 30%



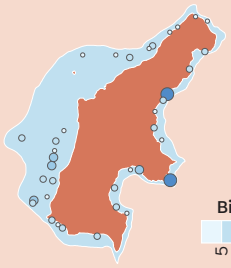
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

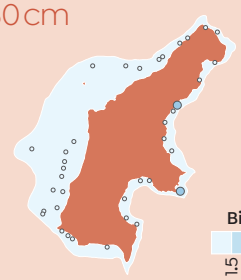
Herbivores

2017	6.8±0.8
2014	7.9±0.8
2011	6.6±1.2



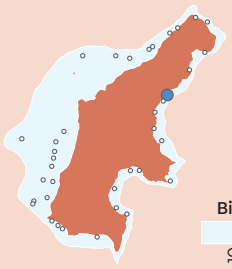
Parrotfish >30 cm

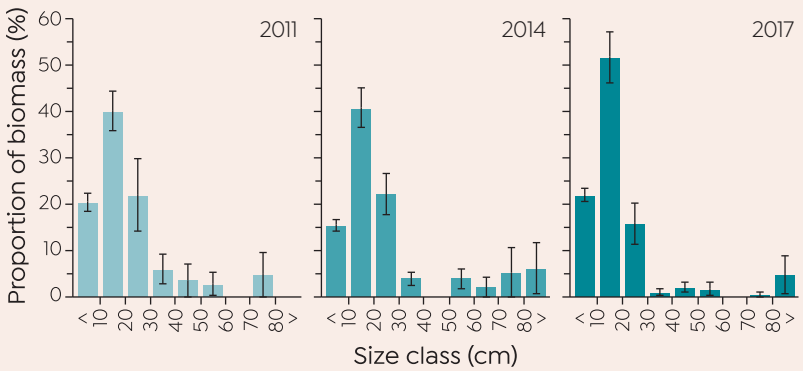
2017	0.2±0.1
2014	0.1±0.1
2011	0.5±0.2



Targeted fish

2017	2.2±0.6
2014	4.3±1.0
2011	3.4±1.4

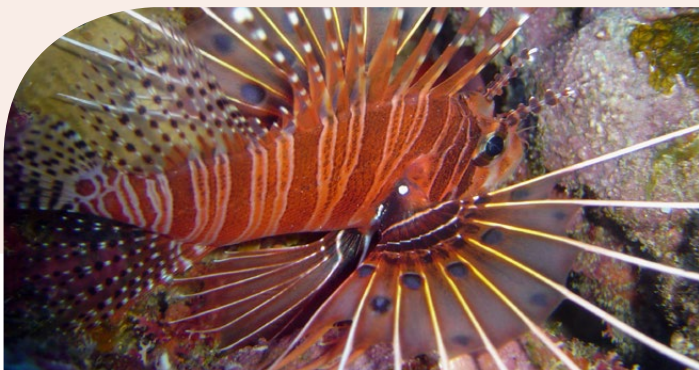




Size class distribution

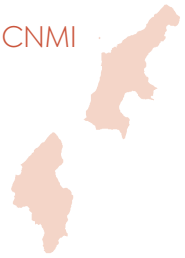
Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

‡ Backreef and lagoon data were removed prior to calculating the sector level values.



Coral reefs – Tinian (2017)

15° 00' N, 145° 38' E



Land area: 101 km²

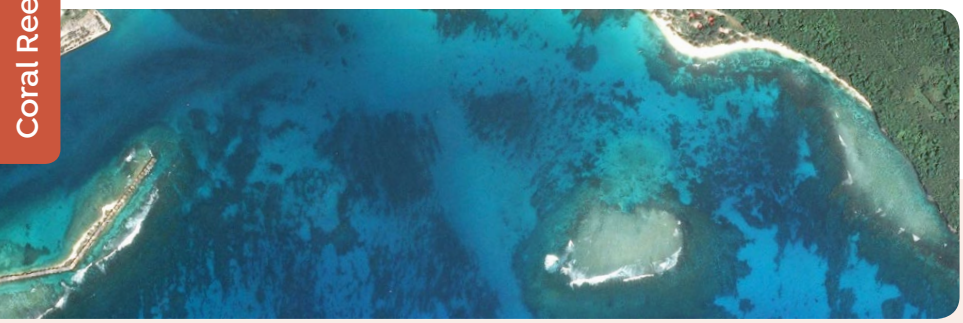
0–100m depth: 42.4 km²

Coral reef area: 14.1 km² (22/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 3,136 (2010)

The coral reefs of Tinian were surveyed in May and June of 2017.*

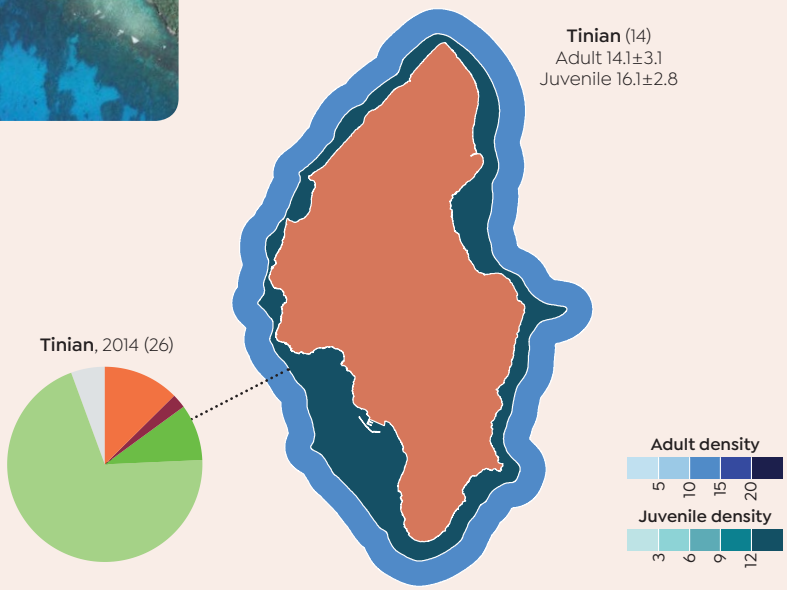


- Coral cover was 12.6% in Tinian.
- Acute and chronic coral diseases were 1.0% or less, as was recent mortality.
- Old mortality of corals was 17.2%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

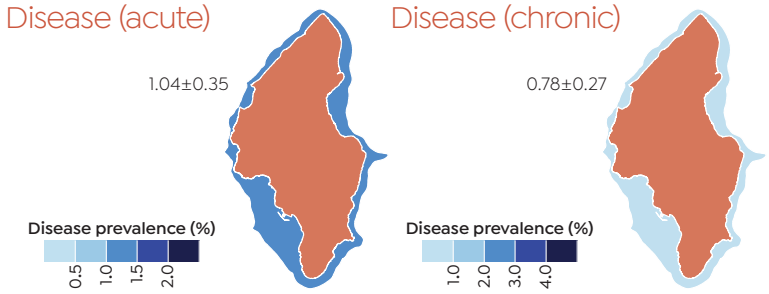


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

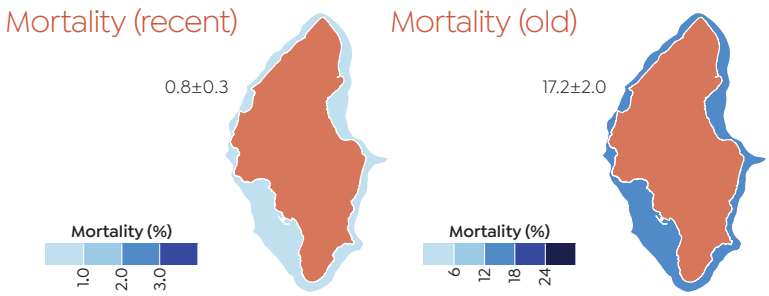
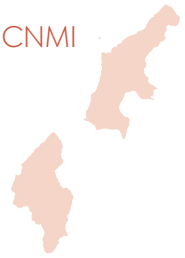


TABLE OF CONTENTS



Coral reef fish – Tinian (2011-2017)

15° 00' N, 145° 38' E

Reef fish biomass: 11.7±1.5 g/m²

Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 14.8±1.7 g/m² in 2011, 10.8±1.1 g/m² in 2014, and 11.7±1.5 g/m² in 2017.
- >50 % of the reef fish sampled were <20 cm in length during the 2011, 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.

Tinian

2017	11.7±1.5, 24, 28%
2014	10.8±1.1, 19, 26%
2011	14.8±1.7, 19, 36%

Biomass (g/m²)
10 20 30 40 50 60 70

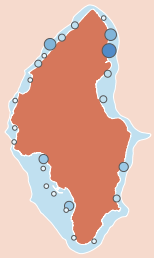
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

Herbivores

2017	6.9±1.2
2014	6.7±1.0
2011	8.1±1.4



Biomass (g/m²)
5 10 15 20 25 30 35

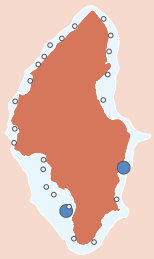
Parrotfish >30 cm

2017	0.2±0.2
2014	0.2±0.1
2011	0.4±0.2

Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

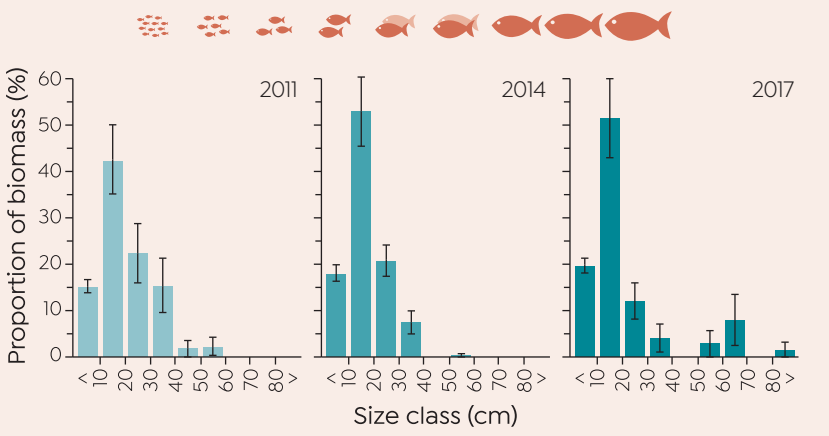
2017	3.6±1.4
2014	2.1±0.5
2011	6.1±1.7

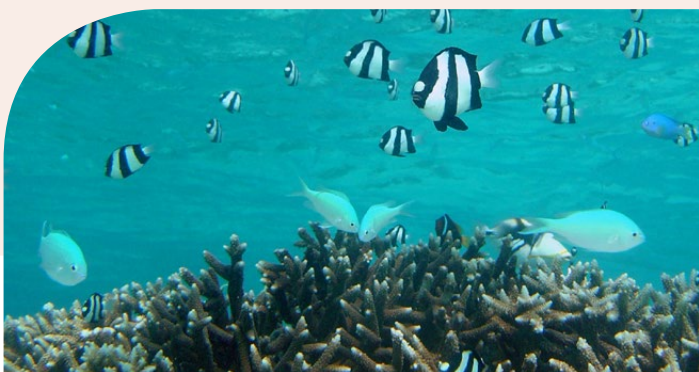


Biomass (g/m²)
10 20 30 40

Size class distribution

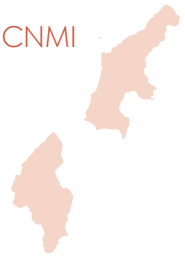
Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.





Coral reefs – Aguijan (2017)

14° 51' N, 145° 34' E



Land area: 7.1 km²

0–100m depth: Data not available

Coral reef area: 4.1 km² (28/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

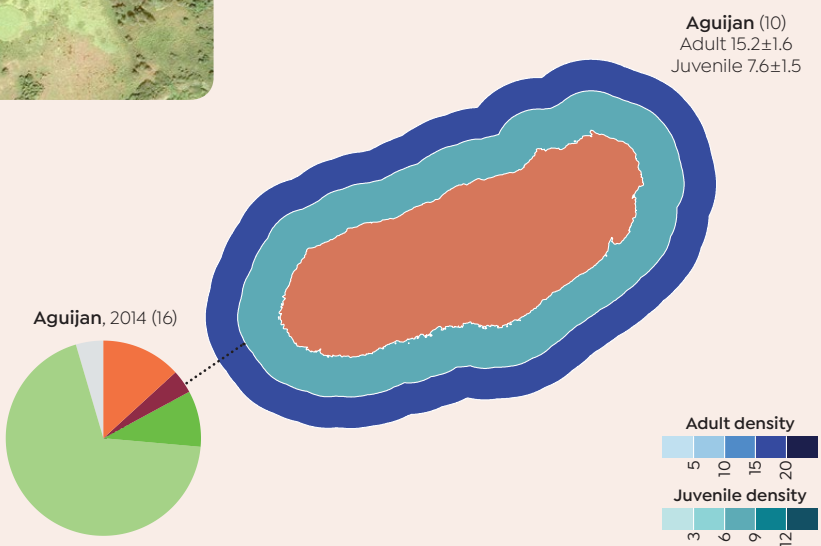
The coral reefs of Aguijan were surveyed in May and June of 2017.*

- Coral cover was 13.2% in Aguijan.
- Acute and chronic coral diseases were <1%, as was recent mortality.
- Old mortality of corals was 18.3%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

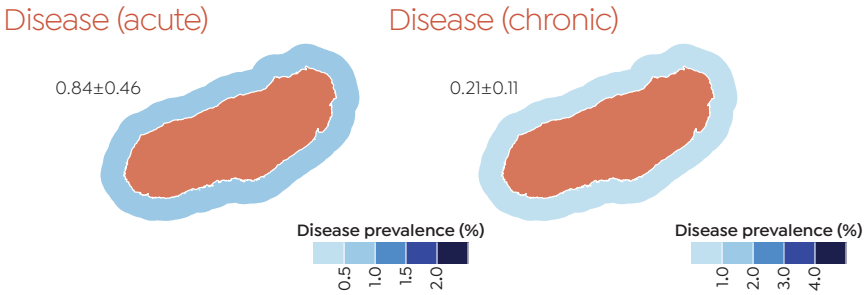


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

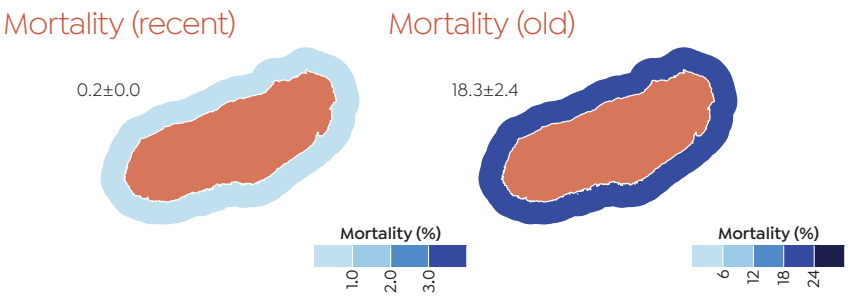
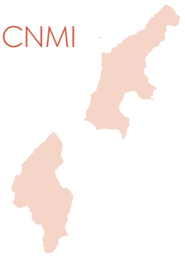


TABLE OF CONTENTS



Coral reef fish – Aguijan (2011-2017)

14° 51' N, 145° 34' E

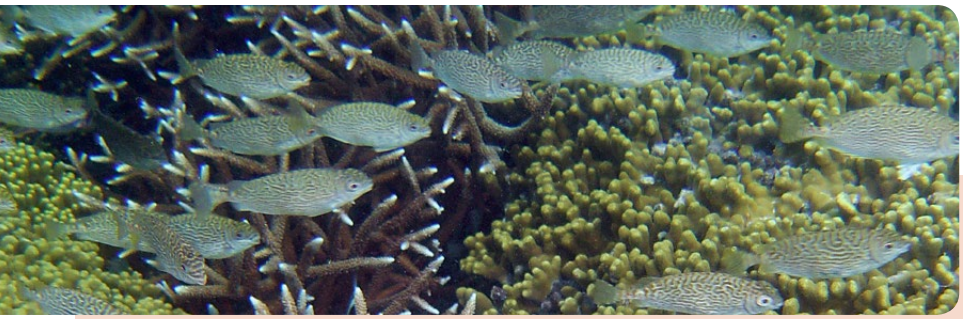
Reef fish biomass: 12.7±1.6 g/m²

100 g/m²

Coral reef fish surveys were conducted in 2017, 2014, and 2011.

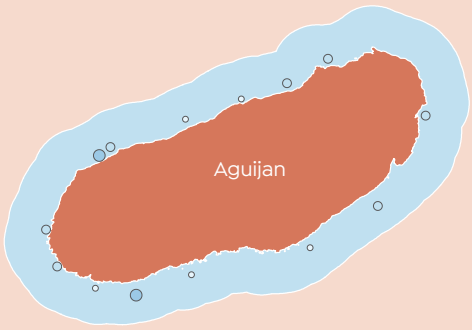
NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 18.3±2.5 g/m² in 2011, 14.9±3.0 g/m² in 2014, and 12.7±1.6 g/m² in 2017.
- >50 % of the reef fish sampled were <20 cm in length during the 2011, 2014, and 2017 surveys.



Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Aguijan

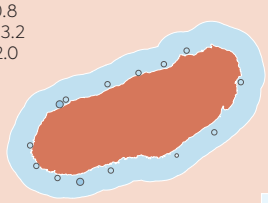
2017	12.7±1.6, 17, 24%
2014	14.9±3.0, 10, 30%
2011	18.3±2.5, 13, 37%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

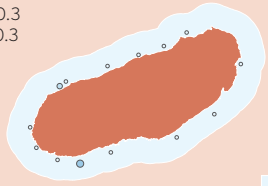
Herbivores

2017	7.5±0.8
2014	10.5±3.2
2011	11.9±2.0



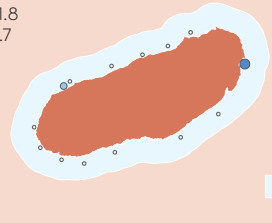
Parrotfish >30 cm

2017	0.3±0.2
2014	0.4±0.3
2011	0.7±0.3



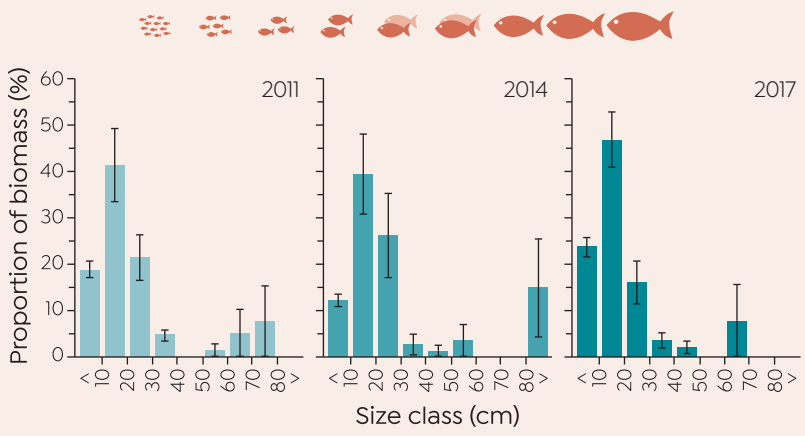
Targeted fish

2017	4.1±1.3
2014	3.6±1.8
2011	6.1±1.7



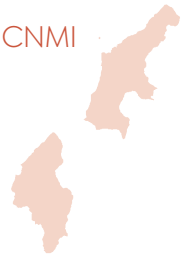
Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Rota (2017)

14° 09' N, 145° 13' E



Land area: 85.4 km²

0–100m depth: 39.6 km²

Coral reef area: 13.3 km² (23/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 2,477 (2010)

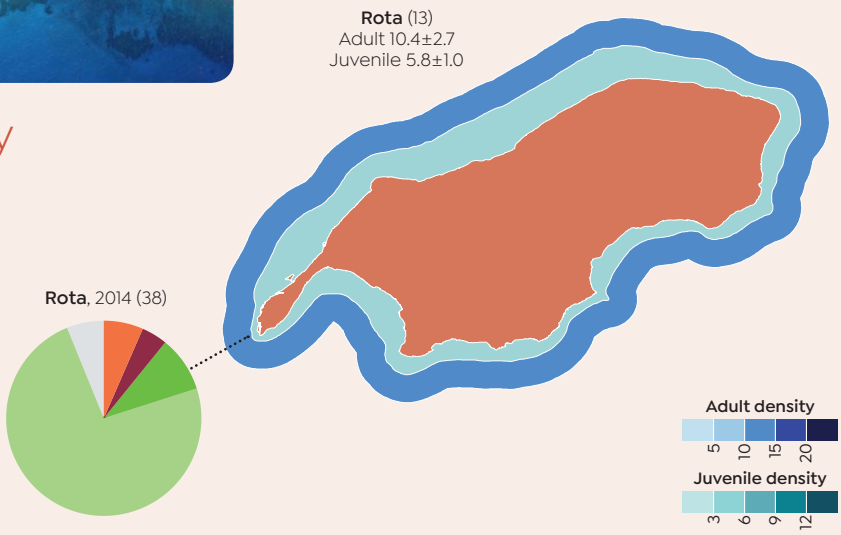
The coral reefs of Rota were surveyed in May and June of 2017.*

