

# American Samoa Methods Documentation

A summary of coastal coral reef biological and environmental data streams and methods conducted in American Samoa

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## Summary

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This methods documentation is part of a project out of NOAA's Pacific Island Fisheries Science Center. The goal is to collate and integrate, where possible, coral reef data sets and data streams collected by jurisdictional partners in American Samoa into a singular data set. Integrated data sets aid in robustness of analyses and can be utilized to inform management decisions.

Coral reef scientists and monitoring programs employ various survey methods depending on the science question or management goal. Within American Samoa, there are five distinct groups associated with various agencies, each with their unique areas of focus: Coral Reef Advisory Group (CRAG), Department of Marine and Wildlife Resources (DMWR), American Samoa National Park Service (AS NPS), American Samoa Environmental Protection Agency (AS EPA), and American Samoa National Marine Sanctuary (ASNMS). The National Oceanographic and Atmospheric Administration's (NOAA) Pacific Islands Fisheries Science Center (PIFSC) conducts monitoring efforts in the region every 3-5 years. In addition to these agency-affiliated monitoring programs, data sources in American Samoa may also originate from standalone projects that do not necessarily serve long-term monitoring objectives.

Here we document collection methods for the following coral reef data sets: benthic and coral, reef fish community, and environmental.

## Benthic and Coral Data

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Benthic surveys generally fall under 2 main types: benthic cover and coral demography surveys.

Benthic cover methods utilized in American Samoa include photoquadrats, line point intercept, and quarter point intercept. In photoquadrats, an underwater camera is used to capture a predetermined number of photos along a transect; these photos are subsequently analyzed in an office setting using Coral Point Count with Excel extensions

(CPCe) or CoralNet software. CPCe employs a random point generation process over a photograph of the benthic environment. Human analysts then review and identify these randomly generated points, enabling the estimation of benthic cover for pre-defined benthic categories. CoralNet is a web-based program designed to streamline and partially automate the photo analysis tasks that were traditionally carried out in CPCe. For line point and quarter point methods, benthic organisms are identified and recorded directly in the field at predetermined intervals along a transect tape.

Demographic survey areas are identified using either a quadrat to randomly select small areas or a predetermined segment along the transect line. In these survey areas, comprehensive measurements and identification of all corals within that designated area are conducted.

Below are benthic and coral demography data streams and methods used by monitoring programs and other stand-alone studies in American Samoa.

## Benthic data inventory

Organization	Project Name	Data sources	Years	Category	Method
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Tutuila reef slopes	NCEI	2005-2015	Benthic cover	Line point intercept
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Tutuila reef slopes	Douglas Fenner	2005-2012	Benthic cover	Line point intercept
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Tutuila flats	Douglas Fenner	2007-2012	Benthic cover	Line point intercept
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Tutuila reef slopes	NCEI	2016-2018	Benthic cover	Photoquads - CPCe
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Tutuila reef slopes	CRAG partner	2019-2020	Benthic cover	Photoquads - CPCe
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Tutuila reef slopes	CRAG partner	2016, 2021	Coral demography	In water quadrats
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Manu'a pools	CRAG partner	2015	Benthic cover	Line point intercept
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring - Manu'a pools	CRAG partner	2017-2019	Benthic cover	Line point intercept
Coral Reef Advisory Group (CRAG)	Leone shipwreck removal	CRAG partner	2019-2020	Benthic cover	Photoquads - CPCe
Ridge to Reef (R2R)	Ridge to Reef (R2R)	AS-EPA, CRAG, NMSAS	2017	Benthic cover	Photoquads - CPCe

Organization	Project Name	Data sources	Years	Category	Method
Ridge to Reef (R2R)	Ridge to Reef (R2R)	AS-EPA, CRAG, NMSAS	2016	Coral demography	In water quadrats
Coral Reef Advisory Group (CRAG)	Reef flat monitoring				
National Oceanographic and Atmospheric Association (NOAA)	Pacific Reef Monitoring Program (RAMP)	NCEI	2006-2010	Benthic cover	Line point intercept
National Oceanographic and Atmospheric Association (NOAA)	U.S. Pacific Islands National Coral Reef Monitoring Program (NCRMP)	NOAA partner	2004-2010	Benthic cover	Line point intercept
National Oceanographic and Atmospheric Association (NOAA)	U.S. Pacific Islands National Coral Reef Monitoring Program (NCRMP)	NOAA partner	2010-2020	Benthic cover	Photoquads - CPCe and CoralNet
National Oceanographic and Atmospheric Association (NOAA)	U.S. Pacific Islands National Coral Reef Monitoring Program (NCRMP)	NOAA partner	2010-2020	Coral demography	In water segments
National Oceanographic and Atmospheric Association (NOAA)	Special missions/projects	NCEI	2020, 2022	Benthic cover	Photoquads - CPCe and CoralNet
American Samoa National Park Service (ASNPS)	Natural Resources Inventory and Monitoring	IRMA and Kelly Kozar	2007-2019	Benthic cover	Photoquads - CPCe
Department of Marine and Wildlife Resources (DMWR)	Key Reef Species Program (KRSP)	overlap with Green et al 2021	1996-2002	Benthic cover	Quarter point intercept
Department of Marine and Wildlife Resources (DMWR)	Key Reef Species Program (KRSP)	DMWR/CRAG partner	2005-2007	Benthic cover	Photoquads - CPCe; stills taken from videos shot in field
Department of Marine and Wildlife Resources (DMWR)	Key Reef Species Program (KRSP)		2008-2012	Benthic cover	Photoquads - CPCe; stills taken from videos shot in field
Department of Marine and Wildlife Resources (DMWR)	Key Reef Species Program (KRSP)		2012-Current	Benthic cover	Photoquads - CPCe
Department of Marine and Wildlife Resources (DMWR)	Marine Protected Area Programs - CFMP		2004-2008 (quarterly)	Benthic cover	Line point intercept

Organization	Project Name	Data sources	Years	Category	Method
Department of Marine and Wildlife Resources (DMWR)	Marine Protected Area Programs - CFMP		2012-2015	Benthic cover	Photoquad - unsure what style
American Samoa Environmental Protection Agency (AS EPA)	Reef Flats Monitoring	AS-EPA   Peter Houk	2010, 2015, 2021	Benthic cover	In water quadrats
Aua historical transect	Aua historical transect	Chuck Birkeland	1917, 1973, 1980	Coral demography	In water quadrats (53.2 m2)
Aua historical transect	Aua historical transect	Chuck Birkeland	1995-1999	Coral demography	In water quadrats (0.062 m2)
External research	Status of coral communities in American Samoa	Chuck Birkeland and Alison Green	1994/95, 2002, 2018	Benthic cover	Quarter point intercept for percent cover and belt transects for coral demography
External research	Long-term sites at Fagatelle and 11 sites around Tutuila	Chuck Birkeland	1982, 1985, 1988, 1995, 1998, and 2001	Coral demography	Point quarter method for coral demography
National Marine Sactuary of American Samoa (NMSAS)	Benthic tow surveys				
National Marine Sactuary of American Samoa (NMSAS)	Long-term Monitoring Program				

## Methods descriptions

### I. Coral Reef Advisory Group

#### 1. Long-term monitoring

The Coral Reef Advisory Group (CRAG) aims to conduct annual surveys at 12 fixed sites around Tutuila on the reef slopes. The surveys began in 2005 and are ongoing. Methods changed in 2015 from line point intercept to photoquadrats analyzed with CPCe. In 2016, CRAG participated in a collaborative project called “Ridge to Reef,” which is further detailed in the Ridge to Reef section of this report. This initiative involved the surveying of CRAG sites plus an additional 19 sites which have been periodically resurveyed.

#### Site selection:

When the monitoring program began in 2005, 12 long-term sites were established. Sites were chosen by the CRAG Monitoring Working Group and represented a reasonable geographic distribution of locations around Tutuila with a variety of reef types and exposures. Sites are located across different management areas: federal, territory, and community-based MPAs. They were also chosen to include all ASEPA watershed classifications (Whaylen and Fenner 2006).

## Benthic cover methods:

### a. 2005-2015: Line point intercept (LPI)

Surveys were conducted along a 10-meter isobath. LPI was conducted in 4 replicates, each a along 50-meter transect with a data point collected every 0.5 meter for a total of 100 points per transect. These data were used to calculate percent benthic cover. The recorded categories for percent cover are: crustose coralline algae, branching coralline algae, living hard coral, so coral, macro algae, filamentous algae, Halimeda, invertebrate, dead coral, bleached coral rubble, sand, and rock. Live corals were recorded in lifeform, genus, and when possible species.

Additional surveys were conducted in 2007-2009 and 2011-2012 at nearby reef flats sites using the same methods.

