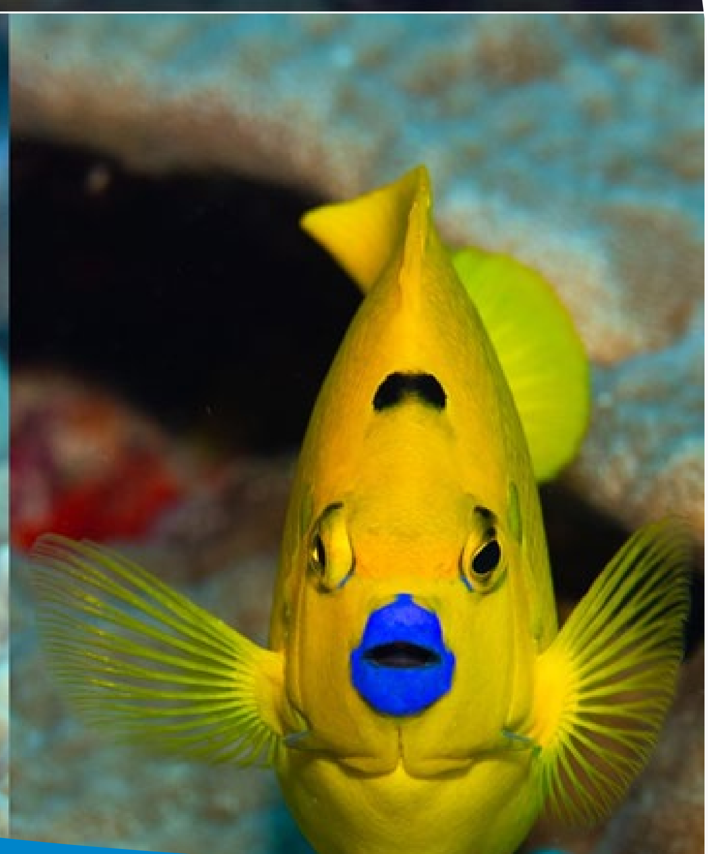
Pacific National Coral Reef Monitoring Program 2023—Reef Fishes of American Samoa



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Pacific National Coral Reef Monitoring Program 2023—Reef Fishes of American Samoa

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About this report

The Pacific Islands Fisheries Science Center (PIFSC) uses the PIFSC Data Report series to distribute scientific and technical information that has been scientifically reviewed and edited. Documents within this series reflect sound professional work and may be referenced in the formal scientific and technical literature.

This report outlines a portion of the National Coral Reef Monitoring Program surveys conducted by the National Oceanic and Atmospheric Administration (NOAA) PIFSC Archipelagic Research Program (ARP) of the Ecosystem Sciences Division (ESD) in 2023 in American Samoa.

Cover photo: Several reef fish that were seen during surveys in American Samoa. Photo credit: NOAA Fisheries/Raymond Boland.

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Introduction

Background

The Archipelagic Research Program of the Ecosystem Sciences Division (ESD) at the Pacific Islands Fisheries Science Center (PIFSC) leads the U.S. Pacific National Coral Reef Monitoring Program (NCRMP; **Figure 1**), formerly known as the Pacific Reef Assessment and Monitoring Program (RAMP). It provides scientific information that supports ecosystem approaches to the management and conservation of coral reefs. Since its inception in 2000, the Pacific RAMP surveyed each region on a biennial basis to establish baseline ecosystem assessments and conduct long-term monitoring that integrates biological observations with water quality and oceanographic data. In 2011, the NOAA Coral Reef Conservation Program (CRCP) established the NCRMP, and the Pacific RAMP was integrated into the broader objective to monitor the status and trends of all U.S. coral-reef ecosystems (including the Atlantic, Caribbean, and Puerto Rico; [NOAA CRCP, 2014]). Starting in 2012, the Pacific NCRMP transitioned to monitoring each region on a triennial cycle.

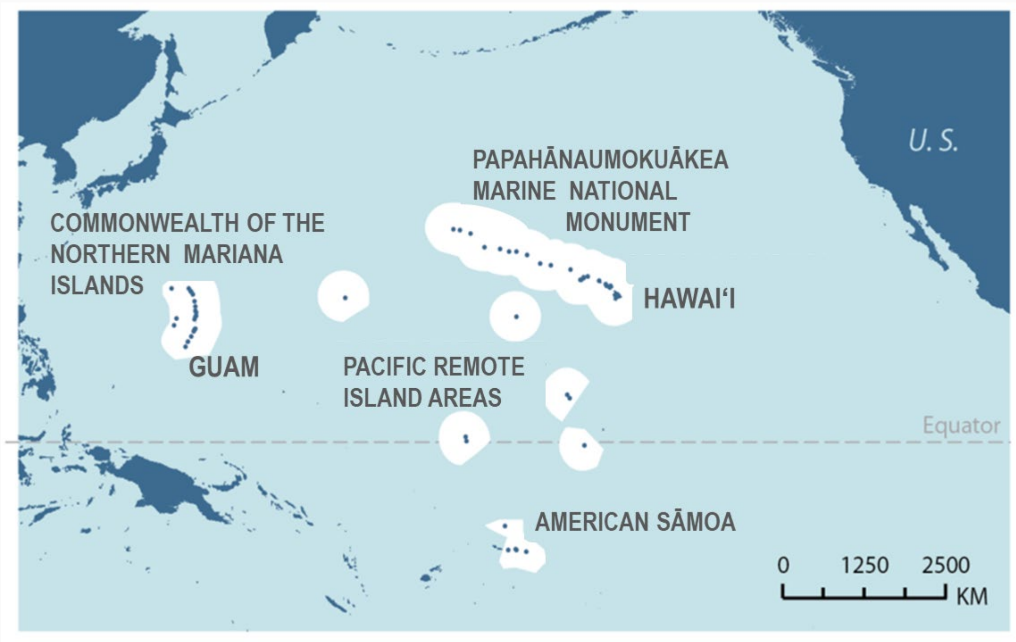

Figure 1. Coral-reef areas surveyed for the Pacific NCRMP. White areas represent the Exclusive Economic Zones (EEZs) for each U.S. Pacific region surveyed.

As an interdisciplinary monitoring program, the NCRMP has three main themes: biological, climate, and socioeconomic monitoring. The Pacific NCRMP executes the biological and climate components of hard-bottomed reef habitats in the 0–30 m depth range. Under the biological monitoring theme, the Pacific NCRMP collects the following reef-fish data for every observed species, including key fish taxa:

- abundance
- size structure
- diversity
- distribution

Partnership and cooperation with other federal and jurisdictional management groups is a core principle of the NCRMP. For example, the University of Guam's Long-term Coral Reef Monitoring Program (GLTMP) conducts reef fish monitoring surveys around Guam using similar survey designs and methods. Data gathered by GLTMP are therefore readily merged with NCRMP data resulting in increased survey domain for local research efforts.

This report focuses on the data collected using the stationary point count (SPC) method to survey the fish assemblage (see **Methods**). Note that the Pacific NCRMP also collects benthic data via benthic transects in the same locations as SPC surveys which are not included in this report (for more information, see NOAA Coral Program (2021)).

Monitoring scope of the NCRMP

CRCP's NCRMP includes the following biological monitoring goals:

- develop and implement consistent and comparable methods and standard operating procedures which detail specific field, laboratory, and/or analytical procedures and best practices for all indicators (with periodic updates to reflect new technologies or logistical considerations)
- develop and maintain strong partnerships with federal, state/territory, and academic partners
- collect scientifically sound, geographically comprehensive data in U.S. coral reef areas
- deliver high-quality data, data products, and tools to the coral reef conservation community
- provide context for interpreting results of localized monitoring
- provide periodic assessments of the status and trends of the nation's coral reef ecosystems
- contribute to local capacity-building through its engagement of jurisdictional entities and private-public partnerships involved in NCRMP data collection

These goals are based on the key monitoring questions for the CRCP and NCRMP support for baseline observations and monitoring (NOAA Coral Reef Conservation Program, 2009; NOAA CRCP, 2014; NOAA Coral Program, 2021).

The Pacific NCRMP involves monitoring over very large spatial scales: ~ 40 islands and atolls spread over thousands of kilometers. The target for fish monitoring is to provide periodic snapshot assessments of coral-reef assemblages at U.S.-affiliated islands in the Pacific' the core reporting unit is the island scale (or sub-island scale for large islands). As such, the survey design and effort are optimized to generate data at the spatial scale of islands and atolls. The NCRMP is therefore explicitly a "wide-but-thin" survey program, with the aim of generating large-scale, regional status and trend information of the nation's shallow (0–30 m) coral-reef ecosystems to provide a broad-scale context and perspective for management and conservation.

Report structure

This report summarizes the reef-fish survey data collected in American Samoa during the Pacific NCRMP survey mission in 2023. The status of reef-fish assemblages is described at the island scale, and at the sector scale for Tutuila. By collecting data using the same methods over time, we are able to provide time series that begin in 2009, when the program started to consistently use SPC fish surveys.

All data used in this report are available through the online data visualization tool (https://ncrmp.coralreef.noaa.gov/), or through NOAA's InPort data system for 2009–2012 (https://www.fisheries.noaa.gov/inport/item/34515), and 2014 on (https://www.fisheries.noaa.gov/inport/item/34518). For all remaining data requests or inquiries, please contact Tye.Kindinger@noaa.gov.

Methods

Sampling domain and survey design

The target sampling domain is hard-bottom habitat in water shallower than 30 m (**Table 1**). All islands/atolls are stratified by reef zone (backreef, forereef, lagoon, protected slope) and depth zone: shallow (> 0–6 m) mid (> 6–18 m), and deep (> 18–30 m). The areas surveyed in American Samoa are all characterized as forereef, except for the interior of Rose Atoll, which consists of a lagoon. Tutuila is further stratified into sectors per island, where sector boundaries reflect broad differences in oceanographic exposure, reef structure, and local human population density.

Table 1. Sampling terms and definitions

Term	Definition
Sampling domain	Hard-bottom habitat in water less than 30 m depth.
Reporting unit	A collection of sample sites, typically an island or atoll and in some cases, small island groups or sectors of larger islands.
Strata	Sectors (e.g., management units and stretches of coastline with broadly similar habitat attributes and local human population density). Reef zone (backreef, forereef, lagoon, protected slope) Depth zone (shallow > 0[1]–6 m, mid > 6–18 m, deep > 18–30 m)
Sample site data	The average values of estimated observed quantities from the SPC surveys conducted at each site. These are typically derived from a single pair of simultaneous surveys. Sites are tied to geographic coordinates.

The number of sites to be surveyed per stratum is based on a weighting factor calculated from the proportional area per stratum per reporting unit (e.g., island) and the variance of the target output metrics (e.g., consumer group biomass and total fish biomass; see **Fish groupings**) in combination with the ship time allotted per island or atoll. The resulting target number of sites are then randomly distributed across each stratum (see below). Details on the sampling effort across survey cruises included in this report are provided in **Appendix B**.

[1] For practical reasons, sites in which the center point of the survey cylinder is shallower than 1.5 m are not surveyed.

Site selection

Prior to each survey mission, sample site locations (latitude and longitude) are randomly drawn from geographic information system (GIS) habitat and strata maps of the entire sampling domain (**Figure 2**).

Maps used in the site selection procedure were created using information from the NOAA National Centers for Coastal Ocean Science, reef zones (e.g., forereef) digitized from IKONOS satellite imagery or nautical charts, bathymetric data from the PIFSC-affiliated Pacific Islands Benthic Habitat Mapping Center at the University of Hawai‘i at Mānoa, and prior knowledge gained from previous visits to survey locations.

Although the Pacific NCRMP aims to survey around the entirety of each island or atoll, the monitoring effort achieved is ultimately determined by field logistics and weather conditions encountered during field operations on each research cruise. If a site is not suitable (e.g., soft- as opposed to hard-bottomed habitat) or accessible (e.g., due to inclement sea conditions), the dive is aborted, and an alternate (backup) site is picked from the randomized list. In some cases, the spatial coverage of sampling sites around the entire area of target sampling domain is incomplete. As such, any inferences about coral reef fish assemblages and habitat made at the island scale are only representative of the areas sufficiently surveyed (**Appendix B**). For further details on the methods and maps used to select sites, see Ayotte (2015) and Williams(2011).

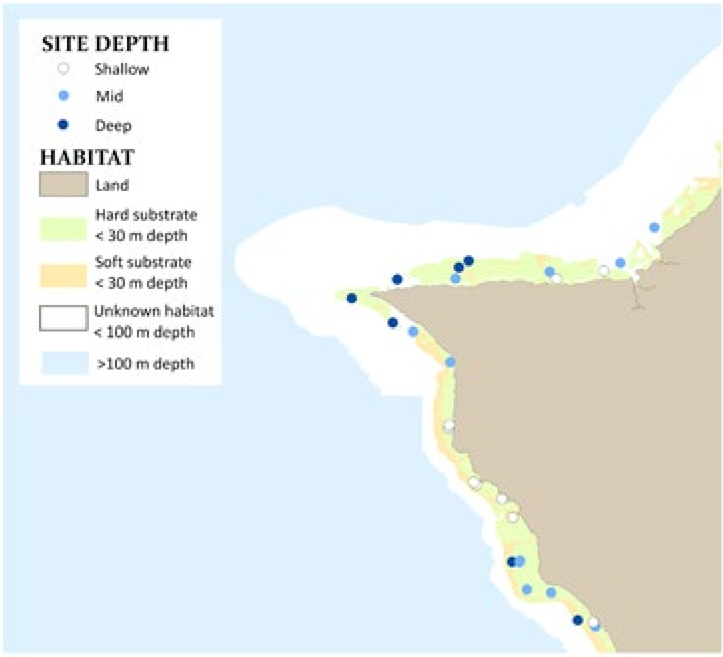

Figure 2. An example of the benthic habitat and depth strata information used in the site selection process. Each circle identifies a site which falls on hard substrata (green) in the three depth strata (see map legend, shallow: < 6 m, mid: > 6–18 m, and deep: > 18–30 m).

