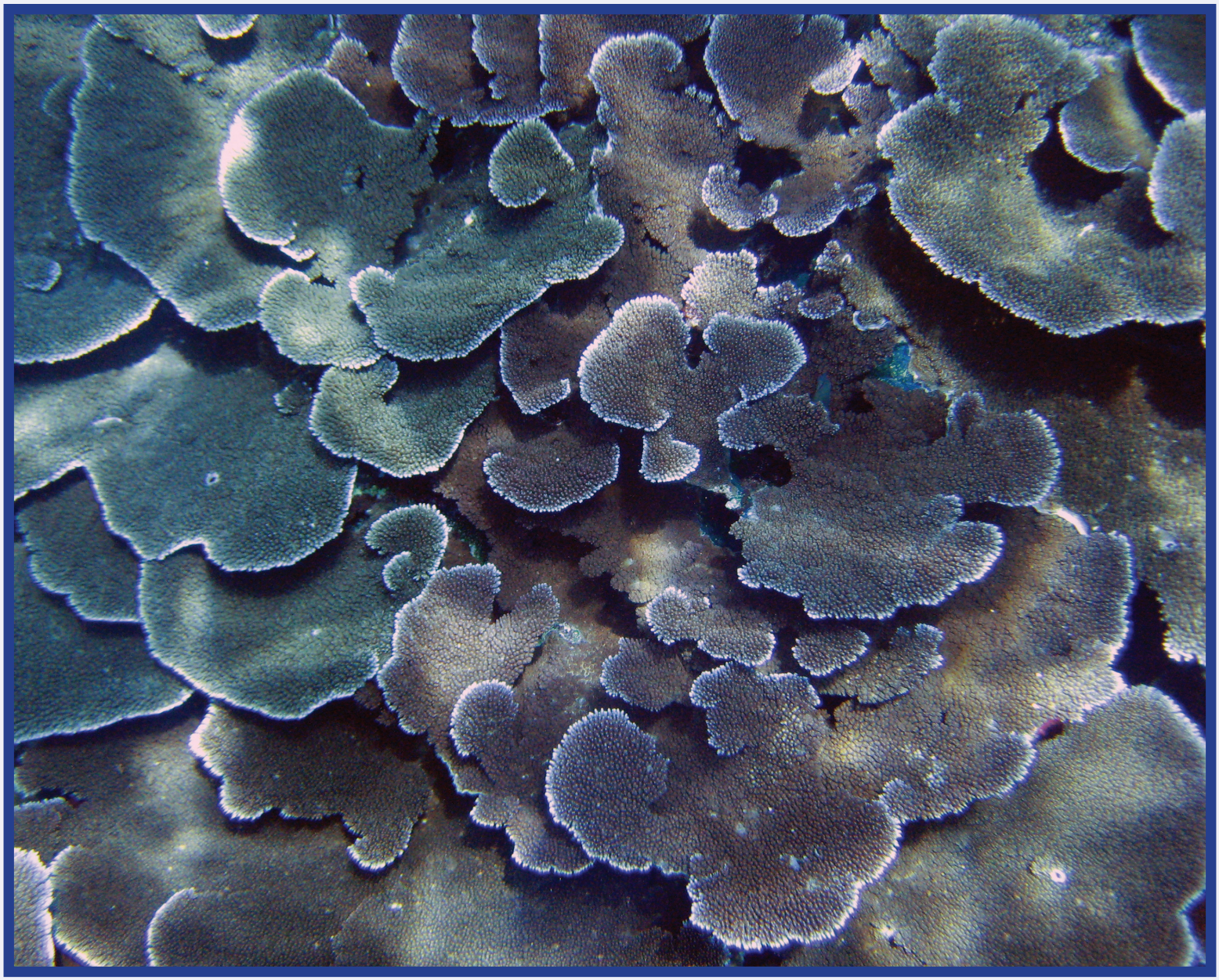
A Biogeographic Assessment of the Samoan Archipelago



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The graphic wrapped on the cover was created by Kang Sevao of American Samoa and used with permission here. This tapa design symbolizes the creation of land and sea. The processes of island formation and reef growth are central to understanding biogeography of the Samoan Archipelago.

