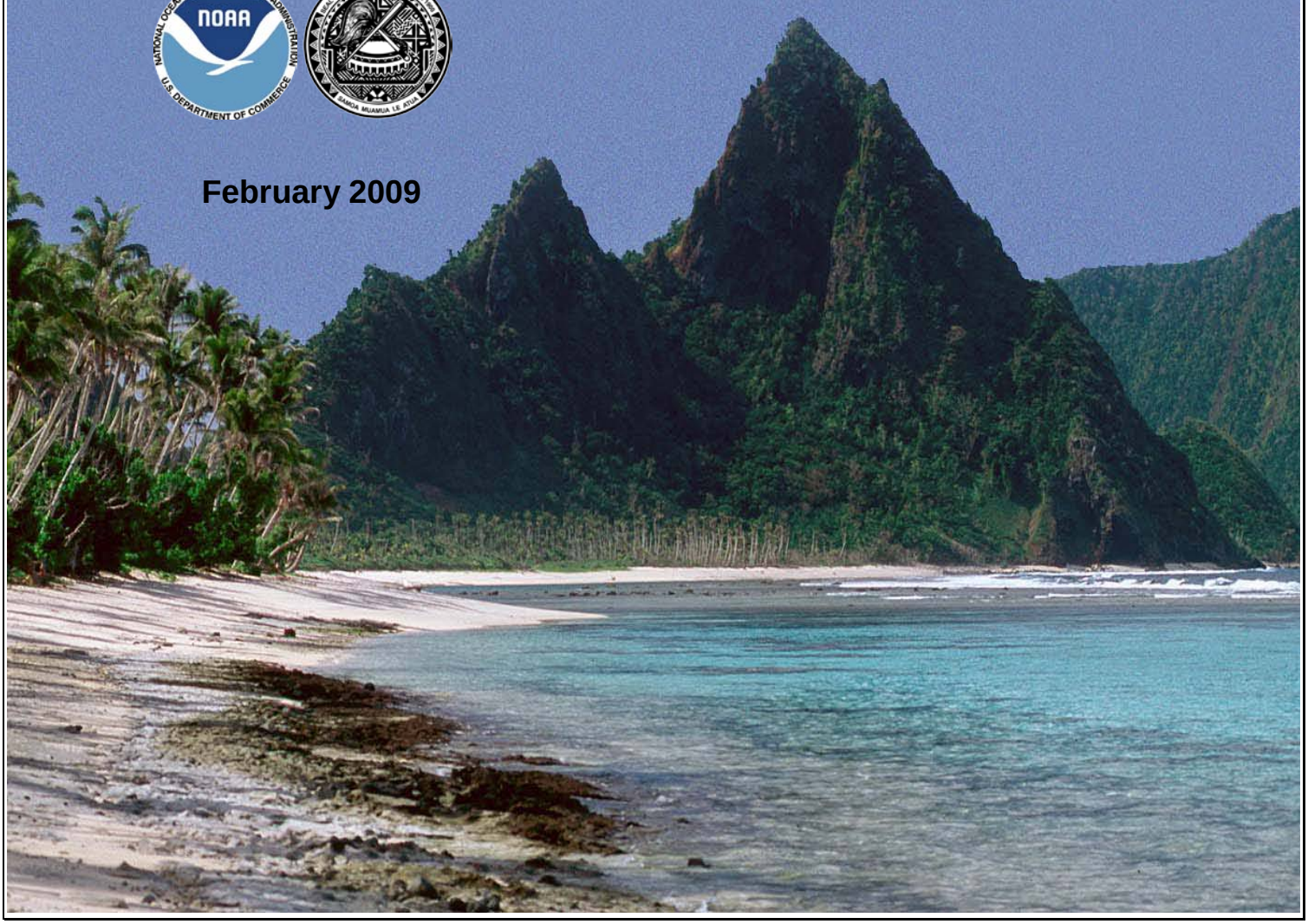
Project Work Plan

Biogeographic Assessment of the American Samoa Archipelago: Creating the Basis for a Network of Marine Protected Areas

A cooperative investigation between NOAA and American Samoa

February 2009



About this document

This draft document was created to inform project partners and other interested groups and individuals about the planned biogeographic assessment activities in American Samoa. The document is intended to serve as a road-map for project tasks and to provide examples of potential products. For more information on this study and the complementary projects listed below please contact the Center for Coastal Monitoring and Assessment's (CCMA) Biogeography Branch at 301-713-3028, visit:

http://ccma.nos.noaa.gov/about/biogeography/welcome.html or contact mark.monaco@noaa.gov

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Complementary projects supported by the Office of the National Marine Sanctuaries and NCCOS: http://ccma.nos.noaa.gov/about/biogeography/welcome.html

- A Biogeographic Assessment off North/Central California for the Office of National Marine Sanctuaries: Phase 1- Marine Birds, Fishes and Mammals, Phase 2- Mammals and Birds
- Biogeographic Assessment of the Channel Islands National Marine Sanctuary to Support Boundary Alternative Assessments
- Boundary Options for a Research Area within Grays Reef National Marine Sanctuary
- Characterization of the Fish, Benthos, and Marine Debris at the Grays Reef National Marine Sanctuary
- Biogeographic Assessment of Stellwagen Bank National Marine Sanctuary
- Biogeographic Assessment of the Northwestern Hawaiian Islands to Support the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve
- Oceanographic Assessment of Olympic Coast National Marine Sanctuary

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Project Summary

The proposed collaborative project will provide information to help identify candidate areas for a network of marine protected areas within the American Samoa archipelago. The project will complement the ongoing Fagatele Bay National Marine Sanctuary (FBNMS) management plan review. In addition, the project will directly support the Territory's goal of identifying 20% of their coral reefs for designation as no–take marine protected areas. The planned assessment includes biological, oceanographic, and human dimension components and will serve as a prototype for assessments in other areas of the Pacific. Planned products include geospatial analyses and maps depicting the spatial and temporal distribution of selected marine species; species assemblages; socioeconomic patterns; identification of biologically significant areas; and delineation of a potential network(s) of marine protected areas based ecological, socioeconomic, and cultural information.

Background

American Samoa consists of five high-volcanic islands plus two low-lying atolls (Figure 1). The volcanic islands are part of a hotspot chain which also includes two larger volcanic islands of the independent nation of Samoa to the west as well as an active undersea volcano to the east. These islands typically have narrow reef flats (50-500 meters), fringing reefs, and steep offshore banks dropping to oceanic depths within 0.5-8 kilometers from shore. The archipelago lies within the South Equatorial Current which is characterized by warm (28-30 °C), westward flowing, highly oligotrophic tropical surface waters, with a deep thermocline (~120-200 m). Winds are generally light and variable during the austral summer rainy season except during occasional cyclones. Consistently stronger trade winds from the east-southeast dominate in the other seasons.

The capital of American Samoa is Pago Pago, located on Tutuila, the largest island of the territory. Tutuila has a land area of approximately 56 square miles and is home to over 90 percent of the territory's total population of 65,000. The harbor at Pago Pago is one of the deepest and best protected in the South Pacific. The total land area of all seven islands is 76 square miles.

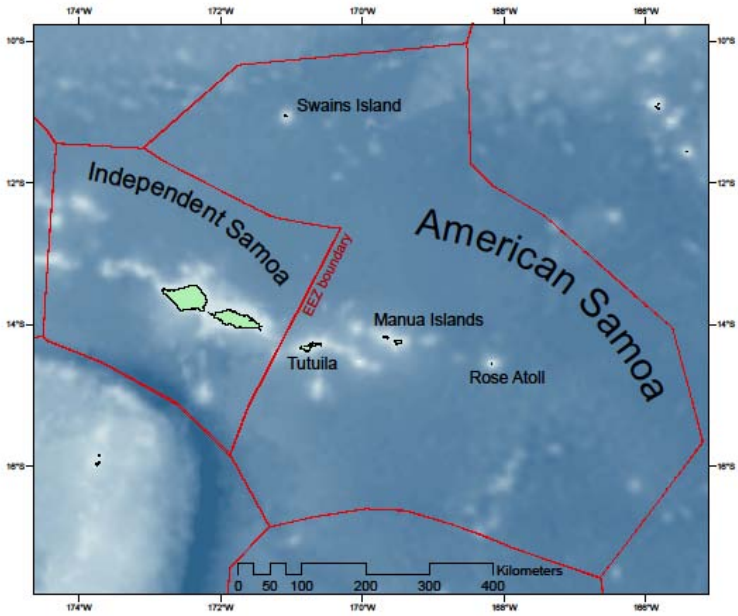


Figure 1. Study region

The primary economy of American Samoa consists of government activities and tuna canneries which each comprise one-third of the total employment respectively. The remaining one-third of employed workers is in the secondary economy, which consists mainly of retail and service enterprises.

There are three types of fisheries in American Samoa, two of which harvest coral reef fishes and invertebrates:
1) subsistence fishing by villagers, which is usually a shoreline activity using a variety of gear, such as rod and reel, spear guns, gillnet, and gleaning;
2) artisanal fishing by free-divers who spear fish, and small-boat fishers who jig for bottomfish around the steeply

sloping islands. Most of these fish are sold at local stores. Subsistence fishing has been declining over the past two decades as a result of the gradual change from a subsistence to a cash-based economy. 3) a pelagic fishery includes small longline boats and large commercial boats that deliver tuna and other pelagics to the local canneries.