Sampling methods

At each survey site, divers record the counts and sizes of observed fish assemblages. The SPC protocol closely follows that used by Ault and colleagues (2006) and involves a pair of divers conducting simultaneous counts in adjacent, visually estimated 15-m diameter cylindrical plots extending from the substrate to the limits of vertical visibility (**Figure 3**). Prior to beginning each SPC, a 30-m line is laid across the substratum. Markings at 7.5 m, 15 m, and 22.5 m enable survey divers to locate the midpoint (7.5 m or 22.5 m) and two edges (0 m and 15 m; or 15 m and 30 m) of their survey plots. Each count consists of two components. The first is a 5-minute species enumeration period in which the diver records the taxa of all species observed within their cylinder. At the end of the 5-minute period, divers begin the tallying portion of the count, in which they systematically work through their species list and record the number and estimated size (total length, TL, to the nearest cm) of each individual fish. The tallying portion is conducted as a series of rapid visual sweeps of the plot, with one species-grouping counted per sweep. To the extent possible, divers remain at the center of their cylinders throughout the count. However, small, generally site-attached and semi-cryptic species, which tend to be underrepresented in counts made by an observer remaining in the center of a 7.5-m radius cylinder, are left to the end of the tally period. The observer then swims through their plot area carefully searching for those species. In cases where a species is observed during the enumeration period but is not present in the cylinder during the tallying period, divers record their best estimates of size and number observed in the first encounter during the enumeration period and mark the data record as “non-instantaneous.” Beginning in 2012, divers also recorded observations of fishes that were first seen inside the cylinders at some point between 5 and 30 minutes into the survey. However, for consistency across time periods, those additional observations were not used in this report. Surveys are not conducted if horizontal visibility is less than 7.5 m, i.e., when observers cannot distinguish the edges of their cylinder (Ayotte, 2015).

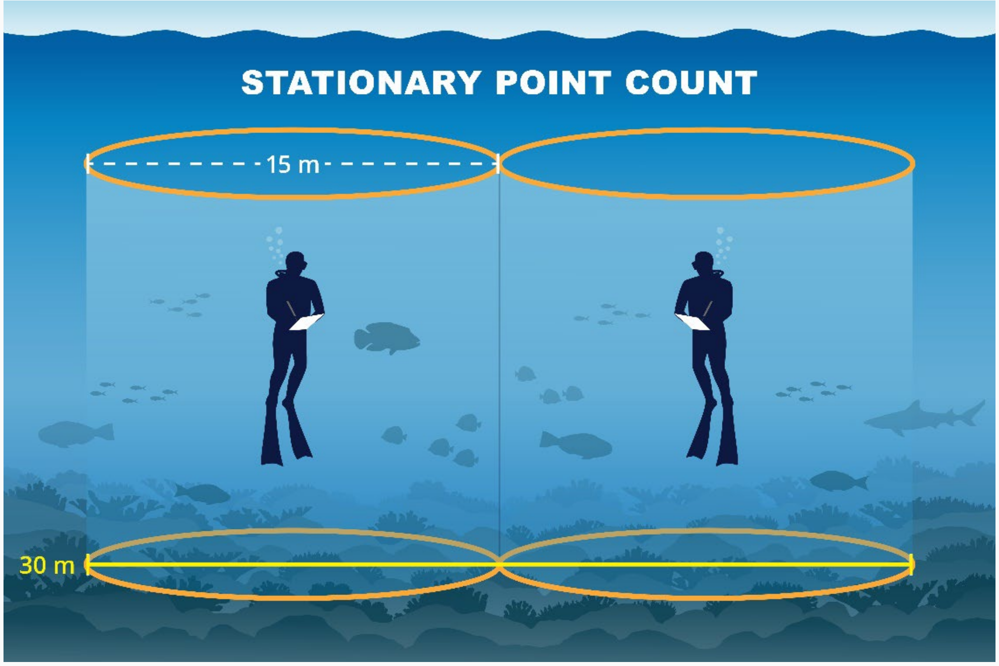

Figure 3. Side view of the stationary point count method. A pair of divers count and size the fishes within adjacent cylinders measuring 15 m in diameter.

Data entry and storage

Data are entered into a custom application built with Oracle Application Express and stored in an Oracle mission-specific database. Upon completion of each monitoring cruise, all data are migrated to an existing master Oracle database that is stored on a server at the PIFSC.

Data quality control

Data quality control is implemented at three main stages:

- Prior to conducting fish surveys for the Pacific NCRMP, each observer must take the full training course. In between field data collections, observers practice survey methods and take fish identification tests (**Figure 4**: Pre-field).
- Observers check the data entered by their dive partner against their datasheet for typing and potential sizing errors (**Figure 4**: In the field). At the end of the cruise, a series of error checking scripts are run prior to migrating from the mission Oracle database to the master Oracle database (**Figure 4**: Post-field).
- Examining diver estimation accuracy occurs during and after the monitoring cruise when diver estimates are compared between dive partner pairs (**Figure 4**: In the field). Observer comparisons from the regions surveyed in 2023 are in **Appendix C**.

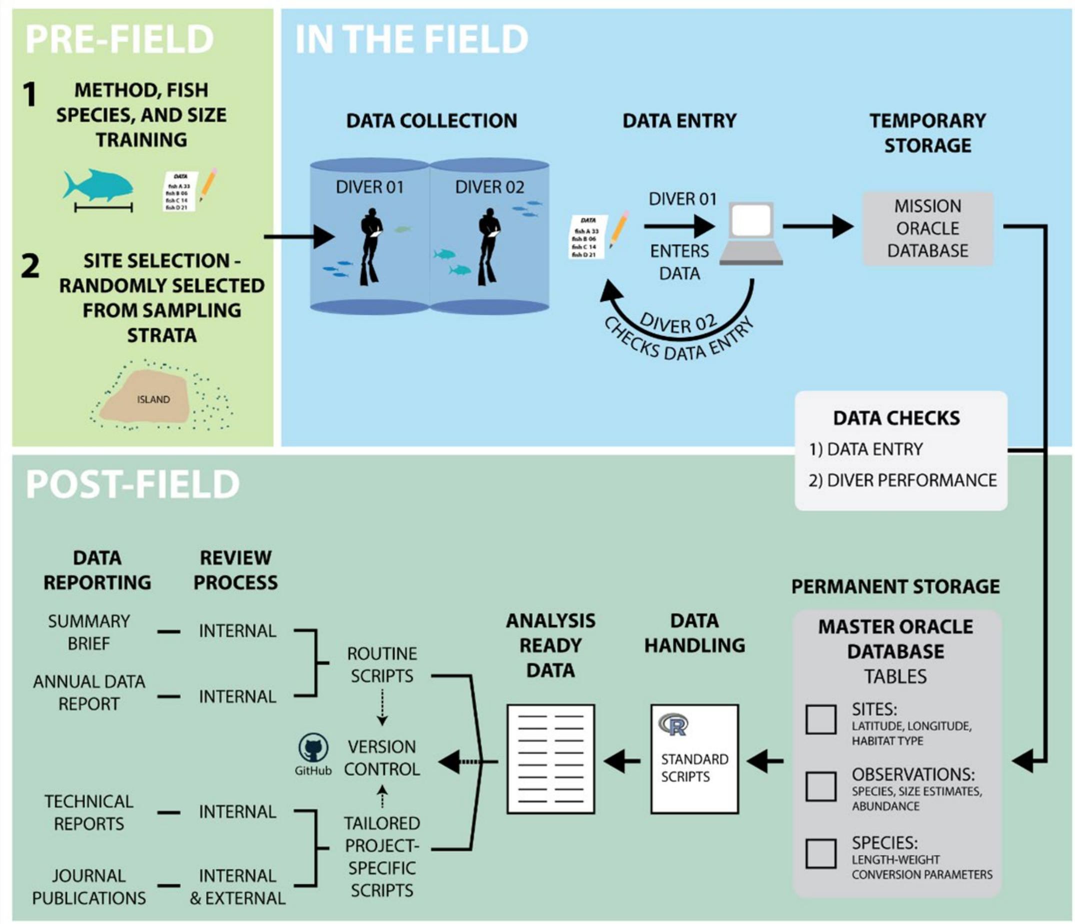

Figure 4. The training, data collection, data processing, and reporting phases for the Pacific NCRMP SPC surveys.

Data handling

Calculating fish biomass per site

Using the count and size data collected per observer in each replicate survey, the body weight of each individual fish is calculated using length-to-weight (LW) conversion parameters and, where necessary, length-length (LL) parameters (for example, to convert TL to fork length [FL] for species with LW parameters based on FL). LW and LL conversion parameters were taken from FishBase (Froese, 2010; Kulbicki, 2005). Biomass per fish is calculated using the standard length-weight equation. Herein, the term “biomass” refers to the aggregate body weight of a group of fishes per unit area (g m^{-2}). Site is the base sample unit, and the estimated biomass of fishes per site is calculated by taking the mean value from the paired SPC surveys.

Fish groupings

In this report, species data are summarized at several different levels: consumer group, total fish biomass ("all fishes"), parrotfish biomass, and average total length. Consumer groups are: "primary consumers" (herbivores and detritivores); "secondary consumers" (omnivores and benthic invertivores); "planktivores;" and "piscivores," with classifications based on diet information taken largely from FishBase (Froese, 2010). Size classes for parrotfish are 10–30 and greater than 30 cm TL, as 30 cm is the legal minimum size for fishing on all islands.

Generating island-scale estimates from the stratified design

Summary statistics (e.g., mean and variance) of survey metrics (e.g., biomass) are calculated by first averaging values within each stratum before calculating the reporting unit values. A weighted-average method to calculate summary statistics is used because survey strata vary in size within each reporting unit.

Estimates of the mean and variance for each survey quantity considered are calculated based on the observed values at sampled sites within each stratum. Then, aggregate estimates of the quantities across all strata are calculated using the formulas below. For example, with respect to biomass we have:

(1) pooled mean biomass (*X*) across S strata: $X = \sum_1^S \quad (X_i * w_i)$; and

(2) pooled variance of mean biomass (*VAR*) across S strata: $VAR = \sum_1^S \quad (VAR_i * \ w_i^2)$

where X_i is the estimate of mean biomass within stratum *i*, VAR_i is the estimated variance of X_i, and w_i is the stratum-weighting factor. Strata weighting factors were based on the size of strata, i.e., if a stratum is 50% of the total habitat area surveyed at an island, its weighting factor will be 0.5, and total of all weighting factors in an island sums to 1 (Smith, 2011).

In this report, only data from sites surveyed under the stratified sampling design are used (i.e., data collected from 2009 onwards; **Appendix D**). In the rare cases where fewer than two sites were surveyed in a stratum during a reporting period, they were removed from the island-scale parameter estimates for that period.

Island-scale values for total fish biomass (i.e., all fishes, fishes by size class) and biomass per consumer group, parrotfish size class, and species of interest (mean and variance) are calculated by year (see **Island status and trends**).

All data handling and analyses were performed using raw site data extracted from the NOAA PIFSC Oracle database, processed using a set of routine processing scripts written in R (R Development Core Team, 2011; **Figure 4**: Post-field), and visualized using the ggplot2 package (Wickham, 2016). The site-level data used to generate all figures and summary statistics are available upon request.

Island status and trends

This section summarizes SPC data collected at each island between 2010 and 2023, when comparable methods were used. For each island within a region, maps illustrate the SPC site-level data, and a standard set of graphs shows summary information on the fish community at the island scale for each year sufficient sampling occurred. On each fish biomass graph for the forereef habitat, a reference line indicates the region-wide mean estimate across all surveyed years (2010–2023), provided as a relevant regional comparison for island-level estimates. Fish biomass estimates are shown for each year of all fish combined, all fish in two size classes, parrotfish in two size classes, species of interest, and by consumer group. All fish, consumer group, and parrotfish biomass are core NCRMP indicators (NOAA CRCP, 2014). Large parrotfishes are important grazers, so parrotfish biomass is separately reported for two size groups: large (> 30 cm TL) and small (10–30 cm TL) fishes. Mean fish size (cm TL) per island and year is also reported, as it can be a useful indicator of fishing pressure; fishes smaller than 10 cm TL are excluded to reduce noise from variable levels of recent fish recruitment. Species of interest were identified by local managers, and biomass for humphead wrasse and all shark species are also shown.

Ofu and Olosega

Ofu and Olosega Islands were surveyed in 2010 (n = 30), 2012 (n = 30), 2015 (n = 52), 2016 (n = 11), 2018 (n = 25), and 2023 (n = 23). These two islands are analyzed together due to their geographic proximity.

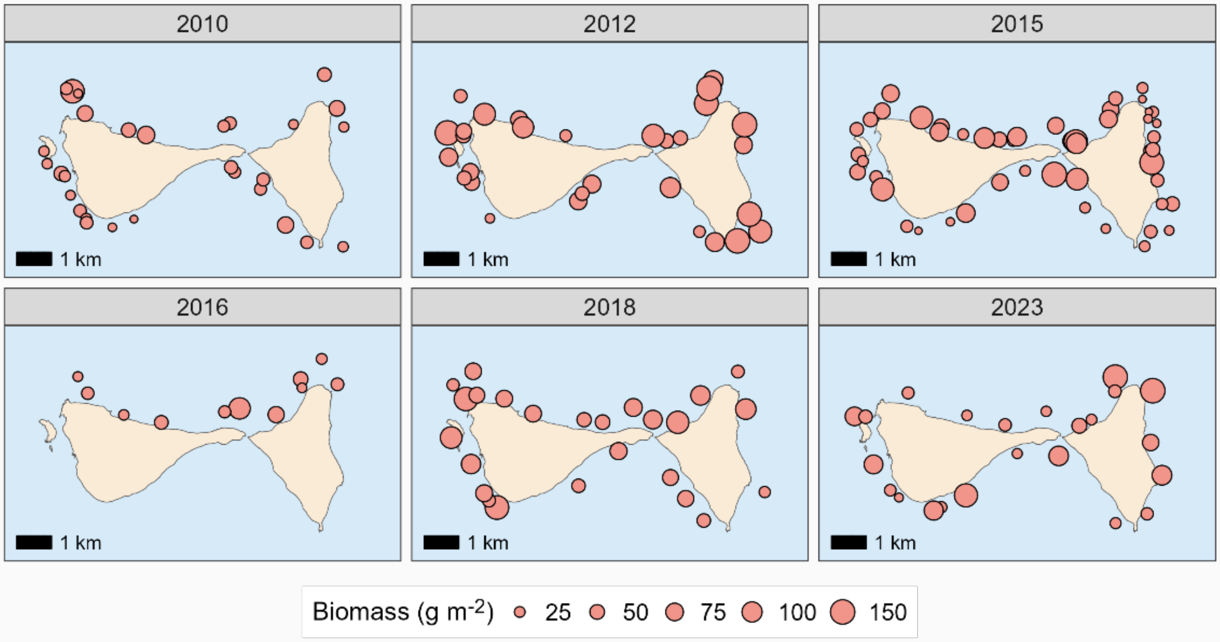

Figure 5. Ofu and Olosega Islands site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