- Coral cover was 6.6 % in Rota.
- Acute and chronic coral diseases were 1.3 % or less, as was recent mortality.
- Old mortality of corals was 16.7 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

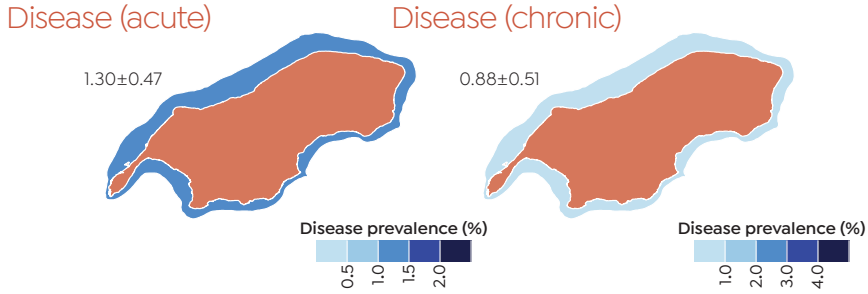


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

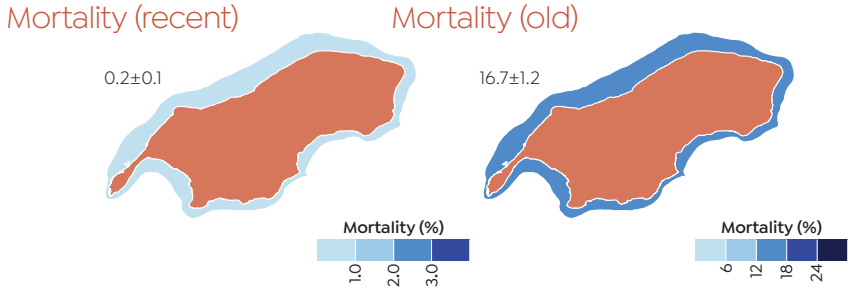
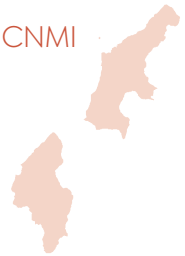


TABLE OF CONTENTS



Coral reef fish – Rota (2011-2017)

14°09'N, 145°13'E

Reef fish biomass: 10.6±1.3 g/m²

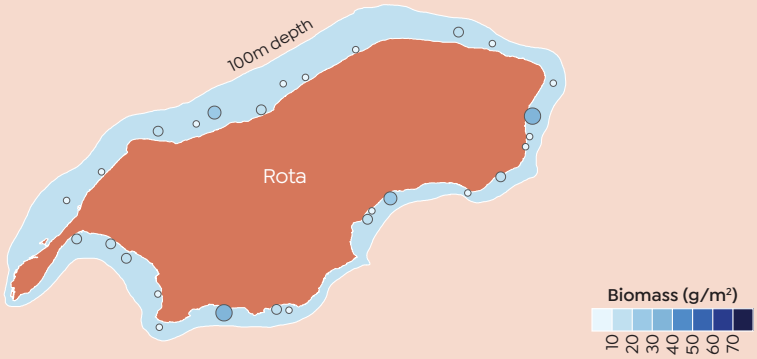
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 12.7±2.4 g/m² in 2011, 11.2±1.2 g/m² in 2014, and 10.6±1.3 g/m² in 2017.
- >50 % of the reef fish sampled were <20 cm in length during the 2011, 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Rota

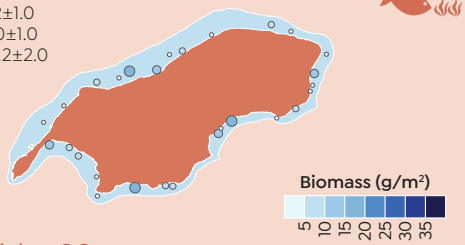
2017	10.6±1.3, 28, 24%
2014	11.2±1.2, 28, 26%
2011	12.7±2.4, 24, 29%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

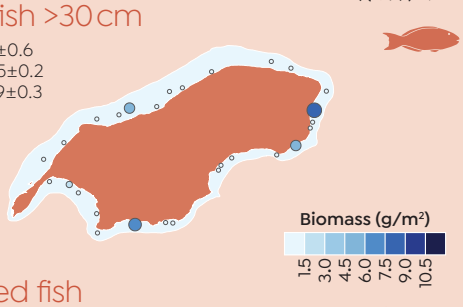
Herbivores

2017	7.2±1.0
2014	9.0±1.0
2011	10.2±2.0



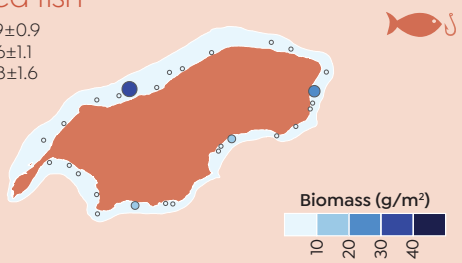
Parrotfish >30 cm

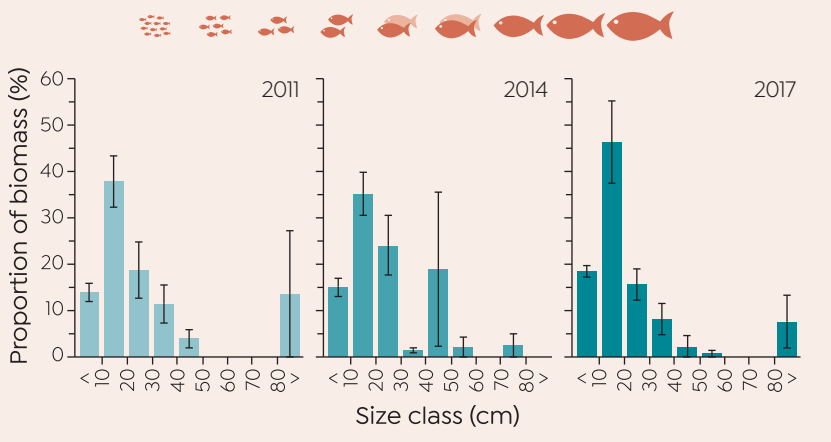
2017	1.1±0.6
2014	0.5±0.2
2011	0.9±0.3



Targeted fish

2017	3.9±0.9
2014	4.6±1.1
2011	5.8±1.6





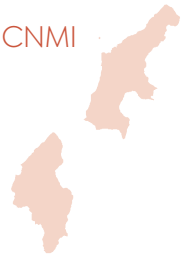
Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral reefs – Sarigan (2017)

16° 42' N, 145° 47' E

CNMI



Land area: 4.5 km²

0–100m depth: 4.9 km²

Coral reef area: 2.0 km² (37/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

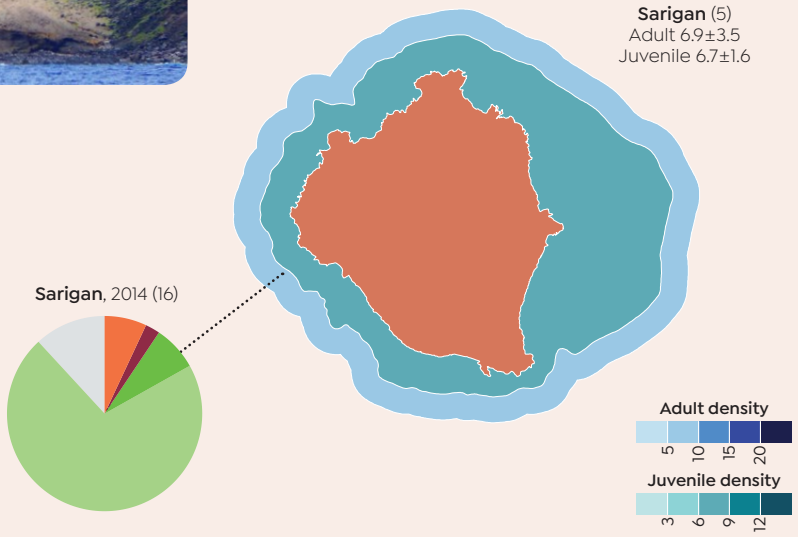
The coral reefs of Sarigan were surveyed in May and June of 2017.*

- Coral cover was 7.0 % in Sarigan.
- Acute coral disease and recent mortality were <1%. Chronic coral disease was 6.5 %.
- Old mortality of corals was 14.3 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

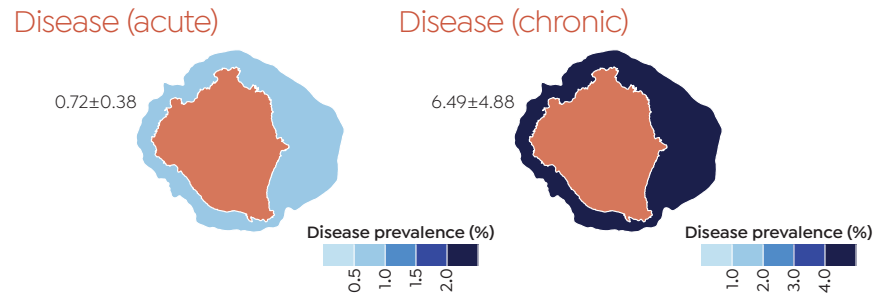


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

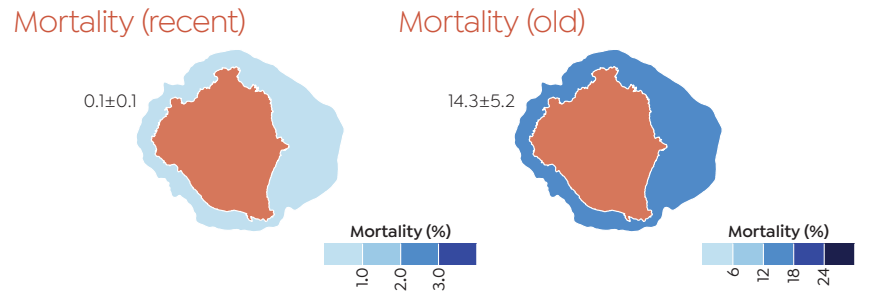
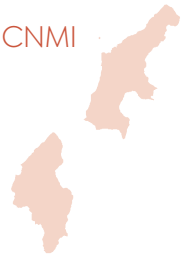


TABLE OF CONTENTS



Coral reef fish – Sarigan (2011-2017)

16° 42' N, 145° 47' E

Reef fish biomass: 24.8±3.0 g/m²

100 g/m²

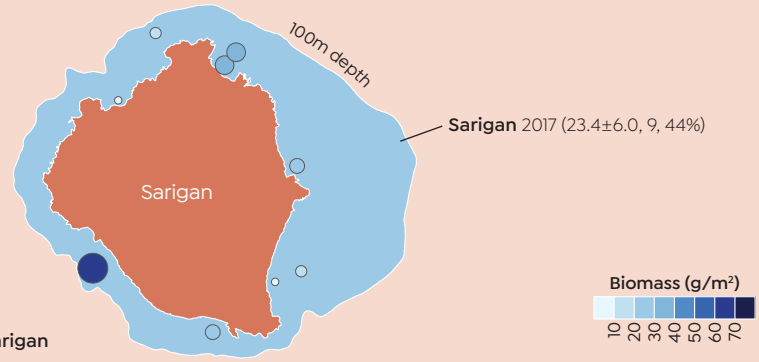
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 37.0±4.1 g/m² in 2011, 40.3±4.0 g/m² in 2014, and 24.8±3.0 g/m² in 2017.
- >30 % of the reef fish sampled were >40 cm in length during the 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Alamagan-Guguan-Sarigan

2017	24.8±3.0, 27, 46%
2014	40.3±4.0, 33, 77%
2011	37.0±4.1, 24, 71%

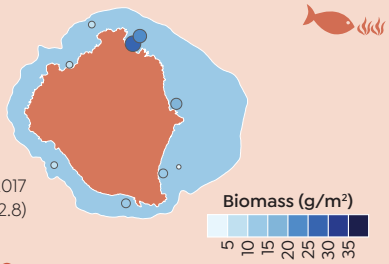
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

Alamagan-Guguan-Sarigan

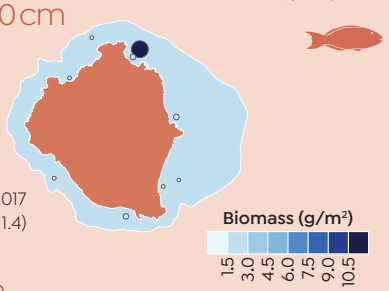
2017	13.7±1.5
2014	24.8±1.9
2011	19.6±3.1



Parrotfish >30 cm

Alamagan-Guguan-Sarigan

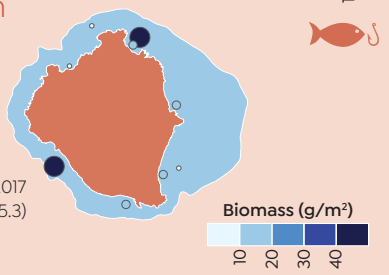
2017	1.9±0.6
2014	4.3±0.9
2011	5.1±1.0



Targeted fish

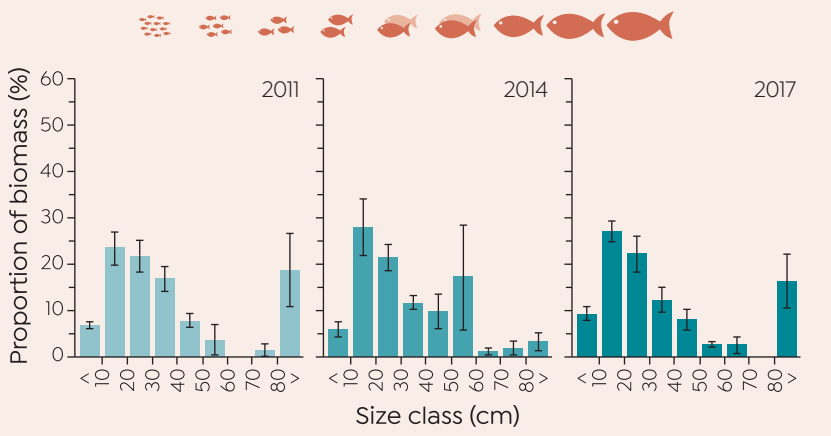
Alamagan-Guguan-Sarigan

2017	17.8±2.3
2014	29.2±2.5
2011	26.1±3.6

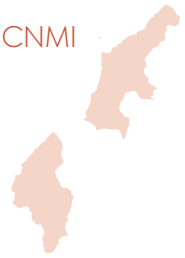


Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Note: Size class distribution is for Alamagan, Guguan, and Sarigan combined.



Coral reefs – Guguan (2017)

17°18' N, 145°50' E

Land area: 3.9 km²

0–100m depth: 6.2 km²

Coral reef area: 2.0 km² (36/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

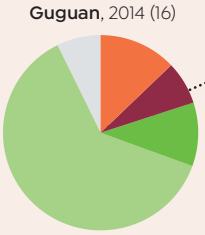
The coral reefs of Guguan were surveyed in May and June of 2017.*

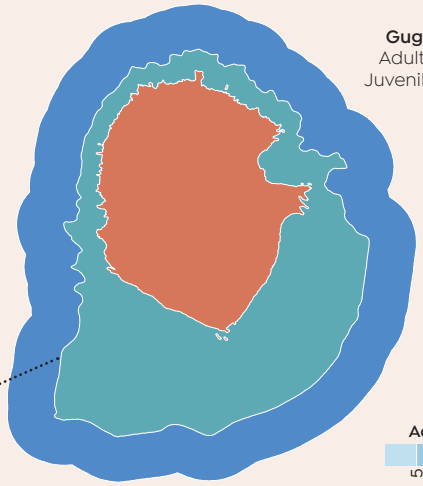
- Coral cover was 12.9% in Guguan.
- Acute coral disease and recent mortality was <0.5%. Chronic coral disease was 2.0%.
- Old mortality of corals was 13.6%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.





Sector (Sampling effort)

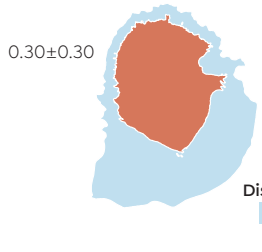
*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

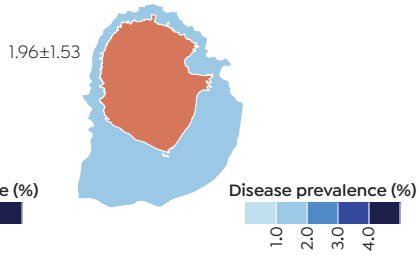
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).

Disease (acute)



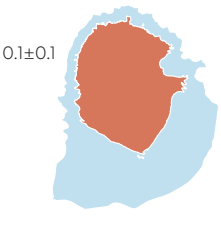
Disease (chronic)



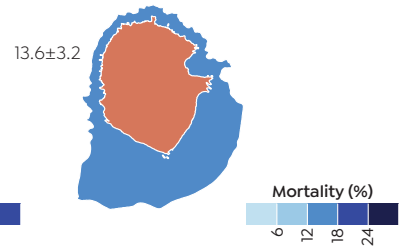
Coral mortality

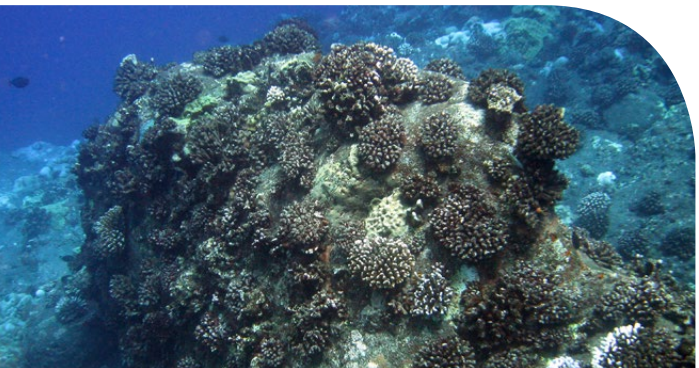
The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

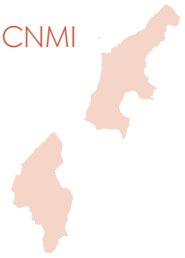
Mortality (recent)



Mortality (old)







Coral reef fish – Guguan (2011-2017)

17° 18' N, 145° 50' E

Reef fish biomass: 24.8±3.0 g/m²

100 g/m²

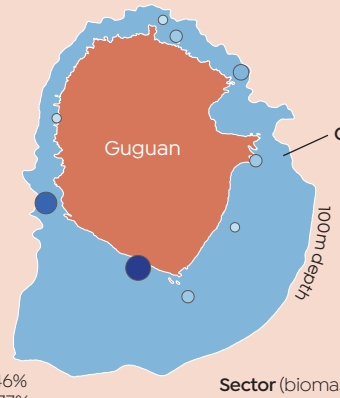
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 37.0±4.1 g/m² in 2011, 40.3±4.0 g/m² in 2014, and 24.8±3.0 g/m² in 2017.
- >30 % of the reef fish sampled were >40 cm in length during the 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Guguan 2017 (32.9±8.0, 9, 61%)

Alamagan-Guguan-Sarigan

2017	24.8±3.0, 27, 46%
2014	40.3±4.0, 33, 77%
2011	37.0±4.1, 24, 71%

Biomass (g/m²)
10 20 30 40 50 60 70

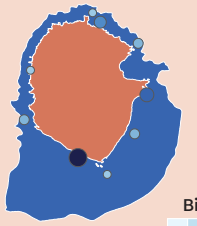
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

Alamagan-Guguan-Sarigan

2017	13.7±1.5
2014	24.8±1.9
2011	19.6±3.1



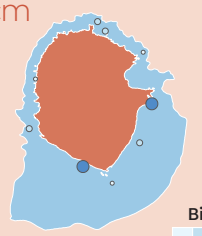
Guguan 2017 (21.1±4.2)

Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

Alamagan-Guguan-Sarigan

2017	1.9±0.6
2014	4.3±0.9
2011	5.1±1.0



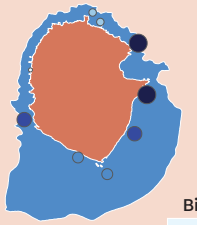
Guguan 2017 (3.5±1.4)

Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

Alamagan-Guguan-Sarigan

2017	17.8±2.3
2014	29.2±2.5
2011	26.1±3.6

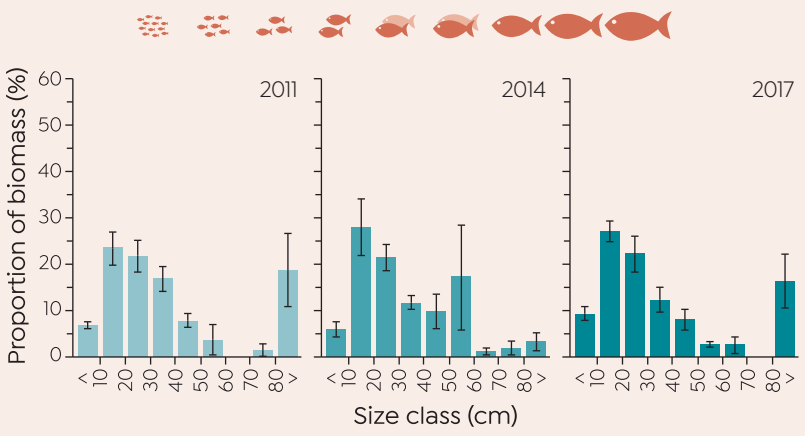


Guguan 2017 (28.0±6.2)

Biomass (g/m²)
10 20 30 40

Size class distribution

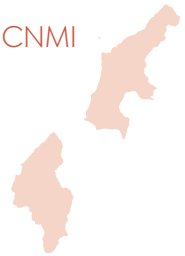
Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Note: Size class distribution is for Alamagan, Guguan, and Sarigan combined.