The Proposed Study

Several complementary activities related to MPAs in the Samoan Archipelago are presently underway and provide the impetus for the proposed regional Biogeographic Assessment (Figure 2). Fagatele Bay National Marine Sanctuary is engaged in a review and update of their management plan including consideration of border modification to potentially expand or include multiple sites thereby forming an American Samoa National Marine Sanctuary Network (ASNMSN). In addition, the government of American Samoa is considering a Territorial MPA Network Strategy that will identify preferred sites to include in a no-take network consisting of 20% of the territory's reefs (Oram 2008). Last, American Samoa and the independent nation of Samoa are engaged in an initiative to identify shared environmental problems, exchange management approaches, and consider resources that would benefit from coordinated management. Such resources may include a network of MPAs throughout the entire Samoan Islands archipelago.

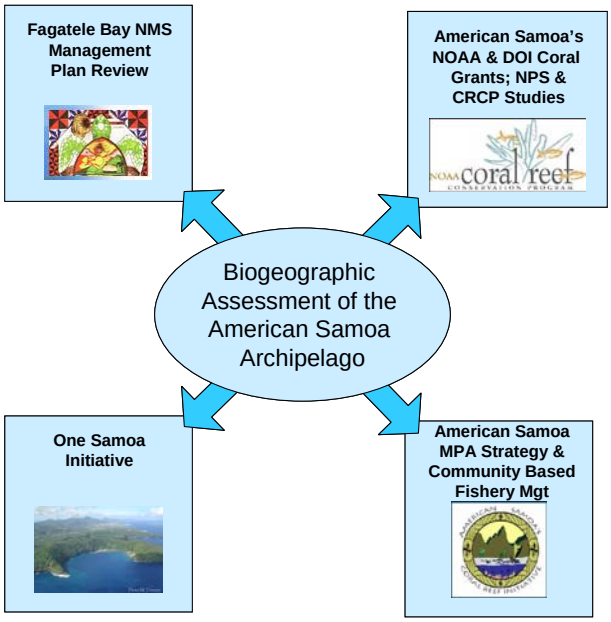


Figure 2. MPA activities in American Samoa

Project kickoff meetings for the proposed assessment were held in American Samoa the week of April 28, 2008. At a series of meetings, NOAA met with local groups to brief them on the potential work and obtain initial feedback on project design and objectives. First, NOAA briefed the Coral Reef Advisory Group and FBNMS Advisory Council. Both groups expressed support for the project and recognized the linkages and benefits to their own needs and activities. Next, a more focused series of meetings and site visits were held between NOAA and several staff with the American Samoa Department of Marine and Wildlife Resources, the American Samoa Environmental Protection Agency, and the National Park Service to discuss data availability. At these meetings, accessible datasets were transferred, other key datasets were identified for later acquisition, and points of contact were identified for data transfer and collaborative analysis. The final meeting of the week was with the Governor of American Samoa. At this briefing, NOAA and local project partners presented a unified project plan, summary of the week's productive meetings, and a commitment to collaborate on common objectives including resource assessment and MPA network design. Overall, the project kickoff meetings resulted in agreement among Federal and Island partners to move forward with development of a project concept plan (Kendall et al. 2008a) that conveys the emerging consensus on project scope and ultimately a project work plan (this document) that describes the technical aspects of the assessment and serves as a road map for implementation. The next set of meetings were held the week of August 17, 2008 in American Samoa and resulted in initial data compilation and agreement on the conceptual document.

General Approach

The assessment will consist of three interrelated components: biogeography, human dimensions, and MPA network design as shown in the project flow chart below (Figure 3). The assessment will provide spatially explicit depictions of ecological resources, oceanographic patterns, socioeconomic concerns, and the relationships among them. These factors represent a primary information need for marine and coastal management decisions.

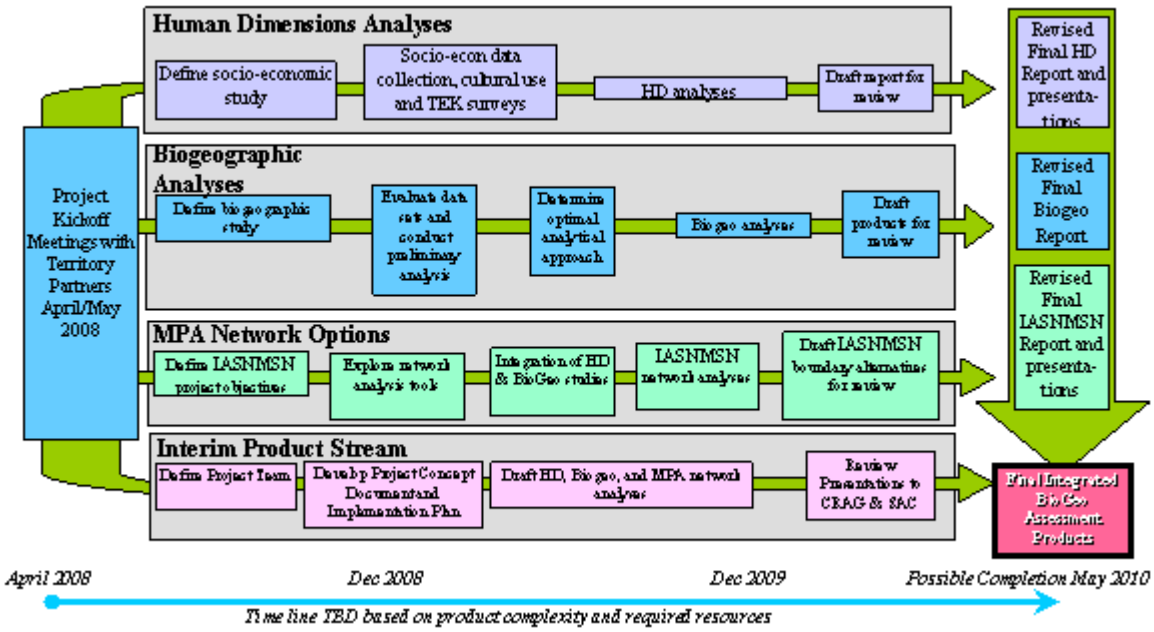


Figure 3. Project flowchart and approximate timeline

Many stages in the project require close collaboration and information exchange among project partners. To facilitate information exchange among project partners in various time-zones a password protected website will be established. The website will be used to share documents, data files, draft products, and other information in electronic formats. In American Samoa, it is also critically important to establish appropriate communication at the village level and through the Office of Samoan Affairs. Suggestions for marine resource management must be made to village leaders to obtain feedback, establish mutual understanding, and ultimately for successful implementation (Coral Reef Advisory Group 2002). For this, communication mechanisms traditional to Samoa must be relied upon (Brighouse 2001).

Objectives

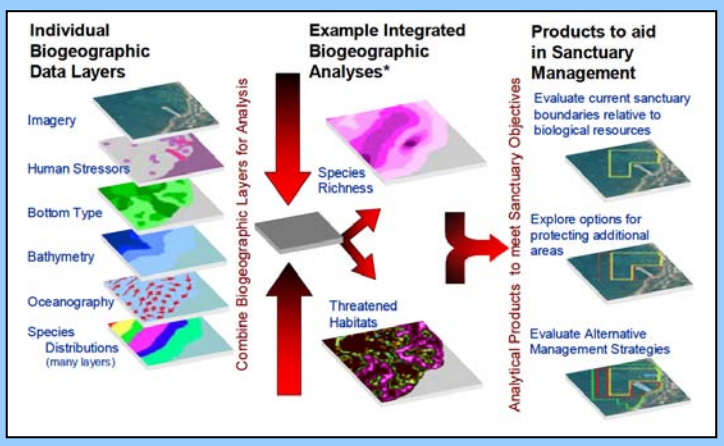
1. Identify and synthesize relevant biological, physical, and socioeconomic data sets for the study area. Organize the data into a common framework within a geographic information system (GIS).
2. Provide spatial and temporal biogeographic analyses of shelf features, reefs and associated bottom types, fish assemblages, and oceanographic variables.
3. Identify the resource users (subsistence fishermen, consumptive divers, eco-tourism, etc.), extent of use (person-days of recreational activity, fishing catch, etc.), spatial distribution of resource use, and how much income, if any, is dependent upon the resources.
4. Provide alternative boundary scenario's for a network of protected areas that is integrated with all Samoan MPA initiatives.

5. Support FBNMS staff in the integration of biogeographic assessment products into their management plan review.
6. Support FBNMS staff and its partners in using biogeographic analysis for developing the Rose Atoll Marine National Monument management plan.

What are Biogeographic Assessments?

The mission of NOAA's Office of National Marine Sanctuaries (ONMS) is to serve as the trustee for a system of marine protected areas, to conserve, protect, and enhance biodiversity. To assist in accomplishing this mission, the ONMS has developed a part-nership with NOAA's Center for Coastal Monitoring and Assessment (CCMA) to conduct biogeographic assessments of marine resources within and adjacent to the marine waters of NOAA's National Marine Sanctuaries (Kendall and Monaco 2003, Monaco et al. 2005).