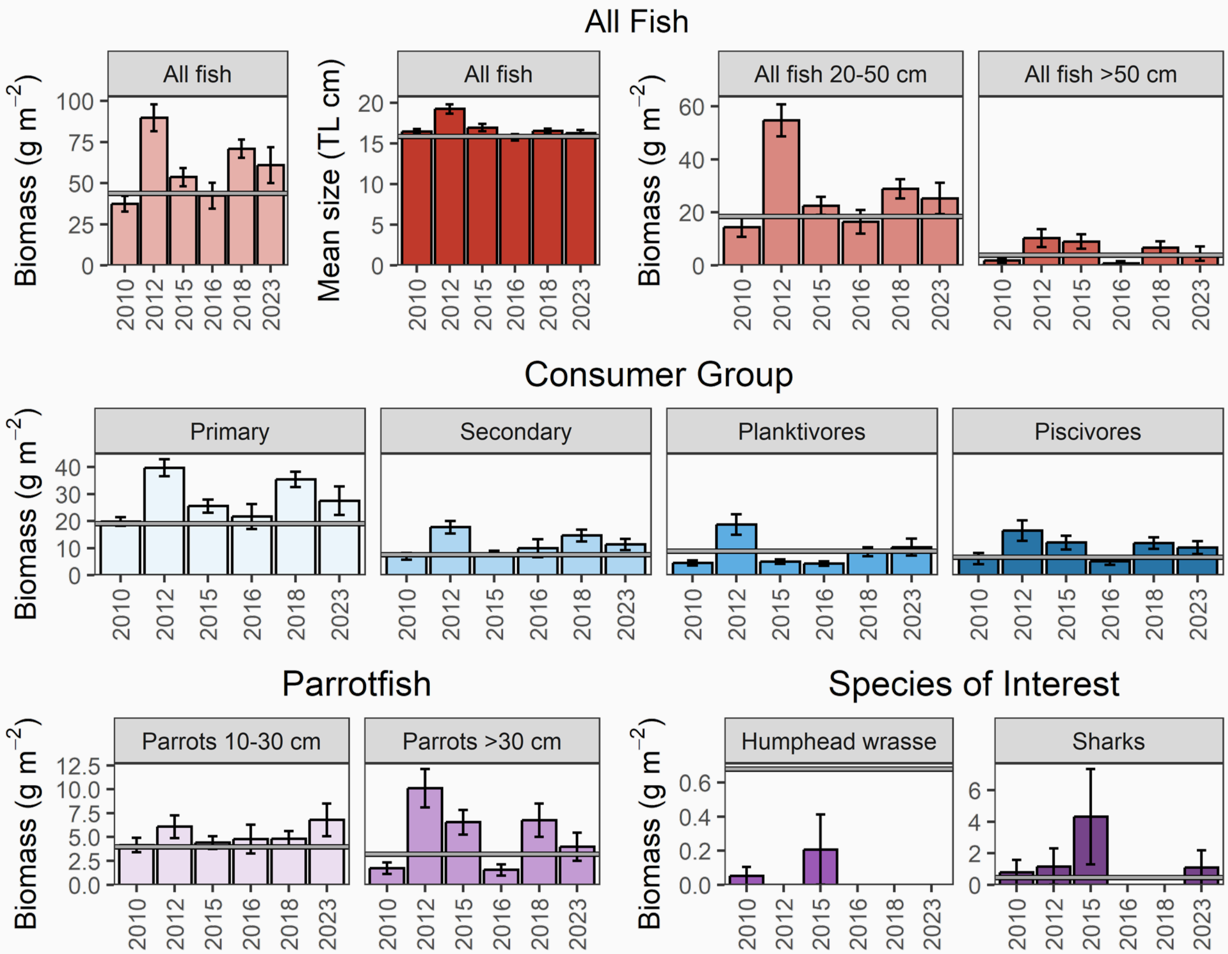

Figure 6. Ofu and Olosega Islands fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The American Samoa regional mean estimates of each metric are plotted for reference (horizontal grey line).

Rose

Rose Atoll was surveyed in 2010 (n = 34), 2012 (n = 48), 2015 (n = 47), 2016 (n = 47), 2018 (n = 20), and 2023 (n = 27). Two habitats were surveyed: forereef and lagoon. Biomass estimates and average total length are shown for each habitat type.

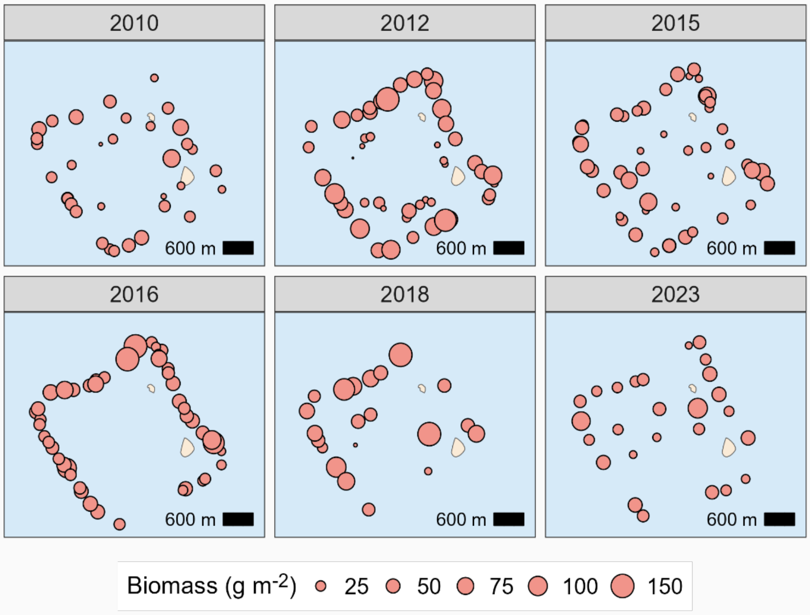

Figure 7. Rose Atoll site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

Forereef

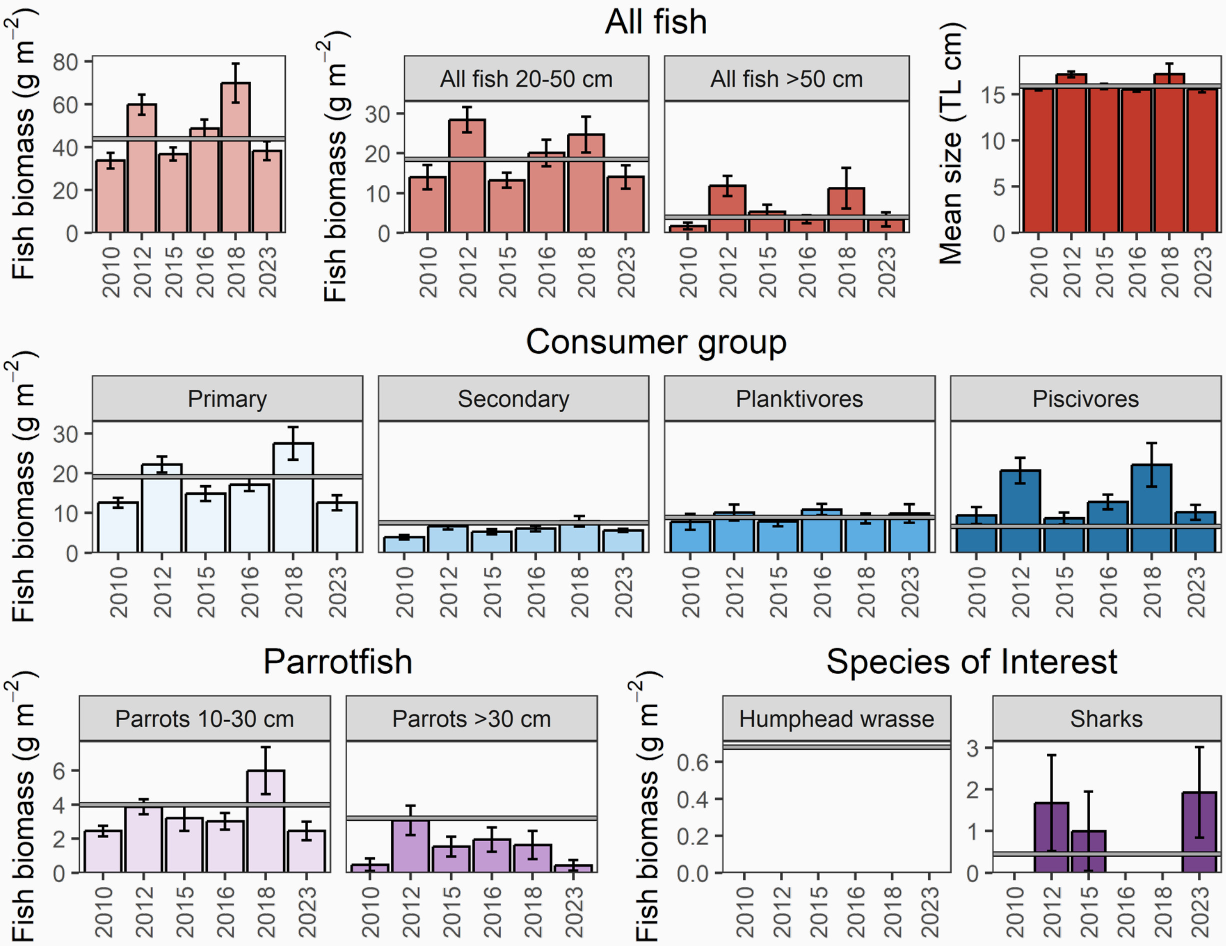

Figure 8. Rose Atoll forereef fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The American Samoa regional mean estimates of each metric are plotted for reference (horizontal grey line). No humphead wrasses were seen in this habitat during surveys.

Lagoon

Rose Atoll lagoon was surveyed sporadically due to logistical constraints.

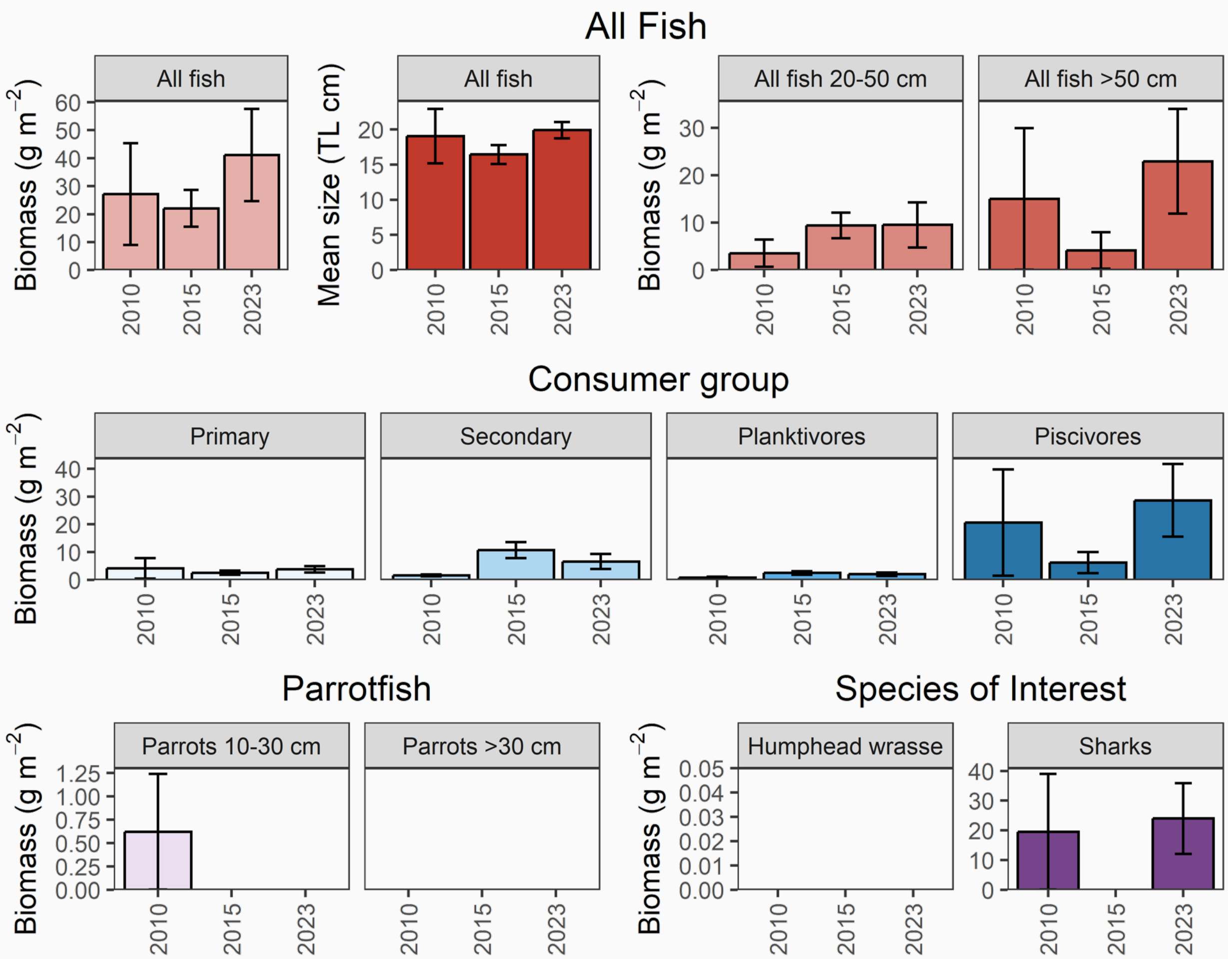

Figure 9. Rose Atoll lagoon fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The American Samoa regional mean estimates of each metric are plotted for reference (horizontal grey line). No large parrotfish or humphead wrasse were seen in this habitat during surveys.

Swains

Swains Island was surveyed in 2010 (n = 24), 2012 (n = 38), 2015 (n = 32), and 2018 (n = 30). Swains was not surveyed during 2023 due to logistical constraints.