Coral reefs – Alamagan (2017)

17° 36' N, 145° 50' E



Land area: 13.0 km²

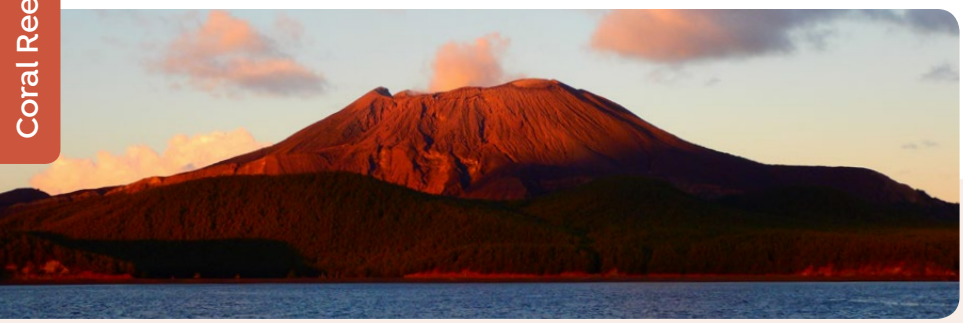
0–100m depth: 9.1 km²

Coral reef area: 3.5 km² (31/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

The coral reefs of Alamagan were surveyed in May and June of 2017.*

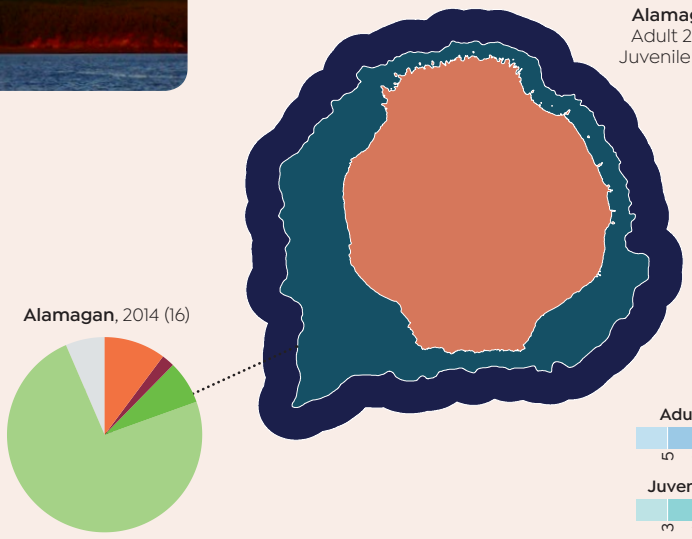


- Coral cover was 10.2% in Alamagan.
- Acute coral disease and recent mortality was <0.5%. Chronic coral disease was 4.3%.
- Old mortality of corals was 12.2%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

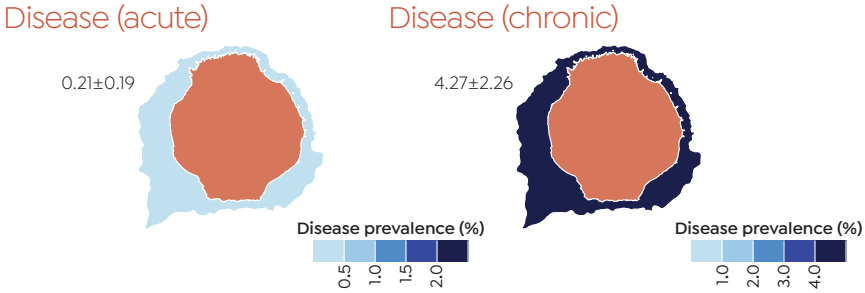


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

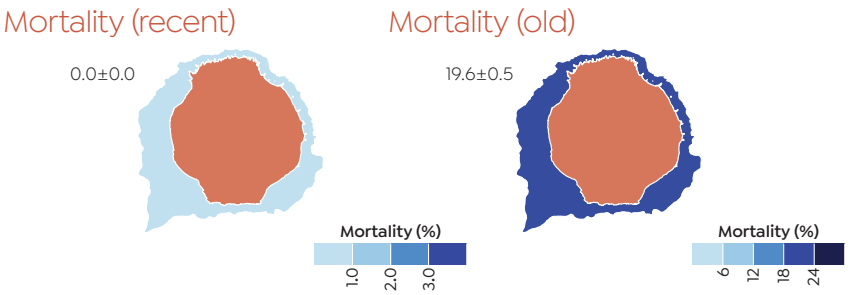
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



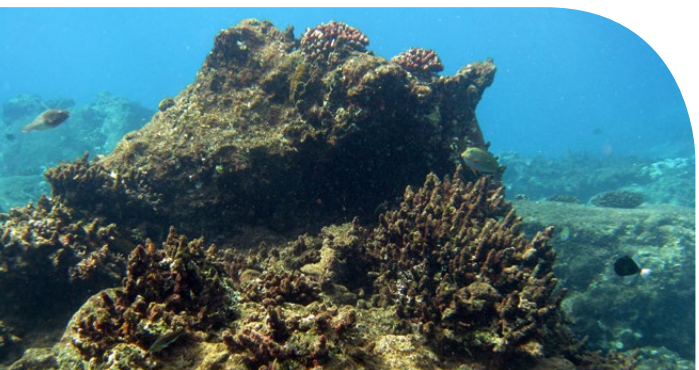


TABLE OF CONTENTS

CNMI

Coral reef fish – Alamagan (2011-2017)

17° 36' N, 145° 50' E

Reef fish biomass: 24.8±3.0 g/m²

100 g/m²

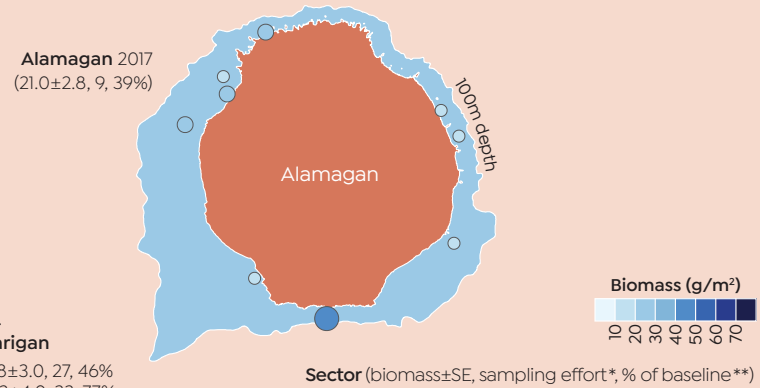
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 37.0±4.1 g/m² in 2011, 40.3±4.0 g/m² in 2014, and 24.8±3.0 g/m² in 2017.
- >30 % of the reef fish sampled were >40 cm in length during the 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Alamagan-Guguan-Sarigan

2017	24.8±3.0, 27, 46%
2014	40.3±4.0, 33, 77%
2011	37.0±4.1, 24, 71%

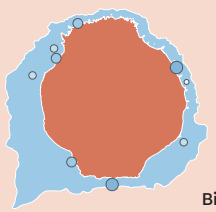
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

Alamagan-Guguan-Sarigan

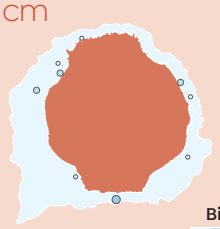
2017	13.7±1.5
2014	24.8±1.9
2011	19.6±3.1



Parrotfish >30 cm

Alamagan-Guguan-Sarigan

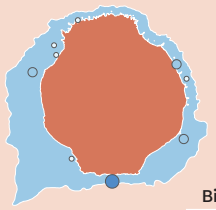
2017	1.9±0.6
2014	4.3±0.9
2011	5.1±1.0



Targeted fish

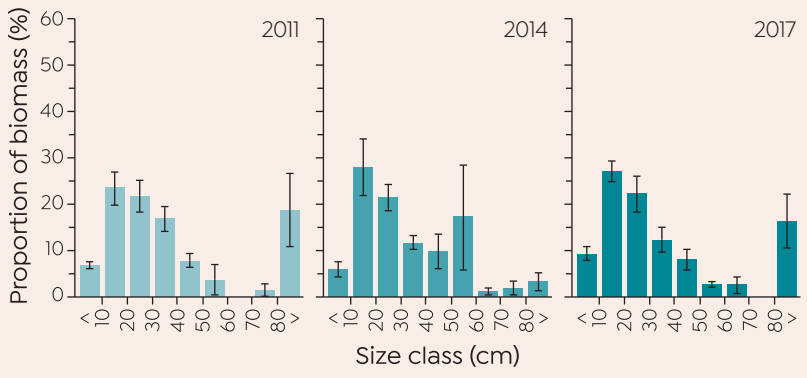
Alamagan-Guguan-Sarigan

2017	17.8±2.3
2014	29.2±2.5
2011	26.1±3.6



Size class distribution

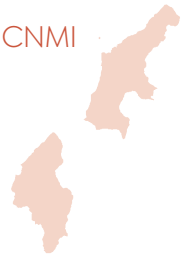
Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Note: Size class distribution is for Alamagan, Guguan, and Sarigan combined.

Coral reefs – Pagan (2017)

18° 08' N, 145° 47' E



Land area: 47.2 km²

0–100m depth: 32.0 km²

Coral reef area: 15.1 km² (21/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 120 (2010)

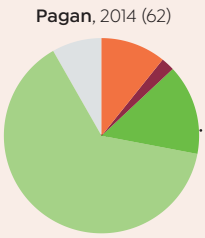
The coral reefs of Pagan were surveyed in May and June of 2017.*

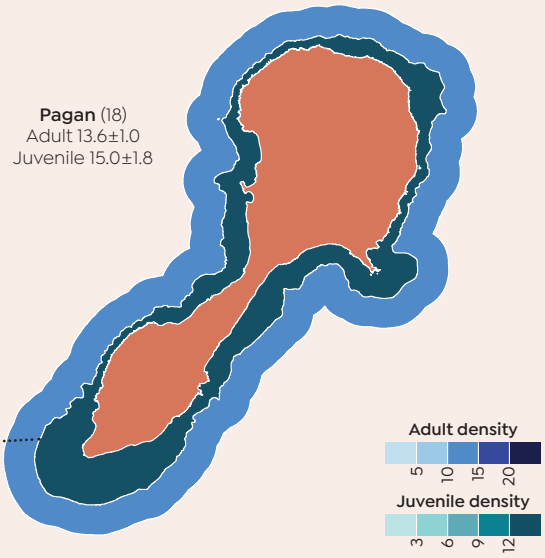
- Coral cover was 10.8 % in Pagan.
- Acute coral disease and recent mortality was <1 %. Chronic coral disease was 2.2 %.
- Old mortality of corals was 16.0 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.





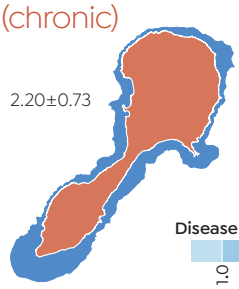
Sector (Sampling effort)

* Benthic cover data are from March to May 2014.

Benthic cover: Hard coral | CCA | Macroalgae | Turf algae | Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

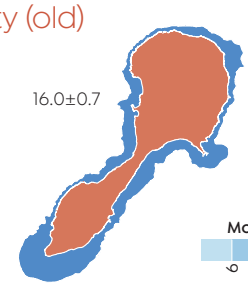
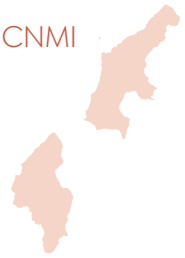


TABLE OF CONTENTS



Coral reef fish – Pagan (2011-2017)

18° 08' N, 145° 47' E

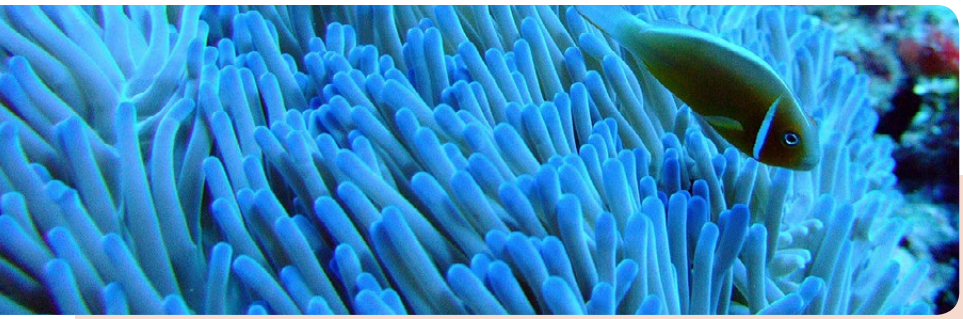
Reef fish biomass: 30.4±3.0 g/m²

100 g/m²

Coral reef fish surveys were conducted in 2017, 2014, and 2011.

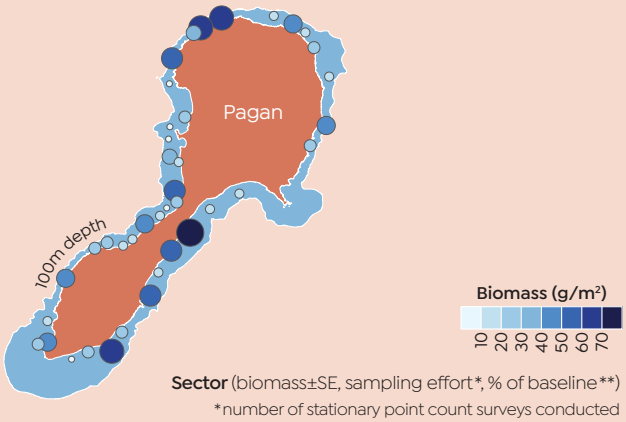
NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 29.5±3.2 g/m² in 2011, 34.7±3.9 g/m² in 2014, and 30.4±3.0 g/m² in 2017.
- >50 % of the reef fish sampled were <30 cm in length during the 2011, 2014, and 2017 surveys.



Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Pagan

2017	30.4±3.0, 40, 82%
2014	34.7±3.9, 43, 92%
2011	29.5±3.2, 29, 80%

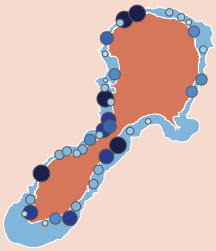
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted

**model of anthropogenic depletion

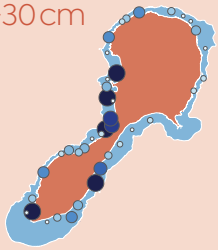
Herbivores

2017	21.1±1.8
2014	18.3±2.2
2011	16.7±1.9



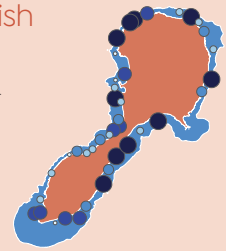
Parrotfish >30 cm

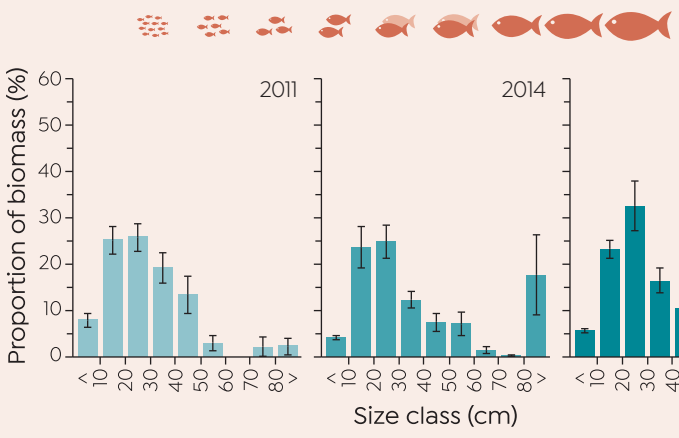
2017	4.9±0.8
2014	4.5±0.9
2011	3.8±1.0



Targeted fish

2017	29.2±2.9
2014	27.8±3.1
2011	23.4±3.4



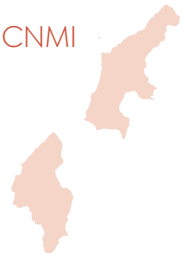


Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral reefs – Agrihan (2017)

18° 46' N, 145° 39' E



Land area: 43.5 km²

0–100m depth: 18.3 km²

Coral reef area: 8.5 km² (26/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

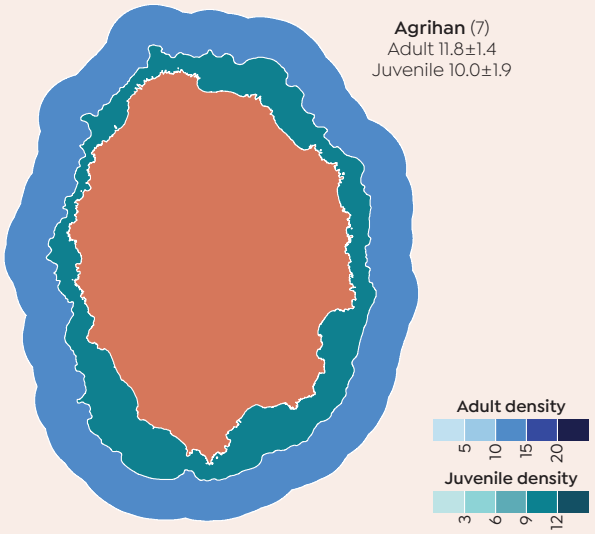
The coral reefs of Agrihan were surveyed in May and June of 2017.*

- Acute and chronic coral diseases were <1%, as was recent mortality.
- Old mortality of corals was 17.1%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

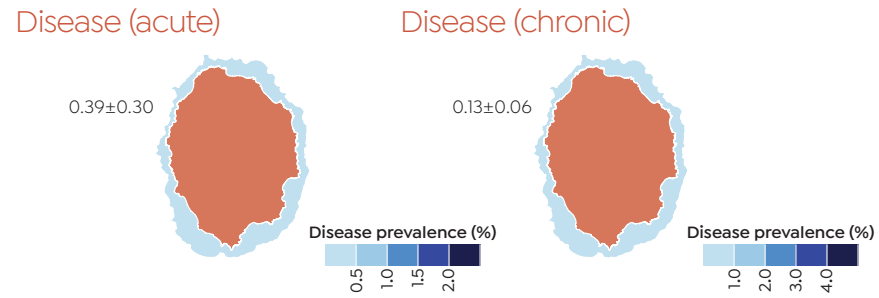


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

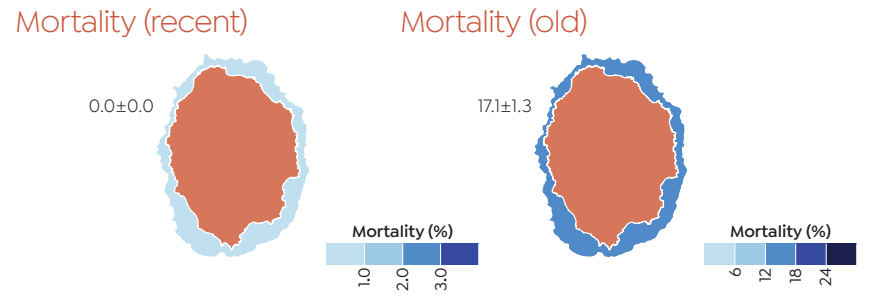
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



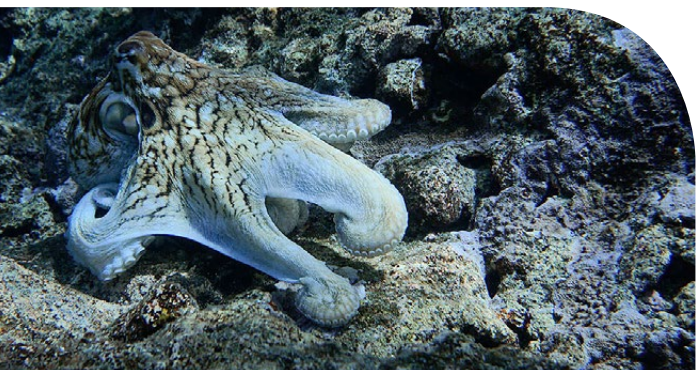
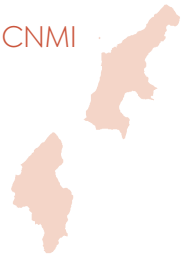


TABLE OF CONTENTS



Coral reef fish – Agrihan (2011-2017)

18° 46' N, 145° 39' E

Reef fish biomass: 30.2±3.8 g/m²

100 g/m²

Coral reef fish surveys were conducted in 2017, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

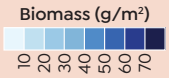
- Reef fish biomass was 39.6±5.5 g/m² in 2011 and 30.2±3.8 g/m² in 2017.
- >50 % of the reef fish sampled were >40 cm in length during the 2011 and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.