Biogeography is the study of spatial and temporal distributions of organisms, their associated habitats, and the historical and biological factors that influence species' distributions. Biogeography provides a framework to integrate species distributions and life history data with information on habitats of a region to characterize and assess living marine resources within a sanctuary. The biogeographic data are integrated in a Geographical Information System (GIS) to enable visualization of species' spatial and temporal patterns, and to predict changes in abundance that may result from a variety of natural and anthropogenic perturbations or management strategies. The complexity of products from biogeographic analysis range from simple species distribution maps or a particular habitat, to more complex products that combine single data layers to create maps of biodiversity or habitat complexity.



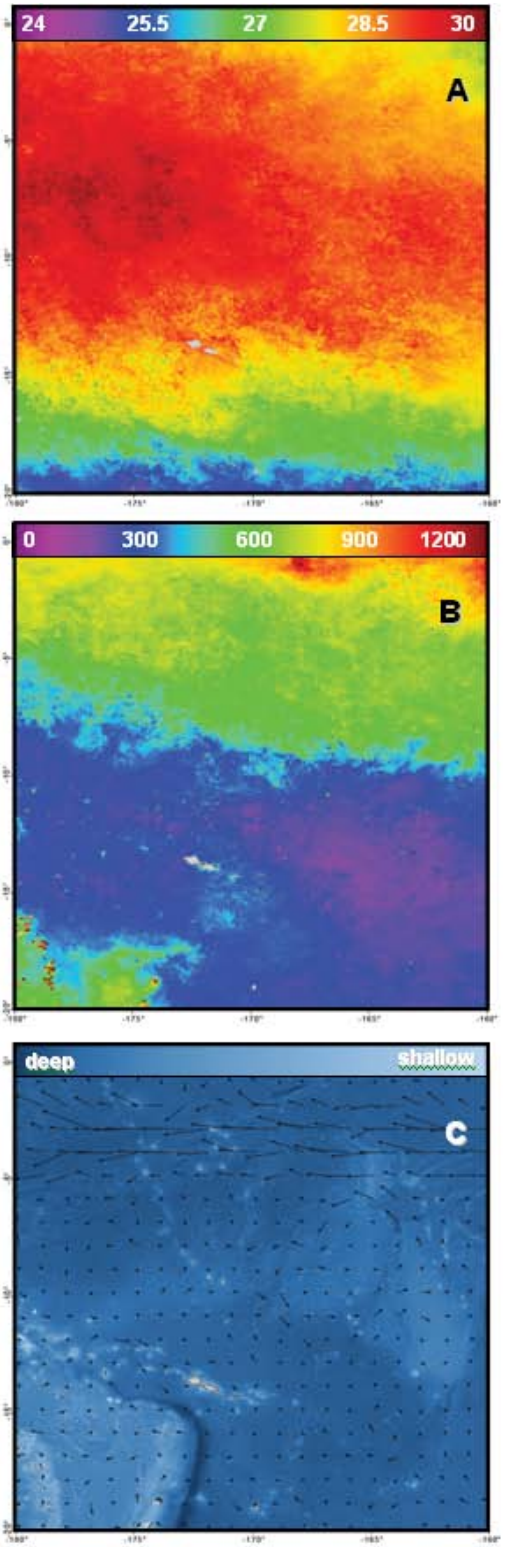
The biogeographic assessment approach was developed by CCMA's Biogeography Branch in consultation with the ONMS in 2003. Typically a biogeographic assessment is comprised of the three primary activities: 1) compile individual biogeographic data layers, 2) perform integrated biogeographic analyses, and 3) develop products to aid in management. A key tool used to develop and implement the assessment is the use of GIS technology which aids in data compilation, spatial analyses, and visualization of results to support place-based management needs. The assessment process shown below is based on geospatial and temporal analyses of existing physical and biological data and has resulted in many spatially-oriented products that assist help managers in understanding how ecosystems function. Often biogeographic analyses focus on determining the strength of coupling between habitats and species and defining discrete areas of biological significance.

Examples of expected products that address each of the above objectives are presented below. Some of the examples provided are drawn from similar assessments completed for other National Marine Sanctuary sites. Others are based on preliminary analysis of data for American Samoa. In both cases, examples are meant to serve as conceptual illustrations of the type of work undertaken during the process. The project objectives and examples of potential products are followed by a list of specific tasks that will be undertaken to meet project objectives and develop the associated products.

Objective 1. Identify and synthesize relevant biological, physical, oceanographic, and socioeconomic data sets for the study area. Organize the data into a common framework within a geographic information system (GIS).

The first step in the biogeographic assessment process involves the identification and initial evaluation of data sets currently available for the study area (Appendix A). These are the basic building blocks of the assessment and will dictate the types of analyses that can be completed. The main types of data sought for this assessment include biological, oceanographic, and socioeconomic. A key goal for each type of data is synthesis into the most continuous and comprehensive spatial coverage for the study area as possible.

Oceanography: Oceanographic variables are important determinants of the structure of many marine ecosystems and species distribution patterns. The islands and seamounts of American Samoa are spread over a vast region of the south Pacific and two archipelagos. Currents, fronts, temperature, and other oceanographic parameters not only dictate some differences among islands but also are needed to place American Samoa into its broader context in the south Pacific. Important data sources for American Samoa include *in situ* sensors (CRED) and satellite data. Seasonal and long term patterns in these and other oceanic variables are a primary product of the assessment.



Example regional sea surface temperature (degrees Celsius; A), primary productivity (mg of carbon per m^2/day; B), and surface currents (arrows indicate direction, length indicates strength; C) during July, 2007.

Figure 4. Snapshot oceanographic datalayers.

Benthic Maps: Benthic variables such as bottom type, shelf zone, and bathymetry are also important determinants of the structure of many marine ecosystems and species distribution patterns. The steep nearshore environment of American Samoan islands has resulted in a highly compressed series of habitats relative to the broader insular shelves that are found elsewhere. Recently the zonation, structure, and cover of these habitats were delineated from satellite imagery (NOAA). Deeper banks connected to these nearshore coral reef ecosystems and seamounts were mapped using multibeam sonar which yielded detailed depth and backscatter surfaces (PIBMC 2007). These data sources can be stitched together to form a more comprehensive understanding of important seafloor features in the study area and used as layer to predict associated species distributions.

Figure 5 below is from the Pacific Islands Benthic Habitat Mapping Center (PIBHMC 2007). They have developed a GIS project with a diversity of benthic data layers including multibeam bathymetry, backscatter imagery, hyperlinked underwater photographs and/or video still framegrabs of the benthos, seafloor classification results of living cover and substrate from optical imagery and towboard diver observations, depth contours, layers of geomorphic information (slope, rugosity, Bathymetric Position Index (BPI) Structures, and BPI Zones), digital NOAA nautical charts, Ikonos satellite imagery where available, and terrestrial topography. The intent behind creating the database is to enable easy access, combination, and analysis of multiple data layers in addressing resource management issues. These datalayers and other benthic maps of the region are essential building blocks of the assessment.

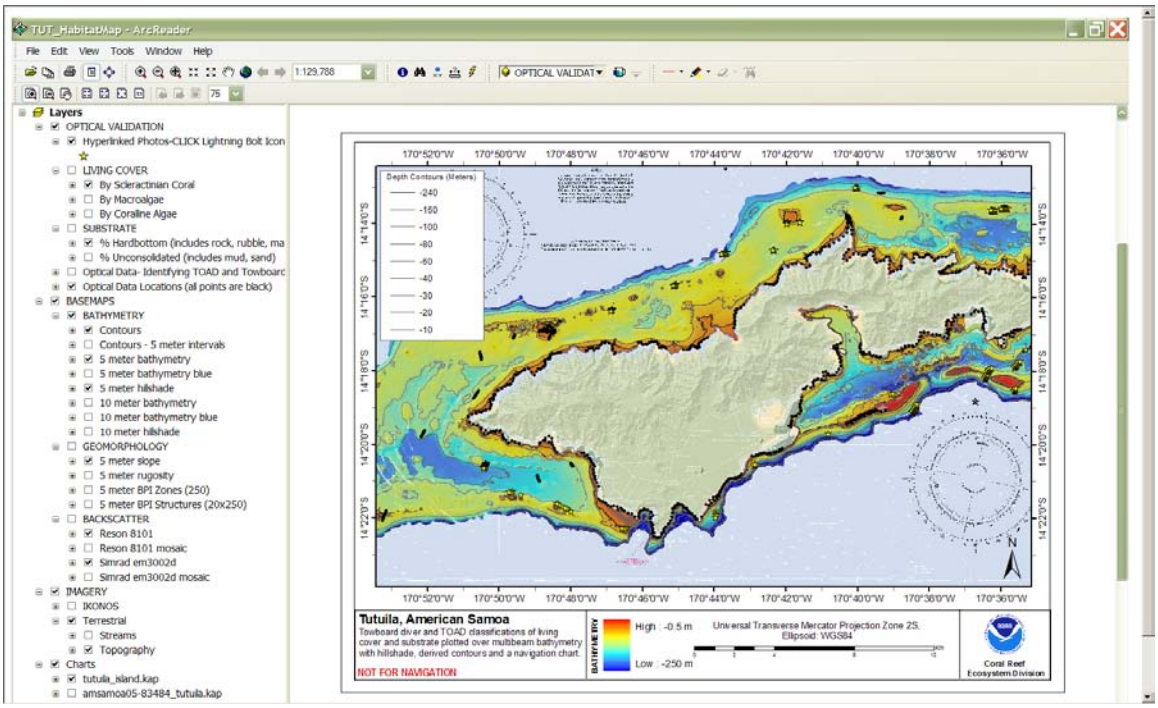


Figure 5. Habitat mapping database created by the Pacific Islands Benthic Habitat Mapping Center (2007).