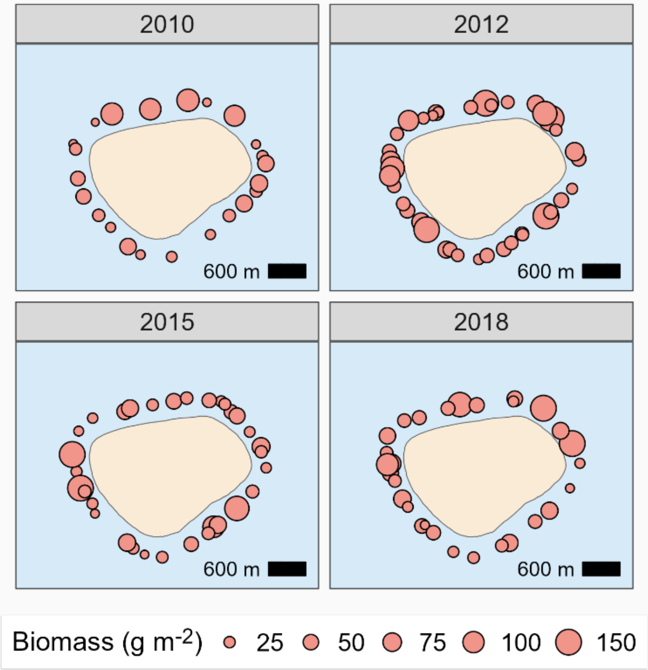

Figure 10. Swains Island site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

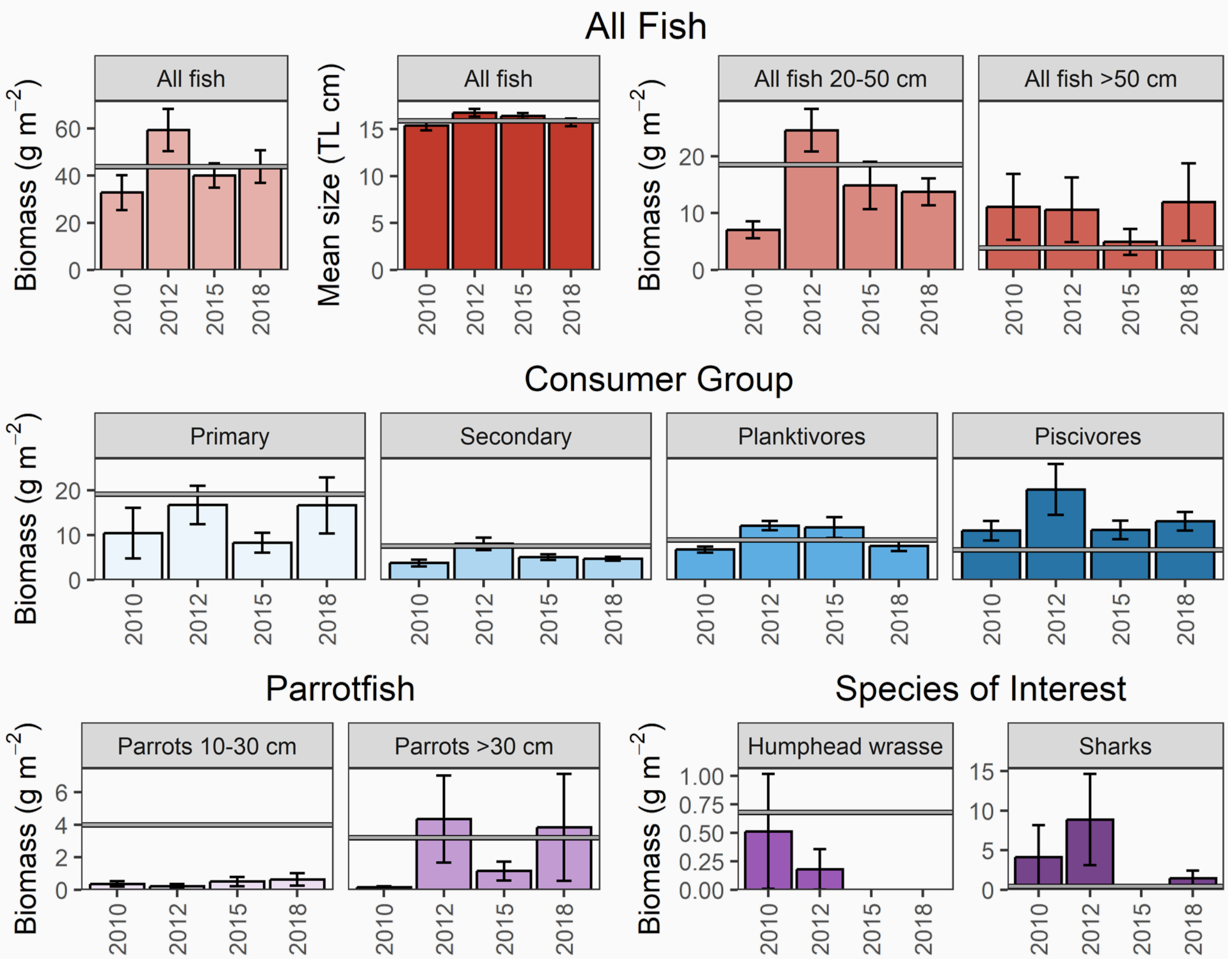

Figure 11. Swains Island fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The American Samoa regional mean estimates of each metric are plotted for reference (horizontal grey line).

Tau

Tau Island was surveyed in 2010 (n = 24), 2012 (n = 22) 2015, (n = 46), 2016 (n = 50), 2018 (n = 28), and 2024 (n = 19).

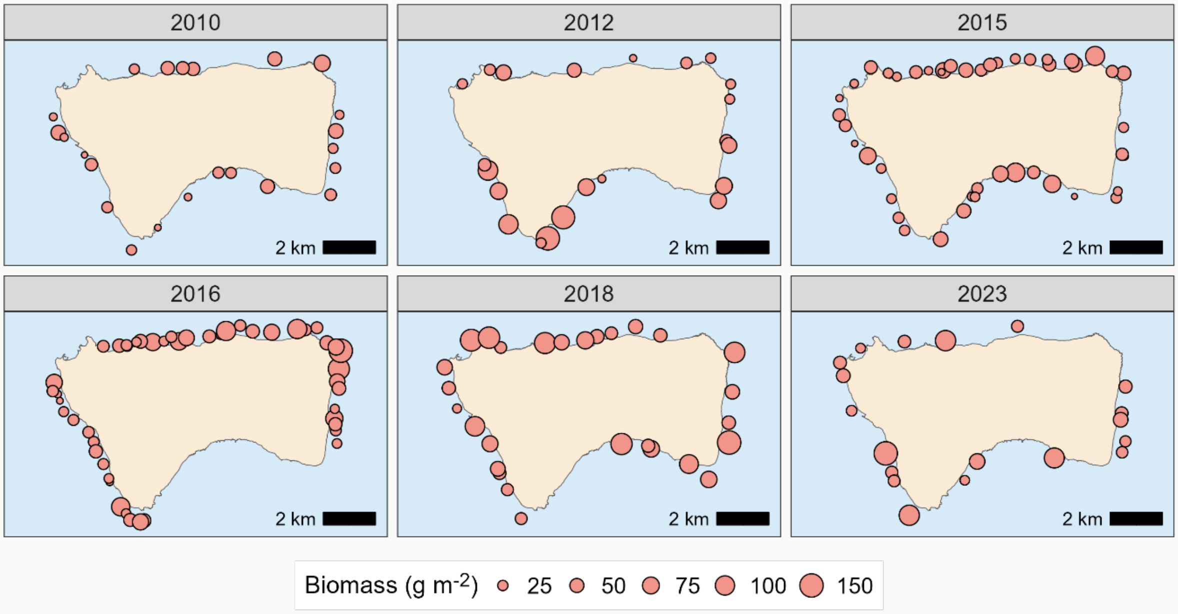

Figure 12. Tau Island site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

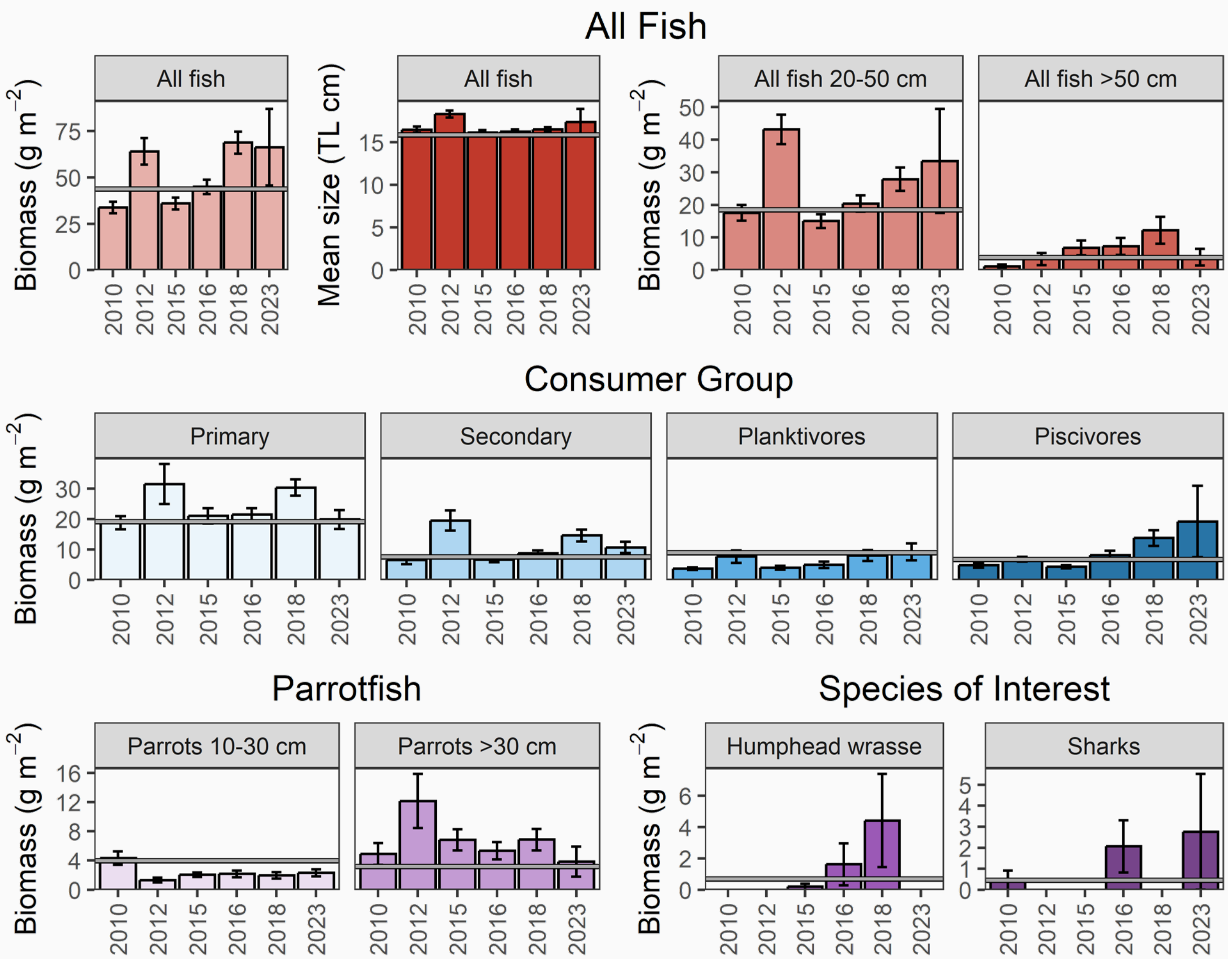

Figure 13. Tau Island fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The American Samoa regional mean estimates of each metric are plotted for reference (horizontal grey line).

Tutuila

Tutuila Island was surveyed in 2010 (n = 127), 2012 (n = 85), 2015, (n = 162), 2016 (n = 77), 2018 (n = 81), and 2023 (n = 90).

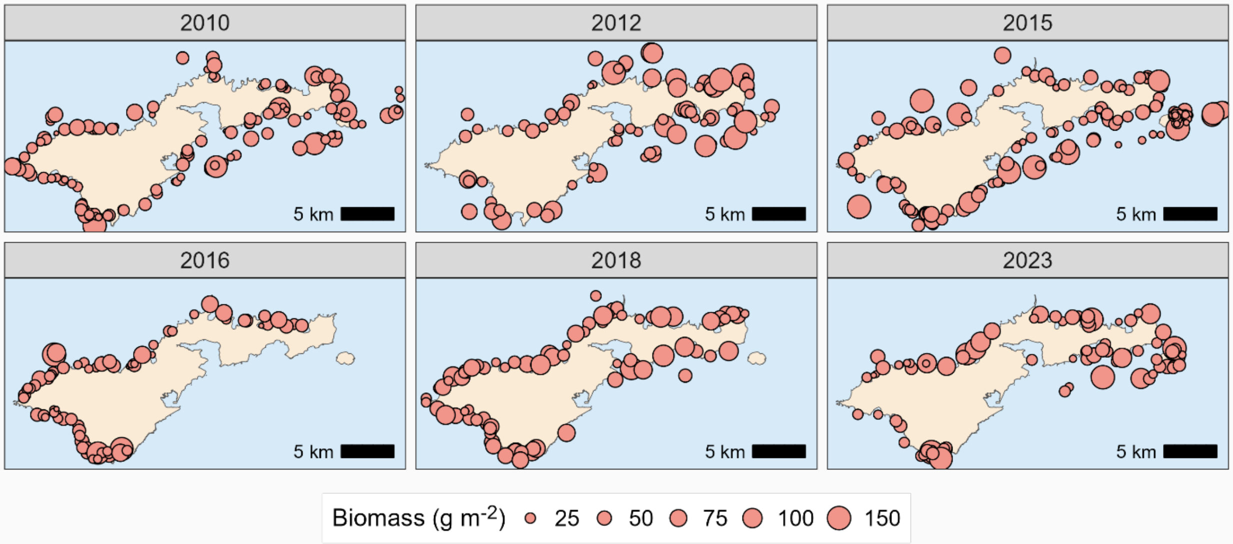

Figure 14. Tutuila Island site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