Agrihan

2017	30.2±3.8, 19, 81%
2011	39.6±5.5, 20, 102%

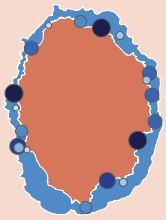


Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

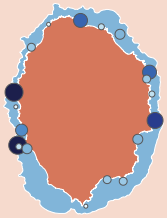
Herbivores

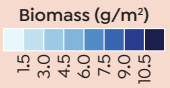
2017	23.7±3.0
2011	22.1±3.5



Parrotfish >30 cm

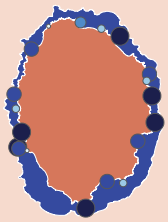
2017	5.5±1.4
2011	6.8±1.8

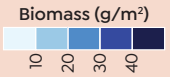


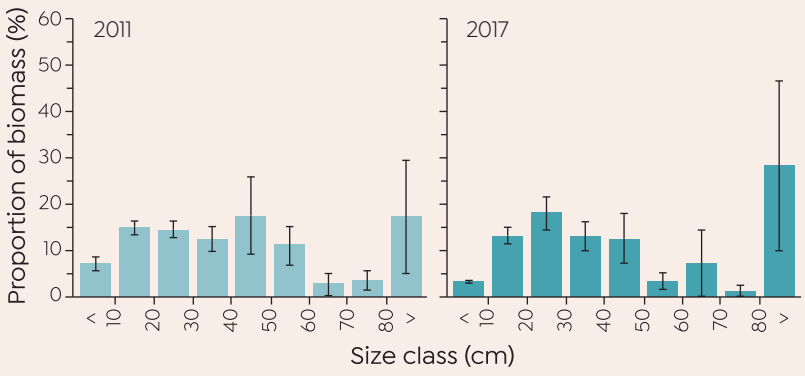


Targeted fish

2017	34.1±4.9
2011	33.0±5.7

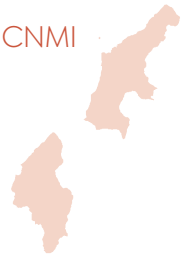






Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Asuncion (2017)

19° 41' N, 145° 25' E

Land area: 7.9 km²

0–100m depth: 5.2 km²

Coral reef area: 2.5 km² (35/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

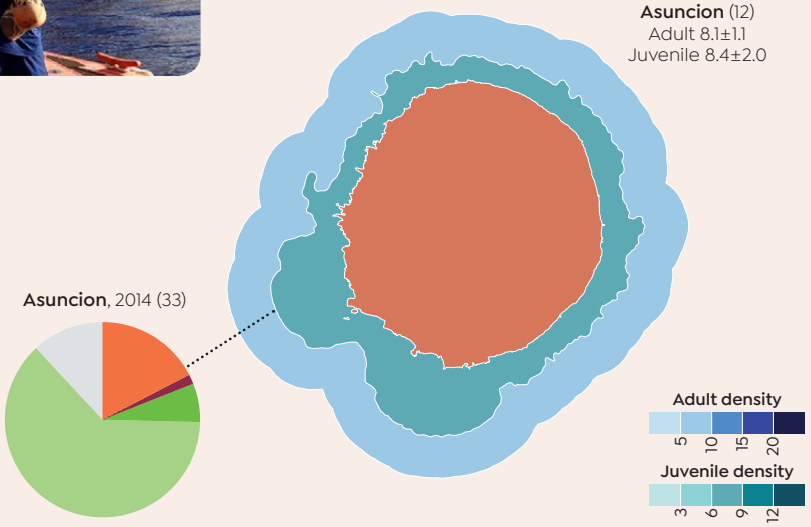
The coral reefs of Asuncion were surveyed in May and June of 2017.*

- Coral cover was 17.4% in Asuncion.
- Acute coral disease and recent mortality was <0.5%. Chronic coral disease was 8.2%.
- Old mortality of corals was 16.9%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

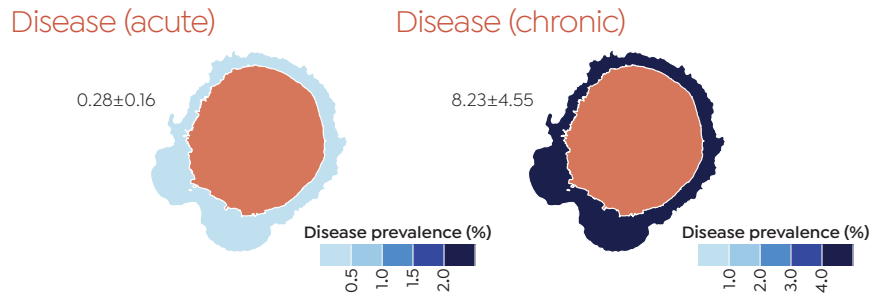


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

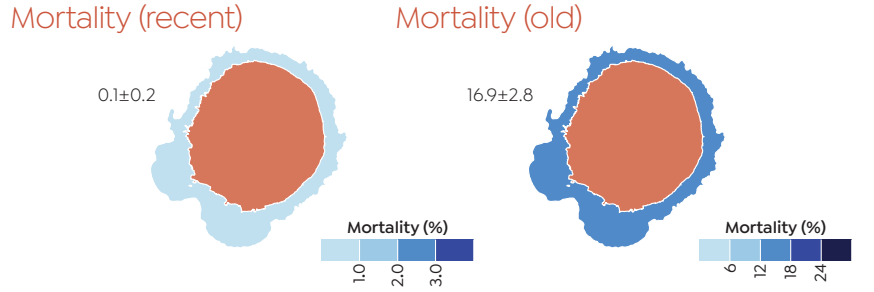
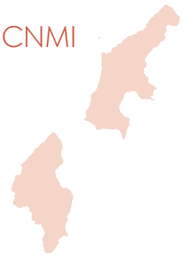


TABLE OF CONTENTS



Coral reef fish – Asuncion (2011-2017)

19° 41' N, 145° 25' E

Reef fish biomass: 45.1±5.9 g/m²

100 g/m²

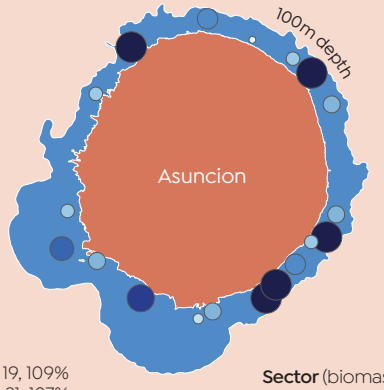
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 36.2±6.1 g/m² in 2011, 44.2±6.1 g/m² in 2014, and 45.1±5.9 g/m² in 2017.
- >50 % of the reef fish sampled were >40 cm in length during the 2011, 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Asuncion

2017	45.1±5.9, 19, 109%
2014	44.2±6.1, 21, 107%
2011	36.2±6.1, 20, 88%

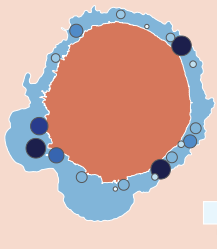
Biomass (g/m²)
10 20 30 40 50 60 70

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

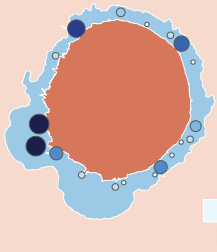
2017	19.8±2.9
2014	18.3±2.7
2011	19.6±2.9



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

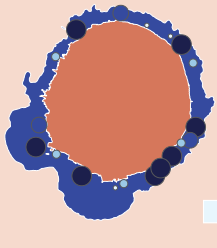
2017	3.8±0.9
2014	1.4±0.6
2011	3.9±0.9



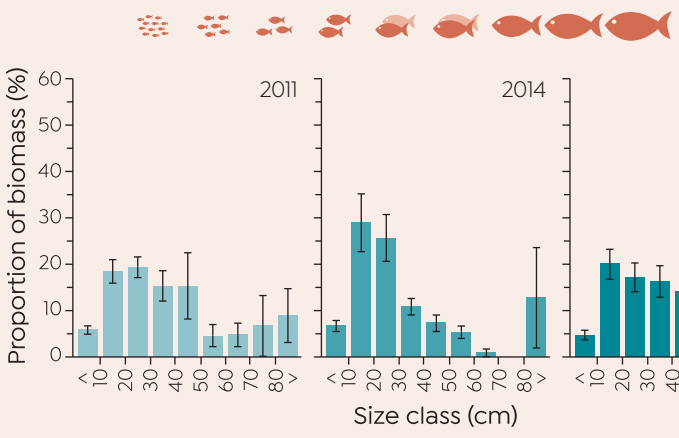
Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

2017	38.3±6.3
2014	27.2±3.4
2011	30.6±5.8



Biomass (g/m²)
10 20 30 40



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral reefs – Maug (2017)

20° 02' N, 145° 13' E

Land area: 2.1 km²

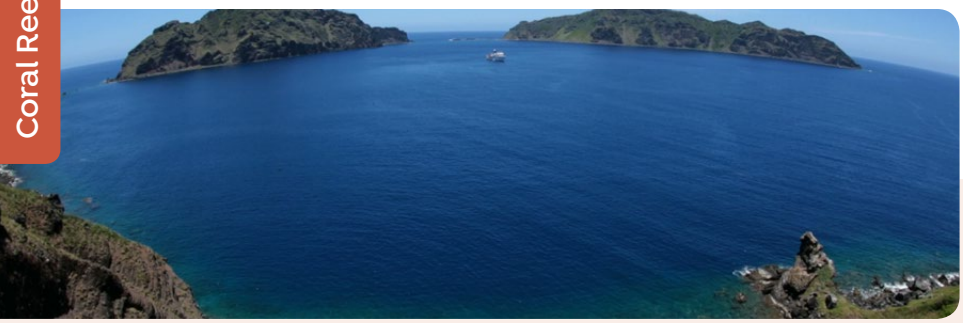
0–100m depth: 5.2 km²

Coral reef area: 3.1 km² (32/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

The coral reefs of Maug were surveyed in May and June of 2017.*

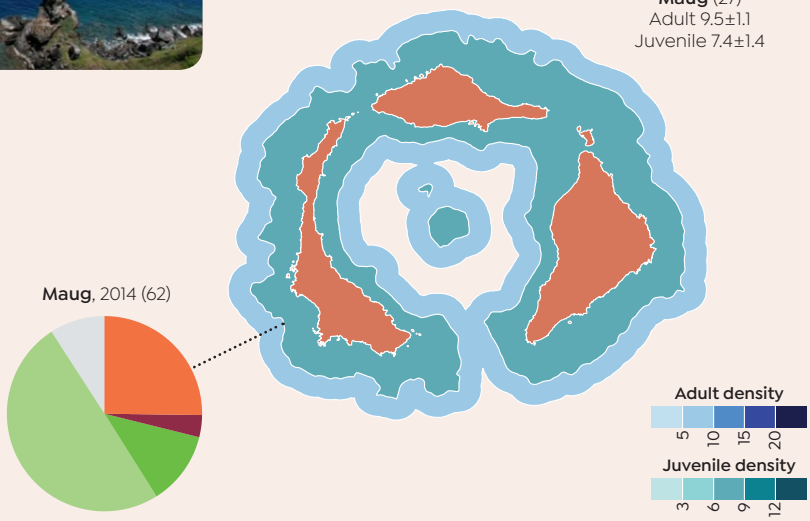


- Coral cover was 25.2% in Maug.
- Acute and chronic coral diseases were <1%, as was recent mortality.
- Old mortality of corals was 24.0%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

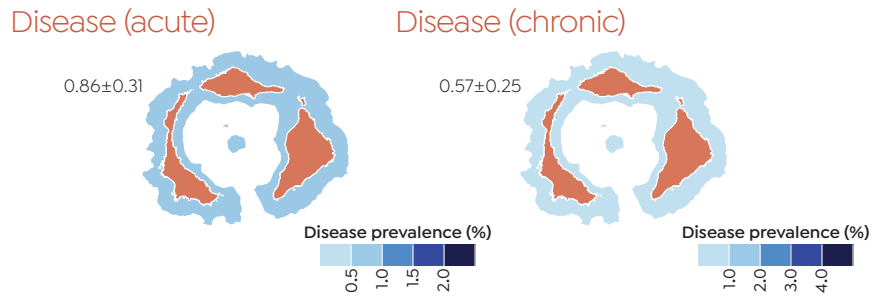


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

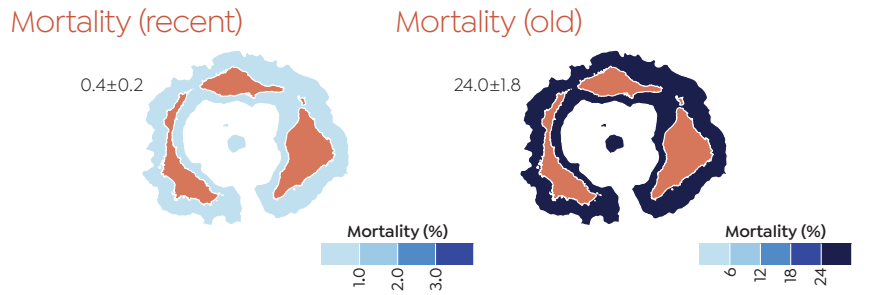


TABLE OF CONTENTS

CNMI

Coral reef fish – Maug (2011-2017)

20° 02' N, 145° 13' E

Reef fish biomass: 34.3±3.4 g/m²

100 g/m²

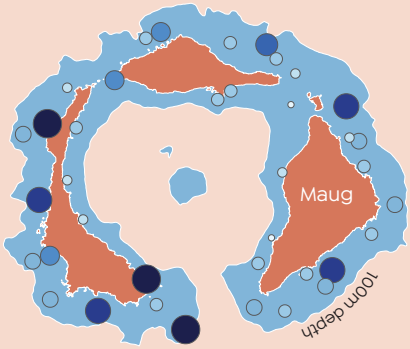
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 34.1±4.1 g/m² in 2011, 34.6±3.4 g/m² in 2014, and 34.3±3.4 g/m² in 2017.
- >50 % of the reef fish sampled were <30 cm in length during the 2011, 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

Maug

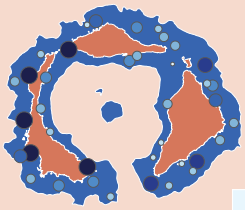
2017	34.3±3.4, 38, 89%
2014	34.6±3.4, 40, 90%
2011	34.1±4.1, 30, 88%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

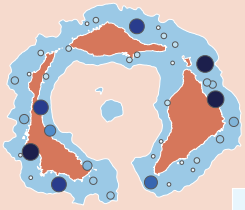
2017	21.1±1.5
2014	16.6±1.4
2011	18.9±1.8



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

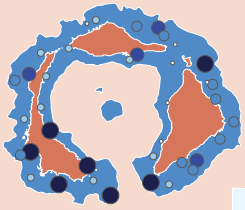
2017	3.8±0.6
2014	3.0±0.4
2011	3.7±0.6



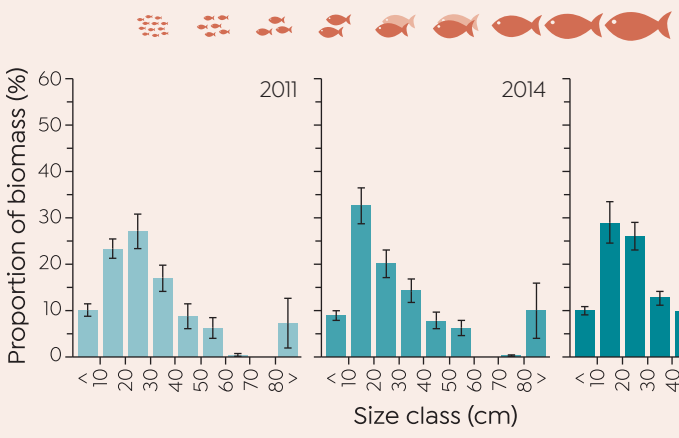
Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

2017	26.2±3.2
2014	23.8±2.7
2011	24.3±3.1

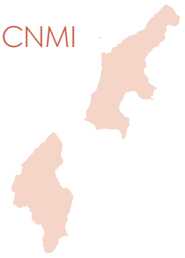


Biomass (g/m²)
10 20 30 40



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Coral reefs – Farallón de Pájaros (2017)

20° 33' N, 144° 54' E

Land area: 2.3 km²

0–100m depth: 2.5 km²

Coral reef area: 1.4 km² (39/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

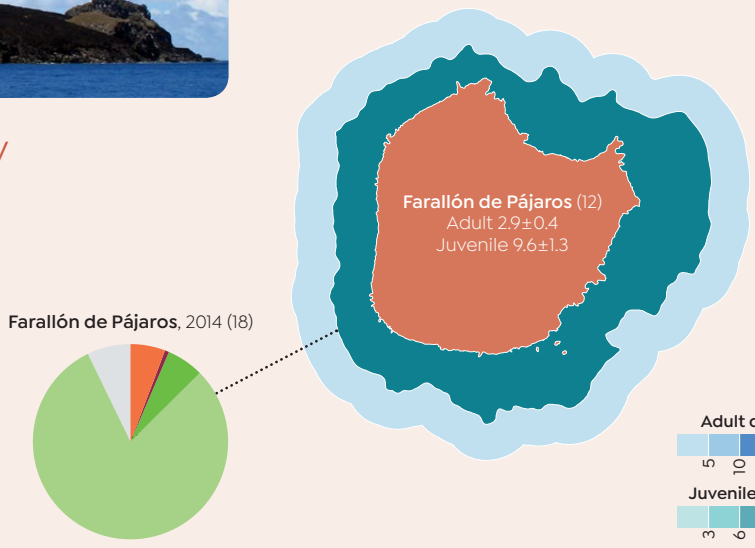
The coral reefs of Farallón de Pájaros were surveyed in May and June of 2017.*

- Coral cover was 5.8 % in Farallón de Pájaros.
- Acute coral disease and recent mortality was <1 %. Chronic coral disease was 2.4 %.
- Old mortality of corals was 21.8 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

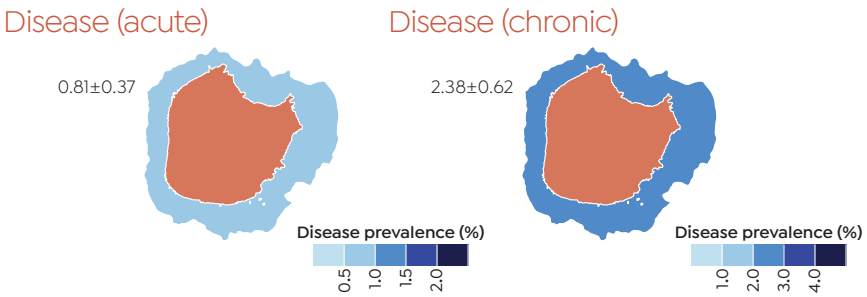


*Benthic cover data are from March to May 2014.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