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ABOUT THIS DOCUMENT

This assessment represents the continuation of ongoing partnerships between NOAA's National Centers for Coastal Ocean Science (NCCOS), Center for Coastal Monitoring and Assessment (CCMA), Biogeography Branch and the Office of National Marine Sanctuaries (ONMS) and Coral Reef Conservation Program (CRCP). The Biogeography Branch has applied a biogeographical approach to inform the management of marine resources within both coral reefs and National Marine Sanctuaries since 1998. To date, nine ONMS sites and most of the coral reef ecosystems in US states and territories have had some level of biogeographic characterization or mapping completed through these partnerships.

The results of this ecological characterization are available via website. For more information on this project and those in other ONMS and reef ecosystem locations please visit the Biogeography Branch webpage at http://ccma.nos.noaa.gov/about/biogeography/ or direct questions and comments to:

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EXECUTIVE SUMMARY

This report examines the marine biogeography of the Samoan Archipelago (~14º S latitude along the international date-line) with a focus on regional ocean climate, connectivity among islands due to larval transport, distributions of reef fish and coral communities, and the extent of existing marine protected areas. Management decisions and prior assessments in the archipelago have typically been split along the international political boundary between the islands of Samoa and those of American Samoa despite their close proximity and shared resources. A key goal in this assessment was to compile data from both jurisdictions and to conduct the characterization across the entire archipelago. The report builds upon earlier assessments by re-analyzing and interpreting many pre-existing datasets, adding more recent biogeographic data sources, and by combining earlier findings into a multidisciplinary summary of marine biogeography.

Image 1. A coral reef in the National Park of American Samoa near Vatia. Photo credit: Matt Kendall, NOAA Biogeography.

The assessment is divided into 5 chapters and supporting appendices. Each chapter was written and reviewed in collaboration with subject matter specialists and local experts. In Chapter 1, a short introduction to the overall scope and approach of the report is provided. In Chapter 2, regional ocean climate is characterized using remote sensing datasets and discussed in the context of local observations. In Chapter 3, regional ocean currents and transport of coral and fish larvae are investigated among the islands of the archipelago and surrounding island nations. In Chapter 4, distinct reef fish and coral communities across the archipelago are quantified on the basis of overall biodiversity, abundance, and community structure. In Chapter 5, the existing network of MPAs in American Samoa is evaluated based on the habitats, reef fish, and coral communities that are encompassed. Appendices provide analytical details omitted from some chapters for brevity as well as supplemental datasets needed as inputs for the main chapters in the assessment. Appendices include an inventory of regional seamounts, a description of shore to shelf edge benthic maps produced for Tutuila, analytical details of reef fish and coral datasets, and supplemental information on the many marine protected areas in American Samoa.

The main objectives and some key findings of each chapter are as follows:

Chapter 1: Introduction

- Objectives were to introduce the physical setting of the archipelago and describe the scope and main components of the biogeographic assessment.

Chapter 2: Oceanography of the Samoan Archipelago

- Objectives were to summarize regional atmospheric and oceanographic conditions as well as trends in winds, waves, currents, sea surface temperature, chlorophyll, and sea surface height anomalies, and discuss potential influences they may have on biogeography of Samoan reef ecosystems.
- Ocean conditions in the region are characterized by small seasonal fluctuations and often much larger multiyear fluctuations in response to broad climatic cycles such as the Southern Oscillation/El Niño. The major source of variability is seasonal for winds, waves, and sea surface temperature whereas chlorophyll and sea surface height are affected more by interannual processes.