Objective 2. Provide spatial and temporal biogeographic analyses of shelf features, reefs and associated bottom types, fish assemblages, and oceanographic variables.

The biogeographic analyses are the core of the investigative process and the basis for the layering of multiple data types and more complex analyses. Multiple data layers will be used to investigate the ecological linkages between species and habitats, larval transport probabilities among islands and, where possible, identify temporal differences in species distributions. Previous biogeographic assessments have relied on both the availability of robust data and modeling techniques that attempt to fill in data gaps through the use of geo-spatial modeling techniques (e.g. surface interpolation, kriging).

Fish assemblages have been investigated among the islands of American Samoa by a number of researchers and organizations over the years (Figure 6). Together, the suite of data provides a powerful assessment of fish resources. Monitoring sites around American Samoa that contributed to the 2008 State of the Coral Reefs report are shown in the figure at right (Fenner et al. 2008) and will be among the datasets examined for the assessment.

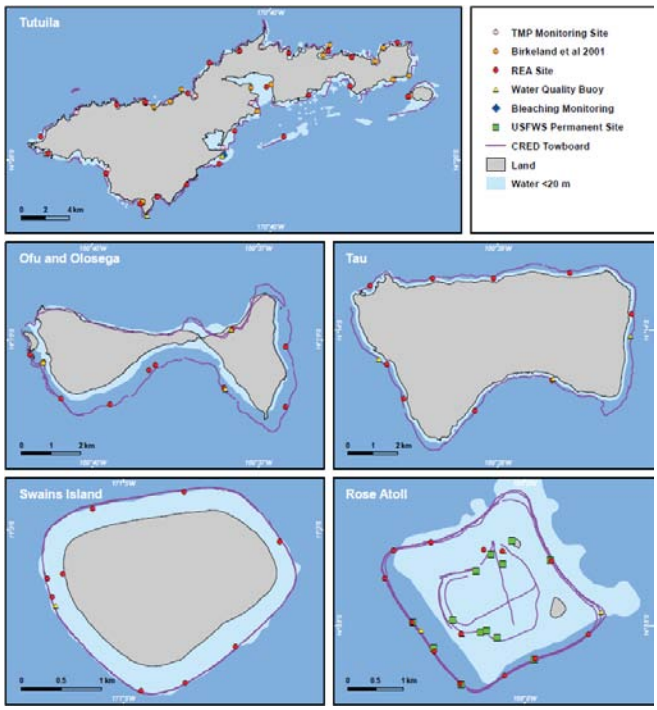
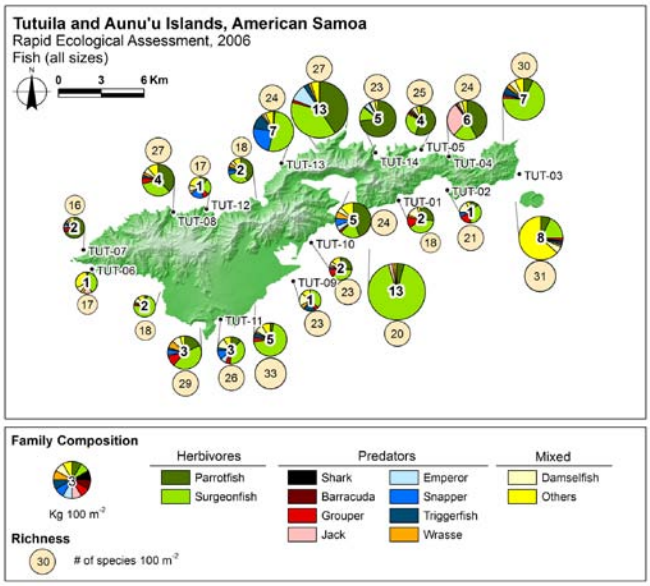


Figure 6. Monitoring activities in American Samoa (source: Fenner et al. 2008).



One such dataset, shown at left in Figure 7, presents total fish biomass, family composition, and species richness of fishes around Tutuila and Aunu`u recorded during American Samoa Reef Assessment and Monitoring Program 2006 Rapid Ecological Assessment belt-transect surveys (Brainard et al. 2008). Such datasets may be combined to enable a continuous prediction surface of fish assemblages around the islands.

Figure 7. Rapid ecological assessment data for fish (source: Brainard et al. 2008).

Larvae of some corals and fish are transported among islands by ocean currents. Understanding how islands are connected to each other through such currents is a key factor shaping biogeography and must be considered in development of regional conservation planning. In the south Pacific, currents have been measured by a variety of means such as drifter buoys in recent years. The drift tracks of buoys deployed off American Samoa illustrate the variability of surface currents and can be used to estimate the connectivity among islands within and outside of the Samoan archipelago.

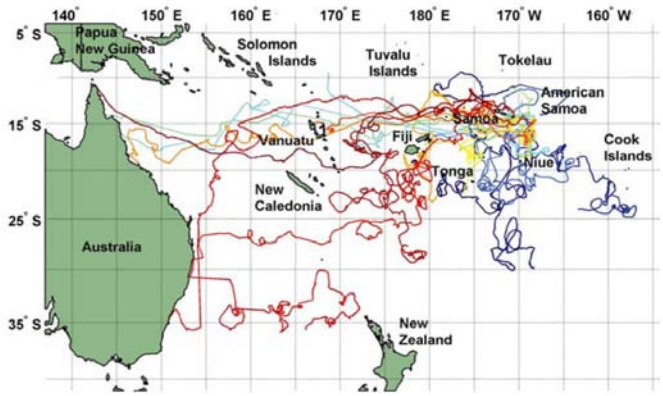


Figure 8. Buoy drift tracks (source: P. Craig, NPS; R. Brainard and E. Smith, NOAA-CRED).

Potential larval transport among islands in the Hawaiian Archipelago was recently investigated using high-resolution geostrophic current data and computer simulation (Kobayashi et al. in review). Dispersal probability plots demonstrate the percent of larval supply originating from an island that may be retained versus transported to adjacent regions (Figure 9). A similar approach may be used to explore island connectivity across the America Samoa Archipelago.

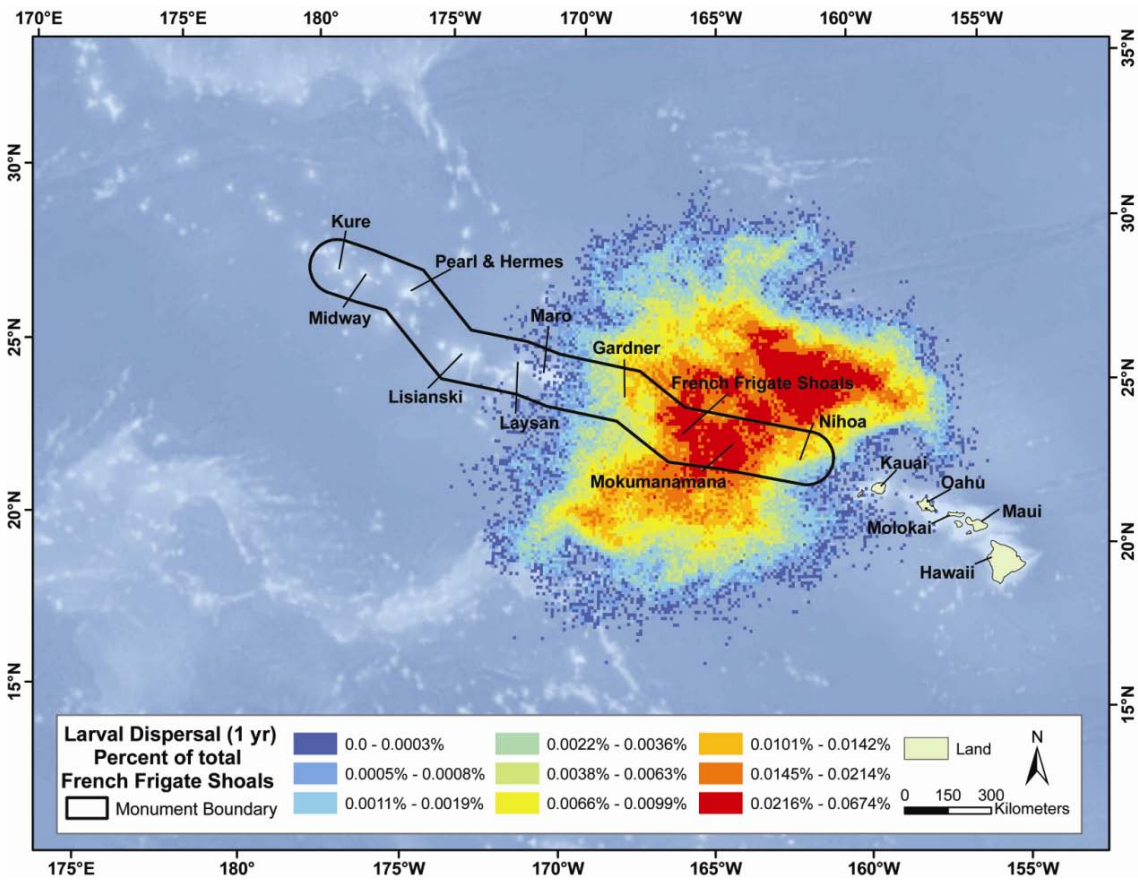


Figure 9. Dispersal probability plot for larvae originating from French Frigate Shoals (Source: Kobayashi et al. in review)

Objective 3. Identify the resource users (subsistence fishermen, consumptive divers, eco-tourism, etc.), extent of use (persondays of recreational activity, fishing catch, etc.), spatial distribution of resource use, and how much income, if any, is dependent upon the resources.