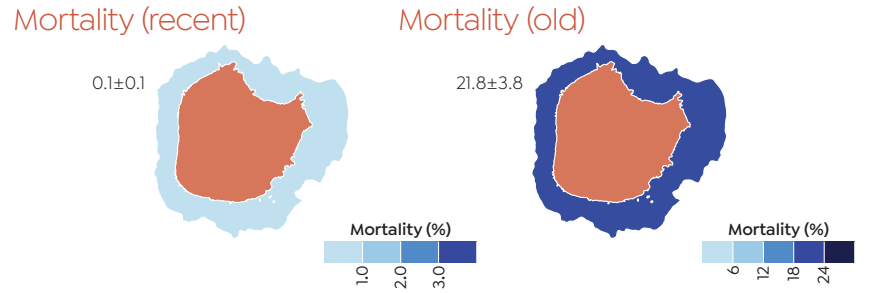
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



CNMI

Coral reef fish – Farallón de Pájaros (2011-2017)

20° 33' N, 144° 54' E

Reef fish biomass: 35.2±4.8 g/m²

100 g/m²

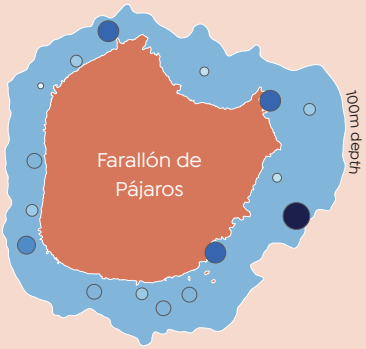
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 49.7±7.2 g/m² in 2011, 53.6±7.9 g/m² in 2014, and 35.2±4.8 g/m² in 2017.
- >50 % of the reef fish sampled were <30 cm in length during the 2011, 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

Farallón de Pájaros

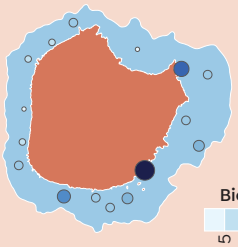
2017	35.2±4.8, 16, 72%
2014	53.6±7.9, 11, 106%
2011	49.7±7.2, 12, 99%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

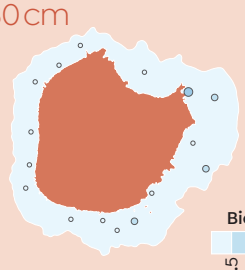
2017	14.5±2.8
2014	21.6±4.5
2011	18.1±3.2



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

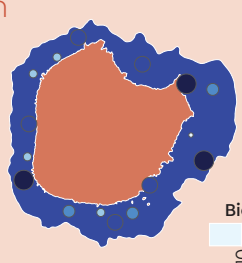
2017	0.6±0.3
2014	1.8±0.9
2011	1.6±0.8



Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

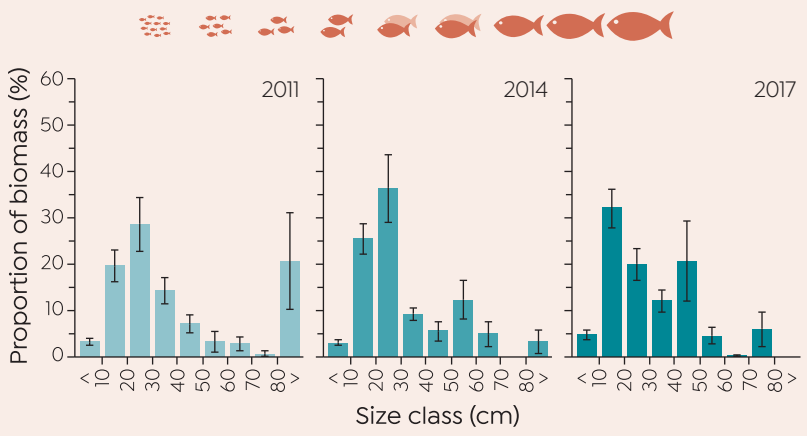
2017	32.3±4.4
2014	34.7±5.2
2011	37.1±3.9



Biomass (g/m²)
10 20 30 40

Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



Scientists prepare for their small boat to be recovered by the Hi'ialakai after a day of diving and data collection on the reefs of Agrihan.

CNMI

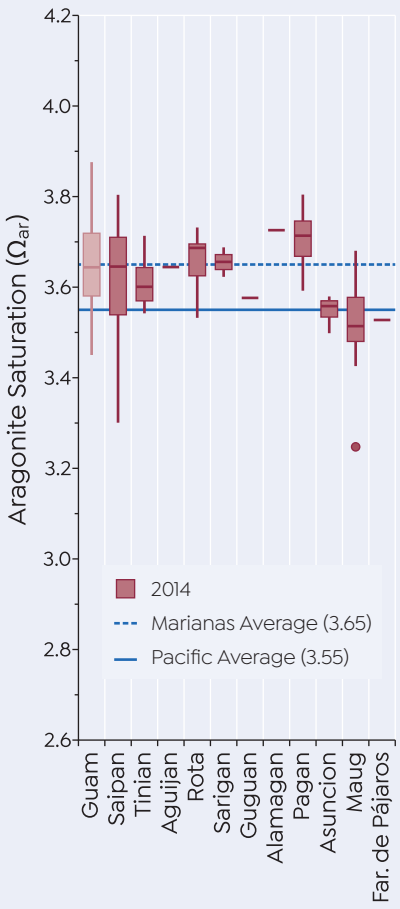
Chemistry (2011–2017)

This section represents the first CNMI NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the Ecosystem Sciences Division of the NOAA Pacific Islands Fisheries Science Center and the NOAA Coral Reef Watch program.

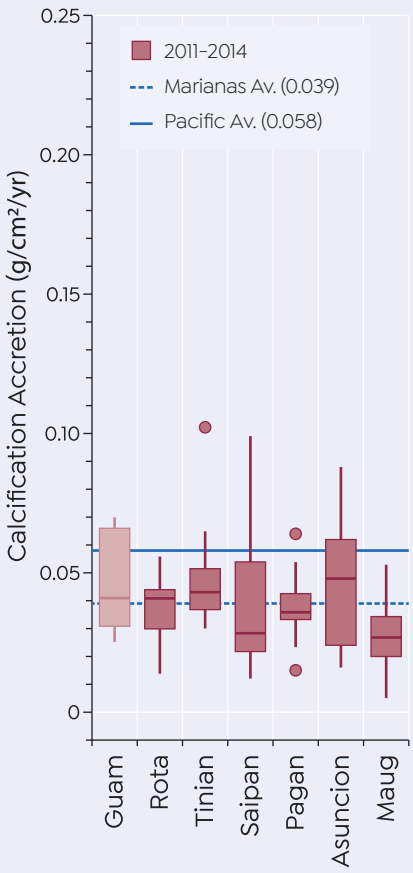
Highlights

- Calcium carbonate accretion in CNMI was below the US Pacific average at all islands.
- Bias-corrected subsurface temperature data reveals that depths >20 m did not provide a refuge for corals from heat stress during the 2015 bleaching event.
- Coral Reef Watch Bleaching Alert Level 2 was triggered throughout the region in 2017. Extensive severe bleaching was observed in 2017 and extensive mortality due to bleaching was observed during surveys in May 2018.

Aragonite saturation state



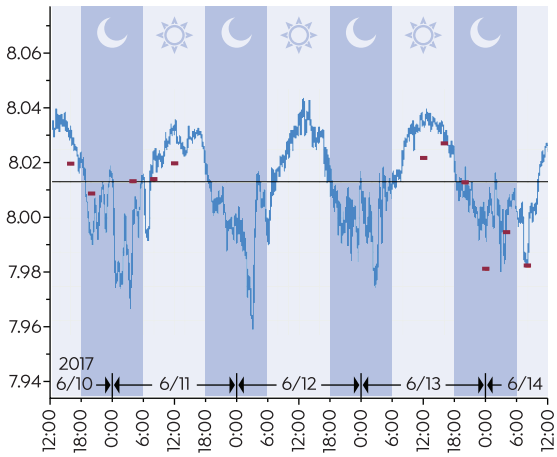
Calcium carbonate accretion



Aragonite saturation state measures carbonate ion concentration; the greater the concentration of carbonate ions is, the easier it is for organisms like stony corals to calcify. Aragonite saturation state was slightly above the Pacific average at all islands in CNMI, except Maug and Farallon de Pajaros and was nearly the same at Saipan and Guam. Aragonite saturation state can be seen as an exposure term – i.e., exposure of calcifying organisms to the conditions that drive calcification.

Calcification Accretion Units measure the response of calcifying organisms to those conditions as the net accretion of calcium carbonate produced over the deployment period (see photos to right). Calcium carbonate accretion was lower than the Pacific average at all islands in CNMI where the data were available.

Diurnal pH – Maug



Processes driving local pH vary throughout the day. Photosynthesis drives up the pH during the day as organisms calcify. pH declines again at night as photosynthesis stops and respiration continues to release CO_2 into the water column. Red lines on the plot are the bottle samples used to validate the 24-hour pH time series from the sensors.

Rates of net calcium carbonate accretion are monitored with calcification accretion units (CAUs) which allow for recruitment and colonization of crustose coralline algae and hard corals. Photos show a CAU newly deployed (left) and two years after deployment (right).

CNMI

Subsurface temperature

Subsurface temperature time series

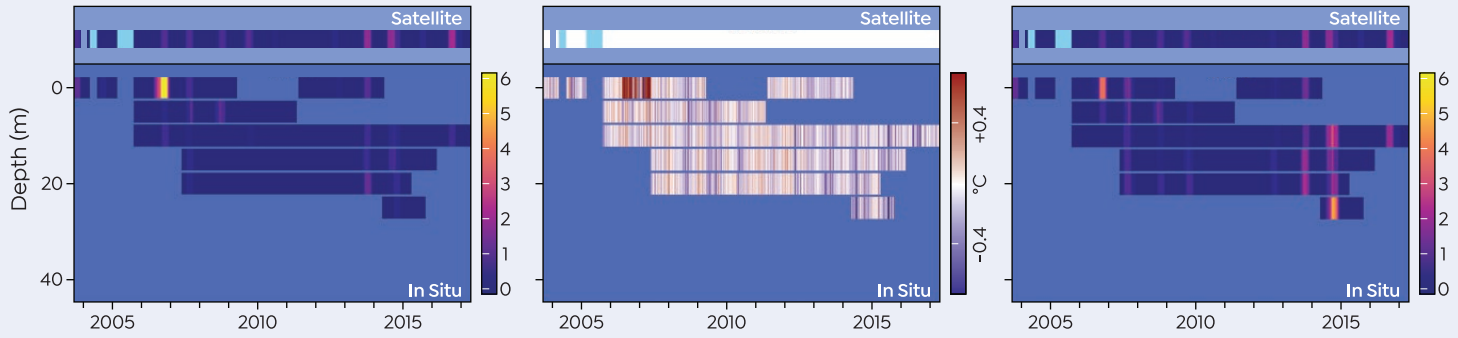
Subsurface temperature time series for 4-15 m for 2014-2016 comparing Guam and Pagan (in CNMI). Warm season months at these locations (May to August) at this depth were very similar between these islands, though slightly higher in Pagan in 2014, and slightly higher in Guam in 2015. Cool season months (December to March) were cooler in 2014-15 in Pagan than in Guam (see inset graph, right). Cool season temperatures provided less of a reprieve from warm season temperatures in Guam than in Pagan.


NOAA temperature buoy

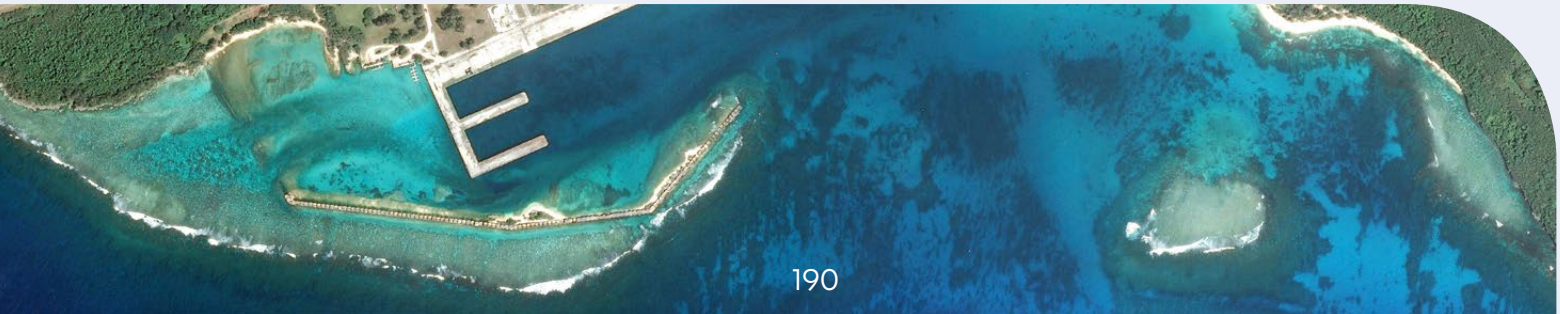
Marianas – Saipan, Tinian, Aguijan
Uncorrected Degree Heating Weeks

Marianas – Saipan, Tinian, Aguijan
In-situ temperature bias relative to satellite

Marianas – Saipan, Tinian, Aguijan
Depth-corrected Degree Heating Weeks



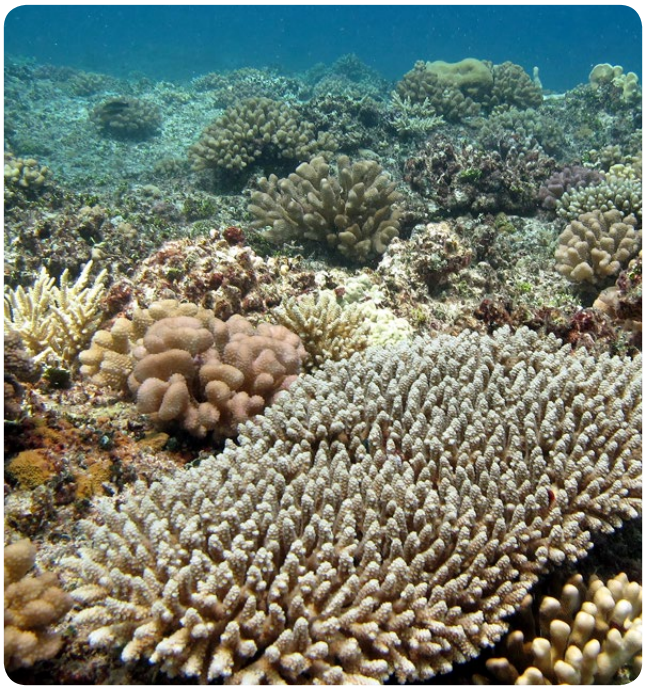
Sea temperature data can be used to calculate Degree Heating Weeks; a metric of the accumulation of heat stress. Remotely sensed sea surface temperature data from satellites are used to calculate Degree Heating Weeks for the surface of the ocean. The difference between temperatures at the surface recorded by satellites and temperatures at depth can be calculated ('the bias'). The resultant bias-correction can be applied to temperatures at depth, enabling more accurate calculations of heat stress at depth. The 10-year time series of sub-surface temperature from the Marianas shows that depths below 20 m did not always provide a refuge from heat stress. Heat stress that may have caused bleaching at depths greater than 20 m accumulated in 2015.



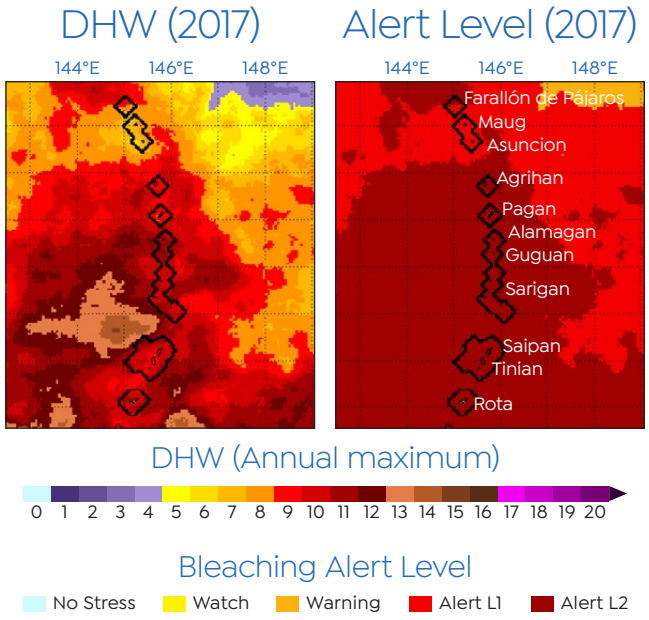
CNMI

Heat stress and coral bleaching

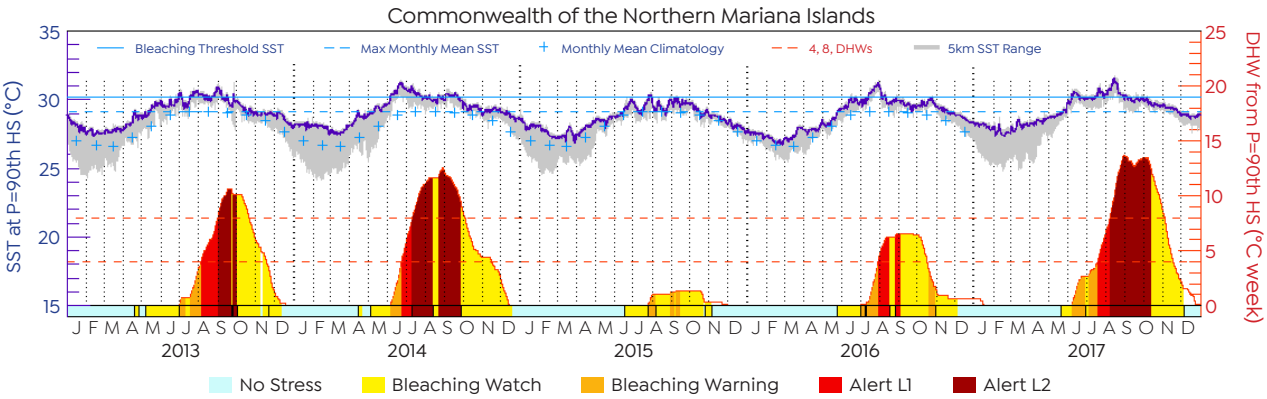
The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. Satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred in CNMI in 1988, 1994, 2001, 2003, 2007, 2009, 2013, 2014, 2016, and 2017.



Coral reef, Saipan

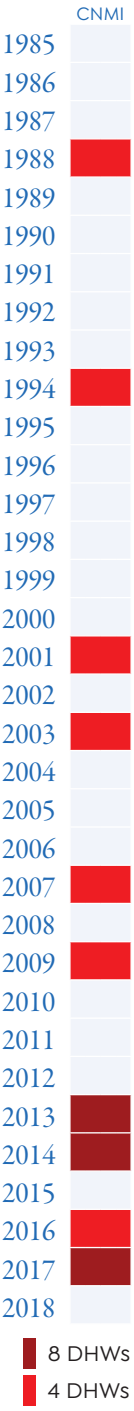


Annual maximum Degree Heating Weeks (DHWs) in 2017 (left panel) were as high as 11 in parts of CNMI when at least six DHWs accumulated at all islands in the region. Heat stress accumulation triggered Alert Level 2 throughout the region in 2017 (right panel) and extensive severe bleaching was observed that year and extensive mortality due to bleaching was observed during surveys in May of 2018.



Degree Heating Week (DHW) accumulation from 2013-2017 in CNMI. Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 1 was triggered in 2013, 2014, 2016, and 2017 and Alert Level 2 was triggered in 2013, 2014, and 2017, and extensive coral bleaching occurred during those years.