- Nearly all aspects of ocean climate for the archipelago vary more significantly by latitude than by longitude such that all islands except Swains, ~400 km to the north of the archipelago, experience very similar conditions.
- The archipelago has relatively more stable oceanic conditions compared to latitudes to the north and south.
- Key climate related changes include gradual sea level rise as well as periodic low sea level events corresponding to El Niño and also rising surface water temperatures and the threat of coral bleaching.

Chapter 3: Ocean currents and larval transport among islands and shallow seamounts of the Samoan Archipelago and adjacent island nations.

- Objectives were to describe regional ocean currents, identify key sources and destinations of coral and fish larvae for each island, and understand the influence of various combinations of larval life history characteristics on larval connections.
- Major surface currents identified around the archipelago were the meandering westward flow of the South Equatorial Current (SEC) directly across the archipelago (13-19º S), the eastward flowing South Equatorial Counter Current (SECC) (8-12º S) that seasonally (October – April) bifurcates the surface flow of the SEC, and a regularly occurring eddy south of the archipelago centered at ~16º S and 172º W.
- A wide range of larval longevities (10 to 100 days), mortality rates (3-46 % daily mortality), and settlement zones (9 to 36 km from islands) were investigated.
- Major sources of larvae in the region are likely to be the large islands of Samoa, which contribute over twice as many larvae as the smaller islands of American Samoa.
- Current transport is primarily westward along the archipelago such that each island tends to seed its natal reefs (especially with short-lived larvae) and island neighbors to the west (especially with long-lived larvae). In addition, the north coasts of Samoa may seed the islands of American Samoa via the feedback loops connecting the SECC with the SEC for organisms with long larval durations.
- Current orientations and the long distance from upstream islands suggest the archipelago is heavily dependent on internal sources of larvae to sustain reef populations. Predicted connections among islands suggest potential benefits to coordinated management of marine resources and conservation planning between Samoa and American Samoa.

Chapter 4: Biogeographic assessment of fish and coral communities of the Samoan Archipelago.

- Objectives were to identify geographic patterns of hotspots, breakpoints, and spatial trends in reef fish and coral communities among and within islands of the archipelago.
- Analysis focused on six variables: coral cover, coral diversity, coral community structure, fish biomass, fish diversity, and fish community structure.
- Results from 8 studies were combined to determine regions with high, medium, and low values for each variable.
- 30 distinct biogeographic regions with distinct patterns in one or more variables were identified across the archipelago.
- 51 regional hotspots with relatively high values for particular fish or coral variables were identified.
- Regions that were hotspots for several variables were northern, northeastern, and southern Savai'i, Swains Island, Ofu and Olosega Islands, Aunu'u and the eastern tip of Tutuila, southwestern Tutuila, and the Fagamalo area of northwestern Tutuila.
- Regions that were not hotspots for any variables investigated included the Apolima Strait between Upolu and Savai'i, the north coast of Upolu, and parts of the northwest coast of Tutuila.
- Regions that were identified as having unique reef fish and/or coral communities included southern Savai'i, Pago Pago Harbor, Aunu'u, Rose Atoll, and Swains Island.

Chapter 5: The existing network of marine protected areas in American Samoa.

- Objectives were to characterize the reef fishes, corals, habitats, and other key features of each existing MPA, evaluate the distribution of MPA sites in the context of the biogeographic regions and ecological hotspots defined in Chapter 4, summarize the area of reef ecosystem that is currently protected, by bottom type and reef type, and identify potentially important areas not currently in the network. Unlike the

other chapters, analysis was restricted to American Samoa due to the lack of needed input datasets for Samoa. Creation of benthic maps and GIS datasets of MPA boundaries and regulations should be a priority for conservation planning and resource management in Samoa.