DMWR began working with local communities on the island of Tutuila in 2001 to develop the Community Based Fisheries Management Program (Sauafea-Ainu'u 2002). Through a series of meetings with representatives from select villages, DMWR sought the voluntary participation of communities in an effort to manage and monitor their own coral reef resources. The program has grown to include eight villages, each of which is responsible for all aspects of managing and monitoring their own resources, with technical assistance from DMWR. Committees from each village have designed and implemented management plans which vary from village to village, but generally include some type of restriction on fishing activity on part of or the entire reef fronting their villages. Monitoring associated with the program has yielded information that will be applicable to many parts of the biogeographic assessment including the socioeconomic analyses. For example, Figure 10 at left shows the average number of individuals on reef flat transects at each of the participating villages.

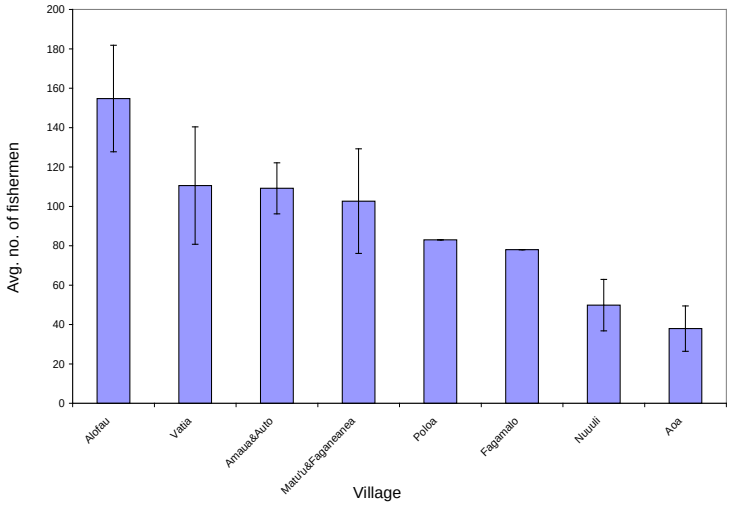


Figure 10. Average number of fishermen seen by village (Source: AS DMWR)

Another type of data collected by DMWR essential for the socioeconomic analysis is creel surveys. Information includes total landings by fishing gear type for each village. Figure 11 shows total pounds by gear type for all villages in 2005 and 2006. The information is needed to determine extent of resource use, spatial patterns among villages, and to predict the impact of potential changes in resource management.

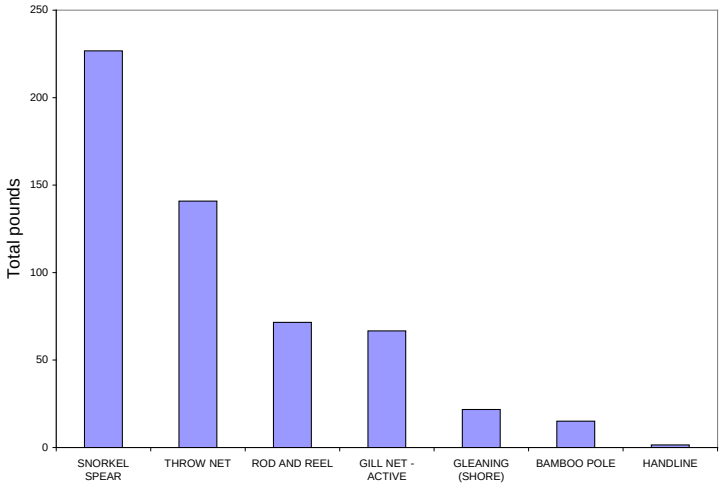


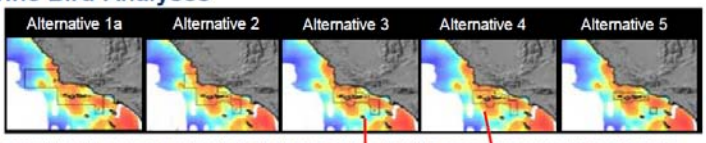
Figure 11. Landings by gear type (Source: AS DMWR)

Objective 4. Provide alternative boundary scenarios for a network of protected areas that is integrated with all Samoan MPA initiatives.

Once the individual biogeographic and human dimension data layers and analyses are complete, a diversity of spatial analysis techniques can be applied for the purposes of evaluating management alternatives such as MPA zoning, boundaries, or network design. An ever-increasing variety of generalized software programs are available to support such analysis and will be considered (e.g. MARXAN, PANDA). Often however, experience has shown that a more customized analysis framework and process is needed to best meet the needs of each unique local situation (Kendall et al. 2008b). This is likely to be true for American Samoa as well to incorporate the local realities of an existing suite of MPAs, village level management and acceptance, and the desire for an integrated network design (Coral Reef Advisory Group 2002).

In the Channel Islands NMS, six different alternative boundary proposals were evaluated in relation to their predicted impact on various species assemblages (NOAA 2005). The analysis used a concept called the Optimal Area Index (OAI) to demonstrate the increase in protection for marine resources from boundary alternatives while taking into account change in area from current boundaries. In this way, managers can easily grasp the potential ecological value of proposed boundary modifications to various taxa from a spatial perspective. Figure 12 at left shows the analysis of the potential value of boundary alternatives for the Channel Islands NMS in relation to their benefit for conservation of marine bird species (NOAA 2005).

Marine Bird Analyses



OAI represents the relative increase in ecological metric for alternative, divided by the relative increase in area compared to current boundaries

Alternative	Area (km²)	Mean Bird Diversity	High Diversity Area (km²)	Δ Area (%)	Δ Mean Diversity (%)	Δ High Diversity Area (%)	Mean Bird Diversity OAI (relative)	High Diversity Area OAI (absolute)
NAA	3745	1.485	2284	-	-	-	-	-
5	4536	1.487	2812	21	0.13	23.12	0.00638	1.094
4	7981	1.523	5507	113	2.56	141.11	0.02262	1.348
3	9044	1.53	6421	141	3.03	181.13	0.02141	1.28
2	13736	1.502	8791	267	1.14	284.89	0.00429	1.068
1a	22591	1.372	10391	503	-7.61	354.95	-0.01512	0.705
1	22613	1.375	10401	504	-7.41	355.39	-0.0147	0.705
SA	17093	1.489	9914	356	0.27	334.06	0.00076	0.937

$$\text{Optimal Area Index (OAI)} = \frac{(B_1 - B_0)/B_0}{(A_1 - A_0)/A_0}$$

B_1 and B_0 are the value of the ecological metric (e.g. sightings, diversity, richness, etc.) within the boundary alternative and the current boundaries respectively, and A_1 and A_0 are the respective areas.

Figure 12. Example OAI analysis for marine birds at CINMS (Source: NOAA 2005)

Territorial MPA initiatives have been moving rapidly in recent years (Coral Reef Advisory Group 2002; Hawkins 2003; Oram 2006; 2008). The Coral Reef Advisory Group (2002) and DMWR (Oram 2006, 2008) have been working to define placement criteria and goals for the territorial MPAs. Workshops have been conducted to define biologically significant areas in the territory that could be considered in MPA planning (Figure 13)(also see Figure 2 and Appendix 2 in Oram 2008). The territorial master plan has been established and defines four sequential phases of the MPA process: research, candidate, proposal, and implementation. Evaluation of candidate sites is underway.

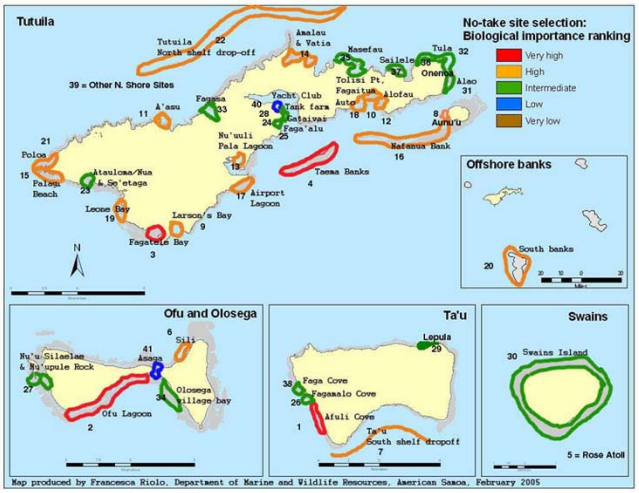
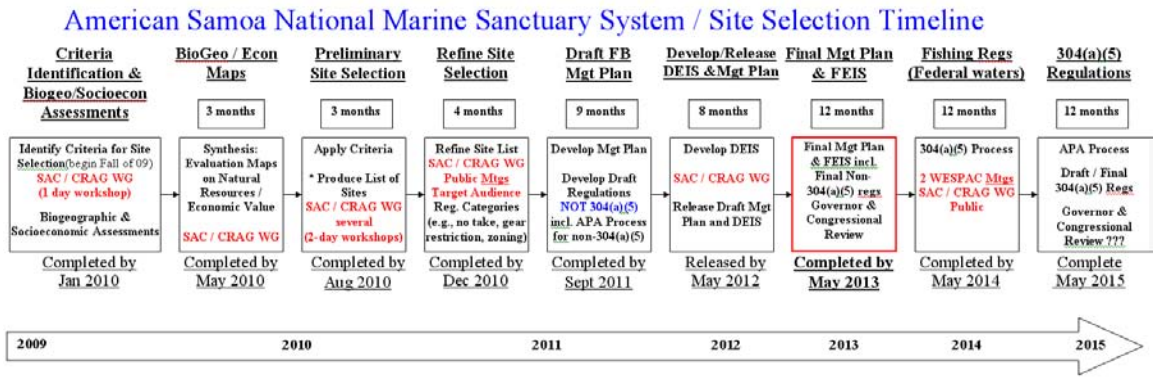


Figure 13. Plot from MPA site selection workshop (Source: DMWR 2005)

Objective 5. Support FBNMS staff in the integration of biogeographic assessment products into the Sanctuary Management Plan Review process.