Thermal History



Pacific Remote Island Areas

Coral Reefs and Reef Fish

Coral reefs – Wake Atoll (2017)

19°17' N, 166°39' E

Land area: 6.5 km²

0–100m depth: 20.4 km²

Coral reef area: 2.8 km² (34/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: approx. 100 (2018)

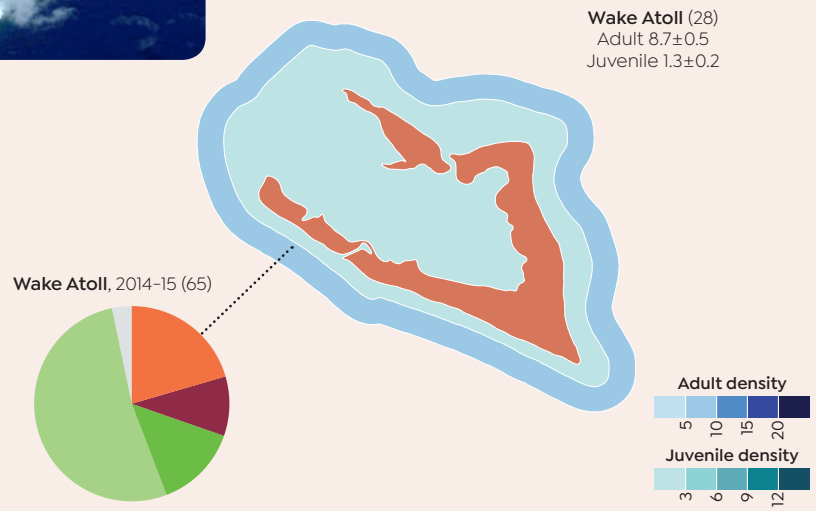
The coral reefs of Wake Atoll were surveyed in April 2017.

- Coral cover was 20.5 % at Wake Atoll.
- Acute and chronic coral diseases were <1 %, as was recent mortality.
- Old mortality of corals was 17.2 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



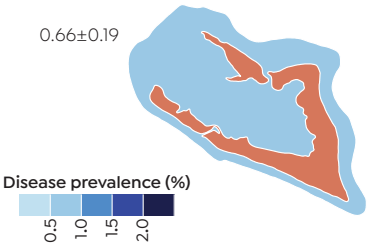
* Benthic cover data are from 2014–2015.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

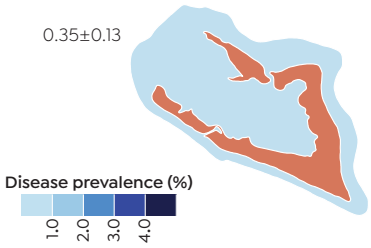
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).

Disease (acute)



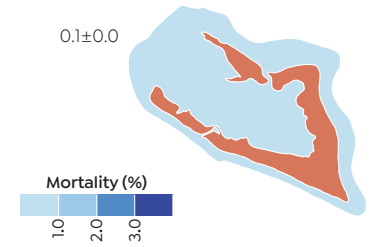
Disease (chronic)



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

Mortality (recent)



Mortality (old)

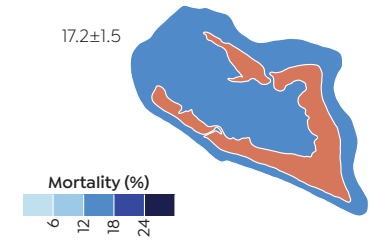


TABLE OF CONTENTS

Coral reef fish – Wake Atoll (2011-2017)

19°17' N, 166°39' E

Reef fish biomass: 39.9±2.9 g/m²

100 g/m²

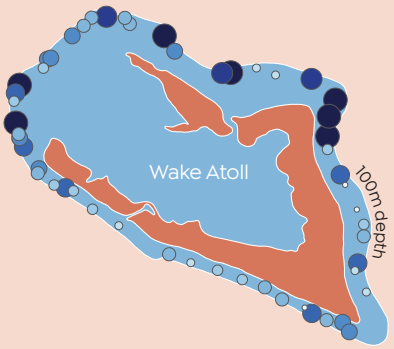
Coral reef fish surveys were conducted in 2017, 2014, and 2011.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 35.1±3.5 g/m² in 2011, 33.1±3.5 g/m² in 2014, and 39.9±2.9 g/m² in 2017.
- >50 % of the reef fish sampled were <30 cm in length during the 2011, 2014, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

Wake Island

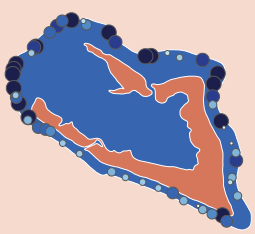
2017	39.9±2.9, 53, 70%
2014	33.1±3.5, 45, 58%
2011	35.1±3.5, 30, 62%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

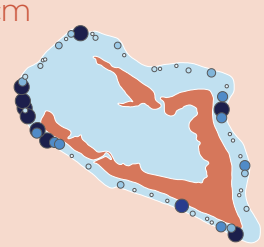
2017	28.9±2.7
2014	23.0±2.7
2011	26.5±2.0



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

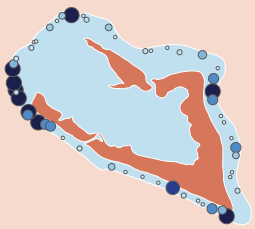
2017	4.4±0.7
2014	3.5±0.8
2011	5.2±0.8



Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

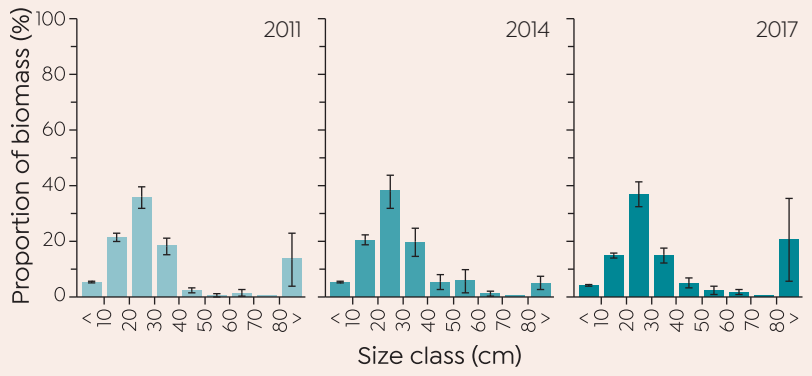
2017	19.8±2.0
2014	16.2±1.8
2011	18.2±2.0



Biomass (g/m²)
10 20 30 40

Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral Reefs and Reef Fish

Coral reefs – Howland Island (2015)

0° 48' N, 176° 38' W

Land area: 1.6 km²

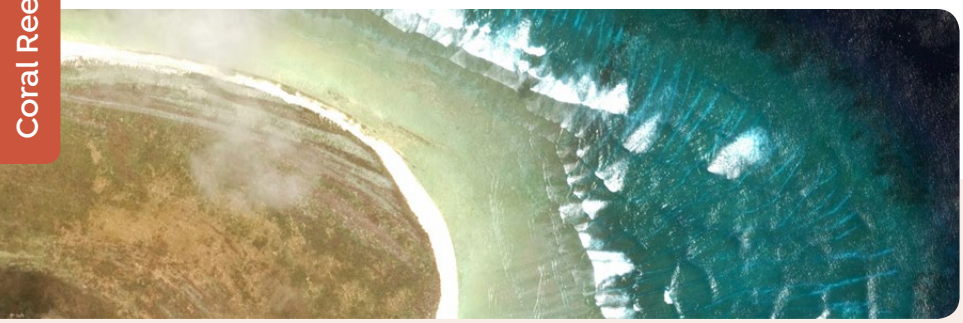
0–100m depth: 3.4 km²

Coral reef area: 1.7 km² (38/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

The coral reefs of Howland Island were surveyed in January to April 2015.

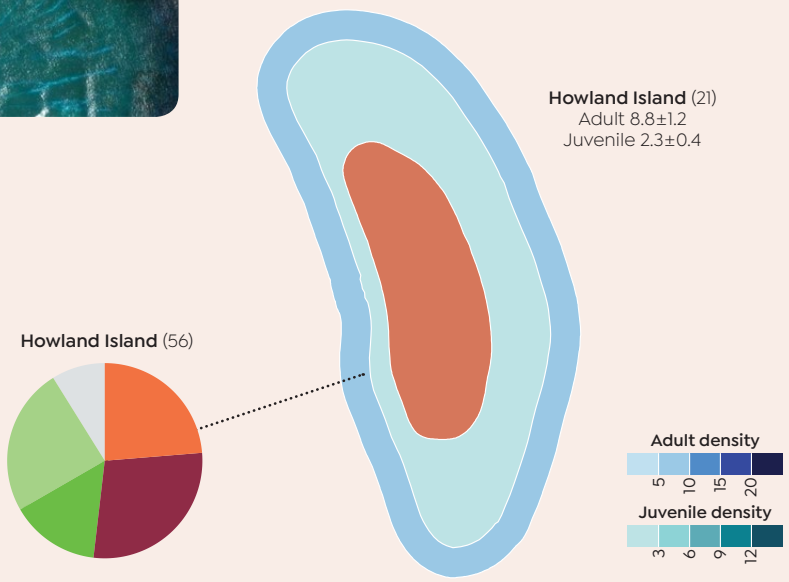


- Coral cover was 23.7% at Howland Island.
- Acute and chronic coral diseases were <1%, as was recent mortality.
- Old mortality of corals was 10.0%.

Benthic cover and coral density

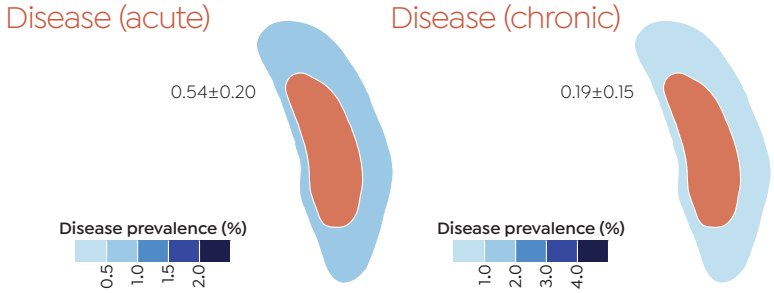
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

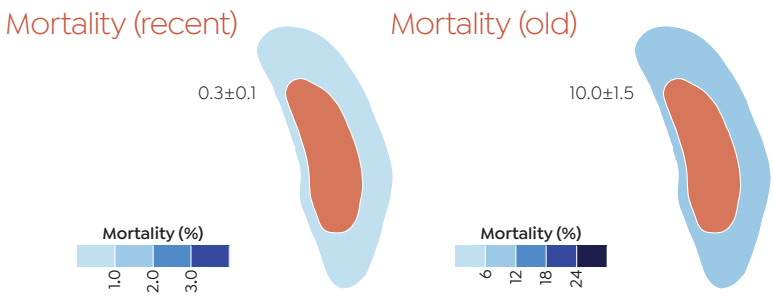


TABLE OF CONTENTS

Coral reef fish – Howland Island (2010-2015)

0° 48' N, 176° 38' W

Reef fish biomass: 67.1±5.9 g/m²

100 g/m²

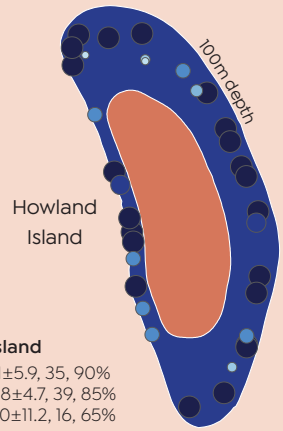
Coral reef fish surveys were conducted in 2015, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 49.0±11.2 g/m² in 2010, 63.8±4.7 g/m² in 2012, and 67.1±5.9 g/m² in 2015.
- >50 % of the reef fish sampled were >40 cm in length during the 2012, and 2015 surveys.

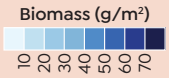
Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Howland Island

2015	67.1±5.9, 35, 90%
2012	63.8±4.7, 39, 85%
2010	49.0±11.2, 16, 65%

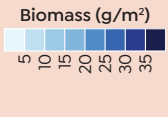


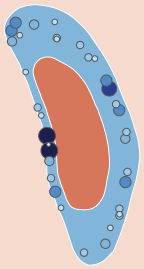
Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

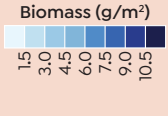
2015	18.5±2.8
2012	21.6±2.9
2010	13.8±1.3

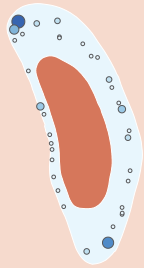




Parrotfish >30 cm

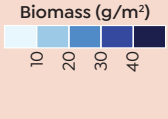
2015	0.9±0.2
2012	3.5±0.9
2010	2.9±0.7

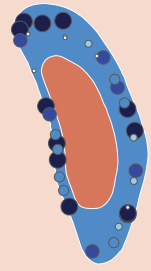




Targeted fish

2015	23.6±2.5
2012	43.1±5.9
2010	31.8±4.1





Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral reefs – Baker Island (2015)

0°12' N, 176°29' W

Land area: 1.7 km²

0–100m depth: 5.6 km²

Coral reef area: 3.9 km² (29/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

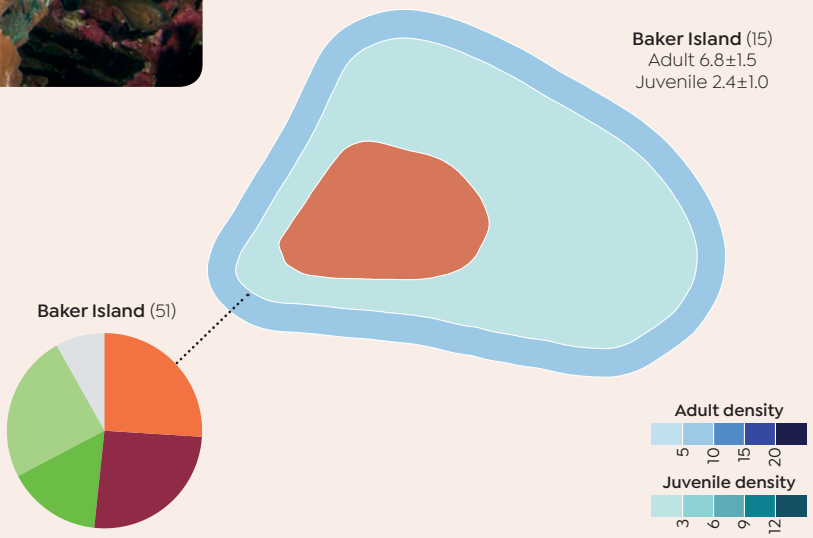
The coral reefs of Baker Island were surveyed in January to April 2015.

- Coral cover was 26% at Baker Island.
- Acute and chronic coral diseases were <1%, as was recent mortality.
- Old mortality of corals was 8.1%.

Benthic cover and coral density

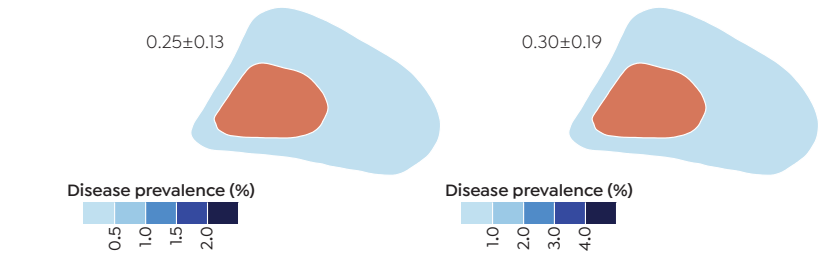
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



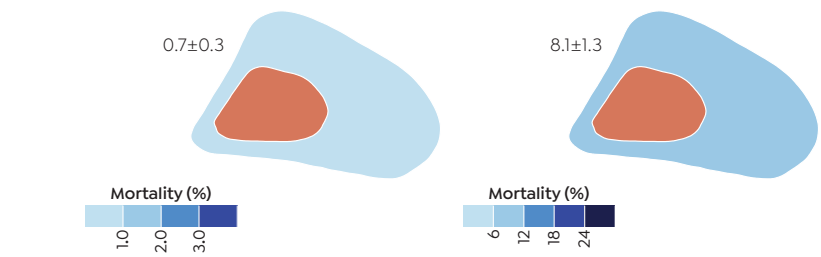
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Baker Island (2010-2015)

0°12' N, 176°29' W

Reef fish biomass: 66.5±10.2 g/m²

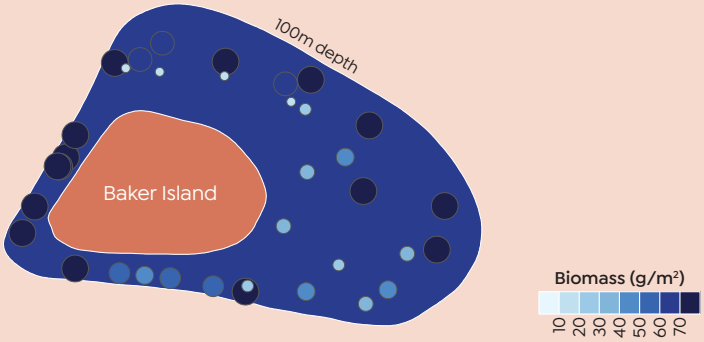
Coral reef fish surveys were conducted in 2015, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 40.6±6.1 g/m² in 2010, 62.2±8.7 g/m² in 2012, and 66.5±10.2 g/m² in 2015.
- >50 % of the reef fish sampled were >40 cm in length during the 2012, and 2015 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Baker Island

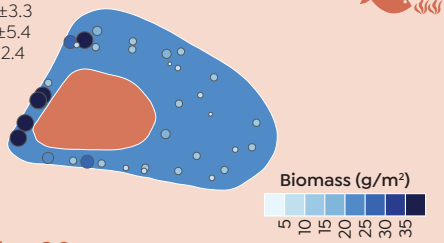
2015	66.5±10.2, 36, 81%
2012	62.2±8.7, 24, 76%
2010	40.6±6.1, 21, 49%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

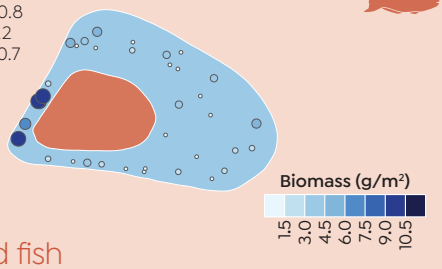
Herbivores

2015	20.0±3.3
2012	26.2±5.4
2010	13.9±2.4



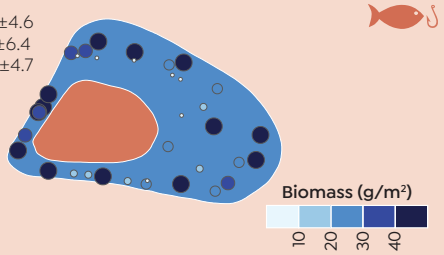
Parrotfish >30 cm

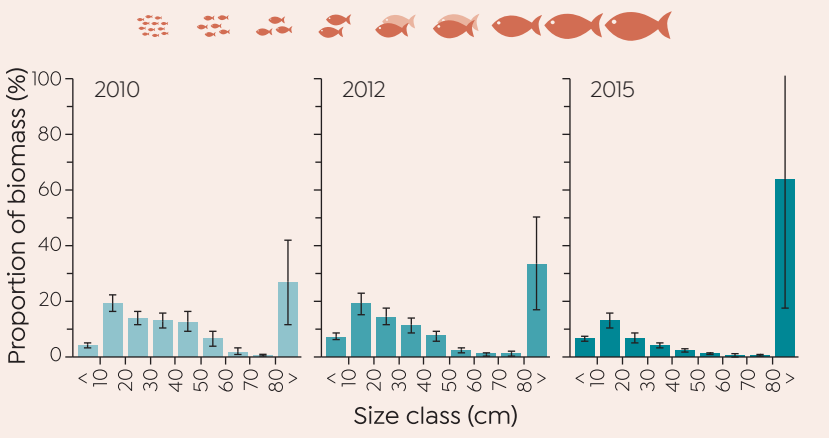
2015	3.6±0.8
2012	4.1±1.2
2010	2.5±0.7



Targeted fish

2015	29.8±4.6
2012	37.3±6.4
2010	30.8±4.7





Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

Coral Reefs and Reef Fish

Coral reefs – Johnston Atoll (2015)

16° 45' N, 169° 31' W

Land area: 2.8 km²

0–100m depth: 211 km²

Coral reef area: 65.7 km² (11/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

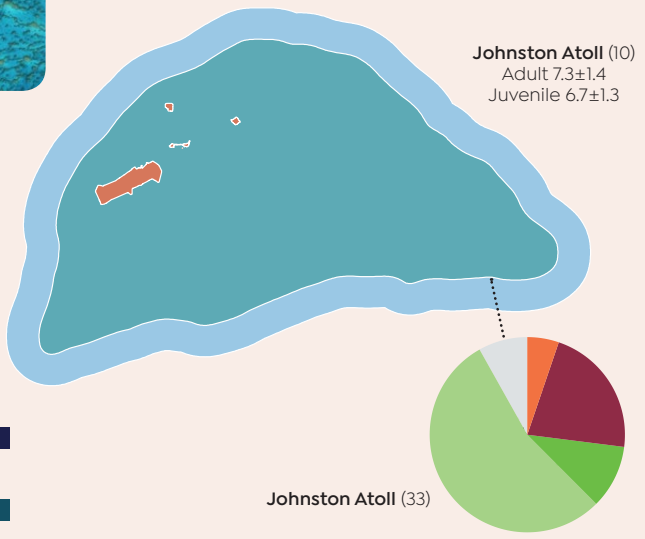
The coral reefs of Johnston Atoll were surveyed in January to April 2015.