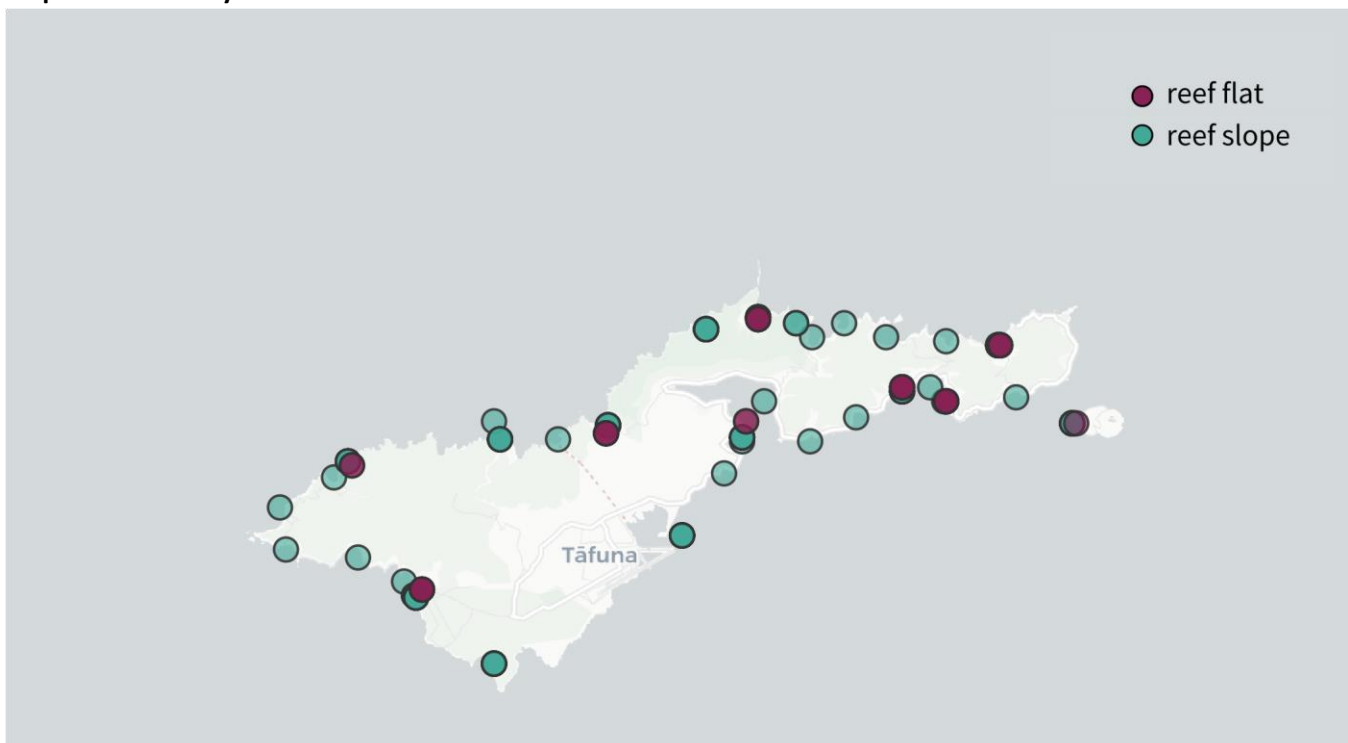
### b. 2015-Current: Photoquadrat surveys analyzed with Coral Point Count with Excel (CPCe)

Photoquadrat surveys are conducted along a 10-meter isobath. Two 100-meter transect tapes are laid down in sequence to create a 200-meter transect. This is separated into 6 individual transects (0-25, 30-55, 60-85, 90-115, 120-145, and 150-175 meter). Photos are taken 1 meter above the seafloor using a monopod at every meter along each transect, resulting in 26 photos per transect (a total of 156 photos per site). Postprocessing is done using the CPCe program, calculating benthic composition based o of 10 randomly generated points per image (Coward 2019). Categories are recorded at the genus level for corals and macroalgae when possible. Non-coral and macroalgae categories include anemone, crustose coralline algae (CCA), fleshy coralline algae (or encrusting macroalgae), rubble, invertebrates, blue green algae, and chrysophyte.

## Coral demography methods:

Surveys are conducted using the same transect as the photoquadrats along the 9-10-meter isobath. Every 20 meters, a 1x1-meter quadrat is randomly placed along the transect for a total of 10 per site. Every coral colony whose the center is within a quadrat was identified to genus, assigned a growth form, and the largest diameter and width were measured to the nearest centimeter (Coward 2019).

## Map of all sites all years:



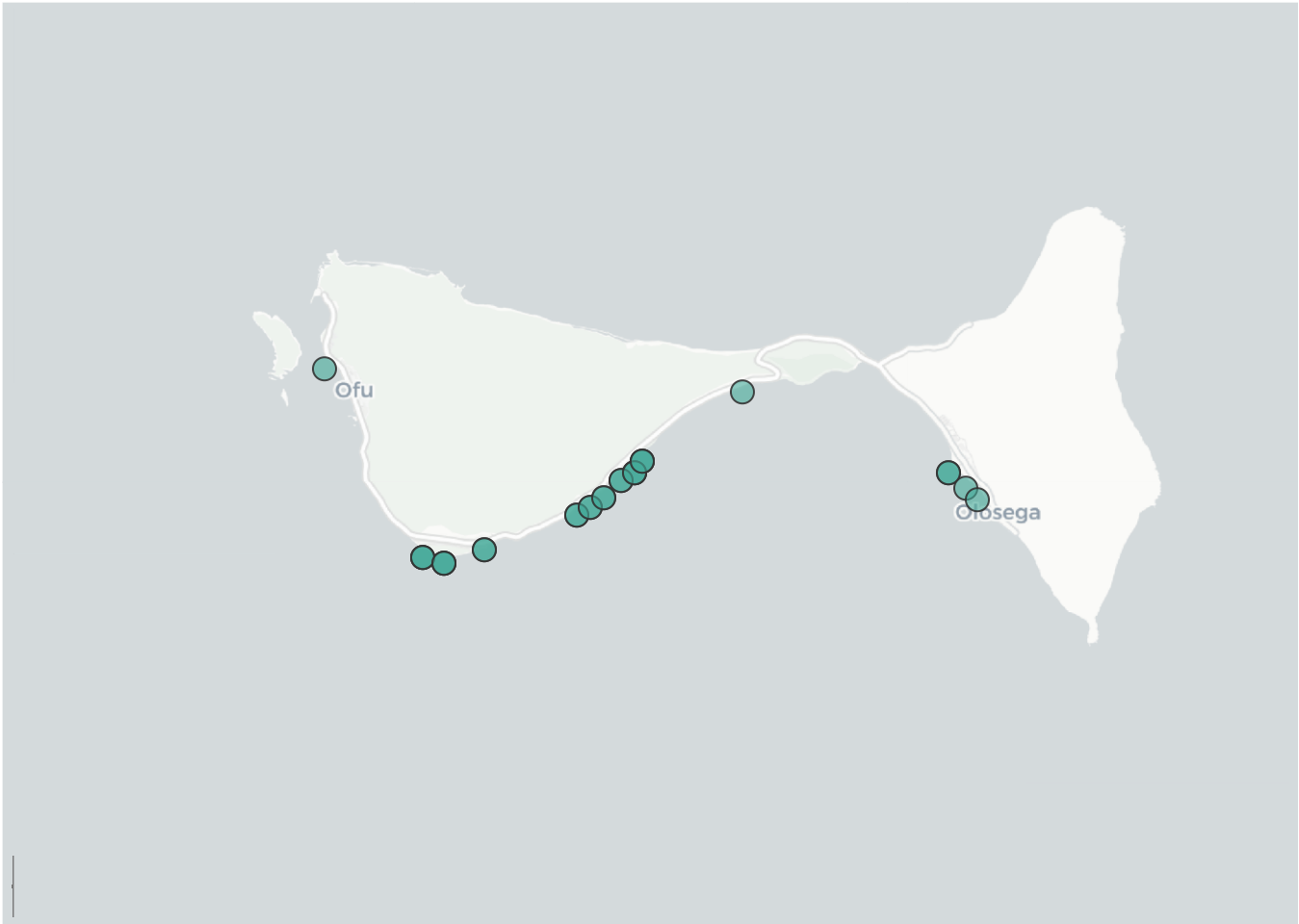
## 2. Manu'a reef lagoons

In 2015, CRAG established 6 long-term monitoring sites in Manu'a. Data were collected annually from 2015- 2019 (Ripley 2019).

### Benthic cover methods:

Each site surveyed in the lagoons ( $\leq 1$  meter deep) consisted of three 100-meter long transect tapes parallel to shore with four separate 25-meter transects separated by 5 meters (0-20, 25-45, 50-70, 75-95 meters). Line point intercept surveys were done for each transect at 50-centimeter intervals (50 points per transect). Categories are recorded at the genus level for both corals and macroalgae when possible, CCA, fleshy coralline algae, rubble, invertebrates, blue green algae, and chrysophyte.

### Map of all sites all years:



## 3. Leone shipwreck removal pre and post surveys

In January 2018 a ship grounded in the village of Leone on the east side of Tutuila; before the shipwreck debris removal project could begin, CRAG conducted a pre- and post- survey at two different areas. These areas were (1) in the shipwreck removal path, and (2) in a nearby CRAG designated “high value” area with high cover of *Acropora*

and Pavona species between the shipwreck and a gravel island. The pre-removal surveys were conducted in October 2019, and the post-removal surveys were completed in March of 2020.

**Site selection:**

Sites were specifically selected for this project.

**Benthic cover methods:**

In the shipwreck removal path three 100-meter long transects were along the wreck removal path. A photo was taken every meter along each transect, these photoquads were then analyzed with CPCe.

In the “high value” area, three 50-meter long transects were laid parallel to the shipwreck and perpendicular to land. A photo was taken every meter along each transect, these photoquads were then analyzed with CPCe (Coward 2020).

**4. Reef flat long term monitoring**

This is a new addition to CRAG’s long-term surveys. The reef flat locations have been selected and set up, but no monitoring has been conducted to date.

## II. Ridge to Reef (R2R)

The Ridge 2 Reef project was undertaken in collaboration with CRAG to assess variations in biological assemblages and evaluate the condition of adjacent watersheds. Benthic surveys for this project were conducted in March and April of 2017, and water sampling was conducted throughout 2016 and 2017.

**Site selection:**

Each site chosen for the R2R project was within 250 meter of a stream discharge. The 32 sites surveyed included all 12 of the CRAG monitoring sites (Comeros-Raynal 2019).

**Benthic cover methods:**

Benthic cover surveys were conducted using the same methods as the CRAG surveys.

**Coral demography methods:**

Benthic cover surveys were conducted using the same methods as the CRAG surveys.

## III. NOAA’s U.S. Pacific Islands NCRMP (National Oceanic and Atmospheric Administration National Coral Reef Monitoring Program)

NOAA’s Coral Reef Conservation Program funds the National Coral Reef Monitoring Program (NCRMP) which monitors coral, fish, and climate across U.S. coral reefs. The U.S. Pacific Islands are surveyed through the Ecosystems Science Division (ESD) at the Pacific Islands Fisheries Science Center (PIFSC) based in Honolulu, Hawai’i. The Pacific Island NCRMP conducts benthic, fish, and climate surveys across the islands of American Samoa, CNMI, and Hawai’i. The islands of American Samoa are surveyed every 3-5 years and accessed via NOAA ships. There have also been several land-based missions that have utilized the same methods as NCRMP.

**Site selection:**

The site selection methodology has changed over time. In 2004, fixed sites were established and sampled until 2010. In 2010, a stratified random sampling design was piloted. Since 2010, all sites chosen annually are stratified random for three depth strata (shallow: 0-6 meter, middle: >6-18 meter, and deep: >18-30 meter).