The National Marine Sanctuary Program and FBNMS are engaged in two interrelated processes over the next several years, both of which are supported by the biogeographic assessment. The current management plan for FBNMS is undergoing revision and the potential for sanctuary expansion/multiple sites is being explored. A road map for considering a sanctuary network has been produced by ONMS (below) and requires the completed biogeogprahic assessment as a basic information input.



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Project Tasks

Below are brief descriptions of the major tasks planned for the biogeogrpahic assessment to address study objectives and questions. Please refer to page 20 for the task schedule and milestone timeline.

Task 1: Project Work Plan
Estimated completion date: February 2009

Produce a project work plan (this document) in consultation with local and federal partners. The work plan will describe the overall project and serve as a blueprint for implementation. The plan will seek to achieve consensus on project components, define partner roles and responsibilities, and convey expected outcomes and deliverables. The work plan should be viewed as an evolving document that will be modified during the early phases of project implementation. Project partners will work in close collaboration to ensure that any modification of the work plan as may be needed to reflect data availability, quality, or distribution will be mutually acceptable.

Products:

- 2 page project proposal (Complete)
- Project concept document (Complete)
- Work plan (This Document)

Sub-tasks:

- Project kickoff meetings, April 2008
- Meetings for data gathering and refinement of project scope, August 2008
- Production of draft project work plan for partner review, December 2008
- Final project work plan, January 2009
- FBNMS scoping meeting, February 2009

Task 2a: Data Gathering and Initial Assessment
Estimated completion date: March 2009

Identify, obtain, and evaluate all biogeographic (marine ecological and oceanographic) datasets. Primary datasets for development of territory-wide products will either be spatially comprehensive throughout American Samoa or at a minimum be based upon a stratified random sampling design to allow territory-wide scope of inference. Datasets that lack spatial attributes, are limited in geographic extent (e.g. one bay or coastal region), cannot be standardized (e.g. density estimates), or are out of date and are therefore not likely to represent current conditions, will not be used to develop territory-wide products. Datasets focused on individual localities may, however, be used to support validation of territory-wide products.

Many datasets of interest have already been identified and obtained from project partners including those from NOAA-CRED, AS CRMP, American Samoa DMWR, and the Western Pacific Fisheries Information Network. Physiographic data on bathymetry, oceanography, benthic habitats, and other parameters of the physical environment will form a fundamental backdrop for the study of species distribution patterns. Major species groups to be studied will likely include reef fish, invertebrates, and pelagic fish.

Products:

- Individual biogeographic data layers including but not limited to those based on the following:
    - insular shelf benthic maps
    - insular shelf bathymetric maps
    - deep sea bathymetric maps
    - archipelago-wide seasonal sea-surface temperature data

    - archipelago-wide seasonal sea-surface color/chlorophyll data
    - archipelago-wide seasonal sea-surface geostrophic current data
    - nearshore (reef fish) fisheries independent monitoring data
    - nearshore (reef fish) fisheries data
    - bottom fish fisheries independent data (none presently identified)
    - bottom fish fisheries data
    - offshore (pelagic fish) fisheries independent monitoring data
    - offshore (pelagic fish) fisheries data
    - benthic and coral cover monitoring data
- Complete biogeographic data inventory

Sub-tasks: Evaluation of each dataset will include key attributes such as:

- Scope of inference
- Spatial extent
- Time period
- Availability
- Comparability with other datasets

Task 2b: Socioeconomic Data Gathering and Initial Assessment
Estimated completion date: March 2009

Identify, obtain, and evaluate key socioeconomic and cultural related datasets. Primary datasets for development of territory-wide products will either be spatially comprehensive throughout American Samoa or at a minimum be based upon a stratified random sampling design to allow territory-wide scope of inference. Datasets that lack spatial attributes, are limited in geographic extent (e.g. one village or coastal region), cannot be standardized, or are out of date and are therefore not likely to represent current conditions, will not be used to develop territory-wide products. Datasets focused on individual localities may, however, be used to support validation of territory-wide products.

Many datasets of interest have already been identified and obtained from project partners including those from American Samoa DOC and DMWR, and the Western Pacific Fisheries Information Network. Major topics to be studied will likely include fishing, cultural values, knowledge, attitudes and perceptions, and resource values.

Products:

- Individual socioeconomic and cultural data layers including but not limited to those based on the following:
    - human population density and growth data
    - demographic, employment, income, and business data
    - resource use data
    - resource value data
    - nearshore (reef fish) fisheries data
    - bottom fish fisheries data
    - offshore (pelagic fish) fisheries data
    - knowledge, attitudes and perceptions data
    - cultural value data
    - traditional fishing
    - education, research and outreach
- Complete socioeconomic data inventory

Sub-tasks: Evaluation of each dataset will include key attributes such as:

- Scope of inference
- Spatial extent
- Time period

- Availability
- Comparability with other datasets

Task 3a: Database Development and Selection of Products and Analytical Techniques
Estimated completion date: June 2009

Specific biota and ecological features chosen for analysis will be dictated by discussion with project partners as well as data availability and quality. Products will be derived from the datasets deemed suitable from Task 2a. Suitable datasets will be converted into consistent units (e.g. density) and input into a GIS. Independent biological and physical datasets will then be synthesized into a spatially comprehensive database. Spatial analyses may range from simple presence/absence of species within a grid cell framework to more complex geostatistical approaches that link biota with physical environmental variables. The variety and comparability of the input datasets are expected to have a major influence on the character of the analyses. A preliminary approach to analysis will be presented to project partners for comment and approval.

Products:
- Biogeographic GIS and database
- Distribution models for the following potential variables:
    - habitat diversity
    - reef fish biomass, density, diversity
    - pelagic fish biomass, density, diversity
    - key fish species biomass, density,
    - key invertebrate species density
    - currents, larval transport, and island connectivity
- Brief report and presentation on data assessment and analytical approach

Subtasks:
- Ingest spatial datasets into GIS
- Convert datasets to consistent spatial framework
- Synthesize datasets for maximum spatial coverage
- Example distribution models
- Identify data gaps/limitations
- Achieve consensus on example analyses

Task 3b: Socioeconomic Database Development and Selection of Products and Analytical Techniques
Estimated completion date: June 2009

Specific socioeconomic and cultural data chosen for analysis will be dictated by discussion with project partners as well as data availability and quality. Products will be derived from the datasets deemed suitable from Task 2a. Analysis will include descriptive information, such as who the stakeholders and users are, the extent of their use (person-days of activity, fishing landing, etc.) and how much of their income is dependant on marine resources. The variety and comparability of the input datasets are expected to have a major influence on the character of the analyses. A preliminary approach to analysis will be presented to project partners for comment and approval.

Products:
- Socioeconomic GIS and database
- Distribution models for the following potential variables:
    - human population density and growth
    - demographic, employment, income, and business patterns
    - resource use
    - resource value
    - reef fish value

    - pelagic fish value
    - key fish species value
    - knowledge, attitudes and perceptions
    - cultural values
    - traditional fishing
    - education, research and outreach
- Brief report and presentation on data assessment and analytical approach

Subtasks:
- Ingest spatial datasets into GIS
- Convert datasets to consistent spatial framework
- Synthesize datasets for maximum spatial coverage
- Example distribution models
- Identify data gaps/limitations
- Achieve consensus on example analyses

Task 4a: Biogeographic Data Analysis
Estimated completion date: October 2009

The goal of this task is development of territory-wide distribution models for key ecological and biogeographic features followed by integrated analysis of multiple data layers. The final list of ecosystem features to be modeled will be determined by data availability, quality, and discussion with project partners. Model accuracy may be assessed with a subset of data not used in model development, the leave-one-out method, and/or based on datasets with limited geographic distribution that were not used in model development. Based on these models, spatial and temporal patterns of ecosystem features will be investigated. Breakpoints, trends, and "hot spots" for key ecosystem features will be identified in these analyses. Results will be input into the socioeconomic, traditional ecological knowledge, and MPA network design components of the assessment.