- There are 23 MPAs in American Samoa managed by Territorial, Federal, or combined authorities.
- Only 8% of the potential coral reef ecosystem (defined as bottom regions less than 150 m deep) in American Samoa is within existing MPAs. Only 3% has complete no-take restrictions.
- Fourteen of the twenty ecologically distinct biogeographic regions identified around American Samoa include at least one MPA, leaving only six with no representation in the present MPA network.
- High-value regions (those that were hotspots for 3 reef fish/coral variables) represented in the existing MPA network include southwestern Tutuila, the Fagamalo area, and Ofu and Olosega Islands. High-value regions lacking an MPA in the network include Aunu'u, the eastern tip of Tutuila, and Swains Island.
- Regions not currently represented in the existing MPA network that have been identified as having unique reef fish and/or coral communities include only Swains Island and Aunu'u.
- A comprehensive and coordinated MPA network strategy based on the findings of this study and other information is needed to define and accomplish conservation and resource management goals across the entire archipelago.

EXECUTIVE SUMMARY TRANSLATED IN SAMOAN

TALA 'OTO'OTO

Translation provided by Veronika Mata'utia Mortenson. O lenei ripoti ua saunia faapitoa e su'esu'e ai le atoatoa o le olaga faa-natura o meaola o le sami i totonu o le atu-Samoa (~14º S o le ekueta, latalata i le laina o loo sui ai aso o le lalolagi) ma e patino lenei lomiga i tulaga o le tau, fesoota'iga ma isi atu-motu ona o feoa'iga o fua o i'a, faasoasoaina o nofoaga o i'a, ā'au ma 'amu, faapea ma le tulaga o loo iai nei nofoaga faasao o le sami. O Amerika Samoa ma Samoa Tuto'atasi o ni motu e tu lalata ma e masani i le fefa'asoa'i o le tamaoaiga faa-natura, peita'i, o faai'uga ma ni isi o su'esu'ega na faatino i totonu o le atu-Samoa ua le maua iai se maliega ona o le ese'esega o faiga-nuu ma faiga-mālo. O le faamoemoe maualuga o lenei ripoti o le tuufaatasia lea o ni faamaumauga ma faaiuga e uiga i le ola faa-natura i Amerika Samoa ma Samoa. O le oto'otoina o lenei lomiga na tuufaatasia mai i le anoano o su'esu'ega ua mae'a ona fa'asalalau, faapea le taumafaiga e tuu atu iai ma ni isi o faamatalaga lata mai e uiga i nofoaga o meaola o le sami..

O su'esu'ega o loo i totonu o lenei Ripoti ua mafai ona vaevaeina i ni mataupu se 5, faapea ma ni isi o faamatalaga e sapasapai ai mataupu ta'itasi. O mataupu uma ua faamauina, na tusia ma iloiloina e ni isi ua atamai ma iai agavaa faapitoa i le aotelega o lenei tusiga. I le Mataupu 1, o le upu tomua e faailoa ai galuega ma tulaga i loo i totonu o le ripoti. O le Mataupu 2 o loo faamatala ai fesuisuiaiga o le tau, mai molimau a tagata lautele faapea ai ma ni isi o su'esu'ega faa-saienisi. I le Mataupu 3, o le gasologa o le āu ma le femālagaa'i o fua o 'amu ma i'a i le va o Samoa ma isi atu-motu. I le Mataupu 4, o le aofa'iga o i'a-ā'au ua lauiloa ma ituaiga 'amu ese'ese ua mafai ona faavasega i le anoanoa'i ma le felanulanua'i o ituaiga ese'ese. I le Mataupu 5, o le iloiloina o le fesootaiga o gataifale faasao i Amerika Samoa e afua mai lea i le mata'ituina o ituaiga i'a ese'ese ma ituaiga 'amu o loo maua ai. O isi Faamatalaga i le pito i tua o le Ripoti o loo auili'ili atu ai ni isi o mataupu taua. O loo aofia ai foi ma le faitau aofa'i o tama'i mauga o loo i le alititai, faapea faamatalaga o le faafanuaina o le talafatai e oo atu i le alititai, ma ni isi o faamatalaga e uiga i gataifale faasao i totonu o Amerika Samoa.