## Benthic cover methods:

### a. 2004-2010: Line point intercept

Surveys were conducted in 2004, 2006, 2008, and 2010 along four 25-meter transects with a data point collected every 0.5 meter for a total of 50 points per transect. Categories were recorded at the species level where possible (coral and macroalgae) and at group level for the rest (Coral Reef Ecosystem Program 2017).

### b. 2010-Current: Photoquadrats

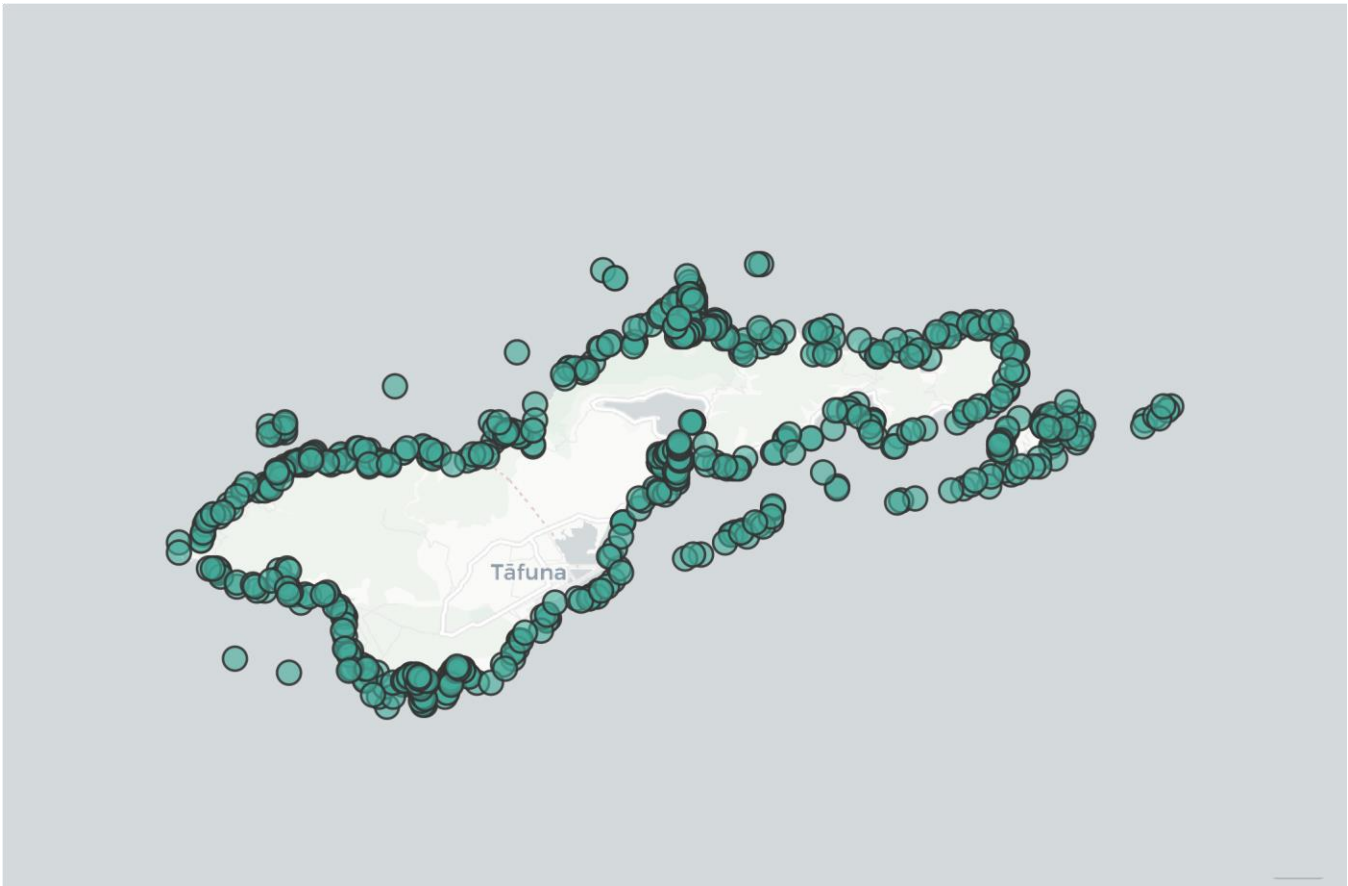
Surveys were conducted in 2010, 2012, 2015, 2016, 2018, 2020, and 2023. Photos were taken every meter with a 1-meter monopod along a 30-meter transect tape. Post-processing of these photos was previously conducted with CPCe but is now being done with CoralNet. The post-processing software randomly places 10 points on each photo and identifies the benthos under each point (Winston 2019).

## Coral demography methods:

Coral demography surveys were conducted along a 30-meter long transect laid out along an isobath at a predetermined depth strata. The transect was split into 4 segments at 0-2.5 meter (segment 0), 5-7.5 meter (segment 5), 10-12.5 meter (segment 10), and 15-17.5 (segment 15), resulting in 10 m<sup>2</sup> surveyed per site. Each segment is 1 meter wide by 2.5 meters long. Each coral in an adult colony (>5 centimeter) is identified (species when possible, genus when not) and measured (maximum diameter). The morphology is determined and partial mortality and condition are assessed. Surveyed juvenile corals less than 5 centimeters are identified to genus and measured for maximum diameter within the first 1 meter of the first three segments (segments 0, 5, and 10) (Winston 2019).

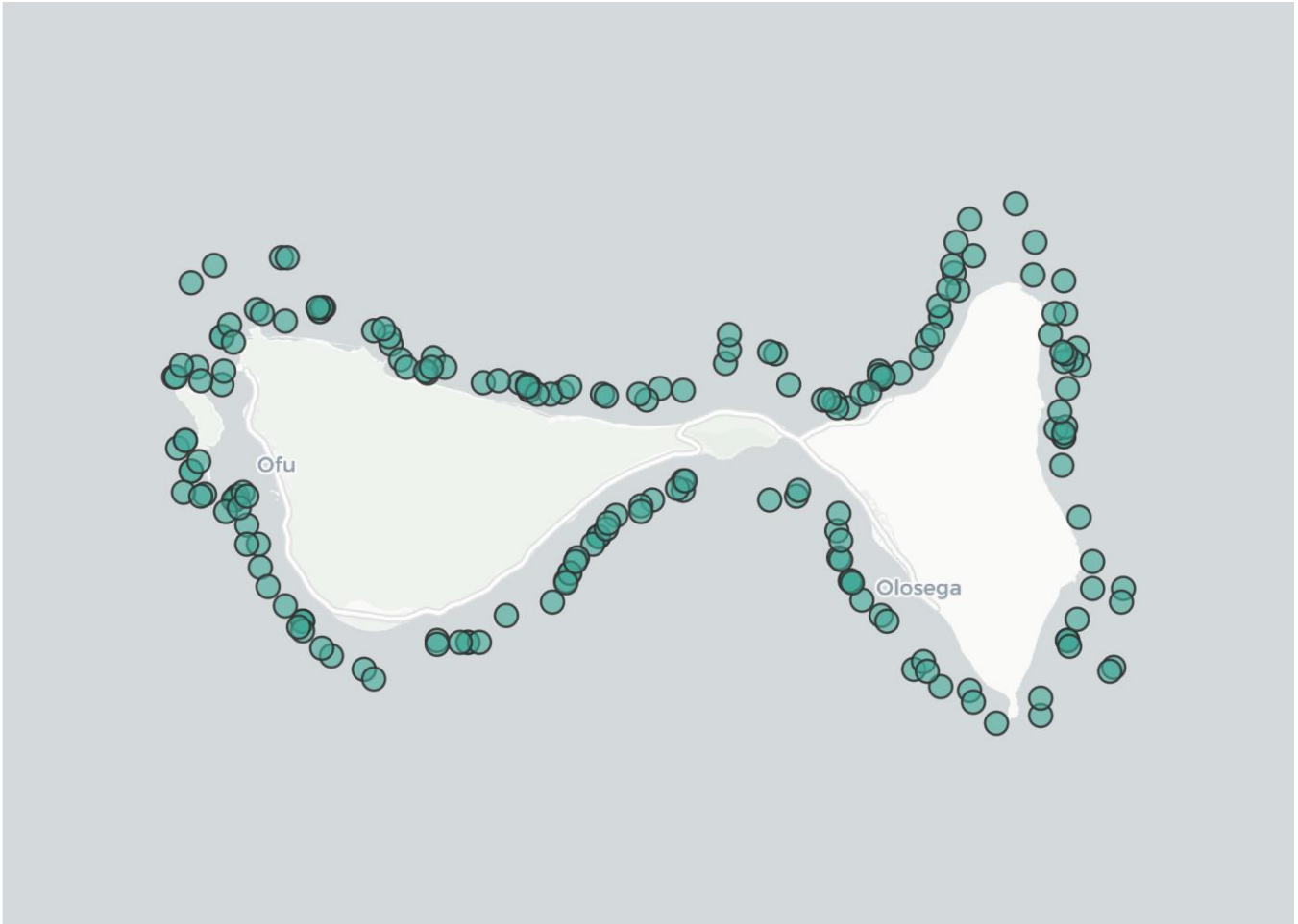
## Map of all sites all years:

### Tutuila





## Ofu and Olosega

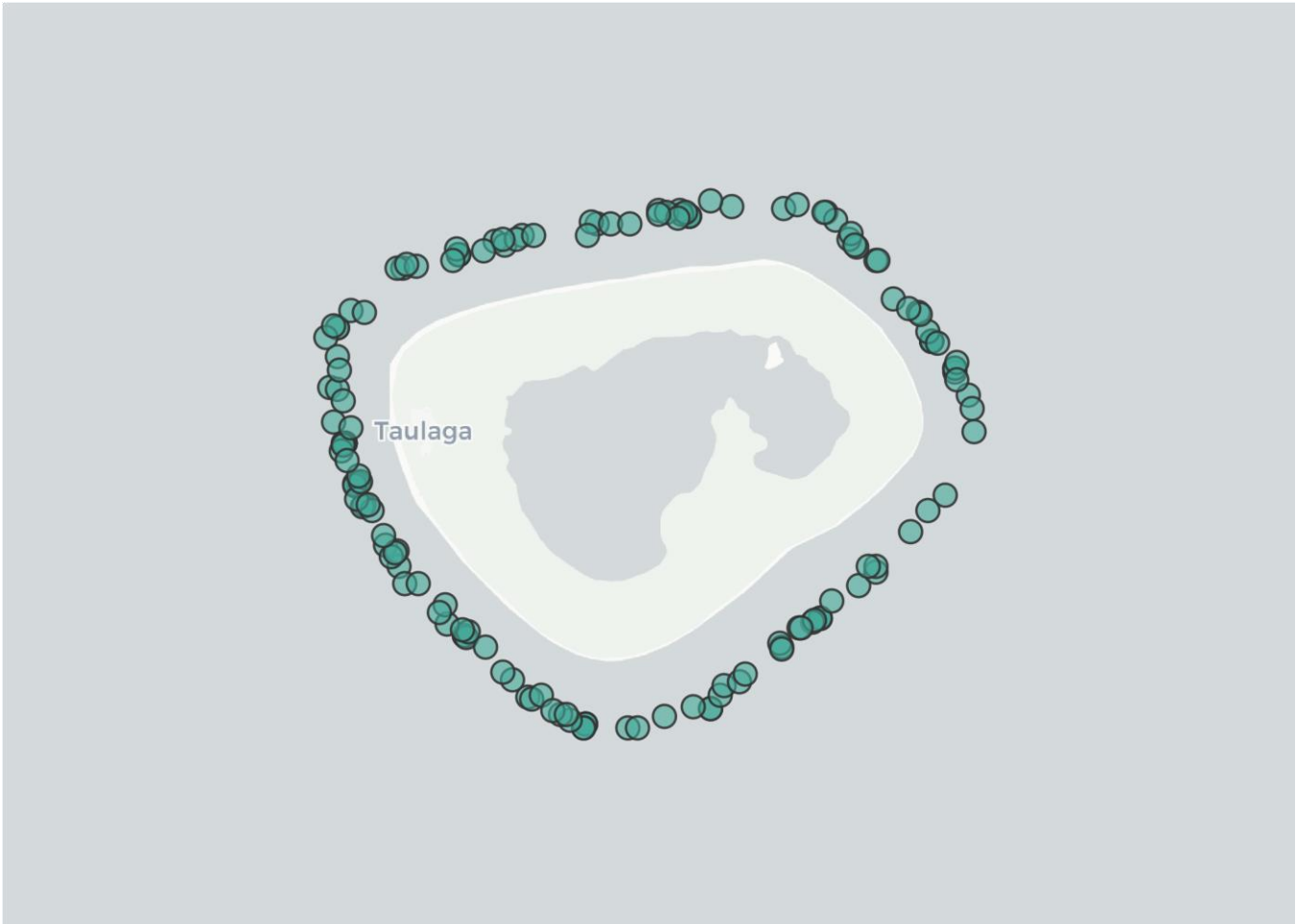


## Tau

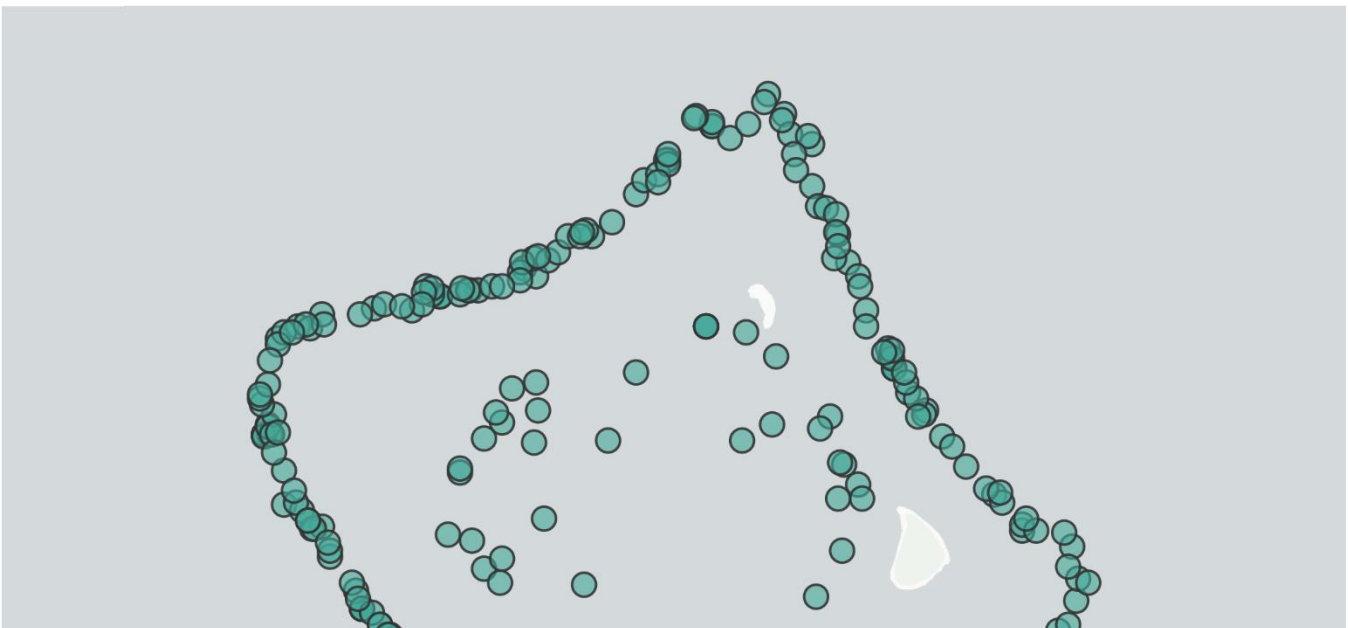


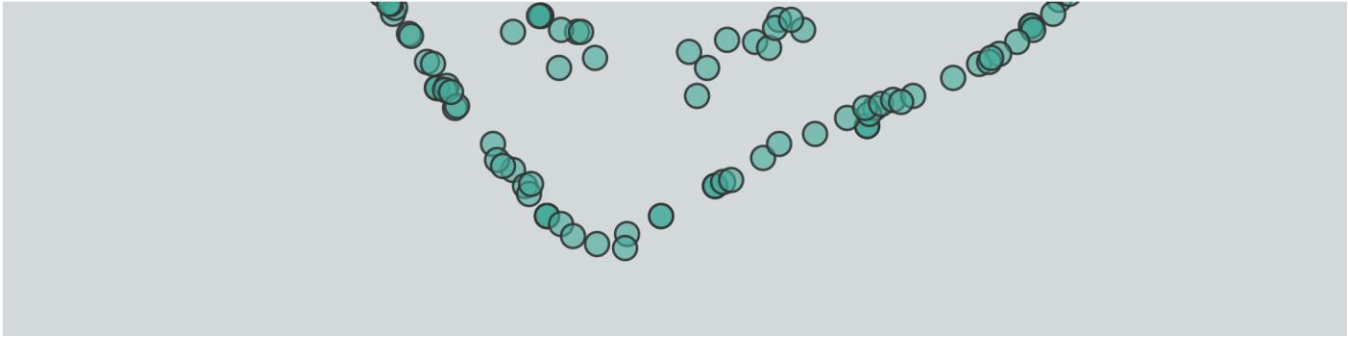


**Swains**



**Rose**





## IV. American Samoa National Park Service (ASNPS)

The American Samoa National Park Service (ASNPS) conducts annual benthic surveys as part of the Natural Resources Inventory monitoring program which began in 2007. Each year, surveys are conducted at 15 fixed sites and 15 randomized sites within the park boundaries located on the northern shore of Tutuila.

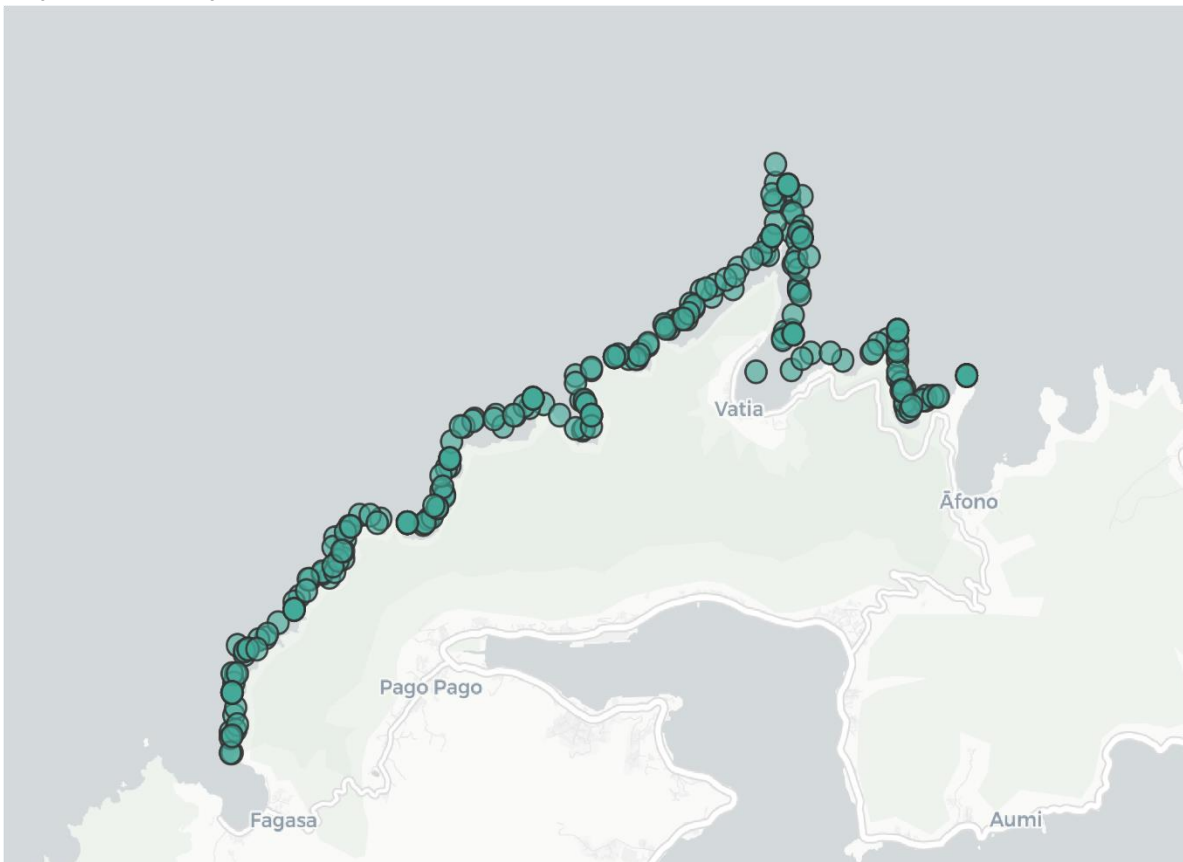
### Site selection:

Site selection is a split panel field sampling design.