- Coral cover was 5.2 % at Johnston Atoll.
- Acute and chronic coral diseases were <1 %, as was recent mortality.
- Old mortality of corals was 6.8 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



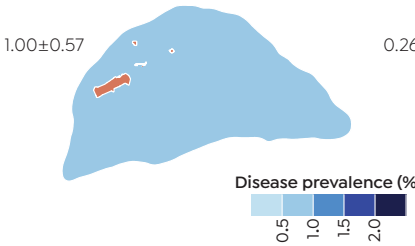
Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Sector (Sampling effort)

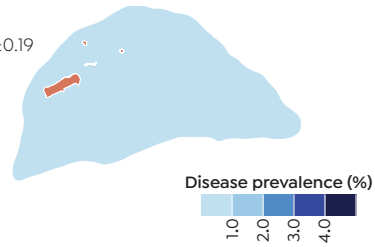
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).

Disease (acute)



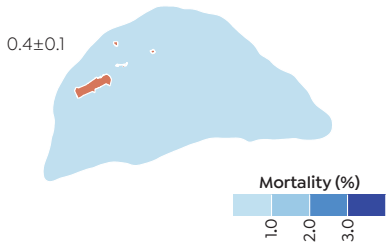
Disease (chronic)



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

Mortality (recent)



Mortality (old)

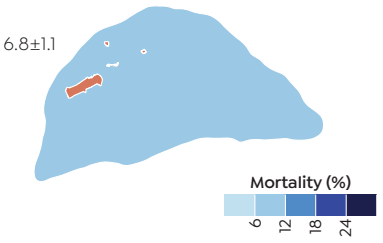


TABLE OF CONTENTS

Coral reef fish – Johnston Atoll (2010-2015)

16° 45' N, 169° 31' W

Reef fish biomass: 37.5±5.1 g/m²

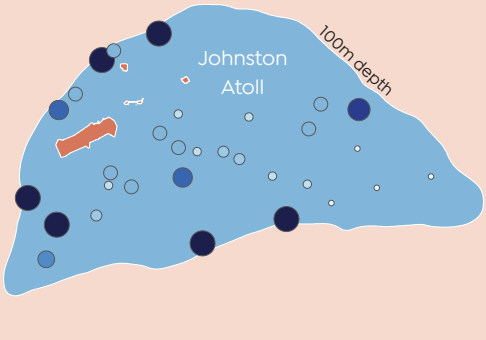
Coral reef fish surveys were conducted in 2015, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 20.0±3.3 g/m² in 2010, 30.7±7.4 g/m² in 2012, and 37.5±5.1 g/m² in 2015.
- >50 % of the reef fish sampled were >40 cm in length during the 2012, and 2015 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Johnston Atoll

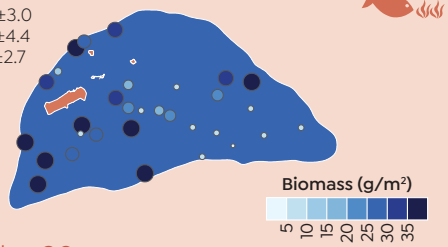
2015	37.5±5.1, 31, 146%
2012	30.7±7.4, 35, 119%
2010	20.0±3.3, 37, 54%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

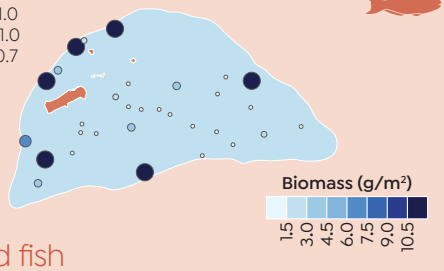
Herbivores

2015	25.7±3.0
2012	18.8±4.4
2010	15.9±2.7



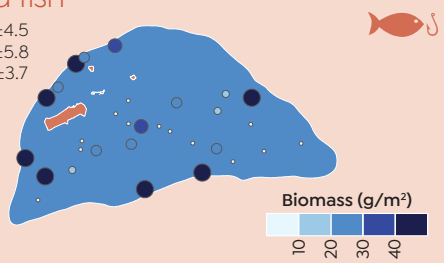
Parrotfish >30 cm

2015	2.9±1.0
2012	2.0±1.0
2010	1.4±0.7



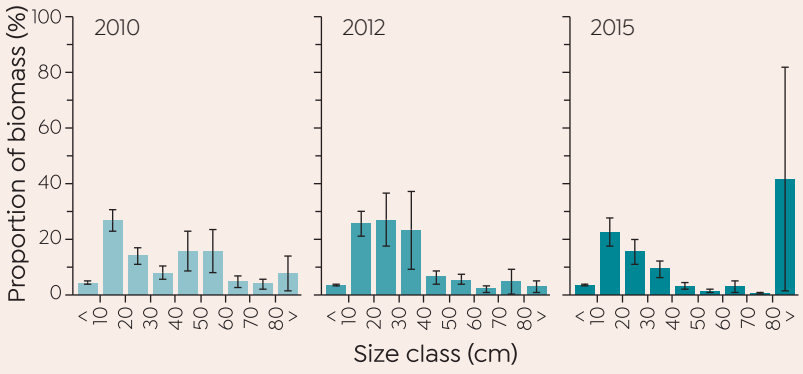
Targeted fish

2015	21.3±4.5
2012	21.4±5.8
2010	18.4±3.7



Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral Reefs and Reef Fish

Coral reefs – Kingman Reef (2015)

6° 24' N, 162° 22' W

Land area: 1.0 km²

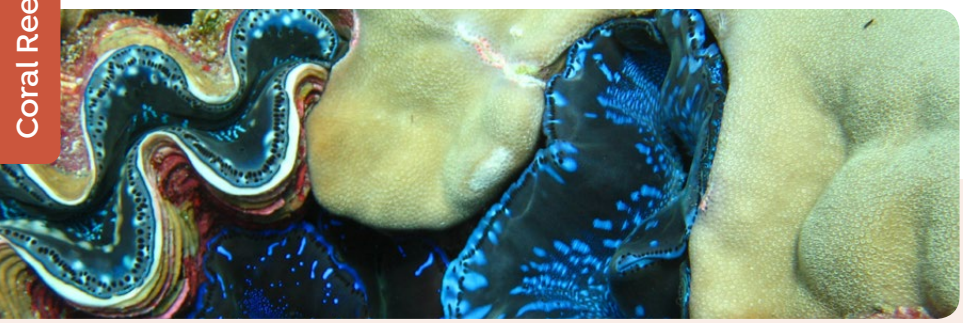
0–100m depth: 83.2 km²

Coral reef area: 21.8 km² (20/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

The coral reefs of Kingman Reef were surveyed in January to April 2015.

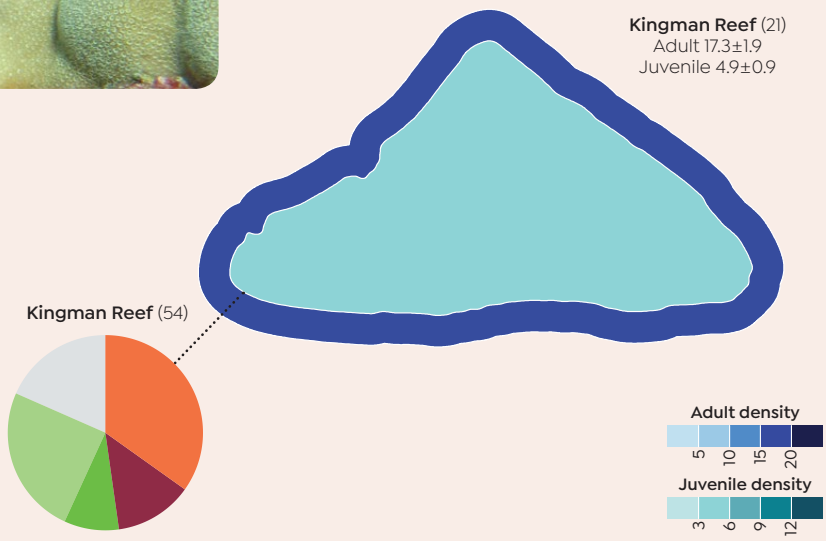


- Coral cover was 40 % at Kingman Reef.
- Acute and chronic coral diseases were <1.5 %, as was recent mortality.
- Old mortality of corals was 7.8 %.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

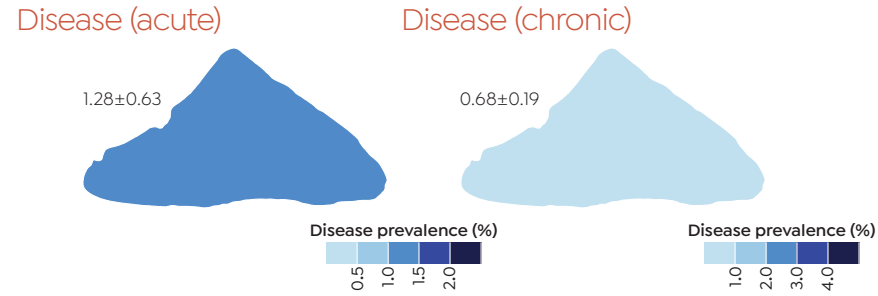


Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Sector (Sampling effort)

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

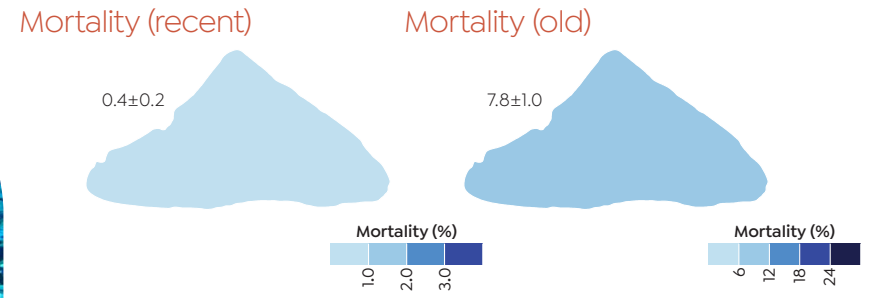


TABLE OF CONTENTS

Coral reef fish – Kingman Reef (2010-2015)

6° 24' N, 162° 22' W

Reef fish biomass: 62.7±4.7 g/m²

100 g/m²

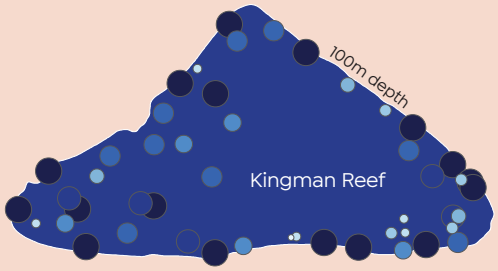
Coral reef fish surveys were conducted in 2015, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 88.2±16.7 g/m² in 2010, 78.6±6.2 g/m² in 2012, and 62.7±4.7 g/m² in 2015.
- >50 % of the reef fish sampled were >40 cm in length during the 2010, 2012, and 2015 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

Kingman Reef

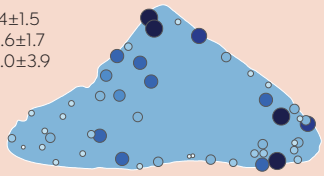
2015	62.7±4.7, 49, 92%
2012	78.6±6.2, 49, 107%
2010	88.2±16.7, 32, 149%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

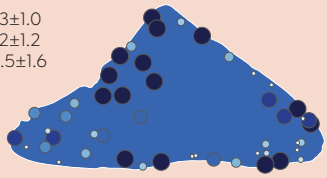
2015	17.4±1.5
2012	23.6±1.7
2010	24.0±3.9



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

2015	8.3±1.0
2012	11.2±1.2
2010	10.5±1.6



Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

2015	53.7±3.2
2012	64.5±6.5
2010	62.3±6.1

Biomass (g/m²)
10 20 30 40

Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral reefs – Palmyra Atoll (2015)

5° 52' N, 162° 04' W

Land area: 2.7 km²

0–100m depth: 55.8 km²

Coral reef area: 27.9 km² (18/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Population: 4–20 (2014)

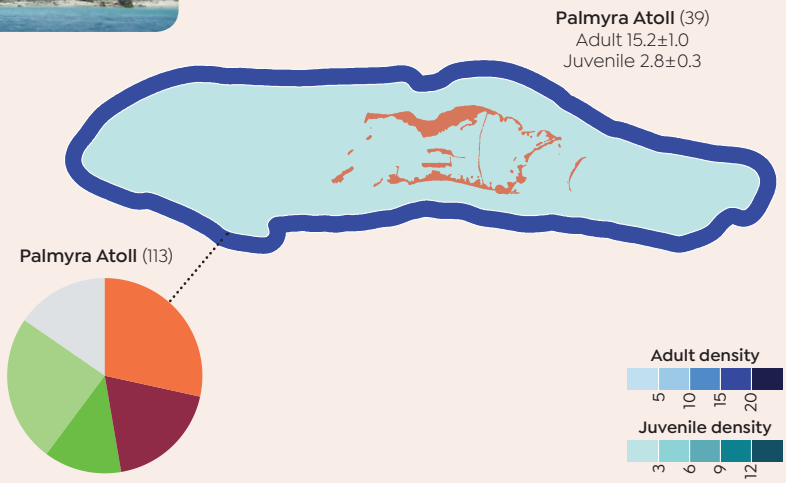
The coral reefs of Palmyra Atoll were surveyed in January to April 2015.

- Coral cover was 28.4 % at Palmyra Atoll.
- Acute and chronic coral diseases were <1 %, as was recent mortality.
- Old mortality of corals was 9.8 %.

Benthic cover and coral density

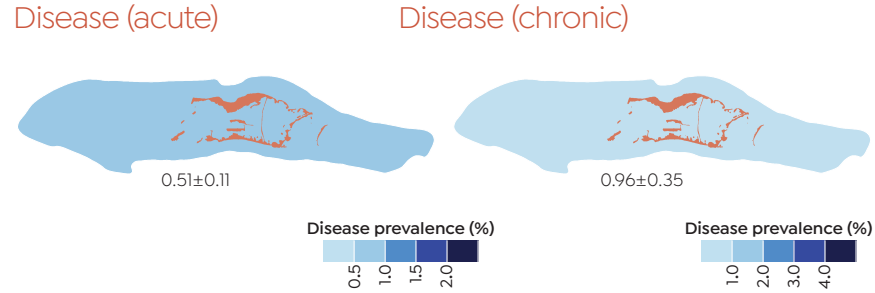
Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.



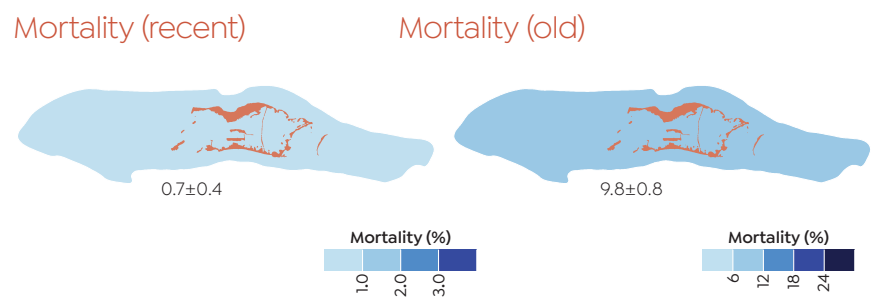
Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.



Coral reef fish – Palmyra Atoll (2010-2015)

5° 52' N, 162° 04' W

Reef fish biomass: 52.8±5.8 g/m²

100 g/m²

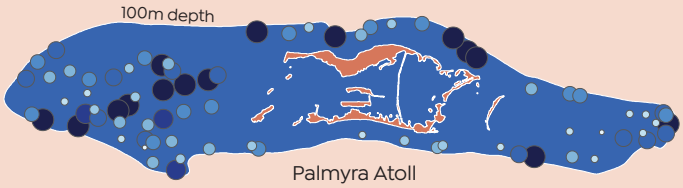
Coral reef fish surveys were conducted in 2015, 2012, and 2010.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 75.0±9.9 g/m² in 2010, 104.0±10.7 g/m² in 2012, and 52.8±5.8 g/m² in 2015.
- >50 % of the reef fish sampled were >40 cm in length during the 2010, 2012, and 2015 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only‡), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

Palmyra Atoll

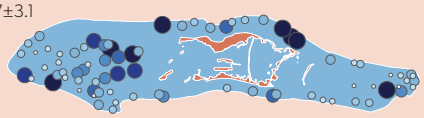
2015	52.8±5.8, 78, 63%
2012	104.0±10.7, 42, 125%
2010	75.0±9.9, 38, 91%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

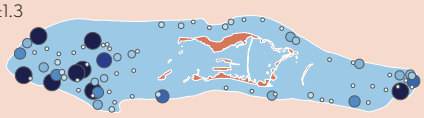
2015	17.9±1.5
2012	31.3±2.9
2010	28.7±3.1



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

2015	3.3±0.6
2012	9.4±1.4
2010	5.7±1.3



Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

2015	42.1±4.3
2012	79.1±9.2
2010	42.3±7.2

Biomass (g/m²)
10 20 30 40

Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.

‡ Backreef and lagoon data were removed prior to calculating the sector level values.

Coral Reefs and Reef Fish

Coral reefs – Jarvis Island (2017)

0° 22' S, 160° 01' W

Land area: 4.5 km²

0–100m depth: 5.4 km²

Coral reef area: 3.7 km² (30/40 in the U.S. Pacific)

Area (km²) 0–1000 10,000

Uninhabited

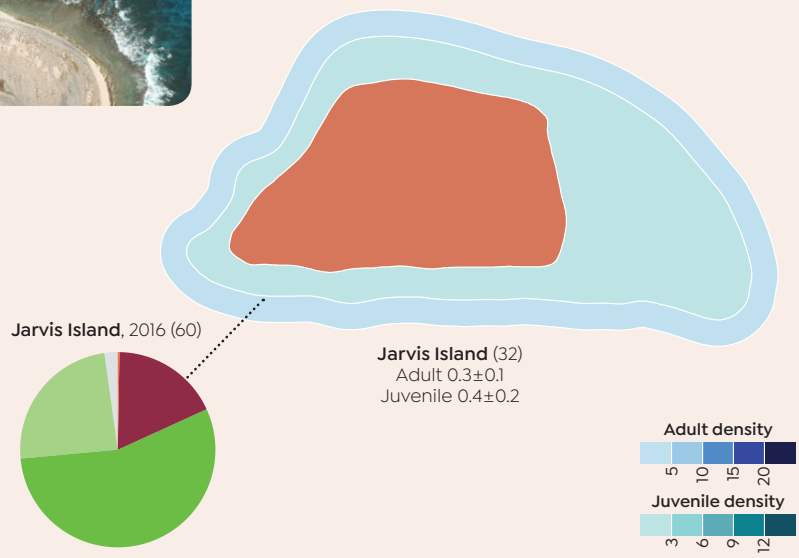
The coral reefs of Jarvis Island were surveyed in April 2017.*

- Coral cover was 0.3% at Jarvis Island. Coral cover was reduced by >98% as a result of the 2015-16 bleaching event.
- Acute coral disease and recent mortality was <1%. Chronic coral disease was 4.2%.
- Old mortality of corals was 27.8%.

Benthic cover and coral density

Pie charts for each sector show benthic cover of hard corals, crustose coralline algae (CCA), macroalgae (>1 cm in height), turf algae (<1 cm in height), and other as a percentage.

Adult (>5 cm) and juvenile (<5 cm) coral densities are shown within the sector areas, set as an inner and outer ring around the island. Sampling effort (number of surveys) is shown within brackets after the name in the sector areas around the island.

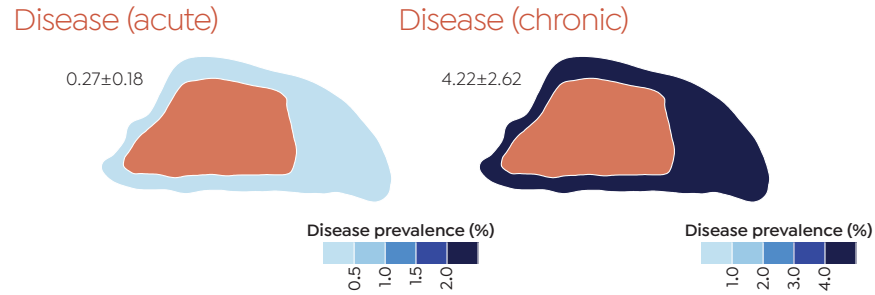


*Benthic cover data are from May 2016.