O le taula'iga ma vaega faapitoa o mataupu ta'itasi:

Mataupu 1: Upu Tomua

- O ta'iala, na faaogaina e faalauiloa ai tulaga o atu-motu ma sa faapea ona faaoga fo'i e faamatala ai le faasoasoaina o meaola i lea motu.

Mataupu 2: Su'esu'ega o le Sami i le atu-Samoa.

- Na faaogaina ta'iala e 'oto'oto ai tulaga o le 'ea ma le sami, faapea ma le tulaga o matagi, o galu, o le tafe o le āu, vevela ma le loloto o le sami – e tau sa'ili ai fesoota'iga o nei mea uma i ā'au ma 'amu o le atu-Samoa.
- O le tulaga ole aga'i i luga ma lalo o le suasami ua mafai nei ona maitauina ona o le vevela o le kelope i le El Niño. O le mafua'aga 'autu o lenei lugā lalō e oso masina pe faa-vāimasina mo matagi, galu ma le vevela o le suasami, a o le a'afia o le maualuga masani o le suasami e oso faa-vāitausaga.
- Se'i vaganā ai le motu o Swains, ~400 km i mātu o le atu-Samoa, e toeitiiti lava tutusa tulaga o le tau i le sami o atu-motu uma e tu lalata i le ekueta.
- O le atu-Samoa e tutusa lelei tulaga o le sami i le itu i matū ma saute o le ekueta.
- O suiga ua tula'i mai i fesuiaiga o le tau e aofia ai le si'isi'i malie i luga o le maualuga masani o le suasami faapea ai ma le maualalo tele ona o le El Niño.

Mataupu 3: O āu o le sami ma le femalagaa'i o fua-o-i'a ma figota i le va o motu faapea tama'i mauga ua ola i le alititai.

- O le 'autū o lenei mataupu o le faamatalaina lea o le ala o āu o le sami, faailo mafua'aga taua o taunu'uga o le femalagaā'i o 'amu ma fua-o-i'a i le va o motu ta'itasi, ma le malamalama'aga i le feso'otaiga o meaola uma o le sami.
- O āu o le sami i totonu o atu-motu ua mafai ona faamau i tusitusiga e aofia ai le South Equatorial Current (SEC) ma e tafe aga'i i sisifo, o le South Equatorial Counter Current (SECC) (8-12º S) e tafe aga'i i sasa'e mai le masina o Oketopa – Aperila ma e vaelua e lenei āu le tafe a le SEC, ma ei totonu o le ~16º i Saute ma 172º i Sisifo.
- O le tele ma le umi o le olaga o fua o i'a (10 i le 100 aso), o le saoasaoa o le faatama'ia o fua-o-i'a (3-46 % i le aso), ma mea o loo ofaga ai (9 i le 36 km mai motu ta'itasi) sa mafai ona su'esu'eina.
- O le anoanoa'i o fua-o-i'a o loo masalomia e tele i motu tetele o Samoa Tuto'atasi, ma fa'aluaina i lo motu laiti o Amerika Samoa.
- O le malaga a fua-o-i'a e tele na aga'i atu i le itu i sisifo ma e 'umi lo latou ola i lo fua-o-i'a e aga'i atu i sasa'e. Ma o le isi, o le tafā-tai i matū o Samoa Tuto'atasi ua mafai ona faafailele ai fua-o-i'a ona toe taamilo mai lea ma aga'i mai i Amerika Samoa.
- Talu ai le mamao o motu, e iai le talitonuga e ao ona faamoemoe le atu-Samoa i fua-o-i'a nei aua le faatupula'ia ma le faaleleia o ā'au. O lenei fesootaiga i le atu-Samoa e aoga tele i le galulue fa'atasi o Samoa-na-lua i le faia lea o faaiuga ma ni maliega 'autasi – aua le puipuia atili o le tamaoaiga a Samoa Tuto'atasi ma Amerika Samoa.