### Benthic cover methods:

Surveys are conducted along a 25-meter transect following a depth contour between 10 and 20 meters on hard substrate, and photoquadrats are taken every 1 meter. Photoquadrats are 0.5 meter × 0.36 meter, and the total area per transect surveyed is 4.5 m<sup>2</sup>. Post-processing is completed using the CPCe program and calculating benthic composition based on 50 randomly generated points per image (National Park Service 2020). Benthos is recorded to the highest taxonomic level possible (coral, macroinvertebrate, macroalgae, so coral, CCA, turf algae, sand).

### Map of all site all years:



## V. Department of Marine and Wildlife Resources (DMWR)

DMWR leads 2 coral surveying monitoring projects: Key Reef Species Program (KRSP) and Marine Protected Area Programs (Community Fisheries Management program (CFMP), No Take Marine Protected Area (NTMPA)).

### 1. DMWR Key Reef Species Program (KRSP)

Over the years, the KRSP monitoring program has a few changes where surveys take place and the methods.

Islands	# Sites	Years	Survey Method	Depth (m)	Survey Area
Tutuila, Manu'a Islands (Ta'u, Olosega, Ofu), Rose, and Swains	27	1996, 2002	Quarter Point Intercept	10	3-5x50-meters long by 3 meters wide
Tutuila, Olosega, and Ofu	15	2005-2007	Video	10	30-meters long transect
Tutuila	15	2008-2012	Video	10	30-meters long transect
Tutuila	15	2012-Current	Photo	10	4x30-meters long transect

#### Site selection:

Sites were evenly distributed around Tutuila throughout each EPA designated watershed while avoiding CRAG permanent sites. These DMWR KRSP sites are permanent sites revised semi-annually, with the goal of surveying 1214 sites a year.

#### Benthic cover methods:

##### a. 1996 and 2002: Quarter point intercept

The data collected during this time frame overlap with the data collected by Green *et al* 2022 "Status of coral communities in American Samoa" project outlined in "VIII. External Research."

##### b. 2005-2012: Videos

Underwater video footage was taken at 1 meter above the benthos along a 30-meter transect tape laid at a 10-meter isobath. Fifty stills were randomly extracted from the footage. For each photo, CPCe randomly generated 10 points that were identified by a human analyzer. The points were identified as one of 12 benthic categories (live coral, dead coral, dead coral with algae, crustose calcareous algae, branching coralline algae, fleshy macroalgae, turf algae, rock, sand, rubble, soft coral, and sponge).

##### c. 2012-Current: Photoquadrats

At each site four separate 30-meter transects separated by 10-15 meters were laid down along a 10-meter isobath. One photo was taken every meter for a total of 120 photos per reef slope site (12-14 sites) and per reef flat site (i.e., ~ 1440-3360 photos per year).

### 2. DMWR Marine Protected Area Programs (CFMP and NTMPA)

Program	Islands	# Sites	Years	Survey Method	Depth (m)	Survey Area
CFMP	Tutuila	12	2004-2008 (quarterly)	Line Point Intercept	1-3	3x30-meter long by 10 meter wide
CFMP/KRSP	Tutuila	12	2012-2015	Photo	10	4x50-meter long by 5 meter wide <i>combined with KRSP</i>

## VI. American Samoa Environmental Protection Agency (AS-EPA)

Since 2010, the American Samoa Environmental Protection agency has participated in the National Coastal Condition Assessment (NCCA) with the USEPA, conducting reef flat surveys every 5 years. Benthic surveys were conducted in 2010, 2015, and 2021 by Peter Houk and his team from the University of Guam.

### Site selection:

In 2010, 50 sites were randomly selected within Tutuila and Annu'u reef flats (Houk and Musburger 2010). Twentyfive of those sites were resampled in 2015 and 2021. Twenty-five additional sites were chosen in both 2015 and 2021 by stratified design with unequal probability of selection based on area within each stratum using 8 unequal probability categories across reef flats (Nimbus 2022).

### Benthic cover methods:

A 25-meter transect was positioned parallel to the shoreline. For every 1 meter interval, a 0.5 x 0.5 meter string quadrat with six intersecting points, was randomly placed along either side of the transect tape, and the living benthos underneath the point recorded (Houk 2015).

## VII. Aua Historical Transect

The Aua historical transect has the largest temporal span of any monitored transect in the world. It was first surveyed by Alfred Mayer in 1917, and 10 more time since by various researchers (1917, 1973, 1980, 1995, 1998, 1999, 2000, 2004, 2007, 2017, and 2019). The transect runs from shore to reef crest (~270 meters), with specific distances from shore surveyed each time. During the 1930s or 1940s, a borrow pit, which is an excavation typically made to source materials like sand, soil, or rock for construction or other purposes, was dug on part of the transect. This borrow pit measured approximately 5 meters in width and extended along the inner 61 meters of the transect. Unfortunately, the excavation of this borrow pit killed most of the corals within that section of the transect. Corals were not recorded in this section of the transect again until 2017 (Birkeland et al. 2021).

### Site selection:

Alfred Mayer selected the site for the Aua transect in 1917.

### Coral demography methods:

#### a. 1917, 1973, and 1980:

A 7.3 x 7.3 meter quadrat (53.2 m<sup>2</sup>) was surveyed at each predetermined distance from shore. Every coral was accounted for and identified to species if possible, otherwise to genus.

b. 1995-2019:

The methods changed slightly with Birkeland and Randall in 1995. Instead of one large quadrat at each distance, a small quadrat of 0.25 x 0.25 meters was placed randomly within 10 meter of the transect line at each distance from shore. An equal amount of quadrats were surveyed on each side of the transect. Every coral was accounted for and identified to species if possible, genus if not.

Map of all distances from shore surveyed:



## VIII. External Research

There have been several previous initiatives aimed at assessing the reefs of American Samoa, encompassing both enduring long-term studies and occasional one-off investigations.

### A. Birkeland et al. long-term sites at Fagatele and 11 sites around Tutuila Summary:

In 1982, Birkeland et al. established permanent transects at 11 sites around Tutuila and Aunu'u and added transects at an additional site (Fagatele Bay) in 1985 (Birkeland et al. 2004). In Fagatele Bay there are six permanent transects. The remaining sites around the island each have and one permanent transect. The transects run perpendicular to the shoreline and are 30-meters long across a depth gradient. Surveys are then conducted perpendicular to the permanent transect along a depth gradient. In Fagatele, surveys were conducted along a depth gradient of 3,6,9, or 12 meters. For the remaining sites (Aunu'u, Aua, Ausai, Cape Larsen, Fagafue Bay, Fagasa Bay, Fatumafuti, Masefau Bay, Massacre Bay, Rainmaker Hotel), surveys were conducted along a 2-3 and 6 meter depth gradient. Most surveys were conducted on reef slopes, but some at Fagatele were done in reef flats along the transect.

### Site selection:

Survey transects within the permanent transects at Fagatele were chosen by stratified random sampling within a certain depth.

### **Coral demography methods:**

Coral area and abundance were estimated using the point quarter method. A 30-meter transect is laid out along the pre-determined depth contour. While swimming down the transect, an object with right angles (ex: dive knife or hammer) is tossed on either side of the transect. From this object four imaginary quadrants are created. Within each quadrant, the distance to the nearest coral and the species ID is recorded and the. These are then used to calculate coral area and abundance (Birkeland et al. 1987).

### **Where to find the data and literature:**

- 1982 and 1985: NOAA Technical Memorandum NOS MEMO#: Biological Resource Assessment of the Fagatele Bay National Marine Sanctuary (Birkeland et al. 1987)
- 1995 and 1998: link to data (<https://data.noaa.gov/dataset/dataset/coral-reef-surveys-of-fagatele-bay-national-marine-sanctuary-and-other-sites-around-tutuila-ame2>), link to metadata ([https://www.nodc.noaa.gov/archive/arc0001/0000622/1.1/data/1-data/meta/simple/as9598\\_pcc.meta](https://www.nodc.noaa.gov/archive/arc0001/0000622/1.1/data/1-data/meta/simple/as9598_pcc.meta))
- 2001: Long-term monitoring of Fagatele Bay National Marine Sanctuary and Tutuila Island (American Samoa) 1985 to 2001: summary of surveys conducted in 1998 and 2001 (Birkeland et al. 2004)

### **B. Status of coral communities in American Samoa (1995, 2002, 2018) Summary:**

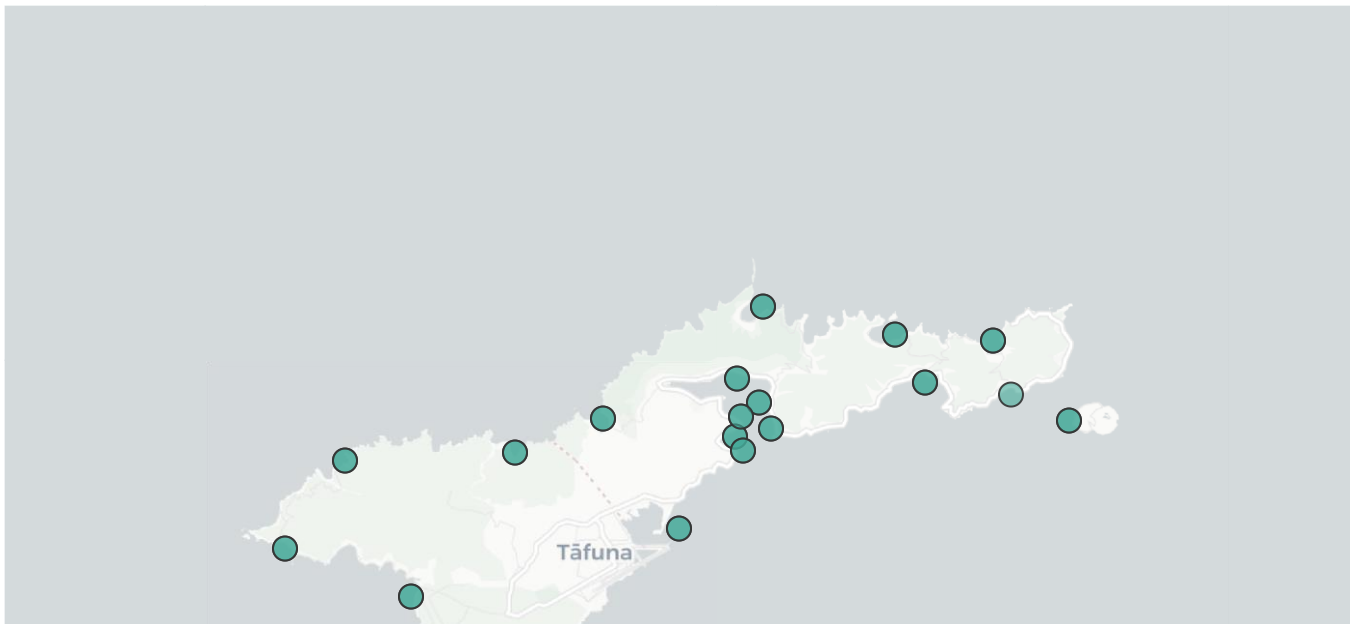
In 1995, Birkeland et al. established long-term monitoring sites at Tutuila, Aunu'u, Ofu-Olosega, and Ta'u with sites at Swains and Rose added in 2002. Surveys were conducted in 1994/95, 2002, and 2018.