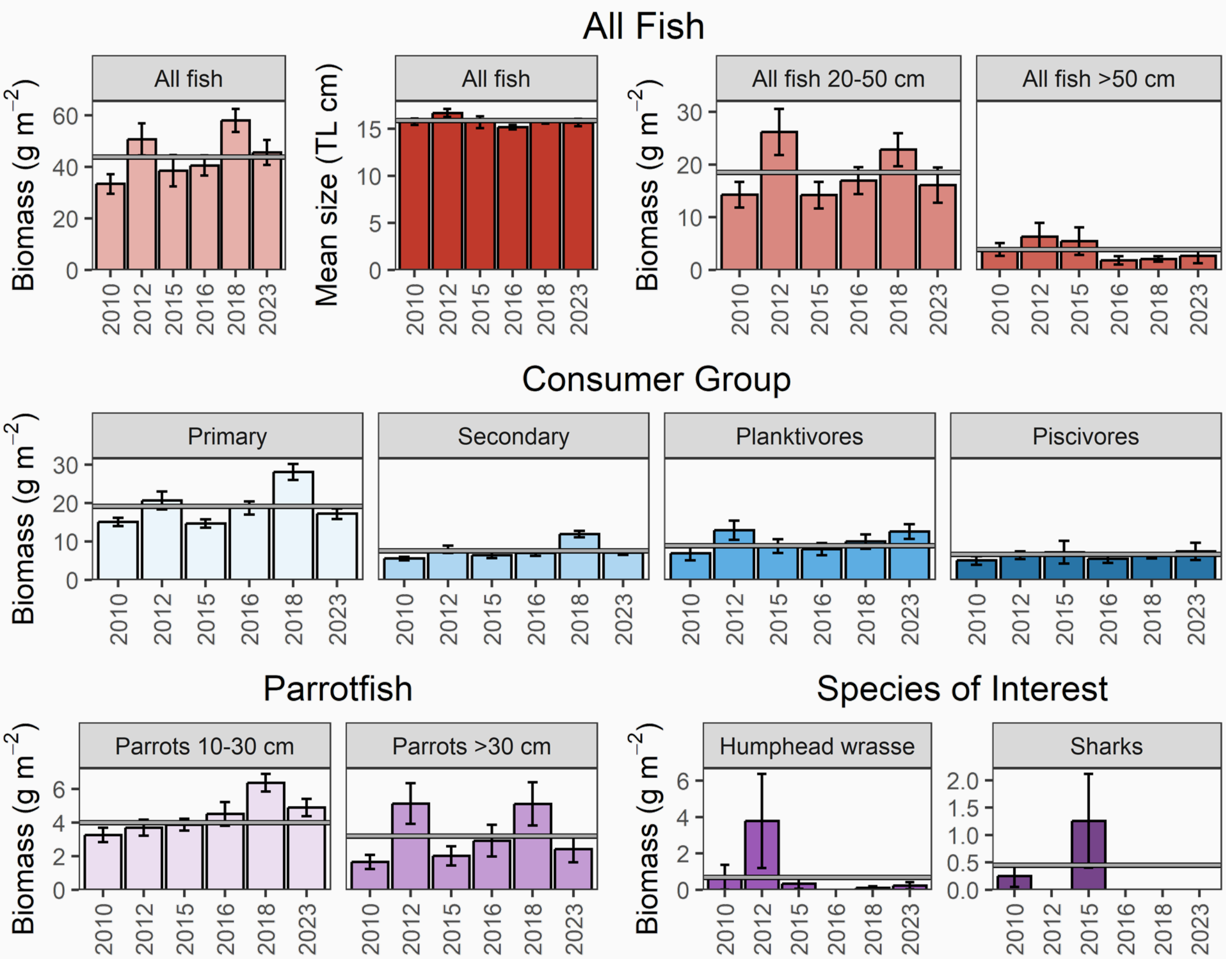

Figure 15. Tutuila Island fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The American Samoa regional mean estimates of each metric are plotted for reference (horizontal grey line).

Due to its large size, Tutuila is further broken down into geographic sectors and protected and open areas. Protected areas have various levels of protection for reef fish, while open areas have no fishing restrictions.

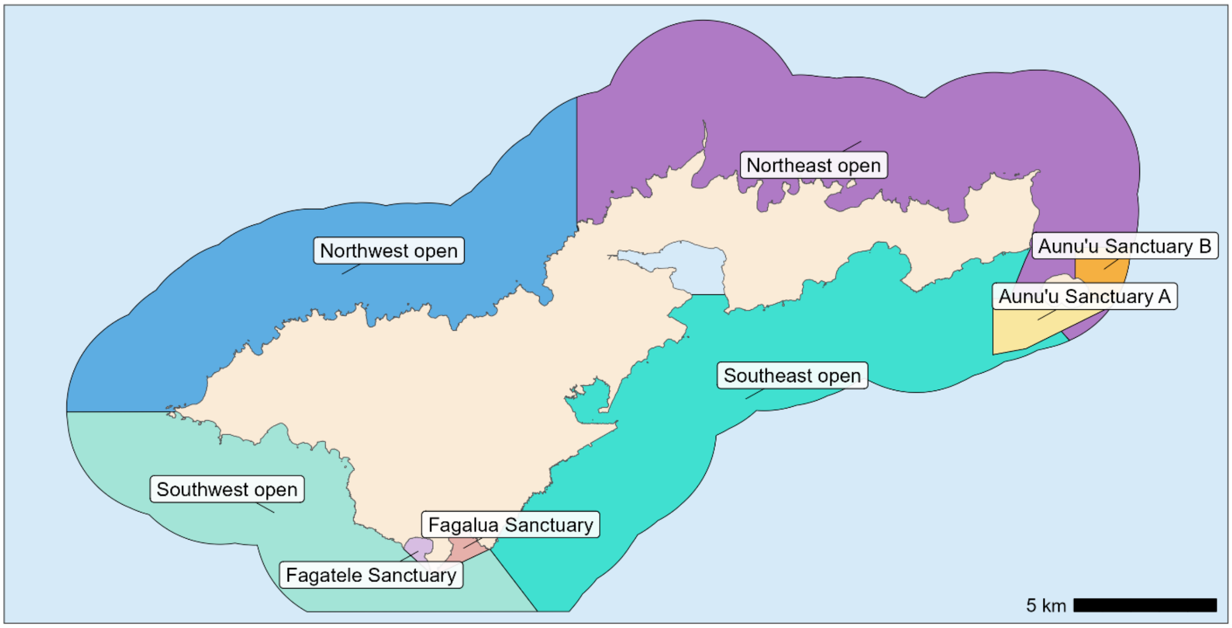

Figure 16. Sectors defined within Tutuila Island. Fagatele, Fagalua, Aunu‘u A, and Aunu‘u B sanctuaries have various levels of protection for reef fishes.

Aunuʻu sector

The sanctuaries around Aunuʻu island are broken into two areas, A and B.

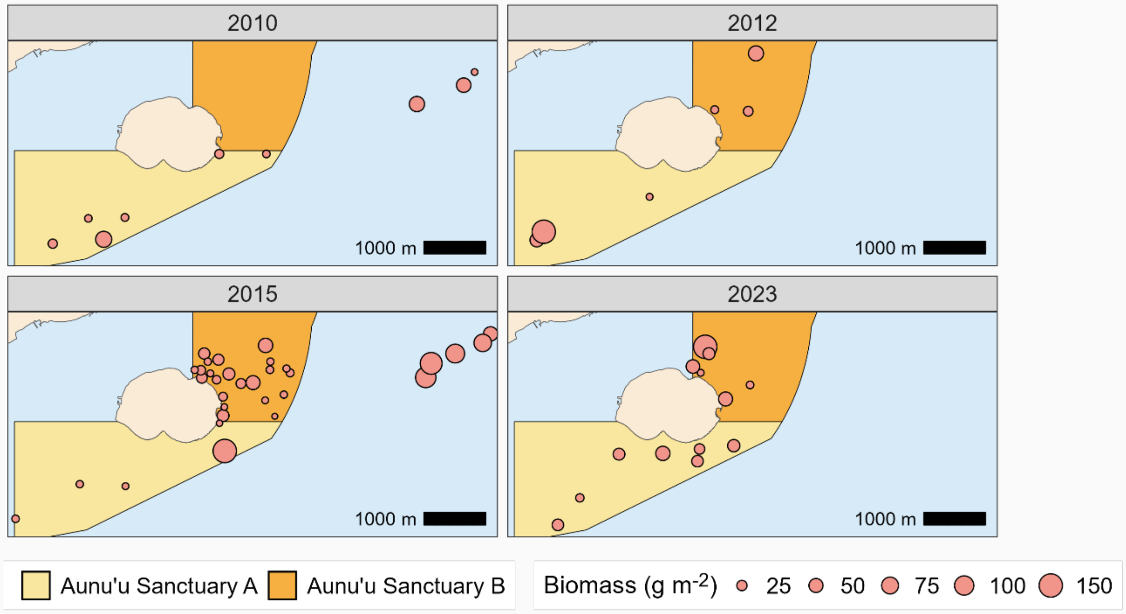

Figure 17. Aunuʻu Sanctuary A (yellow) and B (orange) site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

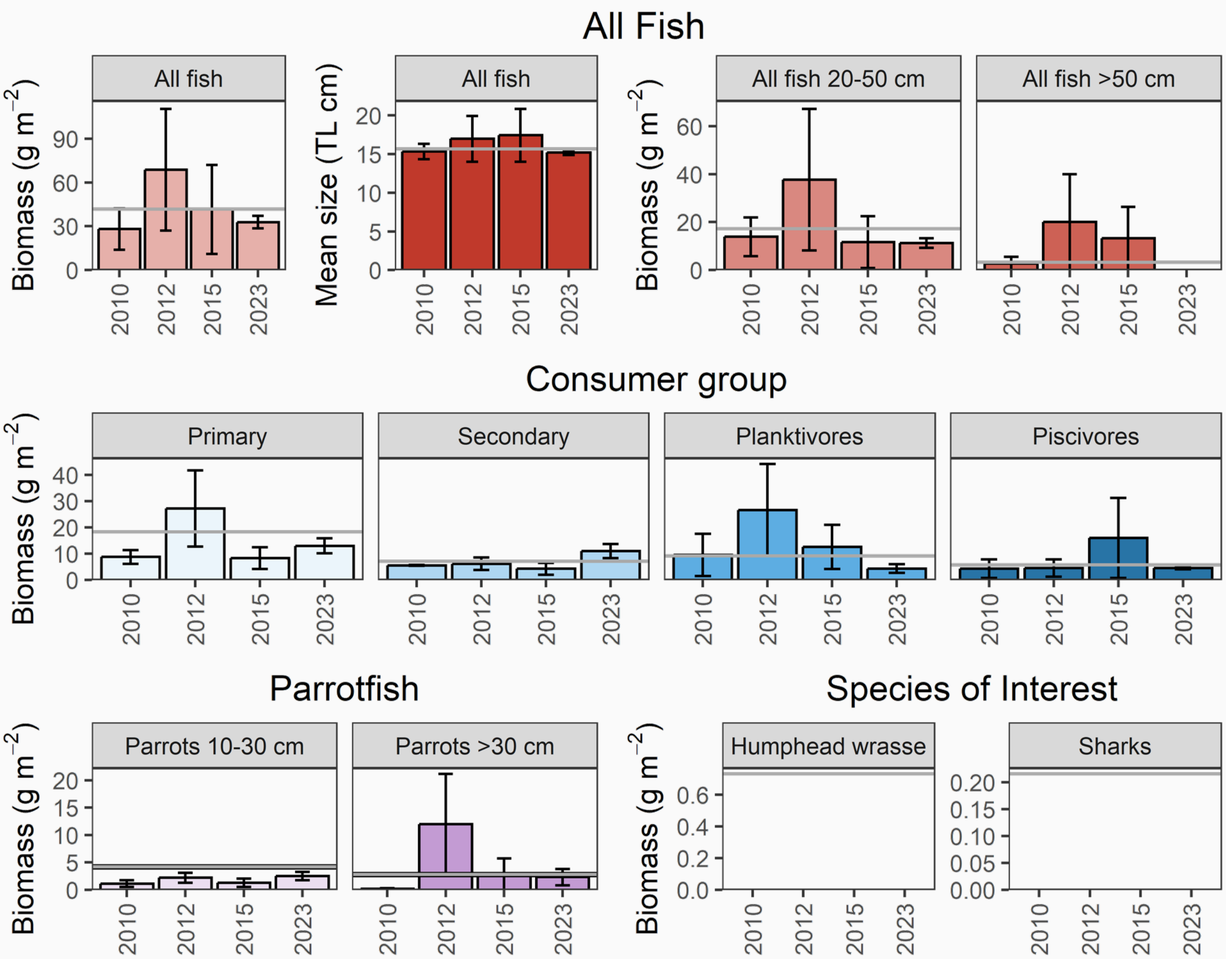

Figure 18. Aunu‘u A fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

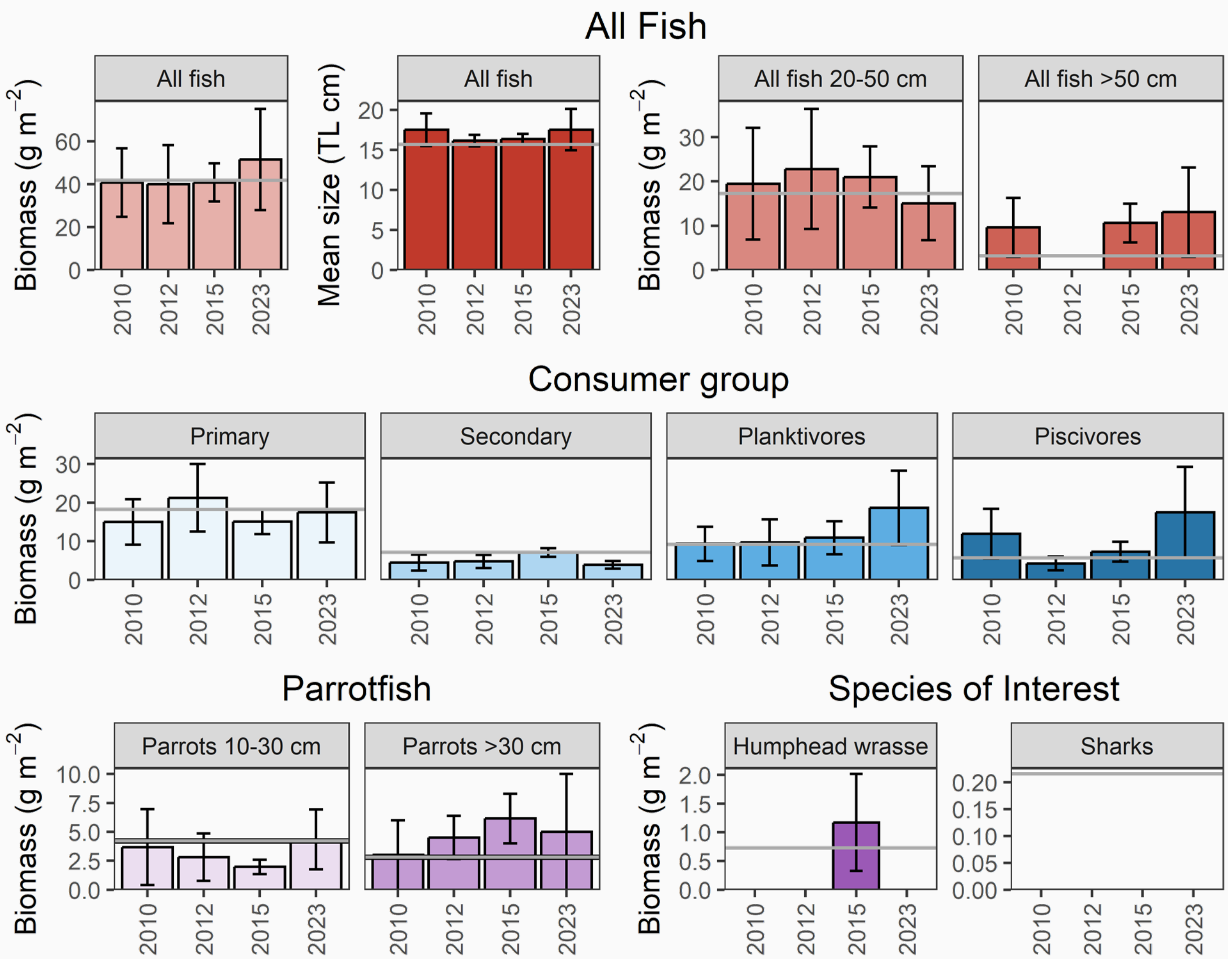

Figure 19. Aunu‘u B fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

Fagalua sector

Fagalua sanctuary was surveyed in 2010 (n = 2), 2012 (n = 1), 2015 (n = 2), 2016 (n = 5), 2018 (n = 3), and 2023 (n = 4).