Mataupu 4: Su'esu'ega o ituaiga i'a ma 'amu ese'ese i le atu-Samoa.

- O sini o nei su'esu'ega o le faailo lea o le anoanoa'i o 'auala ese'ese o loo lamatia ai le olaga o i'a ma 'amu i tafātai ma totonu o le atu-Samoa.
- O nei su'esu'ega na faapito i ni vaega se ono: aofa'iga o 'amu, ituaiga 'amu ese'ese, anoano o 'amu ese'ese i se nofoaga e tasi, o le aofa'iga o le mamafa o i'a i se nofoaga e tasi, ituaiga i'a ese'ese, ma le ituaiga nofoaga e ofaga ai i'a.
- O taunuuga o su'esu'ega e 8 na tuufaatasi e tau sa'ili ai poo fea vaega e maualuga, feololo ma maualalo.
- I totonu o le atu-Samoa, e 30 ni nofoaga na mafai ona faailoa ona o le ma'oti o le itua'iga e tasi pe sili atu fo'i.
- E 51 ni vaega vevela o le sami mai maugamu o loo mauluga ai le faitau aofa'i ma le aoga o i'a ma 'amu.
- O vaega vevela o le sami sa tele ai meaola ese'ese o matū, matū-i-sasa'e, ma sauté o Savai'i, Motu o Swains, Ofu ma Olosega, Aunu'u ma itu i sasa'e o Tutuila, faapea le itu i sauté-sisifo, ma Fagamalo.
- O isi nofoaga e le'i agava'a i vaega vevela o le sami e aofia ai le āva i Apolima i le va o Upolu ma Savai'i, le talafātai i matū o le motu o Upolu, ma ni vaega o le gataifale i matū-i-sasa'e o Tutuila.
- O ni isi nofoaga sa mafai ona iloa ai le tutasi o i'a-a'au ma 'amu ese'ese o Savai'i, Pago Pago, Aunu'u ma le Motu o Swains.

Mataupu 5: O le feso'ota'iga o nofoaga faasao o le gataifale i Amerika Samoa.

- O le manulauti, o le faavasegaina lea o ituaiga i'a, 'amu, le mea o loo ofaga ai, ma isi faailo ua tāua mo Gataifale Faasao - i le faatusatusaina lea i eria o loo 'oā i le tamaoaiga e pei ona faailoa atu i le Mataupu 4.

E le pei o isi Mataupu, sa tapula'a su'esu'ega i Amerika Samoa ona e le'i iai ni faamaumauga mai Samoa. O le fausiaina o ni ata ma faafanua o le alititai e tatau ona tapena iai Samoa, faapea ma ni faamaumauga (GIS) e iloa ai tonu tuā'oi ma tulafono i le puipuiina o le tamaoaiga.

- E 23 ni gataifale faasao o loo iai nei i Amerika Samoa, ma o loo pulea e le Teritori, Malo Feterale, ma isi pulega.
- Na o le 8% o ā'au (e faauiga o nofoaga o loo i le loloto e 150 m) i Amerika Samoa ei totonu o gataifale faasao. E na o le 3% e le mafai ona fagotaina.
- Mai i le sefulufa o nofoaga faapitoa ua mafai ona tāmau i faamaumauga i Amerika Samoa, o loo iai lava se Gataifale Faasao se tasi i totonu o lenei sefulufa, ma e ono e le o maua iai ni faamaumauga i le fesootaiga o gataifale faasao o loo iai nei.
- O nofoaga o loo maualuga le oā o puna'oa (le vaega sa 'avea ma tulaga vevela o le sami mo i'a ma 'amu ese'ese) i totonu o Gataifale Faasao e aofia ai le itu i saute-sisifo o Tutuila, Fagamalo, ma Ofu & Olosega. O nofoaga o loo maualuga ai puna'oa e le o mafai ona tuu i totonu o le fesootaiga o gataifale faasao a Amerika Samoa e aofia ai Aunu'u, le itu i sasa'e o Tutuila faapea ai ma le Motu o Swains.
- O nofoaga o loo tutasi ma tele ai le tamaoaiga, ma e le o iai i totonu o le li'o o Gataifale Faasao e aofia ai na'o le Motu o Swains ma Aunu'u.
- O loo mana'omia ni faamaumauga maumaututū e uiga i le fesootaiga o Gataifale Faasao, ina ia mafai ona aoga i le uiga ma ni taunuuga lelei o le faasao ma puipui atili o le tamaoaiga faa-natura i le atu-Samoa.