### **Benthic cover methods:**

Surveys were conducted along three to five 50-meter transects at a depth contour of 10 meters. Quarter point intercept was used where the substratum type was recorded every 2 meters along the 50-meter transect at three points (under the tape, and 1 meter on each side; Green et al. 2022). The recorded categories were: non-living or lifeforms (plate, massive, digitate, branching, encrusting, mushroom, foliaceous coral, CCA, turf algae, cyanobacteria, macroalgae, and other).

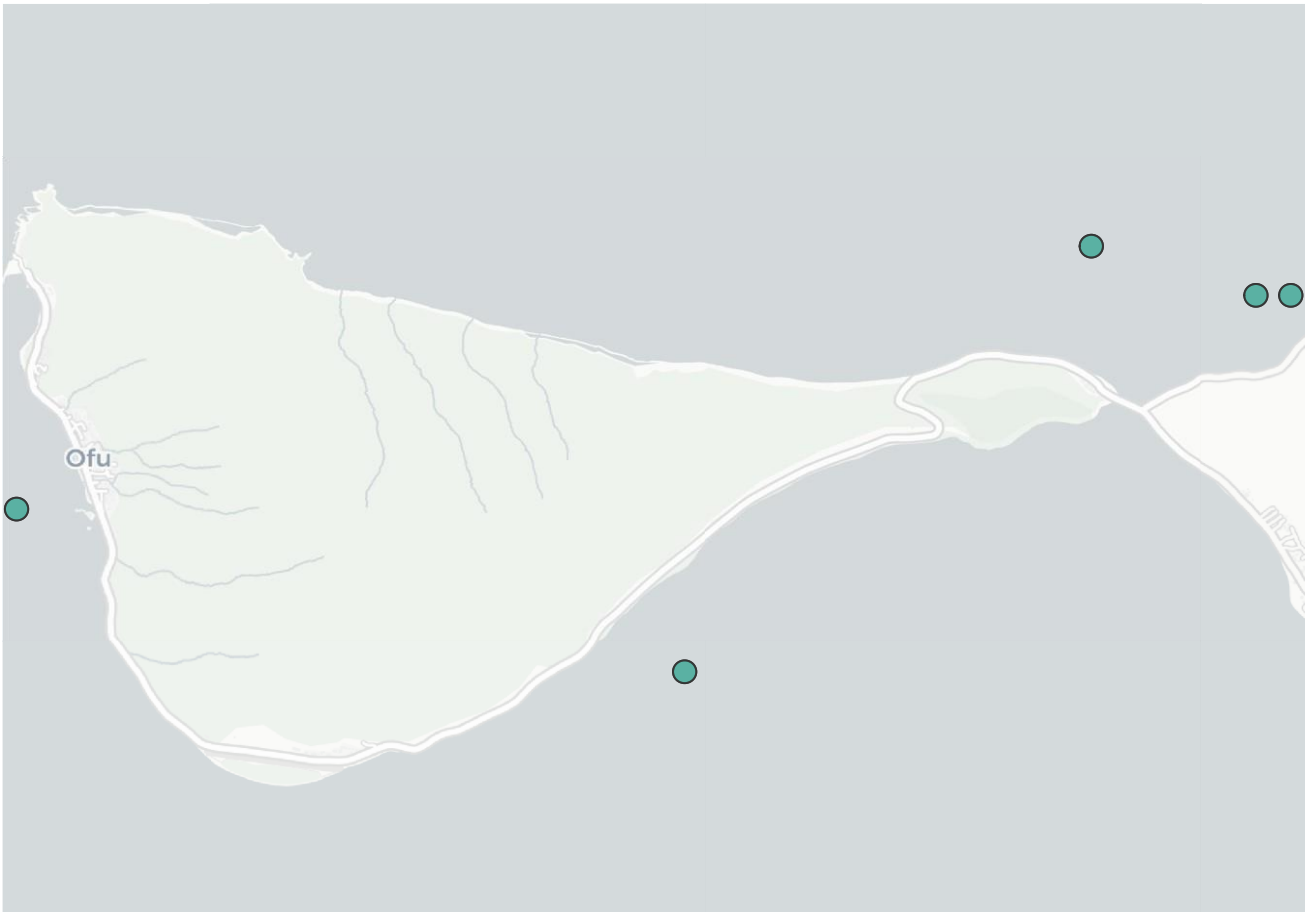
### **Maps of sites:**

#### **Tutuila**

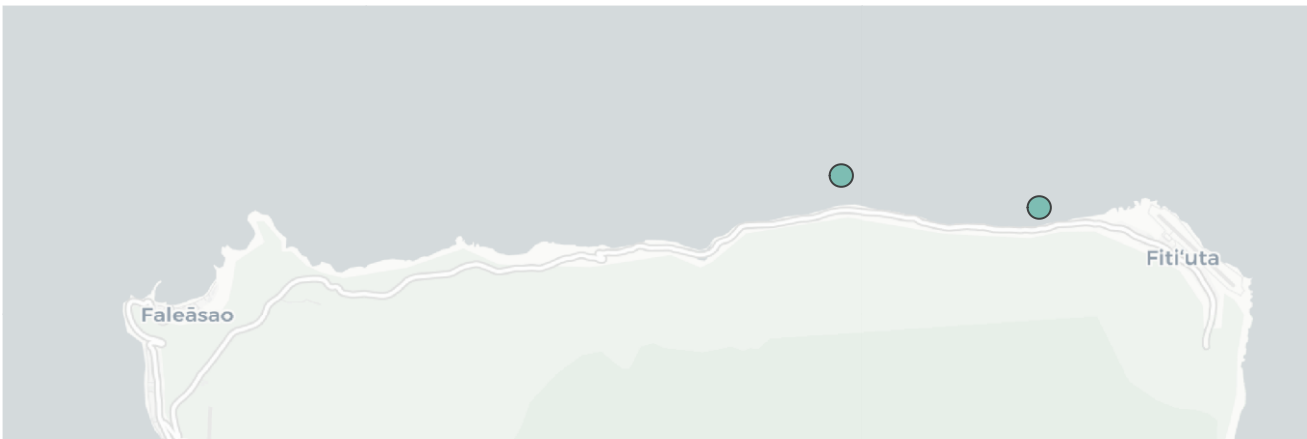




**Manu'a Island (Ofu and Olosega)**



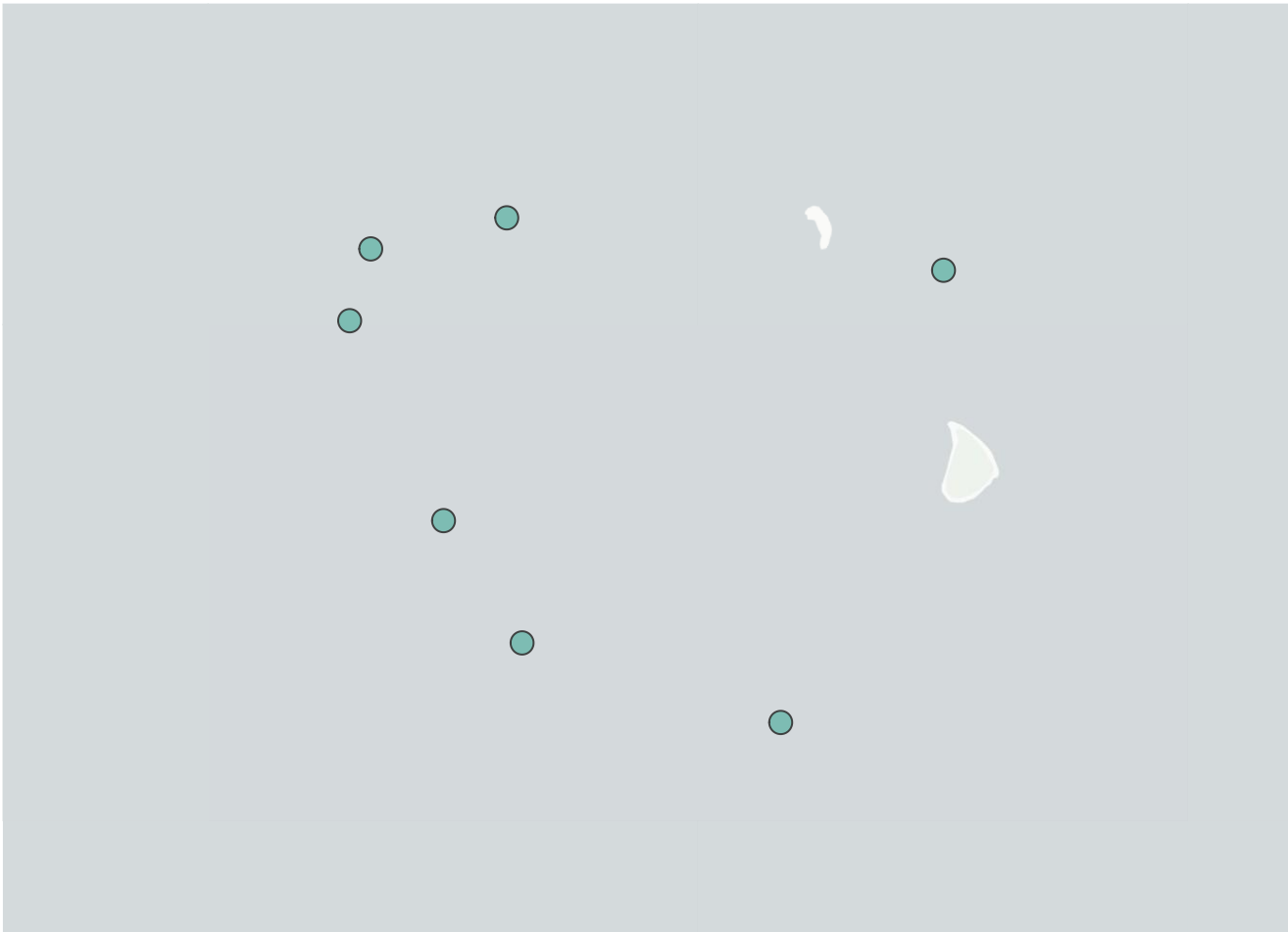
**Tau**







## Rose



### Where to find the data and literature:

- Links to data for 1995 and 2002 can be found in two locations. Meta data for first option ([https://www.nodc.noaa.gov/archive/arc0001/0001470/l.2/data/O-data/meta/simple/AmSamoa\\_meta.txt](https://www.nodc.noaa.gov/archive/arc0001/0001470/l.2/data/O-data/meta/simple/AmSamoa_meta.txt)) and link to data (<https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0001470>); metadata and data for second option (<https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:735>)
- Green et al. 2022 - paper summarizing all surveys conducted (1995, 2002, and 2018). The data were provided by Alison Green on request.

## Other studies:

### 1. Hunter: 1993

Baseline study conducted to assess Ofu for a national park. Ofu Reef Survey Baseline Assessment and recommendation for Long-Term Monitoring of the Proposed National Park, Ofu, American Samoa (Hunter 1993).

### 2. Maragos, Hunter, and Meier: 1994

A report to the American Samoan Government, "Reefs and corals observed during the 1991-92 American Samoa coastal resources inventory," written in 1994 by JE Maragos, CL Hunter, KZ Meier.

# Reef Fish Communities Surveys

The coral reef sciences and monitoring programs employ various fish survey methods determined by the science question or management goal. The two most common method categories in American Samoa are belt transect and stationary point cylinders (SPC).

Belt transect surveys are conducted along a transect line, and fish species within a predetermined width and height are identified, counted, and sized. The size range and levels of specificity in fish identification required for the surveys vary. Stationary point count surveys are conducted in one spot, where the diver carefully observes the surrounding area, swiveling to identify, count, and size fish species for a certain duration.

Many variations of fish survey methods have been used across time and organizations. The differences with how fish surveys are conducted makes it more difficult to integrate data collected.

Below are all the reef fish communities data streams that have been discovered and considered throughout the course of the project.

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Source	Project Name	Data sources	Years	Method
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring (ASCRMP) - Tutuila slopes	CORIS	2006-2011	Belt transects with 4 passes
Coral Reef Advisory Group (CRAG)	American Samoa Long-Term Monitoring (ASCRMP) - Tutuila slopes	CORIS	2015-2020	SPC
Coral Reef Advisory Group (CRAG)	Leone shipwreck removal	CRAG partner	2019-2020	Timed swims
Ridge to Reef (R2R)	Ridge to Reef (R2R)	AS-EPA, CRAG, NMSAS	2017	SPC
Coral Reef Advisory Group (CRAG)	Reef flat monitoring			

Source	Project Name	Data sources	Years	Method
National Oceanographic and Atmospheric Association (NOAA)	Pacific Reef Monitoring Program (RAMP)	NCEI	2004-2008	Belt transects with 2 passes
National Oceanographic and Atmospheric Association (NOAA)	U.S. Pacific Islands National Coral Reef Monitoring Program (NCRMP)	NCEI	2008-Current	SPCe
American Samoa National Park Service (ASNPS)	Natural Resources Inventory and Monitoring	IRMA and Kelly Kozar	2007-2019	Belt surveys with 2 passes
Department of Marine and Wildlife Resources (DMWR)	Key Reef Species Program (KRSP)		1996, 2002, 2005-2015	Belt surveys
External research	Status of coral communities in American Samoa	Alison Green	1994/95, 2002, 2018	Belt transects with 3 passes
External research	Long-term sites at Fagatelle and 11 sites around Tutuila	Chuck Birkeland	1982, 1985, 1988, 1995, 1998, and 2001	Belt transects

## Methods descriptions

### I. Coral Reef Advisory Group (CRAG)

#### 1. Long-term monitoring

See the benthic Coral Reef Advisory Group (CRAG) Long-term monitoring section for information on this monitoring program.

#### Site selection:

See the benthic Coral Reef Advisory Group (CRAG) Long-term monitoring section for information on site selection.

#### Fish assemblage methods:

##### a. 2006-2011: Belt transect

Six replicate 30-meter transects were conducted along a 10-meter depth contour. The observer swims four passes, each with various widths depending on the goal for that pass. The first pass is a 15-meter wide swath; the observer surveys only large mobile fish. The second pass is a 10-meter wide swath, and only parrotfish are surveyed. The third pass is a 5-meter wide swath in which all other fish (except damsel fish) are surveyed. The last pass is a 2-meter wide swath that surveys damselfish only.