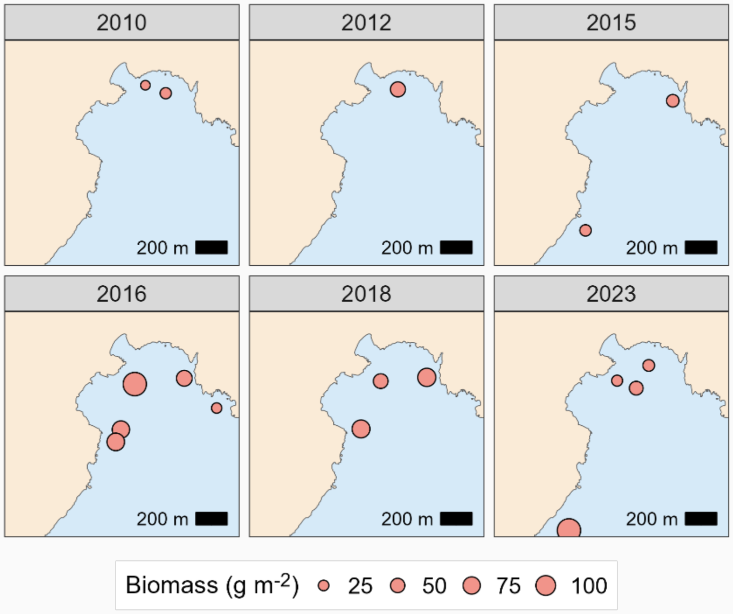

Figure 20. Fagalua sanctuary site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

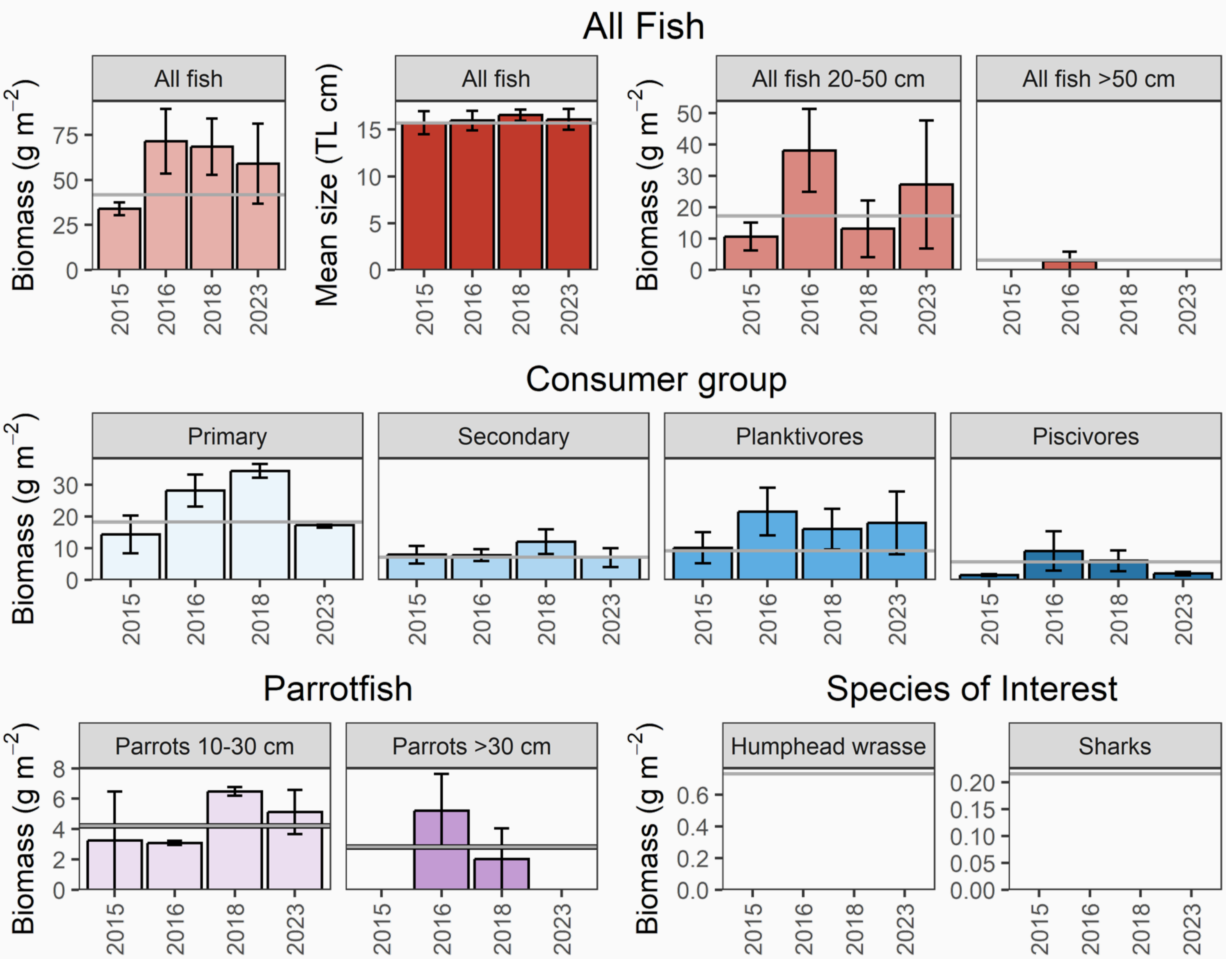

Figure 21. Fagalua sanctuary fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

Fagatele sector

Fagatele sanctuary was surveyed in 2010 (n = 2), 2012 (n = 2), 2016 (n = 4), 2018 (n = 8), and 2023 (n = 11).

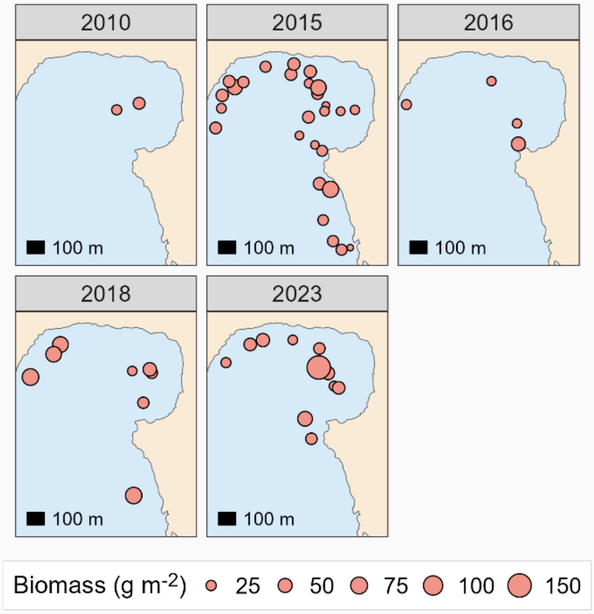

Figure 22. Fagatele sanctuary site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

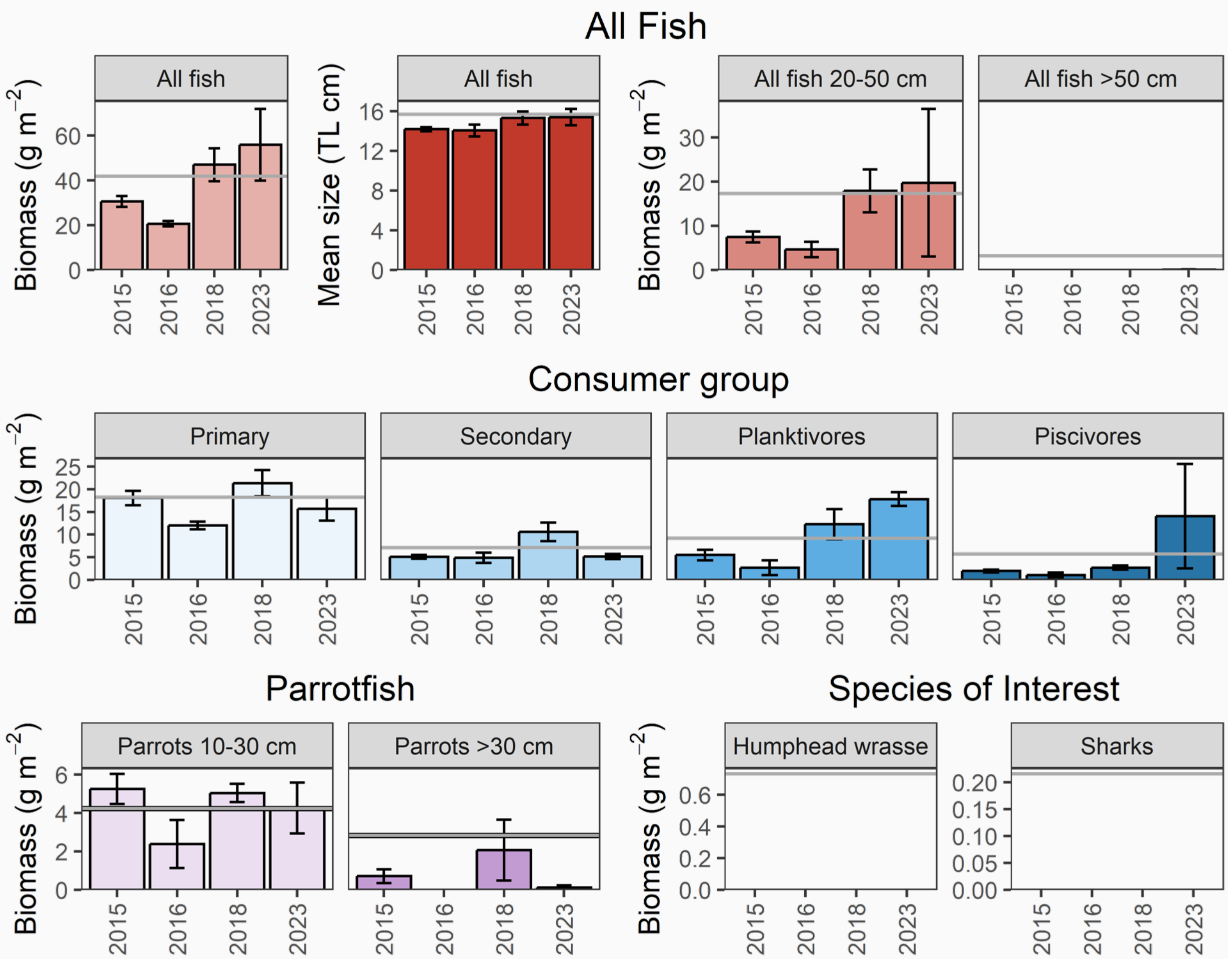

Figure 23. Fagatele sanctuary fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

Northeast open sector

The Northeast open sector was surveyed in 2010 (n = 28), 2012 (n = 25), 2015 (n = 22), 2016 (n = 15), 2018 (n = 20), and 2023 (n = 18).

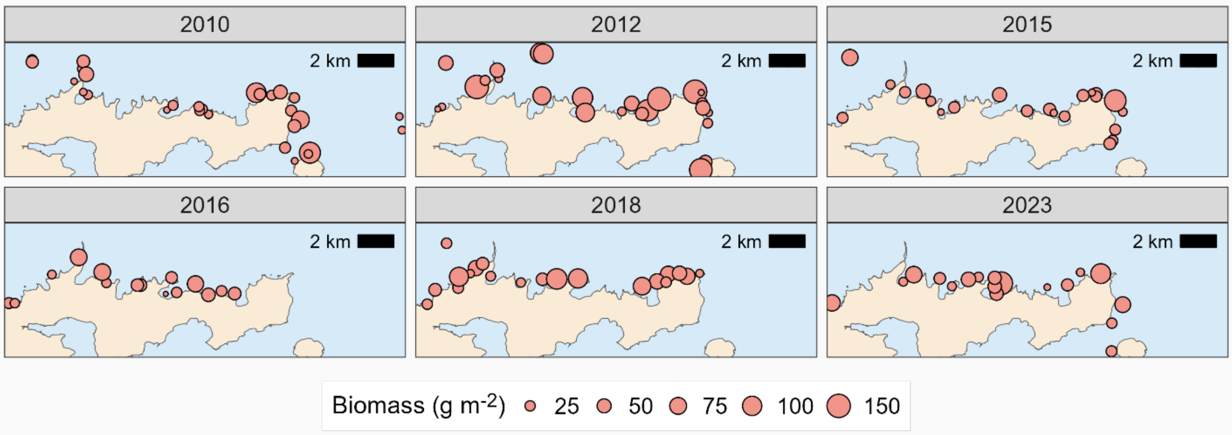

Figure 24. Tutuila northeast open sector site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