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Introduction to the Biogeographic Assessment

Matthew S. Kendall[1]

This report provides an assessment of the marine biogeography of the Samoan Archipelago with a focus on oceanography, reef fish, and coral communities. Biogeography examines the distribution of biota and their habitats as well as the environmental factors that have shaped them. Biogeographic characterizations are among the basic information inputs required not only for making informed management decisions but also building public support for them.

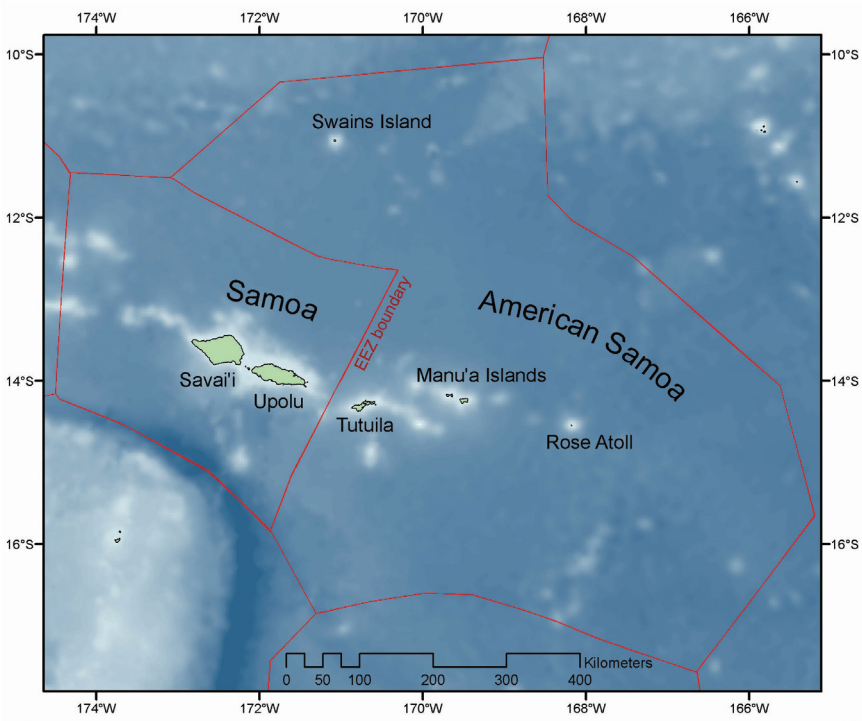

Figure 1.1. Samoan Archipelago study region.

The Samoan Archipelago lies in the South Pacific Ocean along ~14º S latitude at the international date-line (Figure 1). The archipelago is comprised of a chain of volcanic islands, seamounts, and coral atolls and is divided into two countries: Samoa and American Samoa. The much larger islands of Savai'i and Upolu comprise most of the independent nation of Samoa, formerly called Western Samoa. American Samoa (a Territory of the United States) is made up of the comparatively medium sized island of Tutuila, the smaller islands of the Manu'a group, and the two small, remote coral atolls of Swains Island and Rose Atoll that are not derived from the same volcanic hotspot as the rest of the island chain.

Many prior assessments have touched on the biogeography of either Samoa or American Samoa and are cited throughout this document. The present report builds upon these earlier assessments by combining and re-analyzing their original datasets, adding more recent biogeographic data sources, and by combining and re-interpreting their individual findings into a multidisciplinary summary of marine biogeography.