##### b. 2015-2020: Stationary Point Count (SPC)

These surveys are conducted along the CRAG 200-meter benthic transect line at a 10-meter depth contour. Twelve replicate 7.5-meter radius SPCs were conducted every 20 meters along the transect line. Each replicate was timed at 3 minutes. During these surveys, all food fish within a cylinder were recorded. Food fishes included: surgeonfishes (Family: Acanthuridae), parrotfishes (Labridae), groupers (Epinephelidae), jacks (Carangidae), emperor fishes (Lethrinidae), snappers (Lutjanidae), and triggerfish (Balistidae) (Coward 2019). In November 2016, during R2R fish surveys, no transect tape was reeled out, so more mobile fish were recorded.

## **2. Manu'a shallow reef lagoon**

In 2015, CRAG established 7 long-term monitoring sites in Manu'a. These data were collected every year from 2015-2019 (Ripley 2019).

### **Reef fish assemblage methods:**

Four 20-meter transects were laid down with 5 meters separation in between them. All non-cryptic fish species within a 5-meter wide belt (2.5 meters each side of the transect) were recorded to the nearest centimeter and identified to species when possible. Following the belt transects, three 5-minute swims were conducted along the transect with a width of 20 meters (10 meters on each side of transect) (Ripley 2019).

## **3. Leone shipwreck removal pre and post surveys**

See the benthic CRAG Leone shipwreck removal pre- and post-surveys section for information on this project.

### **Site selection:**

These sites were specifically selected.

### **Reef fish assemblages methods:**

Fish surveys were conducted during a 3-minute timed swim within each of the 3 areas assessed: pavement, boulder area and pavona, pavona and acropora (Coward 2020). Fish were counted and identified to species where possible.

## **II. Ridge to Reef (R2R)**

See the benthic Ridge 2 Reef (R2R) section for information on this project.

### **Site selection:**

See the benthic Ridge 2 Reef (R2R) section for information on site selection.

### **Reef fish assemblages methods:**

Reef fish surveys were conducted using the same methods as the CRAG Tutuila long-term monitoring surveys.

## **III. NOAA's U.S. Pacific Islands NCRMP (National Oceanic and Atmospheric Administration National Coral Reef Monitoring Program)**

See the benthic NOAA's U.S. Pacific Islands NCRMP (National Oceanic and Atmospheric Administration National Coral Reef Monitoring Program) section for information on this monitoring program.

### **Site selection:**

There have been three iterations of fish survey methods since PIFSC first began their NCRMP.

- a. 2004 and 2006: all permanent sites
- b. 2008 and 2010: both permanent sites and random
- c. 2012-Current: random stratified

### **Fish assemblages methods:**

- a. 2004 and 2006 Belt transects (BLT):

The surveys were carried out along a single depth contour, following a 25-meter long transect tape. Two observers swam parallel to each other, maintaining a 5 meter distance from the tape on either side while surveying and recording species identification, fish count, and size for all individuals >20 centimeters in total length within a 4 meters in width and 4 meters in height area. Divers turned around to conduct another pass down the transect line this time surveying fish <20 centimeters within a 2 meters in width and 4 meters in height area (Pacific Islands Fisheries Science Center 2011).

b. 2008-2023: New Stationary Point Counts (nSPC)

A pair of divers lays out a 30-meter transect line along the depth contour. Once laid out, the first diver moves to the 7.5 meter mark and the second to 22.5 meter. Data collection occurs in two parts: the enumeration period and the tallying period. During the enumeration period the surveyor spends the first 5 minutes recording all species present or passing through their 7.5 meter radius cylinder. During the subsequent tallying period the diver will go through their species list and record the size and number for each (McCoy 2018).

## IV. American Samoa National Park Service (ASNPS)

See the benthic American Samoa National Park Service (ASNPS) section for information on this monitoring program.

**Site selection:**

Site selection is a split panel field sampling design.

**Fish assemblage methods:**

Surveys were conducted along a 25-meter transect following a depth contour between 10 and 20 meters. As the transect was reeled out, the surveyor counted the fish. On the first pass, the survey area was 4 meters wide by 4 meters high and only fish >20 centimeter were recorded. During the second pass, the survey area was 2 meters wide by 4 meters high and fish that were <20 centimeter long were recorded (Brown et al 2011).

## V. Department of Marine and Wildlife Resources (DMWR)

Reef fish surveys are conducted as part of the DMWR Key Reef Species Program (KRSP).

**Site selection:**

Sites were selected within bays across Tutuila to achieve an even distribution throughout each EPA designation watershed while also circumventing established CRAG permanent sites. These serve as permanent monitoring locations that are visited annually, with the objective of conducting 12 to 14 site assessments.