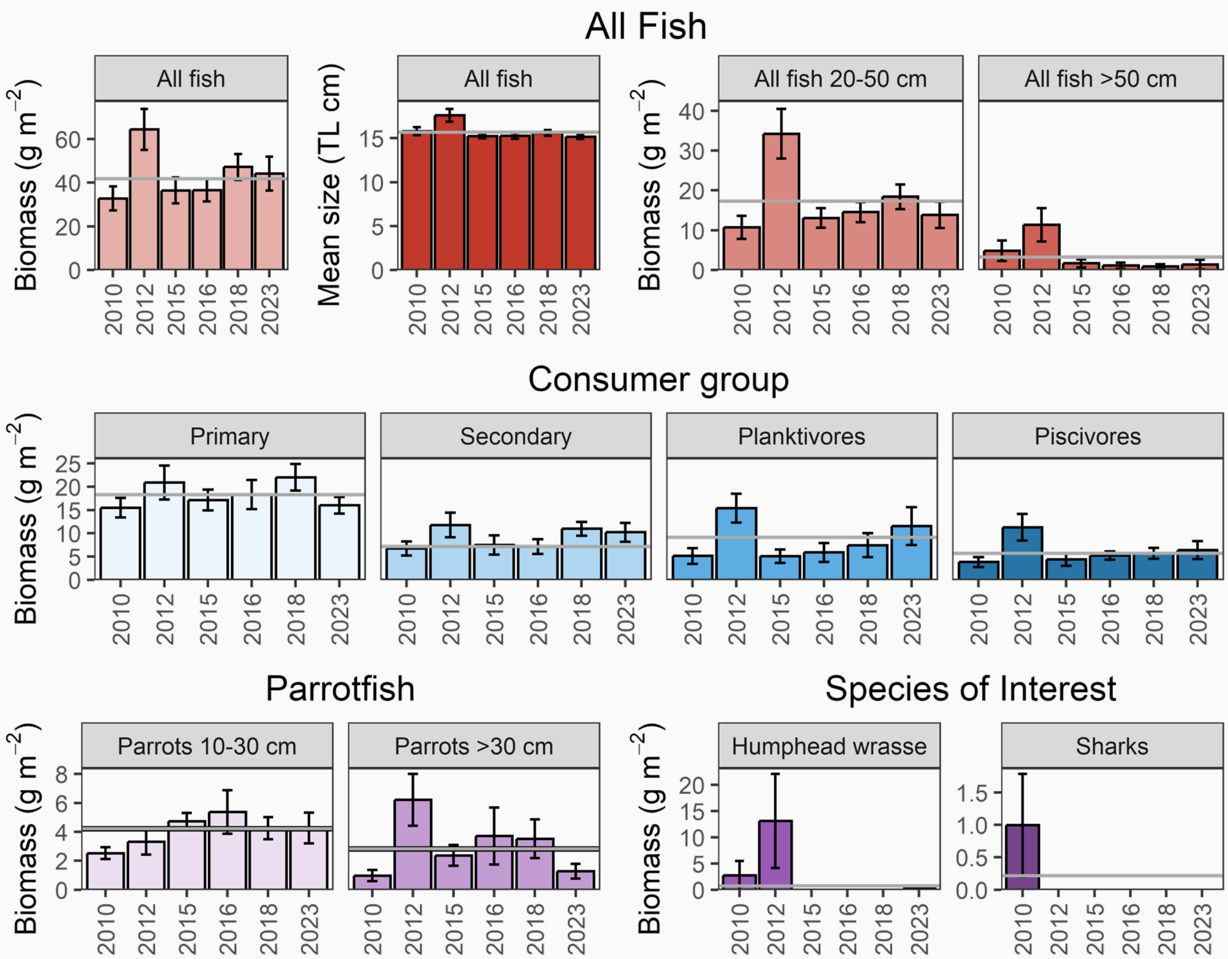

Figure 25. Tutuila northeast open sector fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

Northwest open sector

The northwest open sector was surveyed in 2010 (n = 23), 2012 (n = 12), 2015 (n = 18), 2016 (n = 32), 2018 (n = 23), and 2023 (n = 18).

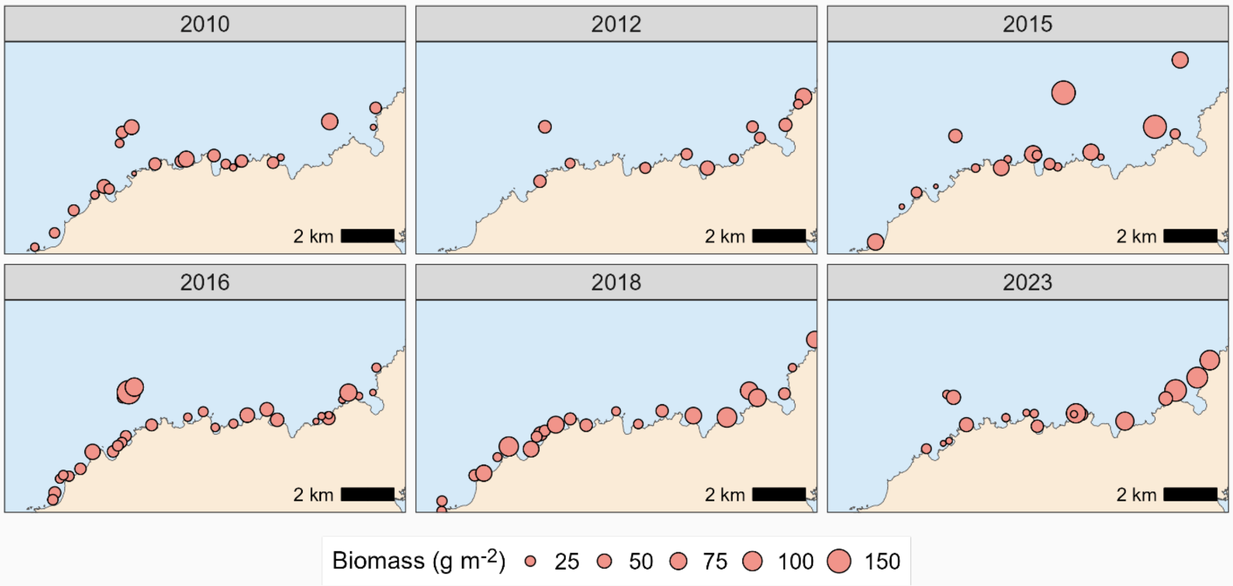

Figure 26. Tutuila northwest open sector site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

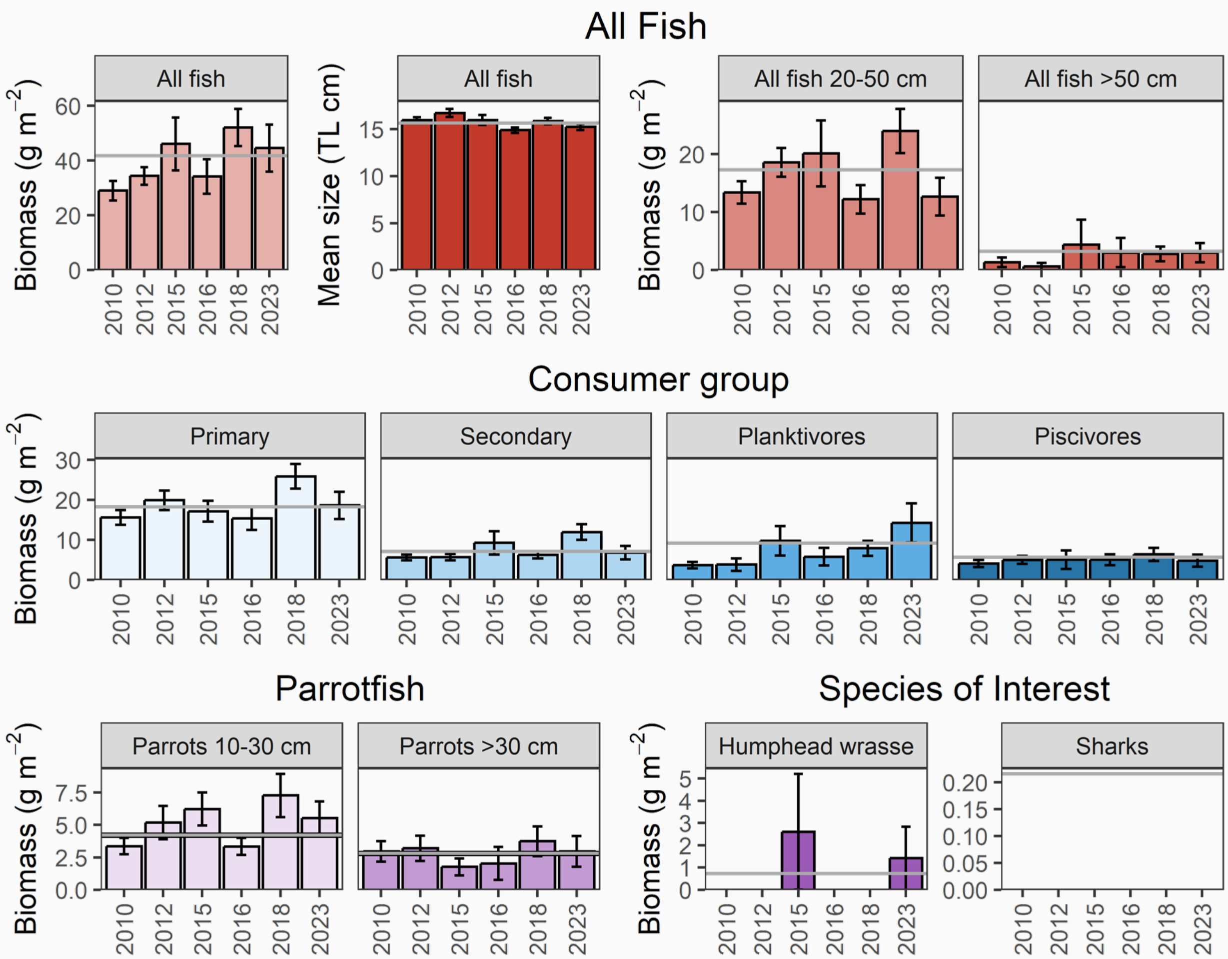

Figure 27. Tutuila northwest open sector fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

Southeast open sector

The southeast open sector was surveyed in 2010 (n = 37), 2012 (n = 33), 2015 (n = 47), 2018 (n = 12), and 2023 (n = 19).

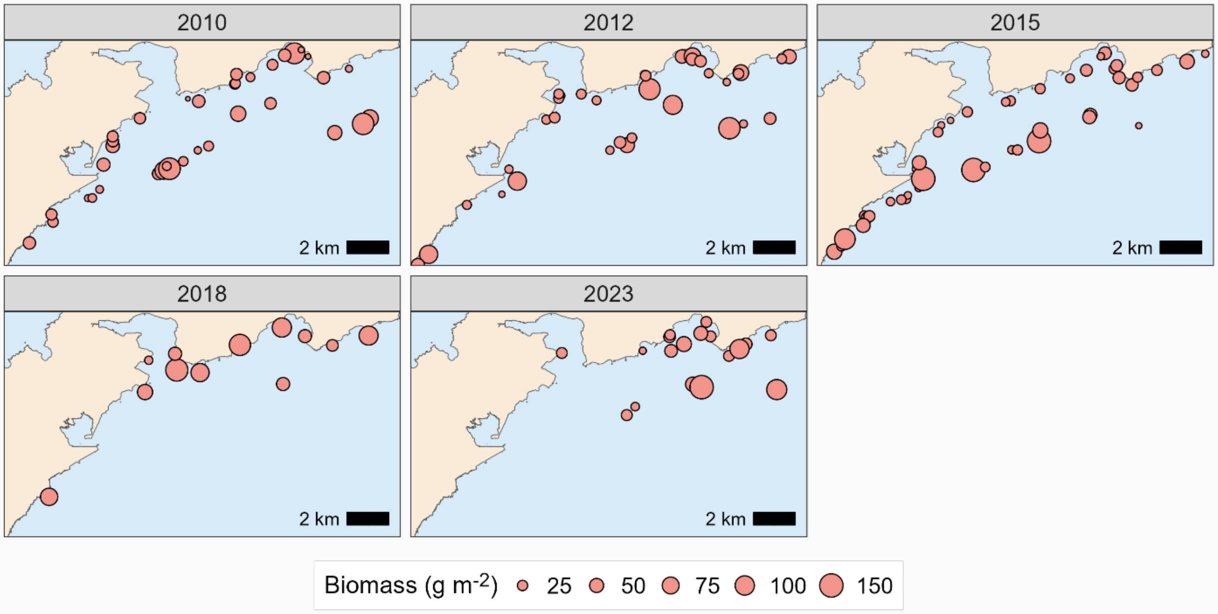

Figure 28. Tutuila southeast open sector site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

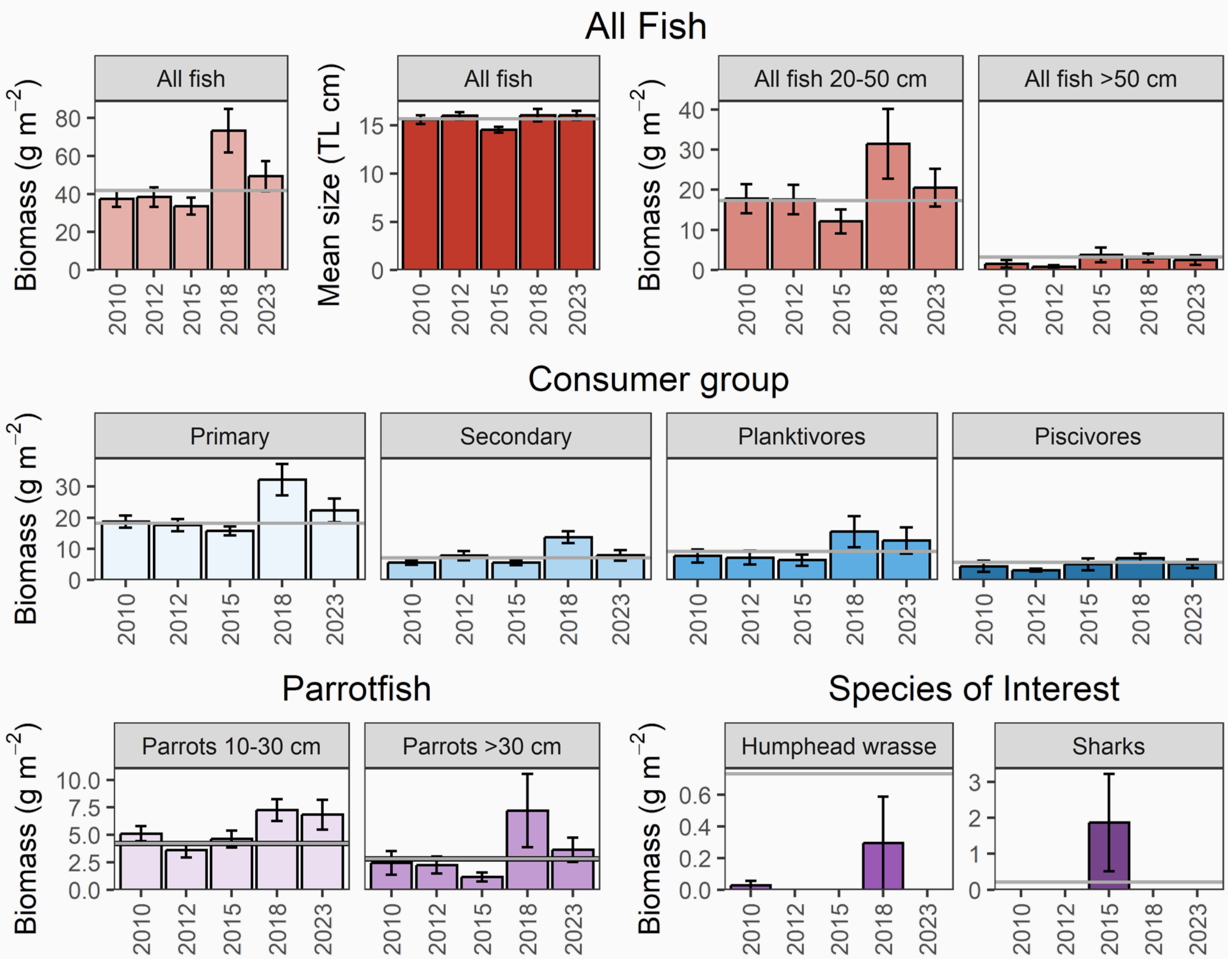

Figure 29. Tutuila southeast open sector fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

Southwest open sector

The southwest open sector was surveyed in 2010 (n = 26), 2012 (n = 8), 2015 (n = 13), 2016 (n = 21), 2018 (n = 15), and 2023 (n = 7).