Products:
- Quantitative and qualitative assessments that identify biogeographic patterns and bio-physical interrelationships of single species, species assemblages, and measures of community structure
- Quantitative and qualitative assessments describing the physical and oceanographic setting within the study area (e.g. area of habitat, substrate distributions, habitat linkages)

Subtasks:
- Ingest modeled coverages into GIS
- Analysis of single data layers to identify important features
- Multivariate analysis of data layers to identify variable relationships

Task 4b: Socioeconomic Data Analysis
Estimated completion date: October 2009

The goal of this task is development of territory-wide distribution models for key socioeconomic and cultural information followed by integrated analysis of multiple data layers. The final list of socioeconomic information to be modeled will be determined by data availability, quality, and discussion with project partners. Results will be used to identify who potentially affected users are, determine how their behavior might be altered under various management scenarios, and estimate the socioeconomic impact of that change.

Products:
- Quantitative and qualitative assessments that identify social, economic and cultural patterns

- Quantitative and qualitative assessments describing the socioeconomic setting within the study area

Subtasks:

- Ingest modeled coverages into GIS
- Analysis of single data layers to identify important features
- Multivariate analysis of data layers to identify variable relationships

Task 5: Integrated American Samoa Marine Protected Area Network design and boundary scenarios
Estimated completion date: December 2009

Once the final biogeographic, socioeconomic, and traditional ecological knowledge components are complete, these three data layers will be evaluated in the context of a territorial MPA network. The network design will consider not only the existing network of federal and territorial MPAs, but also the territorial MPA initiative presently underway as well as modification of the FBNMS management plan, potential national marine sanctuary network, and inclusion of the Rose Atoll Marine National Monument. The spatial framework for MPA network analysis may be grid based, parcel based relative to village boundaries, or using some other geographic construct commensurate with existing political boundaries within American Samoa (e.g. villages) and Samoan custom.

The specific approach and analyses will be designed through consultation among project partners. First, goals of the network must be established to guide the analysis. The territorial MPA initiative has defined a 20% no-take goal as one guiding principle (Coral Reef Advisory Group 2002; Oram 2008) however, potential modification of FBNMS management goals and additional national marine sanctuary network possibilities must be refined. Specific management objectives or a range of alternative objectives are necessary to guide Task 5. Just as a workshop was conducted to identify territorial MPA criteria (Coral Reef Advisory Group 2002) a workshop among interested parties is needed to establish MPA network criteria using the foundation provided by the territorial initiative already underway. Once quantitative placement criteria are established and the spatial framework of analysis is agreed upon, combined analysis of biotic, physical, and socioeconomic goals can proceed. Ideally, a set of suitable MPA network boundary alternatives can be identified and put forward for expert review, further reduction, and ultimately put forward into a community outreach process consistent with Samoan custom (Brighouse 2001).

Products:

- GIS to enable exploration of MPA network boundary alternatives
- Set of alternative boundaries that meet design goals

Subtasks:

- Workshop to define MPA network criteria
- Devise analysis framework
- Create custom GIS to explore alternative boundary scenarios

Task 6: Draft Review
Estimated completion date: January 2010

Drafts of species, habitat, and analysis maps (e.g. species richness, diversity) coupled with statistical results will be made available to FBNMS, DMWR, and other project partners, interested members of the community, and other experts for review in a workshop format. In addition, a report will be developed that provides interpretation of the results of the biogeographic GIS-based analyses that can be easily integrated into federal and territorial management plans. A list of

questions and comments will be provided to reviewers to obtain feedback on specific areas of the analysis.

Products:

- Draft analytical results (maps, statistical results)
- Database on habitat affinities and utilization for selected species
- Comparisons of results among zoning alternatives
- Questions/issues for reviewers
- Map and/or list of data gaps
- Status report

Task 7. Development of Final Digital Products
Estimated completion date: March 2010

Once products have been reviewed, project staff will incorporate review comments and prepare final products in an appropriate format for inclusion in supplements to the sanctuary management plan and use by territorial partners.

Products:

- Final summary report describing the analysis, results, and interpretation of the results
- GIS on species, habitats, and important biological areas in the study area
- Database on species and habitats
- Map and/or list of data gaps

Task 8. Web Site for the Biogeographic Assessment
Estimated completion date: ongoing

A web site will be used to support the biogeographic assessment process by providing background documents and project updates, and allowing for review of draft products. Visit the web site at: http://ccma.nos.noaa.gov/ecosystems/sanctuaries/samoa.html

Products:

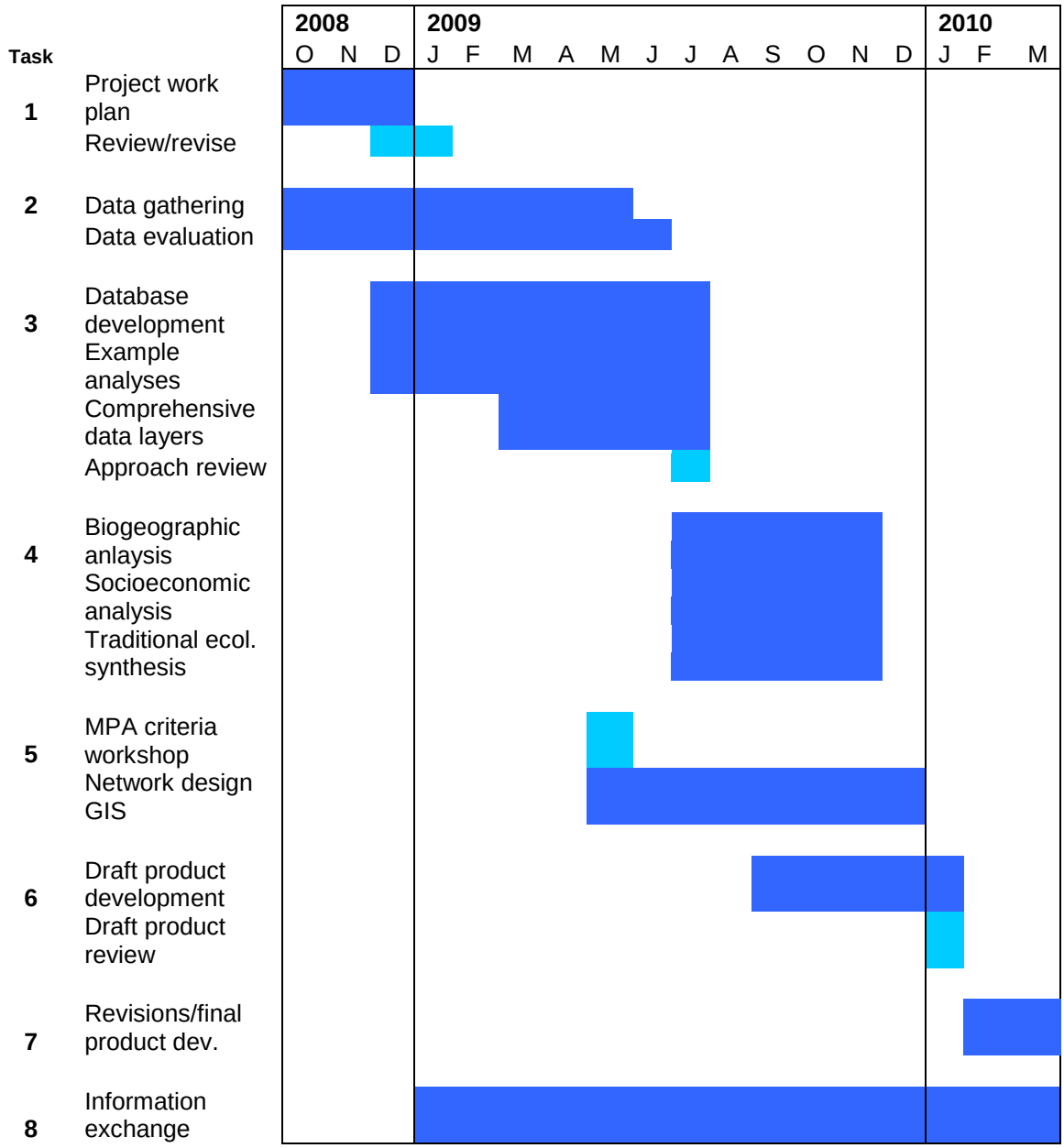
- The website content will be modified throughout the assessment process

Subtasks:

- Determine website content and appropriate information for dissemination to the public

Proposed Project Schedule

A two-year project is anticipated after implementation of the project work plan which is scheduled to begin in January 2009. The estimated project milestone dates assume full funding but will be extended depending on financial constraints. Specific roles of project partners as related to the schedule will be defined depending on level of funding and approach agreed upon in Task 3.



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Partner Agencies

AS CRMP- American Samoa Coral Reef Monitoring Program

AS DMWR- American Samoa Department of Marine and Wildlife Resources

AS EPA- American Samoa Environmental Protection Agency

CCMA- Center for Coastal Monitoring and Assessment

CRED- Coral Reef Ecosystem Division

FBNMS- Fagatele Bay National Marine Sanctuary

NPS AS- National Park of American Samoa

ONMS- Office of National Marine Sanctuaries

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Appendix A

Tables 1-4 for key datasets.

Table 1. Ongoing biological monitoring activities in American Samoa (Fenner et al. 2008).