**Reef fish assemblages:**

Each survey site comprises four 30-meter transects along a 10-meter isobath, each separated by a distance ranging from 10 to 15 meters. These surveys require two divers: one responsible for laying down the transect tape while the other swims ahead to conduct the fish survey. During the survey, the observer counts, sizes, and identifies (to the lowest possible taxonomic group) all larger-bodied fish (sharks, large parrotfish, snappers, and large groupers) exceeding 50 centimeter in length. This assessment was conducted within a 10-meter width of the transect. Simultaneously, the observer also counts, sizes, and identifies all smaller-bodied fish found within a 4-meter width of the transect (Ochavillo 2023).

## VI. External Research

There have been several previous initiatives aimed at assessing the reefs of American Samoa, encompassing both enduring long-term studies and occasional one-off investigations.

### **A. Birkeland et al. long term sites at Fagatelle and 11 sites around Tutuila**

See the benthic External Research section for summary information.

#### **Site selection:**

See the benthic External Research section for information on site selection

#### **Sites:**

See the benthic External Research section for information on sites.

#### **Reef fish assemblages method:**

Fish surveys were conducted at the same sites as the coral surveys, utilizing the 30-meter transect as the primary assessment area (outlined in the benthic section of VI. External Research). Additional surveys were conducted at more depths, including Fagatelle Bay (12 meters), Sita Bay (5-6 meters), and Cape Larsen (8-9 meters), utilizing 100-meter transects with dimensions measuring 2 meters in width and 2 meters in height. The fish survey process involved two distinct steps:

1. Underwater data collection utilized a tape recorder located in the divers regulator, to comprehensively count all fish within the transect. The duration of these surveys was approximately 10 minutes for the 30-meter transect and 30 minutes for the 100-meter transect.
2. Ten to 30 minutes following the dive, a surveyor returned to the survey site. During this secondary assessment that lasted 15-20 minutes, the surveyor sought out and documented species not initially observed during the census. This supplementary survey was conducted within a 20 meter range of the original transect and at the same depth range to provide more insight into species richness and abundance.

#### **Where to find the data and literature:**

See the benthic External Research section for information on where to find the data and literature. **B.**

### **Status of coral communities in American Samoa (1995, 2002, 2018)**

#### **Summary:**

See the benthic External Research section for information.

#### **Reef fish assemblages method:**

Surveys were conducted along a 10-meter isobath. Each site consisted of three to five 50-meter transects. Each survey consisted of three passes; the first surveyed large highly mobile species, the second looked at medium sized mobile species, and the third surveyed small site-attached species (Green et al. 2022).

#### **Maps of sites:**

See the benthic External Research section for maps of sites.

#### **Where to find the data and literature:**

See the benthic External Research section for information on where to find the data and literature.

# Environmental

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## Water Quality

### **1. American Samoa Environmental Protection Agency (AS-EPA)**

Since 2010, the American Samoa EPA has participated in the National Coastal Condition Assessment (NCCA) with the USEPA. These assessments look at multiple indicators including in situ water column measurements (temperature, pH, dissolved oxygen, salinity), water chemistry (total nitrogen, total phosphorus), microbiology (enterococci), and a bioassessment (characterization of the major floral and fauna composition). Data collection occurred in June/July 2010, July 2015, and July 2021.

#### **Site selection:**

See the benthic American Samoa Environmental Protection Agency section for information on site selection.

### **2. Ridge to Reef**

For the Ridge to Reef study samples were collected to test for nitrate, nitrite, and ammonium from a total of 26 streams on a monthly basis, spanning the period from September 2016 to September 2017. Samples were collected during the same monthly 3-day window coinciding with the lowest tide of the month (Comeros et al. 2019).

### **3. National Oceanographic and Atmospheric Administration (NOAA) - Aua LBSP project**

In September 2022, Joy Smith (NOAA) led a land-based source pollution (LBSP) project on Aua reef with a goal of developing a baseline for Aua reef. The project included water sampling, indicator sampling, benthic surveys, and coral demography surveys.

#### **Site selection:**

Site selection followed a random sampling design within hard bottom reef habitat from 3 to 15 meters depth of Aua reef. Eighteen sites were surveyed during the course of this project.

#### **Sampling methods:**

Eighteen sites were sampled on 5 days spanning the 17-day sampling period. Water samples were collected for analysis of total suspended solids (TSS), particulates (chlorophyll a, phaeophytin), particulate nutrient (C,N,P), and dissolved organic and inorganic nutrients.

### **4. National Oceanographic and Atmospheric Administration (NOAA) - Vatia Bay nutrient project**

David Whital (NOAA) led a nutrient and sewer tracer study in Vatia Bay from May 2015-August 2018. The standard suite of nutrient parameters (nitrate, nitrite, ammonium, urea, total nitrogen, orthophosphate, total phosphorus, and silica) and tracers of human waste (sucralose and caffeine) were collected.

#### **Site selection:**

Four strata were designated based on proximity to streams, proximity to shore, and geography. Within each strata, 4 sites were randomly selected for a total of 16 sites. An additional site was selected due to its proximity to the largest stream input to Vatia Bay.

#### **Sampling methods:**

Both surface water (0.1 meter below surface) and bottom water (just above the bottom) were collected. When sites were too shallow for two distinct samples, only surface water samples were collected.

Link to data (<https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0208020>)

## **5. National Oceanographic and Atmospheric Administration (NOAA) - Fagatele Bay nutrient project**

David Whital (NOAA) led a water quality assessment of Fagatele Bay from April 22-26 2019. This project emerged as a result of local concerns regarding the impacts of land-based source pollution. The assessment included over 300 contaminants of emerging concern such as pesticides, personal care products, pharmaceuticals, and hydrocarbons. The standard suite of nutrient parameters was also conducted as well as trace metals analysis and tracers of human waste.

### **Site selection:**

Sites were specifically chosen to capture the influence of groundwater inputs to the reef.

### **Sampling methods:**

Both sediment and water samples were collected in the field and shipped o for analyses.

Link to data and metadata (<https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.nodc:0247462>)

# Climate

## **1. National Oceanographic and Atmospheric Administration (NOAA) - NCRMP temperature loggers:**

See the benthic NOAA's U.S. Pacific Islands NCRMP (National Oceanic and Atmospheric Administration National Coral Reef Monitoring Program) section for information on this monitoring program.

### **Site selection:**

Three permanent sites were chosen within each of the cardinal directions (N,S,E,W) at all islands (Tutuila, Ofu Olosega, Swains, Rose, Tau). These sites are situated roughly perpendicular to shore at each of the three NCRMP depth strata (shallow, middle, deep).

### **Sampling methods:**

Monitoring is conducted using in situ subsurface temperature recorders at each depth for each site (Towle 2021).

## **2. American Samoa National Marine Sanctuary (ASNMS) - climate buoy data**

There are a few buoys around Tutuila managed by the American Samoa National Marine Sanctuary that monitors climate data.

1. Fagatele climate buoy (<https://www.pacioos.hawaii.edu/water/wqbuoy-fagatele/>): This buoy provides real time monitoring data of CO<sub>2</sub>, pH, temperature, salinity, turbidity, chlorophyll, oxygen, xCO<sub>2</sub>, and air pressure. Since it is in an embayment, some readings like pH and CO<sub>2</sub> fluctuate daily due to biological demand of the system and low residence time.
2. Aunu'u wave observation buoy (<https://www.pacioos.hawaii.edu/waves/buoy-aunu/>)
3. Sofar buoy at Fagamalo Reef (<https://aqualink.org/sites/1142>): Provides wave, wind, and temperature data.
4. Sofar buoy at Fagatele Bay National Marine Sanctuary (<https://aqualink.org/sites/1144>): Provides wave, wind, and temperature data.



5. Sofar buoy at Taema Bank (<https://aqualink.org/sites/1145>): Provides wave, wind, and temperature data.

**3. Environmental Research Division's Data Access Program (ERDDAP) - environmental satellite data** Environmental satellite data and summaries are downloaded using the Environmental Data Summary (EDS) tool created at the Archipelagic Research Group at Pacific Islands Fisheries Science Center (Oliver 2023). The datasets included in this project are:

1. Chlorophyll a (8 day, monthly, climatology) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/pmlEsaCCI60OceanColor8Day.html>): concentration of chlorophyll at the ocean surface
2. Kd 490 (weekly) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/nesdisVHNSQkd490Monthly.html>): measures ocean turbidity
3. Kd 490 (monthly) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/nesdisVHNSQkd490Weekly.html>): measures ocean turbidity
4. KdPAR (weekly) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/nesdisVHNSQkdparMonthly.html>): measures light attenuation
5. KdPAR (monthly) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/nesdisVHNSQkdparWeekly.html>): measures light attenuation
6. PAR (8 day) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/erdVH2018par8day.html>) : measures photosynthetically available radiation
7. PAR (weekly) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/erdVH2018parmday.html>): measures photosynthetically available radiation
8. Sea surface salinity (daily) ([https://oceanwatch.pifsc.noaa.gov/erddap/griddap/smos\\_daily.html](https://oceanwatch.pifsc.noaa.gov/erddap/griddap/smos_daily.html))
9. Sea surface temperature (daily) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/jplMURSST41.html>)
10. Sea surface temperature (climatology) ([https://oceanwatch.pifsc.noaa.gov/erddap/griddap/CRW\\_sst\\_v3\\_1\\_2022-clim.html](https://oceanwatch.pifsc.noaa.gov/erddap/griddap/CRW_sst_v3_1_2022-clim.html))
11. Degree heating weeks (monthly) ([https://coastwatch.pfeg.noaa.gov/erddap/griddap/NOAA\\_DHW\\_monthly.html](https://coastwatch.pfeg.noaa.gov/erddap/griddap/NOAA_DHW_monthly.html)): measures accumulated heat stress to corals
12. Wave Watch II model ([https://pae-paha.pacioos.hawaii.edu/erddap/griddap/ww3\\_samoa.html](https://pae-paha.pacioos.hawaii.edu/erddap/griddap/ww3_samoa.html)): peak wave direction and period, significant wave height, swell peak wave direction and period, wind peak wave direction and period, wind significant wave height
13. Wind speed ASCAT (daily) ([https://oceanwatch.pifsc.noaa.gov/erddap/griddap/ascat\\_daily\\_apdrc.html](https://oceanwatch.pifsc.noaa.gov/erddap/griddap/ascat_daily_apdrc.html))
14. Precipitation (daily) (<https://coastwatch.pfeg.noaa.gov/erddap/griddap/chirps20GlobalDailyP05.html>)

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