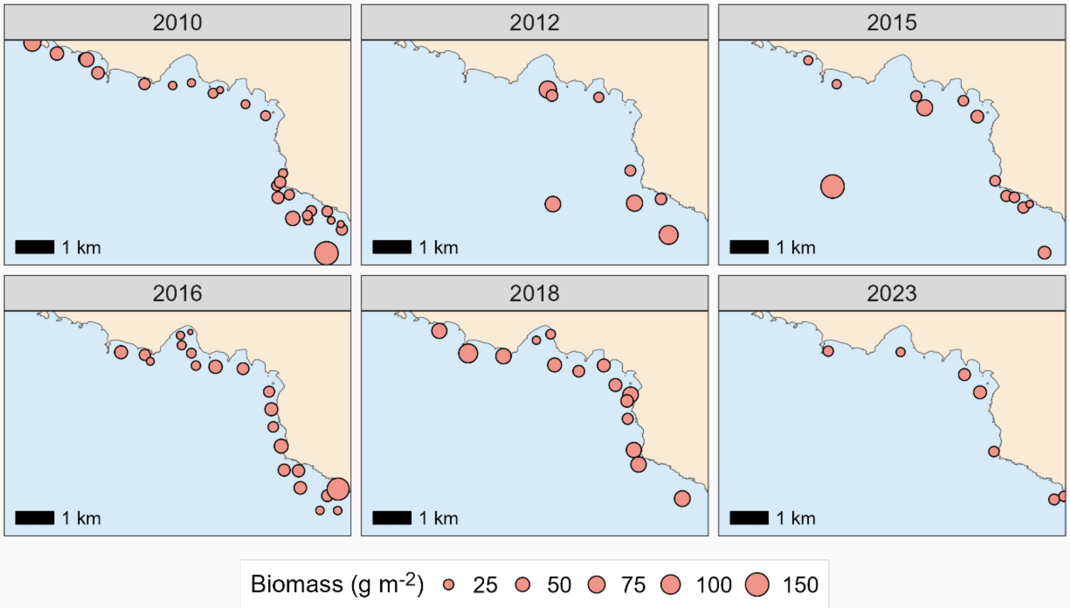

Figure 30. Tutuila southwest open sector site survey data by year. Each bubble represents a survey site, and the size of the bubble corresponds to total fish biomass at each site.

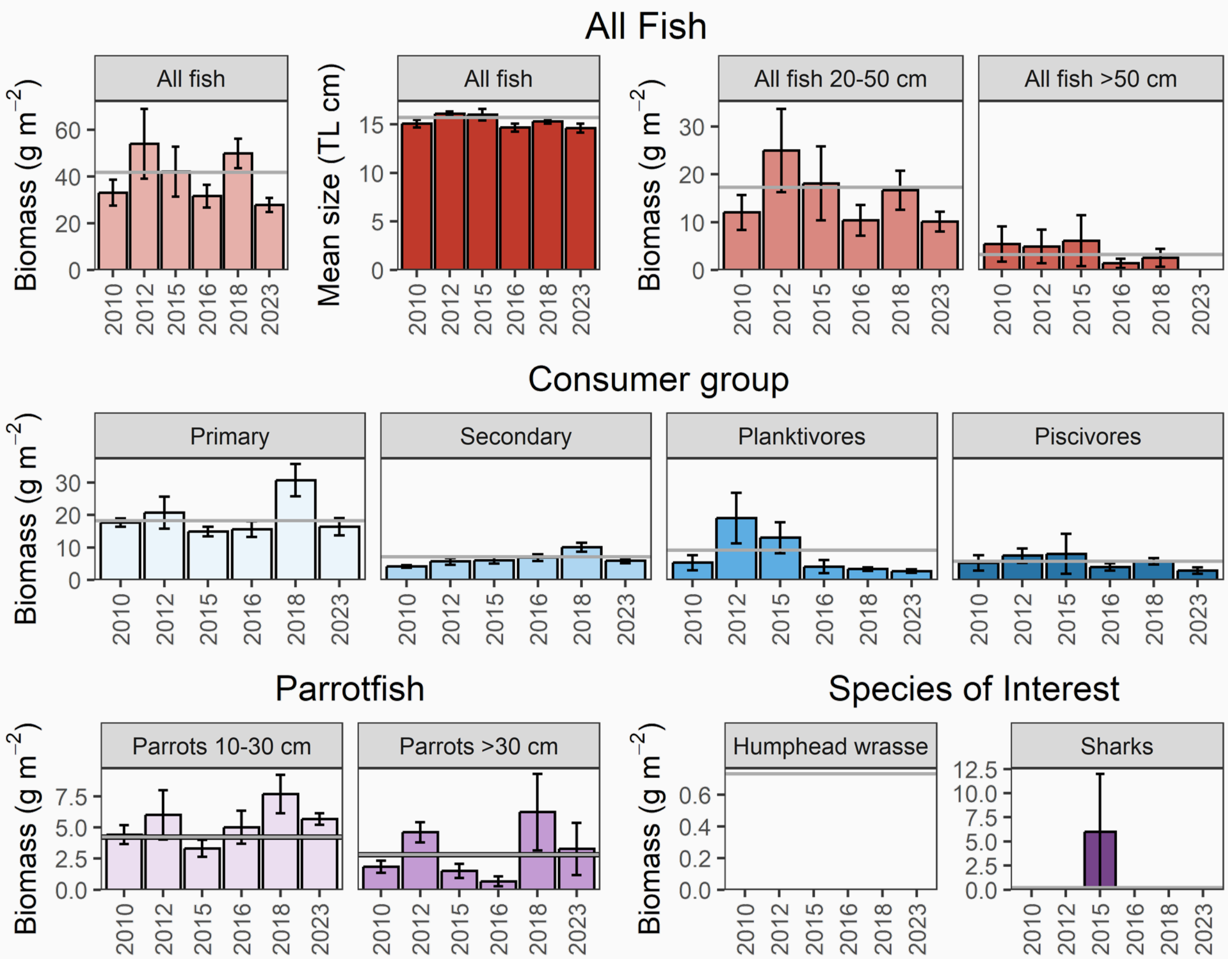

Figure 31. Tutuila southwest open sector fish plots. Mean values ± standard error are plotted for biomass, mean size, and biomass per size class of all fishes observed (top); as well as biomass per consumer group (middle), parrotfish size classes (bottom left), and species of interest (bottom right). The Tutuila Island mean estimates of each metric are plotted for reference (horizontal grey line).

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Report, figures, and maps compiled by K. McCoy.

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Appendix

Appendix A: Surveys per region per year and method used

Table A 1. The number of SPC sites surveyed in American Samoa per year. The SPC data collected prior to 2009 are not used in this report because sites were not selected based on the randomized depth stratified design (see **Methods**). Furthermore, during the methods transition period, sites surveyed at the mid-depth strata in 2009 were the haphazardly selected, fixed sites selected from the previous years. Shallow and deep sites were randomly selected. Here we report all data from 2009 onwards, including the non-randomized mid-depth 2009 sites. In the future, these mid-depth sites should be excluded from any time series analysis.

Year	2010	2012	2015	2016	2018	2023
Method	SPC	SPC	SPC	SPC	SPC	SPC
Number of surveys	241	223	339	185	185	159

Appendix B: Samples per sector and strata in 2023

Table B 1. The number of sites surveyed per depth strata and the sector used to pool the data in island-level parameter estimates. During the site selection process, site locations are randomly selected from the sector area for each island. In Tutuila, the island is broken down into smaller sectors. Deep (> 18–30 m), mid (> 6–18 m), shallow (> 0–6 m).

Island	Sector	Deep	Mid	Shallow
Ofu & Olosega	Ofu & Olosega	5	12	6
Rose	ROS_SANCTUARY	5	12	4
Tau	TAU_OPEN	5	8	2
Tau	TAU_SANCTUARY	2	2	0
Tutuila	TUT_AUNUU_A	3	4	0
Tutuila	TUT_AUNUU_B	2	2	2
Tutuila	TUT_FAGALUA	2	2	0
Tutuila	TUT_FAGATELE	2	6	3
Tutuila	TUT_NE_OPEN	5	9	4
Tutuila	TUT_NW_OPEN	7	8	3
Tutuila	TUT_SE_OPEN	5	9	5
Tutuila	TUT_SW_OPEN	2	3	2

Appendix C: SPC Quality control: Observer cross-comparison

Estimates are compared between dive partner pairs to check for consistency between observers. This can be done for any parameter estimated, but here total fish biomass, species richness (number of unique species counted), and hard coral cover estimates are highlighted. These are three of the most frequently reported summary metrics from the stationary point count survey data. The differences between the estimates of each diver and those of their dive partner at each site are calculated and referred to here as diver performance. Real differences between dive partners are expected as divers are survey adjacent, not in the same cylinder area. However, if there is no consistent bias in the estimates made by a diver, one would expect the median value of their performance to be close to zero i.e., with estimates in half of the counts being higher than their partner's estimates and half of the counts lower than their partner's estimates. Boxplots of diver performance, therefore, give (1) a strong but general indication of relative bias; if there is no consistent bias, then the median differences between a single diver and their dive partners will be close to zero and (2) an indication of how variable each diver's counts are compared to their dive partners—if a particular diver's performance varies widely compared to their partner's (i.e., several very high and/or several very low counts), that may indicate variability in their performances. As dive teams are regularly rotated throughout the course of a survey mission, measures of individual diver's counts reflect their performance relative to the entire pool of other divers participating in those surveys. These boxplots are routinely generated during and after field operations to give divers feedback on their performance relative to their colleagues and are summarized here by region (**Figure C1**).

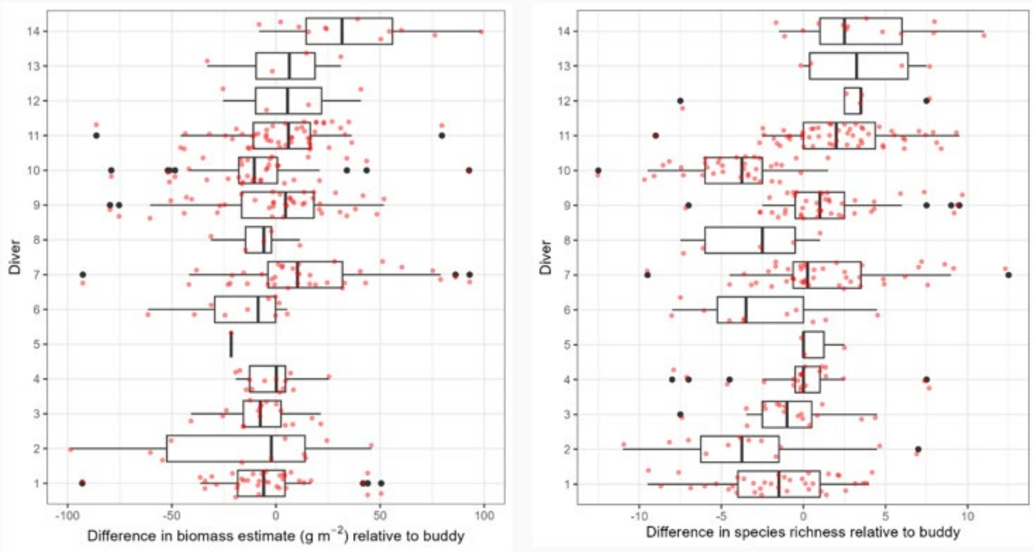

Figure C 1. Comparison of observer diver vs diver partner estimates for total fish biomass (left plot) and species richness (right plot) during 2023 surveys. The boxplot shows the median difference (thick vertical line) in estimates for each diver. The box represents the location of 50% of the data. Lines extending from each box are 1.5 times the interquartile range which represents approximately 2 standard deviations; points greater than this (outliers) are plotted individually (black dots).

Appendix D: Random stratified sites surveyed at each island per year

Table D 1. The total number of sites surveyed per island per year under the stratified-random sampling design, using the stationary point count method to survey the fish assemblage.

ISLAND	2008	2010	2012	2015	2016	2018	2023
Ofu & Olosega	13	30	30	52	11	25	23
Rose	26	34	48	47	47	21	27
Tau	12	24	22	46	50	28	19
Tutuila	44	127	85	161	77	81	90
Swains	17	24	38	32	-	30	-

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We are committed to providing ecological monitoring information that is transparent, readily accessible, and relevant to the sound management of coral reef resources. For data requests contact: Tye.Kindinger@noaa.gov.

We would welcome comments from any users of this data report on how to improve the utility of this document for future versions. Comments or suggestions on the content of this annual data report may be submitted to: Kaylyn.McCoy@noaa.gov with the subject line, ‘Feedback on Monitoring Report.’