Benthic cover: Hard coral, CCA, Macroalgae, Turf algae, Other

Coral disease

The prevalence of acute and chronic coral diseases among sectors (±SE).



Coral mortality

The average percentage of recent (last few months) or old (months or years ago) mortality of coral tissue in observed coral colonies.

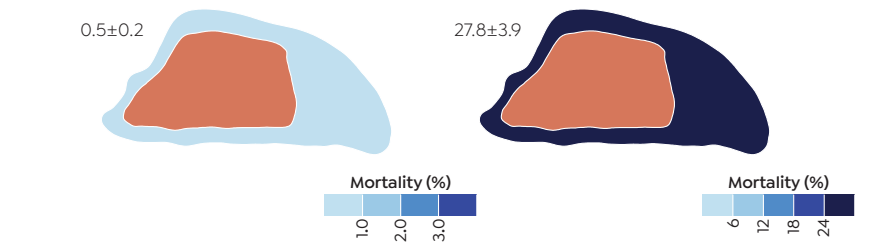


TABLE OF CONTENTS

Coral reef fish – Jarvis Island (2015-2017)

0° 22' S, 160° 01' W

Reef fish biomass: 73.6±5.5 g/m²

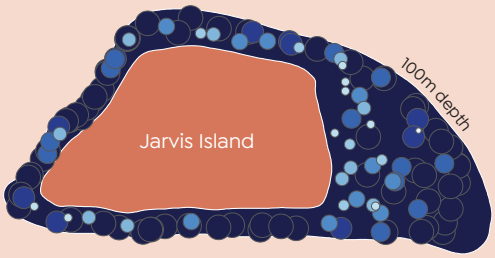
Coral reef fish surveys were conducted most recently in 2017, 2016, and 2015.

NCRMP surveys are randomly-located in all hard bottom habitats in <30 m deep waters. Choosing such a wide 'domain' means that resulting data are useful for a wide range of purposes, particularly where broad coverage of species' distributions is useful, but does increase among site variability, as surveys include complex coral-rich areas and more marginal habitats, such as low-relief pavement.

- Reef fish biomass was 74.9±5.1 g/m² in 2015, 55.8±4.2 g/m² in 2016, and 73.6±5.5 g/m² in 2017.
- >50 % of the reef fish sampled were >40 cm in length during the 2015, 2016, and 2017 surveys.

Reef fish biomass

Biomass of reef fish (g/m² ± SE, below) for the most recent survey year (within sectors on maps – outer reef only), with data from sampling sites shown for the past three survey periods. Herbivore, Parrotfish (>30 cm), and Targeted fish are shown to the right in the same format. Targeted fish are all large bodied species (max size >40 cm) in these families: Scaridae, Lutjanidae, Carangidae, Lethrinidae, Serranidae, Acanthuridae, Holocentridae, Scombridae, and Mullidae.



Biomass (g/m²)
10 20 30 40 50 60 70

Jarvis Island

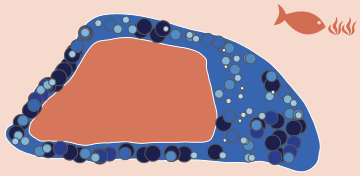
2017	73.6±5.5, 28, 74%
2016	55.8±4.2, 30, 56%
2015	74.9±5.1, 62, 76%

Sector (biomass±SE, sampling effort*, % of baseline**)

*number of stationary point count surveys conducted
**model of anthropogenic depletion

Herbivores

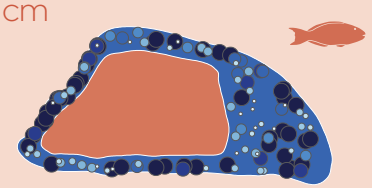
2017	29.0±2.3
2016	30.9±2.9
2015	29.2±3.1



Biomass (g/m²)
5 10 15 20 25 30 35

Parrotfish >30 cm

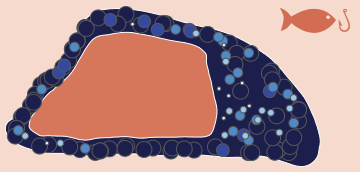
2017	8.2±1.1
2016	10.1±1.3
2015	8.9±1.0



Biomass (g/m²)
1.5 3.0 4.5 6.0 7.5 9.0 10.5

Targeted fish

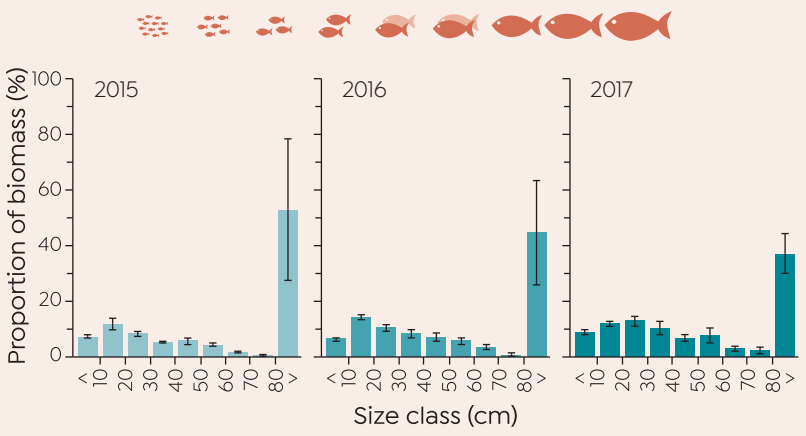
2017	61.4±8.9
2016	40.2±3.6
2015	48.7±4.6



Biomass (g/m²)
10 20 30 40

Size class distribution

Distribution of reef fish biomass among nine size classes for the most recent and past survey periods.



NOAA diver in a cloud of vibrant fish hovering above the coral reef at Baker Island.

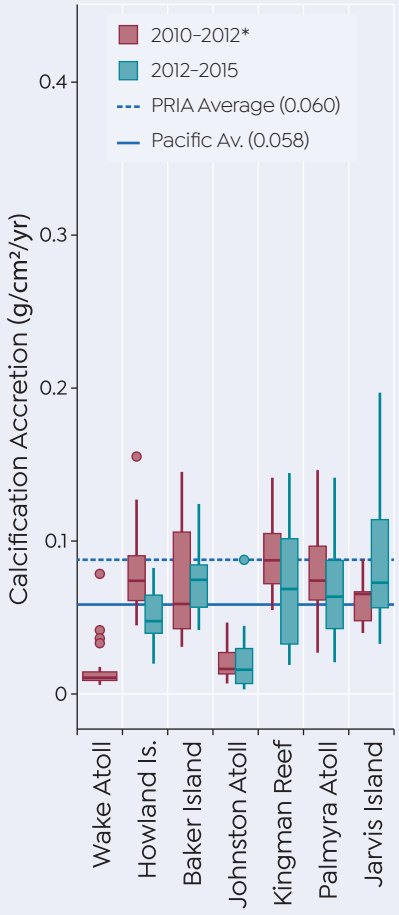
Ocean Chemistry and Temperature

Chemistry (2010–2016)

This section represents the first Pacific Remote Island Areas (PRIA) NCRMP data report on Ocean Chemistry and Temperature. The data and results presented were collected by staff working with the Ecosystem Sciences Division of the NOAA Pacific Islands Fisheries Science Center and the NOAA Coral Reef Watch program.

Aragonite saturation state

Calcium carbonate accretion



Aragonite saturation state measures carbonate ion concentration; the greater the concentration of carbonate ions is, the easier it is for organisms like stony corals to calcify. Aragonite saturation state was below the Pacific average for PRIA locations except Wake Atoll, Kingman Reef and Palmyra Atoll. Aragonite saturation state can be seen as an exposure term – i.e., exposure of calcifying organisms to the conditions that drive calcification.

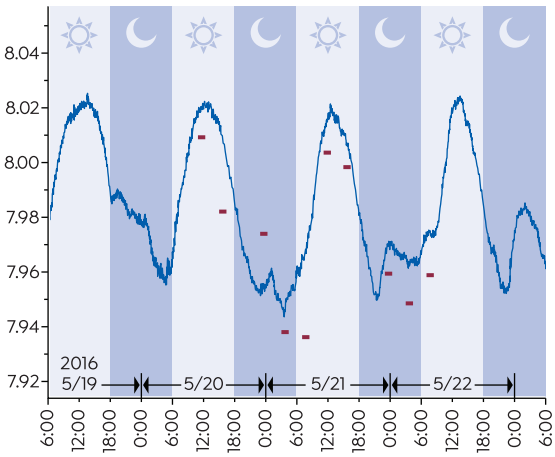
Calcification Accretion Units measure the response of calcifying organisms to those conditions as the net accretion of calcium carbonate produced over the deployment period (see photos to right). Calcium carbonate accretion was greater than the Pacific average for PRIA locations except Wake Atoll, Howland Island and Johnston Atoll. The differences within an island between years were subtle, while differences among islands were stable across years, and therefore likely robust.

* Wake Atoll data: aragonite saturation state (2014); calcium carbonate accretion (2011–2014).

Highlights

- Calcium carbonate accretion in the PRIA was above the US Pacific average at all islands, except Wake Atoll, Howland Island and Johnston Atoll.
- Bias-corrected subsurface temperature data reveals that depths >20 m did not provide a refuge for corals from heat stress in 2010.
- At least 20 Degree Heating Weeks accumulated at all reefs surrounding Jarvis Island in 2015 and extensive severe bleaching was observed there that year.

Diurnal pH — Jarvis Island

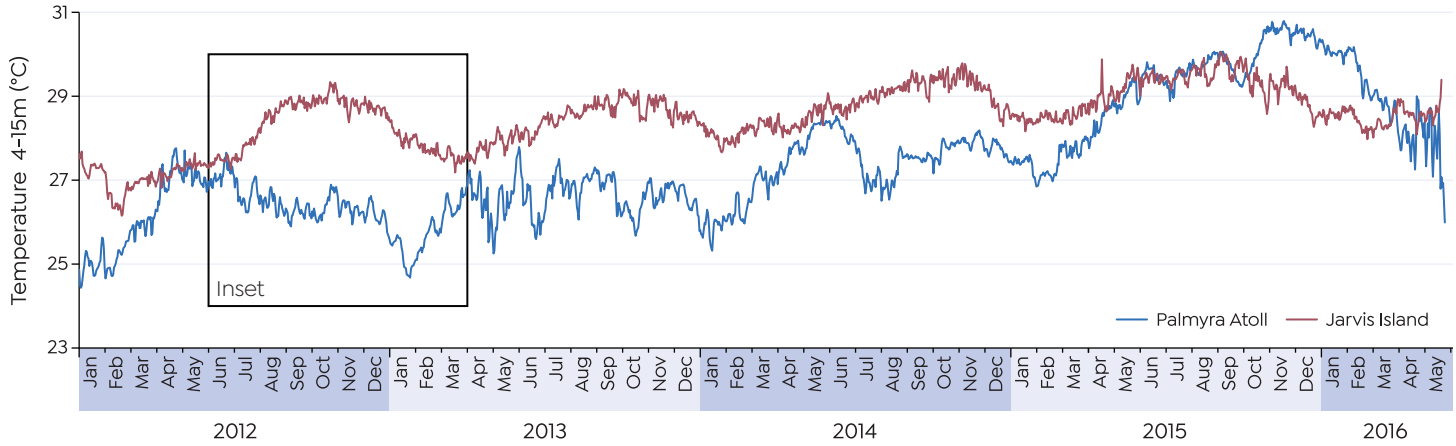


Processes driving local pH vary throughout the day. Photosynthesis drives up the pH during the day as organisms calcify. pH declines again at night as photosynthesis stops and respiration continues to release CO_2 into the water column. Red lines on the plot are the bottle samples used to validate the 24-hour pH time series from the sensors.

Rates of net calcium carbonate accretion are monitored with calcification accretion units (CAUs), which allow for recruitment and colonization of crustose coralline algae and hard corals. Photos show a CAU newly deployed (left) and two years after deployment (right).

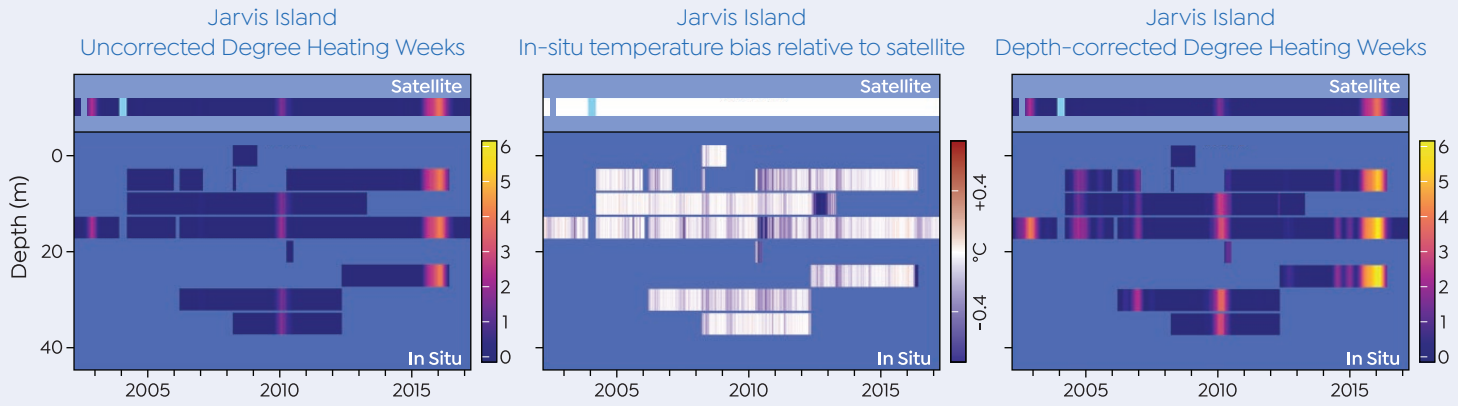
Subsurface temperature

Subsurface temperature time series



Subsurface temperature time series for 4–15 m for 2012–2016 comparing Palmyra Atoll and Jarvis Island. Warm season months at these locations (May to August) at this depth were very similar. Cool season months (September to February) were much cooler in 2012–2015 at Palmyra Atoll than at Jarvis Island, especially in 2012–13 (see inset graph, right). This pattern switched in 2015–16 with cool season temperatures warmer at Palmyra Atoll than Jarvis Island.


Coral bleaching, Jarvis Island, November 2015

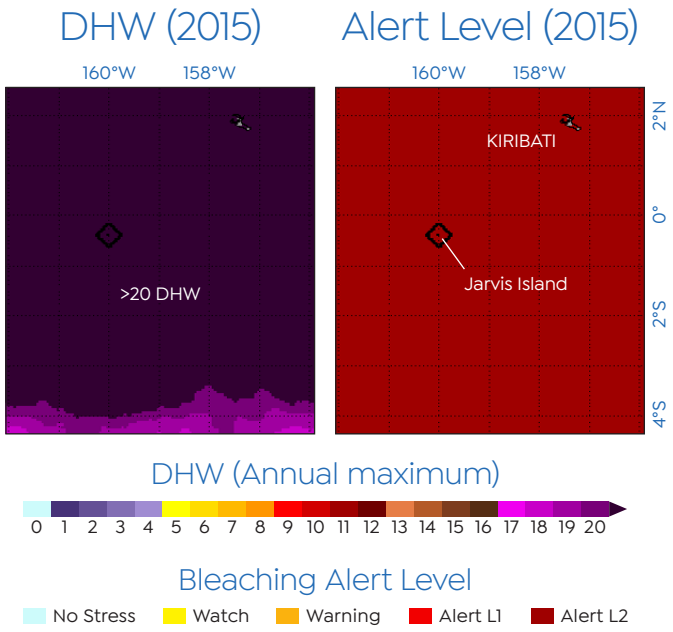


Sea temperature data can be used to calculate Degree Heating Weeks; a metric of the accumulation of heat stress. Remotely sensed sea surface temperature data from satellites are used to calculate Degree Heating Weeks for the surface of the ocean. The difference between temperatures at the surface recorded by satellites and temperatures at depth can be calculated ('the bias'). The resultant bias-correction can be applied to temperatures at depth, enabling more accurate calculations of heat stress at depth. The 10-year time series of sub-surface temperature from Jarvis Island shows that depths below 20 m did not always provide a refuge from heat stress. Heat stress that may have caused bleaching at depths greater than 20 m accumulated in 2010.

Heat stress and coral bleaching

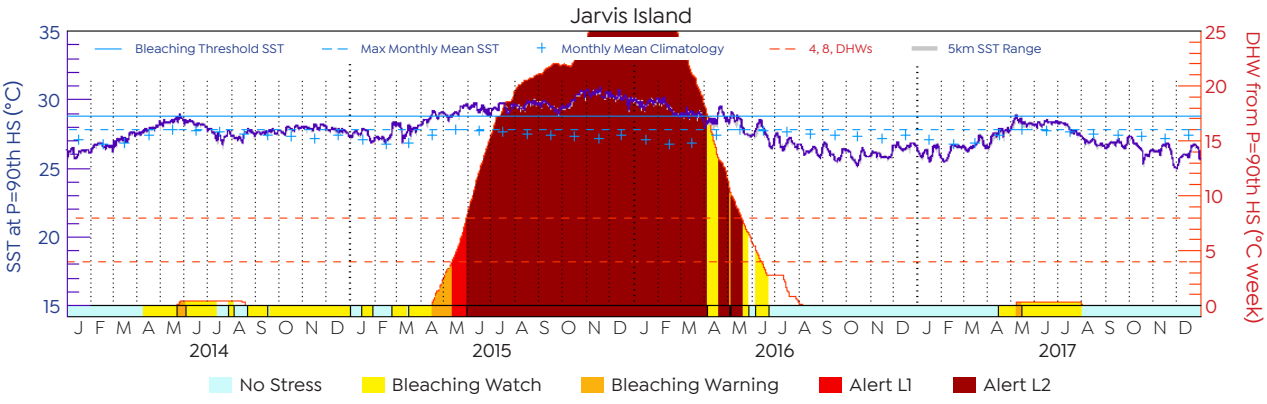
The NOAA Coral Reef Watch (CRW) program uses satellite data to provide current reef environmental conditions to quickly identify areas at risk for coral bleaching. During the 33 year period between 1985 and 2018, satellite temperature analyzed shows that heat stress severe enough to cause coral bleaching occurred three times at Wake Atoll, 17 times at Howland and Baker Islands, one time at Johnston Atoll, two times at Kingman-Palmyra, and 15 times at Jarvis Island.

Coral bleaching, Jarvis Island, November 2015

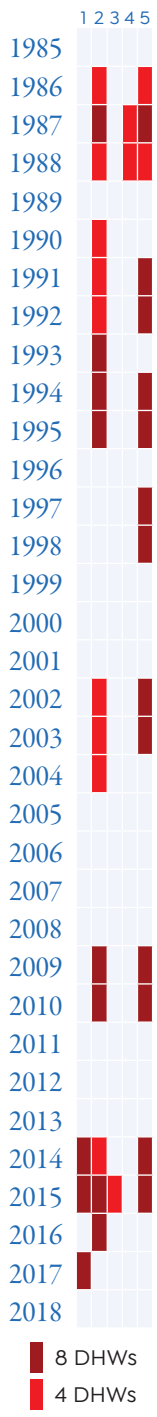


Annual maximum Degree Heating Weeks (DHWs) in 2015 (left panel) exceeded 25 at Jarvis Island when at least 20 DHWs accumulated at all reefs surrounding Jarvis Island.

Heat stress accumulation triggered Alert Level 2 throughout the Jarvis Island area in 2015 (right panel) and 98% of corals died due to bleaching.



Degree Heating Week (DHW) accumulation from 2014-2017 at Jarvis Island, one of the US Pacific Remote Island Areas (PRIA). Alert Level 1 (lower dashed red line) is triggered when at least four DHWs have accumulated; a level of heat stress associated with minor and moderate bleaching. Alert Level 2 (upper dashed red line) is triggered when at least eight DHWs have accumulated, which can cause severe bleaching. Alert Level 2 was triggered in 2015.



* 1. Wake Atoll, 2. Howland-Baker, 3. Johnston Atoll, 4. Kingman-Palmyra, 5. Jarvis Island

Corals thrive and support a wide diversity of reef fish in the sunny, shallow water at Baker reef.

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Atlantic – Caribbean

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