PROJECT	LOCATION	YEAR	AFFILIATION/ FUNDING	PRINCIPLE INVESTIGATOR	FREQUENCY	STATUS
Aua Transect	Aua Village, Tutuila	1917	CRAG, CRI	Birkeland	Periodic	Ongoing
TMP	Tutuila and Manua	2005	DMWR, CRAG, NOAA	Fenner and Carroll	Annual	Ongoing
Resource Assessment and Monitoring Program	All Islands	2002	NOAA PIFSC-CRED	Brainard et al.	Biannual	Ongoing
Key Reef Species (fish)	Tutuila and Manua	2005	DMWR, FedAid Sportfish Recovery	Sabater	Annual	Ongoing
Coral Disease	Tutuila and Manua	2005	DMWR, FedAid Sportfish Recovery	Fenner	Annual	Ongoing
Rose Atoll	Rose Atoll	2002	USFWS	Maragos	Periodic	Ongoing
MPA Reef Flats	MPA Villages, Tutuila	2004	DMWR, FedAid Sportfish Recovery	Vaitautolu	Approx. Annual	Ongoing
Fagatele Bay Monitoring	Fagatele Bay, Tutuila	1985	Fagatele Bay NMS	Birlkeland and Green	3 years (Approx.)	Ongoing
Long-Term Monitoring	Tutuila and Manua	1982	DMWR	Green and Birkeland	5 years (Approx.)	Ongoing
Nonpoint Source Pollution	Tutuila	2003	AS EPA	Houk and Peshut	Annual	Ongoing
Inshore Creel Survey	South Shore, Tutuila	1978	DMWR, FedAid Sportfish Recovery	Iramatra	Daily	Ongoing
Reef Monitoring	National Park, North Shore, Tutuila	2007	National Park of American Samoa	Brown and Craig	Annual	Ongoing
Stream/ Beach Monitoring	Tutuila	2002	AS EPA	Zennaro and Paselio	Weekly	Ongoing
Shallow-water Benthic Habitat Maps	All Islands	2005	NOAA CCMA-BB	Battista and Monaco	One Time	One Time

Table 2. Ongoing oceanographic monitoring activities (Fenner et al. 2008).

System	Variables Monitored	Dates	Agency
Deepwater CTDs* at select locations near the islands	Conductivity (salinity), temperature, depth, dissolved oxygen, chlorophyll to a depth of 500 m	February 2002 - present	PIFSC-CRED
Shallow-water CTDs* - multiple sites each island/atoll	Temperature, salinity, turbidity	February 2002 - present	PIFSC-CRED
Water Samples	chlorophyll and nutrients (nitrate, nitrite, silicate, phosphate) concurrent with deep and shallow-water CTDs at select depths	January 2006 - present	PIFSC-CRED
Coral Reef Early Warning Buoys -1 Standard (Rose Atoll)	Enhanced: temperature (1 m), conductivity (salinity), wind, atmospheric pressure	February 2002 - present	PIFSC-CRED
Sea Surface Temperature (SST) Buoys - 3 (Tau, Tutuila)	Temperature at 0.5 m	February 2002 - present	PIFSC-CRED
Subsurface Temperature Recorders - 33 (all islands)	Temperature at depths between 0.5 m and 30 m	February 2004 - present	PIFSC-CRED
Ocean Data Platforms (ODP) - 1 (Swains)	Temperature, conductivity (salinity), spectral waves, current profiles	February 2002 - present	PIFSC-CRED
Wave and Tide Recorders (WTR) - 2 (Rose Atoll, Tutuila)	Wave and tidal heights	February 2004 - present	PIFSC-CRED
Ecological Acoustic Recorder (EAR) - 4 (Tutuila)	Ambient sounds up to 12.5 kHz and vessel generated sounds	February 2006 - present	PIFSC-CRED

* CTD: Conductivity, temperature and depth.

Table 3. Key fishery independent data for American Samoa (Fenner et al. 2008).

STUDY	PROJECT	YEAR	AVAILABLE DATA	METHOD USED	DEPTH	# OF SITES	REP'S/ SITE	TRANSECT/ SURVEY DIMENSION
Wass (1982)	Fish community characterization	1977-1979	Abundance, biomass, and species composition of diurnal fish	Belt transect	4-15 m[a]	63	1 5	100 x 2 m[b] 20 x 2 m
Green (1996) Green (2002)	Status of coral reefs of the Samoan archipelago	1996 2002	Abundance, biomass, and species composition of diurnal fish	Belt transect Belt transect	1,5,10,20 m 10 m	18 18	5 5	50 x 3 m 50 x 3 m
Page (1998)	Ecology, biology and fishery of parrotfishes	1996-1998	Abundance, biomass, species composition,	Belt transect	3,10,20 m	26	5	50 x 5 m
Green et al. (2005)	Fagatele Bay National Marine Sanctuary Monitoring Program	1977-2004	Abundance, biomass, and species composition of diurnal fish	Belt transect	12,6,9m[c] 3,6,9, 12,18 m	3 1	3 6	100 x 2[d] 30 x 2 m
PIFSC-CRED ongoing	American Samoa Reef Assessment and Monitoring Program	2002-2006	Abundance, biomass, and species composition of diurnal fish	Belt transect Stationary point count[i] Towed-diver survey[j]	10-15 m 10-15 m 15 m	76[f] 76[f] n/a	3 4 n/a	25 x 4 m[g], 25 x 2 m[h] 10 m radius n/a
Whaylen and Fenner (2006); Fenner and Carroll (*in review*)	American Samoa Territorial Monitoring Program (ASCRMP)	2005 2006	Abundance, biomass, and species composition of diurnal fish	Stationary point count Belt transect	10 m 10 m	11 11	6 6	7.5 m radius 30 x 10 m[k], 30 x 5 m[l], 30 x 2 m[m]
Sabater and Tofaeono (2006) Sabater and Tofaeono (2007)	Key Reef Species Program	2005 2006	Abundance, biomass, and species composition of targeted fish species	Belt transect Belt transect	10 m 10 m	24 20	3-4 3-4	30 x 5 m 30 x 5 m

A: Depth varies depending on the habitat being surveyed
B: Belt area varies between habitat types and transect orientation
C: Depth shown are for Fagatele Bay, Sita Bay and Cape Larsen, respectively
D: Transect area for years prior to 2004; later surveys used 30 x 2 m transect area
E: Belt transect used for quantifying relatively small bodied and abundant fish
F: The number of sites successfully surveyed varies between years. Numbers show total number of monitoring sites.
G: Transect dimension used to survey fish ≥20 cm TL
H: Transect dimension used to survey fish < 20 cm TL
I: Stationary point count for quantifying relatively larger and agile fish species
J: Towed-diver survey was used for quantify large bodied (>50 cm TL), wide-ranging fishes over a broad spatial scale
K: Belt dimension used to survey highly mobile species (e,g, Kyphosidae, Scaridae, Siganidae, Lethrinidae, Serranidae, etc.)
L: Belt dimension used to survey demersal species (e.g., Chaetidontidae, Pomacantidae, Acanthuridae, Balistidae, etc.)
M: Belt dimension used to survey Pomacentridae including only herbivorous and excluding planktivorous species

Table 4. Key human dimension data sets for American Samoa.

Project	Location	Year	Affiliation/ Funding	Avail-able Data	Principle Investigtor	Project Status
Documenting Traditional Knowledge of Marine Resource Use and Management in American Samoa	Tutuila and Manua	2008	NOAA, CRAG	Yes	Arielle Levine	Ongoing
Knowledge, Attitudes and Perceptions Towards Marine Conservation in American Samoa. Survey of Villages Adjacent to Fagatele Bay	Tutuila	2008	NOAA	Yes	Emily Gaskin	Ongoing
Public Knowledge and Perceptions of Coral Reefs: A Study of Tutuila, American Samoa	Tutuila	2005	CRAG	Yes	Rachel Turner	Final
Economic Valuation of Coral Reefs and Adjacent Habitats in American Samoa (Jacobs)	All Islands	2004	ASDOC	Yes	James Spurgeon	Final
Initial assessment of the potential for applying economic values to enhance coastal environmental policy in American Samoa (Jacobs)	All Islands	2007	ASDOC	Yes	Toby Roxburgh	Draft
American Samoa Territorial Marine Science Center Business Plan	Tutuila	2008	ASDOC	No	Steve LeGore	Final
A Description and Economic Analysis of Large American Samoa Longline Vessels	Tutuila	2002	UH, JIMAR, NOAA	No	O'Malley and Pooley	Final
The Commercial, Subsistence and Recreational Fisheries of American Samoa	All Islands	1993	DMWR	No	Peter Craig	Final
Ecotourism Plan for American Samoa	All Islands	2005	ASDOC	No	UH Pacific Business Center Program & School of Travel In-dustry Management	Final
American Samoa Business Opportunities Report	All Islands	2007	USDOI - OIA	No	Adam Stein and Rick Turner	Final
A Geographic Information System for Fisheries Management in American Samoa	All Islands	2005	DMWR	Yes	Francesca Riolo	Final
Impact of Increased Minimum Wages on the Economies of American Samoa and the Commonwealth of the Northern Mariana Islands	All Islands	2008	USDOL	No	Office of the As-sistant Secretary for Policy	Final
American Samoa Archipelago Fishery Ecosystem Management Plan	All Islands	2005	Western PRFMC	Yes		Final
American Samoa's Economic Future and The Cannery Industry	Tutuila	2008	USDOI - OIA	Yes	Malcolm D. McPhee	Final
Decision Support for Coral Reef Fisheries Management: Community Input as a Means of Informing Policy in American Samoa	Tutuila	2006	U of CA	Yes	S. Kilarski, et al.	Final