Despite their close proximity and shared resources, management decisions and prior assessments in the region have typically been split along the international political boundary between Samoa and American Samoa. In contrast, a key goal in this assessment was to compile data from both areas and to conduct the characterization across the entire archipelago. Results of the assessment are intended partly to support the "2 Samoa's Initiative", a recent cooperative agreement between the two jurisdictions that seeks to foster improved collaboration, coordination, and information exchange on natural resource management and other topics. The Governments of Samoa and American Samoa should be contacted directly for more information on the current status of this unfolding initiative.

Of note, much of the data used in this assessment was collected prior to the September 2009 tsunami that devastated some shallow water and low lying segments of the archipelago. Most parts of this assessment however, were conducted at a broad analysis scale and the types of data used were not highly sensitive to this significant and anomalous natural disturbance. For more information on tsunami impacts, interested readers are directed to specific studies that were conducted to evaluate the extent and severity of damage due to that event.

[1] NOAA/NOS/NCCOS/CCMA Biogeography Branch

A key application intended for the report is to provide guidance in the ongoing development of a network of Marine Protected Areas (MPA) in the Samoan Archipelago. The region is already home to a diversity of MPAs implemented at various levels of government from individual villages and communities to federally protected areas of international significance. Many of the different MPAs in the network were created through independent processes for different objectives but each contributes to the mosaic of marine resource management in the region. Understanding what fish, coral, and habitat resources this diverse network of MPAs collectively encompasses is a key objective of this work and is critical for understanding the scope of current protection and thoughtfully designing additional network elements.

Image 2. Reef fish sold in a local grocery.
Photo: Matt Kendall, NOAA Biogeography.

As a result of discussions with project partners in the design phase of the assessment, this report focuses on corals and reef fish, transport of their larvae, and the reef habitats where they live. Additional aspects of biogeography that are not included in this assessment but are important to the region and Samoan culture include sea birds, cetaceans, deep coral habitats, and pelagic fish communities to name but a few. Including these resources was beyond the scope of our assessment although they have been investigated in several individual studies that should be consulted for more information.

The assessment is divided into 5 chapters with supporting appendices. Each chapter was based on compilation of multiple pre-existing datasets, original analysis, and discussion that has not been previously published. Each chapter was written or reviewed in collaboration with subject matter specialists and local experts. Here in Chapter 1, the overall scope and approach of the report is introduced. In Chapter 2, regional ocean climate is characterized including wind and wave climate, sea surface temperature, primary productivity, and sea level fluctuations. The focus is on the spatial and temporal patterns and trends in ocean climate that may affect marine biogeography. In Chapter 3, regional ocean currents and transport of coral and fish larvae are investigated among the islands of the archipelago as well as the surrounding island nations. The degree of self seeding versus dependency on outside sources of fish and coral larvae for maintaining each islands reef ecosystem is quantified. Major and secondary sources of larvae for each island are discussed in terms of resilience of reefs to disturbance. In Chapter 4, the reef fish and coral communities of the archipelago are quantified on the basis of overall biodiversity, abundance, and community structure. Biogeographic trends, breakpoints, and hotspots are identified among and within each of the islands in the archipelago. In Chapter 5, we summarize the existing network of MPAs in American Samoa based on their habitats, reef fish, and coral communities. Presently protected features are compared to regional resources, and remaining gaps in resource protection are highlighted. Appendices include analytical details omitted from some chapters for brevity as well as important secondary analytical products needed as inputs for the main chapters in the assessment. This includes an inventory and summary of regional seamounts needed for the larval connectivity chapter (Chapter 3), analytical details of the reef fish and coral datasets (Chapter 4), a description of the shore to shelf edge benthic maps created and used for the MPA network analysis (Chapter 5), and supplemental information on the many marine protected areas in American Samoa (Chapter 5).